



ELECTRICITY MINI GRID CODE OF LIBERIA

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Table of Contents

Foreword.....	7
PART A: GENERAL PROVISIONS.....	8
SECTION 1: PREAMBLE.....	9
1.1 Purpose and Scope of Mini Grid Code	9
1.2 Scope of Mini Grid Supply System.....	9
1.3 Structure of the Mini Grid Code.....	10
SECTION 2: ACCRONYMS AND ABBREVIATIONS	11
SECTION 3: APPLICATION OF THE CODE.....	12
3.1 Main Actors, Processes and Installations.....	12
3.2 General Requirements	12
3.3 Service Provider Responsibilities	13
SECTION 4: MANAGEMENT AND GOVERNANCE OF THE MINI GRID CODE.....	14
4.1 Purpose and Scope.....	14
4.2 Conduct of Service Provider.....	14
4.3 Role of LERC	14
4.4 Role of RREA.....	15
4.5 RREA to Report on Service Provider’s Performance to LERC	15
4.6 Revision of the Mini Grid Code	15
PART B: LICENSING/ PERMITTING PROVISIONS AND CONDITIONS.....	17
Introduction	17
SECTION 5: SERVICE PROVIDER LICENSING PROCESS	18
5.1 Conditions Prior to Licensing.....	18
<i>Construction Permit</i>	18
<i>Construction Period</i>	18
5.2 Requirement for a License or Permit for operations	18
<i>Authorization to Commence Operations</i>	19
SECTION 6: TRANSPARENCY AND NON-DISCRIMINATION REQUIREMENTS	20
6.1 Publication of Procedures	20
6.2 Equal Application of the Mini Grid Code	20
6.3 Exercise of Discretion by the Service Provider and other Officials	20
6.4 Tariffs and Charges for Mini Grid Services	21
6.5 Compliance with Laws and Industry Standards.....	21

SECTION 7: PLANNING AND DESIGN	22
7.1 National Planning	22
<i>Mapping and demographic analysis</i>	22
7.2 System Development Planning and Design.....	22
<i>Coordinating Roles</i>	22
<i>Energy Consumption Projection Parameters and categories</i>	23
<i>System Sizing Criteria</i>	23
<i>Engineering analysis and system investment plan</i>	24
7.3 Financial Forecast Assessment	24
SECTION 8: CONNECTIONS	26
8.1 Purpose.....	26
8.2 Customer Service Agreement (CSA)	26
8.3 Customer Charter	26
8.4 Connections and Connection point.....	26
8.5 Facilities ownership.....	27
8.6 Metering of Services	27
8.7 Number of services	27
8.8 Single-phase or Three-phase supply service.....	27
8.9 Service Drop Conductors	28
8.10 Customer’s Internal Wiring.....	28
8.11 System of Earthing.....	28
<i>AC conductor earthing</i>	29
<i>DC conductor earthing</i>	29
8.12 Lightning Protection	29
8.13 Fault Current	29
8.14 Alternative Power Supply Installed by Customer	29
PART C: RULES OF PRACTICE	31
SECTION 9: GENERAL PROVISIONS	32
9.1 Liability	32
9.2 Force Majeure.....	32
SECTION 10: CONDITIONS OF SERVICE & ASSET MANAGEMENT	34
10.1 Establishment	34
10.2 Good Asset Management	35

10.3	Customer’s Electrical Installation and Equipment.....	36
10.4	Service Provider’s Equipment on Customer Premises.....	36
	OPERATIONS SUB-CODE.....	38
	SECTION 11: MINI GRID SYSTEM TECHNICAL REQUIREMENTS (or FRAMEWORK).....	38
11.1	Purpose.....	38
11.2	Mini Grid Distribution Network Requirements.....	38
	<i>General</i>	38
	<i>Medium voltage (MV) distribution standard</i>	38
	<i>Low voltage (LV) distribution standard</i>	39
	<i>House wiring</i>	40
11.3	Solar PV Generation Design Parameters.....	40
	<i>General</i>	40
	<i>Solar PV array rack (mounting structure)</i>	41
	<i>Photovoltaic (PV) modules</i>	41
	<i>Solar photovoltaic array Dimensioning</i>	42
	<i>Solar PV Batteries</i>	42
	<i>Inverters</i>	43
	<i>PV charge controllers</i>	44
	<i>Battery storage and inverters - design & Dimensioning</i>	45
11.4	Hydropower Generation Design Parameters.....	45
	<i>General</i>	45
	<i>Powerhouse</i>	45
	<i>Civil works – concrete and steel</i>	46
	<i>Weir & intake</i>	46
	<i>Channel</i>	47
	<i>Forebay</i>	48
	<i>Penstock and Supports</i>	48
	<i>Micro-hydropower generator and controls</i>	49
11.5	Electricity Supply Stations.....	50
	<i>Safety and Protective arrangements</i>	50
	<i>Battery installations (where applicable)</i>	51
	<i>On-site fuel storage</i>	51
11.6	Classification of Levels of Service.....	52

11.7	Quality of Supply	52
	<i>Nominal Voltage</i>	53
	<i>Transient voltage variations</i>	53
	<i>Voltage imbalance</i>	53
	<i>Frequency</i>	53
	<i>Total Harmonic Distortion (THD)</i>	53
11.8	Availability of Supply	54
11.9	Supply Reliability	54
SECTION 12: MINI GRID INTERCONNECTION REQUIREMENTS		56
12.1	Purpose.....	56
12.2	Liberia Power System characteristics	56
12.3	Interconnection Requirements	56
	<i>Generation</i>	56
	<i>Synchronization</i>	56
	<i>Voltage</i>	57
	<i>Active and reactive power</i>	57
	<i>Isolation</i>	57
	<i>Quality</i>	58
SECTION 13: MINI GRID OPERATIONS		59
13.1	Purpose.....	59
13.2	General Responsibilities of a Mini Grid Service Provider	59
13.3	Mini Grid Operating States.....	60
13.4	Mini Grid System Monitoring and Control.....	61
13.5	Operations Plan, Procedures and Manuals	61
13.6	Service Provider’s Right to Interrupt Supply	62
13.7	Planned Interruptions.....	62
13.8	Unplanned Interruptions and outages.....	63
13.9	Disconnection and Reconnection	63
13.10	Unauthorized Energy Use.....	63
13.11	Illegal Supply and/or Power Theft.....	64
SECTION 14: Safety, Health & Environment.....		64
14.1	Purpose.....	64
14.2	Safety Coordination.....	64

14.3	Safety Code.....	65
	<i>Minimum Working Clearances from Energized Overhead Electric Utility Lines</i>	65
	<i>Construction site signaling</i>	66
14.4	Health Safety and Environment	66
PART D: STANDARDS OF PERFORMANCE		67
SECTION 15: BENCHMARKS AND INDICES FOR STANDARDS OF SUPPLY: QUALITY AND RELIABILITY		68
15.1	Purpose.....	68
15.2	Standards for Power Quality and Reliability.....	68
15.3	Reliability of Supply Targets	68
SECTION 16: METERING		69
16.1	Purpose.....	69
16.2	Ownership	69
16.3	Customer responsibility	69
16.4	Technical Characteristics	70
	<i>Meter Type/Accuracy</i>	70
16.5	Meter Installation/Reading/Testing	70
	<i>Customer Access & Installation</i>	70
	<i>Meter Sealing</i>	71
	<i>Meter Testing</i>	71
16.6	Metering Data	71
SECTION 17: INFORMATION EXCHANGE AND REPORTING		72
17.1	Purpose and Scope.....	72
17.2	General Principles for Implementation of Information and Data Exchange	72
17.3	Planning Information.....	72
17.4	Network/System Information Exchange.....	73
17.5	Time Standard	73
17.6	Data Retention and Archiving.....	73
17.7	Mini Grid Performance Data Reporting.....	74
17.8	Events Reporting.....	75
17.9	Significant Incident.....	75
SECTION 18: COMPLAINTS AND DISPUTE RESOLUTION		76
18.1	Complaints Handling Process	76

SECTION 19: BREACH OF THE MINI GRID CODE	77
19.1 Service Provider’s Obligation to Remedy.....	77
19.2 Notification of Non-compliance	77
19.3 Customer’s Obligation to Remedy.....	77
PART E: DEFINITIONS	78
TECHNICAL SCHEDULES.....	82
TECHNICAL SCHEDULE TS-A: QUALITY OF SUPPLY STANDARDS/BENCHMARKS ...	82
TECHNICAL SCHEDULE TS-B: RELIABILITY OF SUPPLY STANDARDS/BENCHMARKS	84
APPENDIX A: PERFORMANCE REPORTING INDICATORS TEMPLATE.....	85
Appendix B: Customer Service Agreement Template (General).....	88

Tables

Table 1: Average energy consumption by customer category	23
Table 2: Maximum channel velocity for different types of hydro channels	48
Table 3: SE4All Levels of Service classification	52
Table 4: Characteristics of the Liberia power supply system	56

Foreword

The Mini Grid Code provides the legal, technical, and safety guidance for the development and operation of mini grids in the Republic of Liberia. The Code covers mini grids that are designed to operate either in isolation from the national grid or interconnected to the national grid.

The Code takes cognizance of the present situation in Liberia, where only a small percentage of the population has access to electricity and LEC only supplies the Monrovia area from the national grid and a few other select areas receiving electricity from “mini grids” that are connected to cross-border supplies from neighboring Cote d’Ivoire which are operated on behalf of LEC by private operators. The Code also takes note of the policy of government to achieve *electricity for all* through development and operation of isolated mini grids whilst embarking on pragmatic and consistent expansion and extension of the national grid to interconnect the mini grids in the future. A few parts of the country are currently being supplied from mini grids majority of which are operating in isolation of the national grid and a lot more of such developments are expected under the sponsorship and promotional oversight of RREA, an institution that was established by law under the auspices of the MLME for the purpose.

The LERC in support of government policy has the mandate to develop codes and standards to guide the development and safe operation of mini grids to provide access to reliable electricity supplies using modern renewable energy sources that abound in the country. In line with regulation 40 of the MULR issued by the LERC, isolated mini grid Service Providers are encouraged to source and maintain at least fifty percent (50%) of their annual electricity supplies from renewable energy sources.

The Code provides guidelines for prudent design, construction and operation of mini grid power systems including provisions to ensure that a Mini Grid can be operated in a manner that does not put at risk the target population receiving the supply. The Code shall be used by RREA and LERC to oversee operations of service providers that are granted mini grid operating licenses or permits in Liberia.

Service Providers under this Code are also informed about the existence and contents of the Distribution Code which may provide further guidance to Service Providers in the development and planning of their mini grid networks and systems, especially if the mini grid is to be interconnected to the national grid in the future.

PART A: GENERAL PROVISIONS

Introduction

The General Provisions contains the purpose and scope of the Mini Grid Code, a definition of roles, responsibilities, terminology, and arrangements for the management and governance of the Mini Grid Code.

SECTION 1: PREAMBLE

1.1 Purpose and Scope of Mini Grid Code

- 1.1.1** The Electricity Law of Liberia, 2015 (ELL), hereinafter referred to as the Law, establishes the legal basis for public and private electricity service providers to offer commercial electricity supply services in Liberia, using grid expansion and off-grid supply services to rural and remote communities. This Law enables legal incorporation of entities which, under a license or permit issued by the Liberia Electricity Regulatory Commission (LERC), is authorized to generate and distribute electricity within a prescribed service area.
- 1.1.2** The Mini Grid Code establishes technical and safety requirements that applicants for electricity supply licenses or permits will be required to meet.
- 1.1.3** The Code sets out the legal and technical requirements for provision of commercial mini grid electricity supply services and establishes procedures, practices, quality and reliability of service, safety standards and other conditions that govern the development, operation, maintenance, and use of a mini grid electricity supply service in Liberia.
- 1.1.4** The purpose of the Mini Grid Code is to ensure that the Service Provider provides fair, transparent, adequate, safe, reliable, secure, and cost-efficient delivery of modern electrical energy supply to consumers.
- 1.1.5** The Mini Grid Code is issued by LERC and is based on the provisions of sections 3.3: A. 5, 6, 8, 9, B.4 and 3.4 of the Law.

1.2 Scope of Mini Grid Supply System

- 1.2.1** In accordance with the Law, LERC has determined that a Mini Grid system shall comprise a small electricity supply system with its own power generation capacity or source of supply with installed capacity not exceeding 10MW and supplying electricity to a number of customers not exceeding 20,000 customers.
- 1.2.2** A Mini Grid shall have a generation facility in its network which may be operated by the Mini Grid Licensee/Permit Holder or a third party.
- 1.2.3** A Mini Grid may be classified as:
- (a) Isolated Mini Grid – in which case the system operates as an off-grid network or
 - (b) Interconnected Mini Grid – in which case the system operates as a small network connected to a distribution or transmission network.
- 1.2.4** The scope of a Mini Grid system as provided in this Code includes both the Isolated Mini Grid and Interconnected Mini Grid. Despite the separation, the different Parts of the Mini Grid Code are intended to be consistent and complementary for the satisfactory delivery of Mini Grid electricity supply services. Nothing in this Mini Grid Code precludes the application of evolving technologies and processes as they become available.

1.3 Structure of the Mini Grid Code

- 1.3.1** The Parts of the Mini Grid Code are generally organized according to the legal instruments by which they are to be implemented.
- 1.3.2** Part A, the General Provisions, contains the purpose and scope of the Mini Grid Code, a definition of roles, responsibilities, terminology, and arrangements for the management and governance of the Mini Grid Code.
- 1.3.3** Part B of the Mini Grid Code defines the requirements and procedure for obtaining a License or Permit to construct and operate a Mini Grid infrastructure to provide commercial electric power services in Liberia. This Part contains sub-codes that deal with aspects of the Conditions of a License or Permit such as planning, connection arrangements, rights and the requirements for transparency and nondiscrimination.
- 1.3.4** Part C, the Rules of Practice, details the technical requirements and interconnection requirements for a Mini Grid system, arrangements for operations and safety considerations.
- 1.3.5** Part D, the Standards of Performance, states the indicators and benchmarks for quality and reliability of supply for each level of service provided. The Part also contains the sub-code for metering which describes the applicable standards and installation arrangements for metering.
- 1.3.6** Part E, the Definitions, provides meanings and definitions for special words and technical terms used in the text to bring out the meanings in the context that they have been used in the Mini Grid Code.

SECTION 2: ACCRONYMS AND ABBREVIATIONS

ABC	Aerial Bundled Cable
AC	Alternating Current
ANSI	American National Standards Institute
DC	Direct Current
CSA	Customer Service Agreement
EPA	Environmental Protection Agency
GPS	Global Positioning System
GoL	Government of Liberia
IEC	International Electro-technical Committee
KPI	Key Performance Indicator
IRR	Internal Rate of Return
kVA	kilovolt-ampere, or one thousand volt-amperes
kVar	Kilovar, or one thousand volt-amperes of reactive power
kW	Kilowatt or one thousand watts of active electric power
kWh	Kilowatt-hour or one thousand watt-hours of electrical energy
LEC	Liberia Electricity Corporation
LERC	Liberia Electricity Regulatory Commission
LV	Low Voltage
MME	Ministry of Mines and Energy
MULR	Micro Utility Licensing Regulations
MV	Medium Voltage
MW	Megawatt, one million watts of active electric power
NEC	National Electrical Code (USA)
NPV	Net Present Value
ROE	Return on Equity
RREA	Rural and Renewable Energy Agency
STC	Standard Test Conditions
UL	Underwriters Laboratories

SECTION 3: APPLICATION OF THE CODE

3.1 Main Actors, Processes and Installations

- 3.1.1** Unless otherwise stated in a License, Permit or Code issued under the Law, the sections of this Code shall apply to the design, development, construction and operations of a Mini Grid with generation Capacity of up to 10 MW and/or supplying electricity service to number of customers not exceeding 20,000.
- 3.1.2** The main actors earmarked under this Code include:
- (a) the owner and/or developer of a Mini Grid;
 - (b) the operator of a Mini Grid;
 - (c) the generation provider where the supply to a Mini Grid is provided by another party;
 - (d) the target customers of the Mini Grid supply service; and
 - (e) any national institution or agency that interacts with Mini Grid owners, developers, operators, and customers in Liberia.
- 3.1.3** A Service Provider under this Code refers to the Operator of the Mini Grid system and includes the supply source provider where the generation is provided by another party.
- 3.1.4** The Code is applicable to:
- (a) the design and construction of the Mini Grid infrastructure;
 - (b) the process of applying for a License or a Permit to operate;
 - (c) the safe and reliable operation of the facilities;
 - (d) Customer rights and obligations to receive supply from a Service Provider; and
 - (e) the preparation and submission of performance reports to RREA and LERC.
- 3.1.5** The Code shall be administered by RREA under the oversight of the LERC.

3.2 General Requirements

- 3.2.1** The Code is based on technical standards commonly used in the electricity supply industry to guarantee safe and reliable operation of electricity generation and distribution facilities throughout the operating life of the facilities. The Code provides guidelines for prudent design, construction and operation of mini grid power systems including provisions to ensure that a Mini Grid can be operated in a manner that does not put at risk the target population receiving the supply and the general public.
- 3.2.2** The Code does not foresee all operational conditions that may arise in the provision of electricity supply services to rural communities. The Code provides and presents design and operating guidelines and principles, standards of safety, standards of service and specifies reporting requirements for a Service Provider.
- 3.2.3** In this context, a Service Provider shall act, during the reasonable and prudent discharge of the responsibilities, to meet the following requirements:

- (a) Avoidance of unscheduled outages for Mini Grid electricity supply service;
- (b) Rapid restoration of service and minimization of the number of consumers affected when faults occur;
- (c) Strict adherence to all standards of safe design, safe construction, and safe operation of all mechanical and electrical works in the generation and distribution segments of a Mini Grid; and
- (d) Adherence to providing fair business practices with regards to metering, billing, and collection of revenues from mini grid electricity supply customers.

3.3 Service Provider Responsibilities

3.3.1 A Service Provider shall operate the Mini Grid to provide services in accordance with the Performance and Reliability Standards of this Code.

3.3.2 The Service Provider's responsibilities in this regard shall include the following:

- (a) Apply for a License (or a Permit), with the assistance of RREA, to build facilities and to offer commercial electricity supply services to households, businesses and other community consumers following the process established under the MULR issued by LERC;
- (b) Prepare and submit a complete set of design drawings and specifications of power generation and distribution facilities in applying for a License or Permit to commercialize electric power. The design drawings must be accompanied by:
 - (i) a geographic map of the proposed service area,
 - (ii) the number of potential consumers per category, and
 - (iii) an indication of the proposed levels of service to be provided.
- (c) Operate all facilities in accordance with the specified levels of service quality, including voltage limits, frequency limits, and maximum number and duration of service outages as required under its License or Permit.
- (d) Connect customers that place an application unless their location does not guarantee a safe supply (voltage drop for example)
- (e) Establish the means and conditions to receive and register customer complaints relevant to the services provided through a customer service and call center.
- (f) Monitor and record generation-distribution system performance and submit monthly performance reports to RREA in the specified reporting format.
- (g) Present and collect bills for services or provide the means for consumers to prepay for electricity supply service.
- (h) Follow agreed procedures established in this Code and the Customer Service and Quality of Supply Regulations for disconnection of defaulting consumers that fail to pay for the service within the authorized payment period for post-paid consumers.

- (i) Establish an open and transparent dispute resolution process for disagreements that may arise with consumers in accordance with the guidelines provided in this Code.
- (j) Prepare and present investment plans to RREA and LERC including plans for expansion and extension of the services to other areas under the License or Permit on an annual basis.

SECTION 4: MANAGEMENT AND GOVERNANCE OF THE MINI GRID CODE

4.1 Purpose and Scope

This section defines the arrangements for the management and governance of the provision of mini grid network services and for the implementation of the Mini Grid Code.

4.2 Conduct of Service Provider

- 4.2.1** A Service Provider which has been given the exclusive mandate to operate a mini grid facility and provide electricity supply services in a designated area shall be responsible for the good governance and management of its mini grid system in accordance with the Mini Grid Code and guided at all times by generally accepted best practices.
- 4.2.2** The Service Provider shall be guided by the fundamental principles of fairness, transparency and non-discrimination in the governance and management of its mini grid system.
- 4.2.3** A report of the activities of the Service Provider shall be made available for review by an interested customer or community consumer representative(s).
- 4.2.4** The Service Provider shall be accountable to LERC through RREA, or otherwise directly to LERC as specified in the License or Permit, for the performance of the mini grid facility and compliance with the intent of the Mini Grid Code.

4.3 Role of LERC

- 4.3.1** The primary purpose of LERC with regard to the operation of the Mini Grid system shall be to ensure compliance with the Mini Grid Code.
- 4.3.2** LERC shall oversee all technical operations, activities and transactions on the Mini Grid system and also supervise and monitor the performance of all the functions of the Service Provider towards ensuring the fulfilment of Service Provider's role as required under the Mini Grid Code.
- 4.3.3** LERC shall have the mandate to:
 - (a) review and assess on a regular basis the following:
 - (i) performance of a Service Provider and its mini grid system;
 - (ii) compliance with rules and regulations by Service Provider and Customers;

- (iii) fairness and non-discrimination in all operational activities;
- (b) consider, investigate, assess, and advise on the following issues as may be found appropriate:
 - (i) possible unacceptable behavior of a customer or service provider,
 - (ii) proposals for the revision of the Mini Grid Code,
 - (iii) procedures, practices, rules or regulations covering the Mini Grid system,
 - (iv) mini grid Standards of Performance and penalties, and
 - (v) any mini grid system related complaints;
- (c) audit, approve or affirm as relevant the following:
 - (i) Compliance Plans and remedial programs, and
 - (ii) data archiving systems; and
- (d) establish guidelines on procedures for resolution of disputes.

4.4 Role of RREA

- 4.4.1** Despite the provisions in section 4.3 of this Code and in accordance with Section 2.1(c)(xiv) of the RREA Act, RREA shall be responsible for the regulatory monitoring of all rural, isolated Mini Grids operating as off-grid energy supply systems and electrification projects on behalf of LERC.
- 4.4.2** Subject to section 4.4.1, RREA shall play the oversight roles listed under section 4.3 in relation to Isolated Mini Grids and report periodically to LERC as stated in section 4.5.

4.5 RREA to Report on Service Provider's Performance to LERC

Subject to RREA's oversight responsibility under section 4.4, RREA shall collate and analyze the performance records of a Service Provider and submit to LERC a Regulatory Performance Report on each Service Provider twice a year (bi-annually) with appropriate recommendations.

4.6 Revision of the Mini Grid Code

- 4.6.1** Proposals for the revision of any provision of the Mini Grid Code may be made by a Service Provider, Customer, RREA or LERC, the "Proposer".
- 4.6.2** All proposals for Mini Grid Code revisions shall be in writing and shall be sent to LERC with a copy to RREA.
- 4.6.3** The LERC shall receive, register, and acknowledge all submissions within 5 business days upon receipt.

- 4.6.4** The LERC shall notify all Service providers and Main Actors of such proposals and make copies accessible to them either over the internet or through other appropriate means to provide their views to the LERC within three months of receipt.
- 4.6.5** The LERC shall in consultation with RREA consider the submissions of the “Proposer”, views from Service Providers and Main Actors and advise all the parties of its decision with full and written justifications.

PART B: LICENSING/ PERMITTING PROVISIONS AND CONDITIONS

Introduction

This section of the Mini Grid Code defines the requirements and procedure for obtaining a License or Permit to construct and operate a Mini Grid infrastructure to provide commercial electric power services in Liberia. This Part contains sub-codes that deal with aspects of the Conditions of a License or Permit such as planning, connection arrangements, rights and the requirements for transparency and nondiscrimination.

SECTION 5: SERVICE PROVIDER LICENSING PROCESS

5.1 Conditions Prior to Licensing

Construction Permit

5.1.1 The Service Provider must submit to RREA engineering design drawings and construction plan together with an application for a *Construction Permit*. A *Construction Permit* shall be issued by RREA authorizing the Service Provider to proceed with investment and construction of the Mini Grid supply infrastructure.

Construction Period

5.1.2 The construction period for a Mini Grid supply infrastructure shall not exceed two (2) years. All supply infrastructure including services to premises of registered customers must be completed within a period of two years.

5.1.3 Upon completion of construction of the Mini Grid supply system, the developer shall notify RREA of such completion and RREA shall issue the Developer with a Project Completion Certificate after satisfactory inspection and commissioning test of the facility by competent technical teams of both the RREA and the developer with the LERC in attendance upon invitation by RREA.

5.1.4 Subject to section 5.1.3, RREA may decide to engage the services of an independent competent engineer or firm to assist with the technical assessment, inspection, and commissioning of the facility.

5.1.5 Failure by a Service Provider to comply with section 5.1.3 will result in an incomplete submission during the Application process of the License or Permit.

5.1.6 The Service Provider shall submit copies of the detailed commissioning test results of the facility and the Project Completion Certificate issued by RREA, to LERC as part of its documentations required during the License or Permit Application Process described in section 5.2.

5.2 Requirement for a License or Permit for operations

5.2.1 A Service Provider must apply for a License or Permit, through RREA, to LERC prior to operations of a facility it has developed for the provision of electricity supply services in a designated area subject to meeting requirements under section 5.1. The application process shall be in accordance with provisions specified in regulation 5 of the MULR issued by the LERC.

5.2.2 Despite section 5.2.1, the requirements for a License or Permit application shall include submission of information to varying levels of detail, depending on the type and category of authorization required as described in regulations 6 and 7 of the MULR, including the following:

- (a) Presentation of a clear definition of the geographic scope of the Mini Grid service area including:
 - (i) a description of the location;
 - (ii) the scope of the service area;
 - (iii) a map of the entire service area using GPS locational technology (showing house and other building locations);
 - (iv) an indication of the number of houses and businesses that will be served;
 - (v) the proposed supply technology(ies) for the mini grid service; and
 - (vi) single line diagrams of the entire proposed electric generation/distribution system.
- (b) A description and indication of:
 - (i) the proposed level of service in watts or kilowatts to be provided;
 - (ii) the expected energy consumption level that will be satisfied by the generation system;
 - (iii) the hours of service to be provided per day;
 - (iv) the expected average weekly or monthly rate of consumption (in kWh);
 - (v) the expected peak load (in kW) in year 1, year 5 and year 10, where applicable; and
 - (vi) the number of streetlights that will be installed as part of the Mini Grid system.
- (c) Provision of an analysis of the cost of service for each consumer category.
- (d) A brief business plan is required stating the following :
 - (i) the expected capital cost of the project;
 - (ii) a financial analysis of the project;
 - (iii) sources and uses of funds to finance the project;
 - (iv) provision of information on the principal investment partners in the project; and
 - (v) a demonstration that the investment partnership has the capability to raise the capital required to finance the project.
- (e) Environmental impact assessment report and Permit indicating EPA approval for the project.

5.2.3 The LERC shall, following a successful assessment of the application, issue the applicant with the appropriate License or Permit for provision of the services requested subject to terms and conditions determined by the LERC in accordance with the MULR.

Authorization to Commence Operations

5.2.4 The Service Provider shall, upon the issuance of a License or Permit by the LERC, commence commercial operations after receipt of authorization to commence with commercial operations issued by LERC in consultation with RREA.

SECTION 6: TRANSPARENCY AND NON-DISCRIMINATION REQUIREMENTS

6.1 Publication of Procedures

- 6.1.1** A Service Provider shall develop and publish in detail all the requirements, qualifications, and administrative procedures to be fulfilled or followed by those seeking to be provided services by the Service Provider.
- 6.1.2** The requirements to be published shall include the modes of communication with the Service Provider, technical requirements for connection to the Mini Grid, technical operating parameters, operating period and performance benchmarks for service provision.
- 6.1.3** The qualifications shall include all legal, financial, and technical qualifications to be fulfilled by the prospective customer seeking to be connected to the Mini Grid system.
- 6.1.4** The administrative procedures shall include all administrative, financial, technical and any other procedures to be followed prior to commissioning of a service connection as well as the obligations of the customer for continued provision of the service.
- 6.1.5** The LERC and RREA shall publish the Mini Grid Code on their respective websites and make copies readily available to the public as well as all other related publications upon the payment of a published fee by the person that made the request.

6.2 Equal Application of the Mini Grid Code

The Mini Grid Code shall be fairly and uniformly applied to all classes within a category of Customers. Conditions and situations that are similar shall all receive consistent and equitable treatment.

6.3 Exercise of Discretion by the Service Provider and other Officials

- 6.3.1** The Service Provider or any other person shall not make a decision that is inconsistent with the Mini Grid Code in respect of usage or provision of services from the Mini Grid system.
- 6.3.2** A Service Provider may use its discretion and good judgment in making decisions on any matter on which the Mini Grid Code does not contain complete or adequate stipulations.
- 6.3.3** The exercise of a discretionary power shall however accord with good sustainable energy supply services practices and shall be justified in writing to RREA and the affected party while such decision is taken and the LERC informed by RREA as may be deemed necessary.
- 6.3.4** The principles and rationale for any discretion exercised or decision taken by a Service Provider shall be published and made available to RREA, and to any person upon request.

6.3.5 A person aggrieved by a discretionary decision taken by a Service Provider may request for a review by the LERC in consultation with RREA as may be necessary.

6.3.6 The LERC and RREA shall consider the complaint and uphold or recommend a reconsideration of the decision.

6.4 Tariffs and Charges for Mini Grid Services

Tariffs and charges for use of the mini grid services provided by a Service Provider shall be in accordance with the guidelines prescribed in the MULR and modalities specified in the Tariff Regulations and Methodology published in the Gazette by the LERC.

6.5 Compliance with Laws and Industry Standards

6.5.1 Service providers and their customers shall comply with all relevant laws, the Regulations, the requirements of the Mini Grid Code, License or Permit conditions and in accordance with Prudent Utility Practice.

6.5.2 A Service Provider shall comply with the terms of agreement with the community, the customer contract as well as the decisions, orders, and directions of RREA and LERC as may be applicable.

6.5.3 Failure by a Service Provider to comply with any of the conditions specified in sections 6.5.1 and 6.5.2 may result in the revocation of the License or Permit, and relevant approvals granted by RREA for provision of the service.

SECTION 7: PLANNING AND DESIGN

7.1 National Planning

- 7.1.1** In accordance with the National Energy Policy, the MME shall prepare and issue an indicative national electrification plan as well as the Renewable Energy Strategy and Master Plan that will illustrate population centers and rural areas where grid service is most likely to expand in five-year increments, and also map out those areas that will be served by off-grid service providers in the interim period.
- 7.1.2** The indicative national electrification plan must be prepared on a geospatial platform and the results which shall be published on the websites of the MME, RREA and LERC will be shared with investors and prospective Service Providers.
- 7.1.3** Candidate service area where electrification projects will be developed must be identified in the geospatial framework using population data, economic activity data, location of public service facilities such as hospitals, schools, worship centers or houses and government administrative facilities, and other factors that may contribute to load growth.
- 7.1.4** Investors or communities that choose to develop mini grid projects in Liberia shall collaborate with RREA for design and project development assistance in accordance with its mandates.

Mapping and demographic analysis

7.1.5 All Service Providers shall prepare a map of the proposed service area and that will include:

- (a) the administrative boundaries;
- (b) the terrain features of the service area including roads, permanent buildings, rivers, lakes, protected areas, etc.;
- (c) any existing or planned electric generation and distribution system structures and information; and
- (d) all proposed expansion of existing power system infrastructure including new generation plant, distribution infrastructure and other facilities necessary.

7.1.6 Projects that result in development of Isolated Mini Grid will serve remote communities that are distant from formal population centers and grid electric service.

7.2 System Development Planning and Design

Coordinating Roles

7.2.1 In accordance with the provisions of Chapter 11 of the Law, RREA shall liaise and coordinate individual Mini Grid system development plans of Service Providers and provide LERC with a consolidated rural electrification System Expansion

Development Plan which shall provide input for the development or periodic updates of the National Electricity System Development Plan.

Energy Consumption Projection Parameters and categories

7.2.2 The anticipated energy supply systems will serve consumers that use high-efficiency end-use lighting devices with a relatively lower average level of energy consumption compared with consumers connected to the main grid.

7.2.3 A Mini Grid system must be designed to serve all consumers that are within the service area covered by the mini grid distribution network as defined in the proposed system design. Consumer categories shall be classified as the following:

- (a) Residential
- (b) Commercial
- (c) Street lighting
- (d) Health facility
- (e) School
- (f) Water supply

System Sizing Criteria

7.2.4 The power system shall be sized using minimum levels of assumed consumption as provided in Table 1. The prospective Service Provider applicant may use higher assumed levels of consumption but will need to provide justification based upon actual surveys pointing to use of the higher values.

Table 1: Average energy consumption by customer category

Consumer category	Monthly Average Consumption Year 1, kWh	Consumption Growth (%)	Consumer growth (%)
Residential	12	1.5	2.5
Commercial	35	3.0	2.5
Streetlights	12 ¹	n/a	As needed
Health facility	100	n/a	n/a
School	85 ²	2.5	n/a
Water supply	90 ³	2.5	
PUE spot load	Assessment studies required		

Notes:

1. One streetlight shall be installed for every 25 residential consumers. Streetlighting consumption is dimensioned to provide lighting service from dusk to midnight.
2. 250 children per school, 4.4 persons per household, 40% households with school age children.

3. Pump with 0.5 hp motor operating 6 hours per day in a 25m well. Provides 100ltr/day each to 150 households

7.2.5 A consumption or load projection shall be developed using the consumption and growth parameters provided in Table 1 and a 100% penetration of the prospective consumers. A ten-year horizon shall be used for the load projection and the results of the consumption projection shall be used to dimension the generation station capacity.

Engineering analysis and system investment plan

7.2.6 The distribution network must be planned using household locations and available roads. The design criteria shall be as follows:

- (a) Systems with a demand of up to 100kW must use LV distribution systems only;
- (b) The use of MV distribution system is recommended for systems with demands greater than 100kW or with extremely low-density service area such that the distances from the source to the final consumers exceeds one kilometer (1km);
- (c) The use of three phase distribution in rural electrification for economic reasons must be minimized and/or appropriately justified;
- (d) Conductor size selection shall be in accordance with the standard to maintain voltage levels and loss level targets over the intended project horizon;
- (e) Investment costs and technical losses will be considered in the calculations resulting in the selection of conductor sizes;
- (f) The limits for voltage variations from the nominal voltage must be maintained within the standard ranges as provided in Technical Schedule TS-A;and
- (g) Safety standards (i.e., clearances, insulation levels, etc.) must be established, maintained and guaranteed.

7.2.7 A load flow program must be used to calculate power flow in the network and based on the results, the final network design will be determined together with the associated construction cost.

7.3 Financial Forecast Assessment

7.3.1 Financial forecast is the process of evaluating the costs and revenues over the life of the rural electrification project. Costs include capitalized installation costs and yearly operation costs. Revenues are derived from tariff collection from customers for supplied energy.

- 7.3.2** Revenues shall be estimated based on tariff assessments that shall be guided by provisions specified in Part IV and Part V of the Tariff Regulations (issued by LERC) for Service Providers operating with a micro utility License or Permit, respectively.
- 7.3.3** Section 12 of the Tariff Methodology guided by Section 6 of the Regulatory Accounting System guidelines for a chart of accounts further provides a standard tariff methodology in the determination of the revenue requirements for micro utility licensees.
- 7.3.4** The Tariff Regulations, Tariff Methodology and the Tariff Model altogether provide guidelines on ROE, IRR, NPV and project times and cost recovery mechanism over the lifespan of the project.

SECTION 8: CONNECTIONS

8.1 Purpose

This section provides the general characteristics, conditions and the basic requirements that shall apply to all the types of consumer service connections to the Mini Grid network of a Service Provider.

8.2 Customer Service Agreement (CSA)

8.2.1 A prospective customer of a Service Provider shall be presented with a standardized Customer Service Agreement (CSA) by the Service Provider and shall be required to complete and execute the CSA prior to connection of the customer's premises to the Service Provider's system for power supply.

8.2.2 The CSA presented to the customer by the Service Provider shall be in the form of the template attached as Appendix H to the MULR (reproduced and attached as Appendix **B** to this Code) and must indicate the following:

- (a) the type of service;
- (b) number of phases;
- (c) the expected connected load; and
- (d) the deposit to be paid by the customer.

8.2.3 The characteristics of electric service (voltage, number of phases, capacity, etc.) shall be determined in accordance with availability of the service level required at the customer premises unless otherwise negotiated between the customer and the Service Provider.

8.2.4 The CSA of a customer shall be scanned and submitted to RREA, with copies retained as part of the permanent operating records of the Service Provider.

8.3 Customer Charter

A customer shall be provided with a copy of a Customer Charter established in line with provisions under section 10 that summarizes the rights and obligations of the customer and that of the Service Provider which shall form the basis for the CSA provided in section 8.2.

8.4 Connections and Connection point

8.4.1 Upon receipt of the executed CSA and payment of the required charges for connection of the service, the Service Provider must comply with all other requirements relevant to the connection process specified in this Code.

8.4.2 Prior to connecting the service, a Service Provider must evaluate the new customer premises to assess the technical conditions allowing for connection of the new service. The Service Provider may refuse connection of the premises if technical conditions are not met.

8.4.3 The connection point is the point at which customer's wiring and the Service Provider's network are connected. The demarcation of a connection point could be

any of the following installations depending on whether a metering device is used or not:

- (a) meter socket,
- (b) service distribution enclosure,
- (c) pull-box, or
- (d) disconnect switch.

8.4.4 The connection to the Service Provider's network must be conducted with the proper conductor size according to the customer's connected load.

8.5 Facilities ownership

8.5.1 Unless otherwise agreed to in writing, the Service Provider shall own all electric facilities in the public right-of-way.

8.5.2 Subject to section **16.2.1**, the Service Provider and the Customer shall own all electric facilities on their respective sides of the service connection point and shall generally assume all maintenance and operation responsibilities of the facilities on their respective sides of the service point.

8.6 Metering of Services

8.6.1 Where possible, individual meters shall be installed and used as the basis for energy sales from the Service Provider to the customer. Meters may include prepaid or postpaid meters.

8.6.2 In the event that postpaid meters are used, the Service Provider shall carry out at least one meter reading per month within a time frame of 28 to 32 calendar days.

8.6.3 The customer is entitled to request for a meter test once per year at no charge to the customer. The cost of additional request for meter testing will be charged to the customer.

8.7 Number of services

8.7.1 A Service provider may

- (a) require more than one service connection to large premises.
- (b) agree to provide an additional service on customer's request and at customer's expense.

8.7.2 The CSA shall specify if the additional service is required to provide electricity to a separate and clearly defined portion of the premise or to the whole of the electrical installation as a source of reliability.

8.8 Single-phase or Three-phase supply service

8.8.1 Single-phase supply service at 230V shall be the basic standard electricity supply service provided throughout the Service Provider's service area.

8.8.2 Three-phase supply service at 230/400V shall be furnished only where the customer's load and equipment warrant a three-phase supply service and where

the Service Provider has the necessary facilities installed and to make the service available.

8.9 Service Drop Conductors

- 8.9.1** Service entrance conductors are required to connect the Service Provider supply lines with the customer's internal wiring of the premises. The service connection shall be installed using a twisted pair insulated Aluminum service entrance conductor with a minimum size of 10mm².
- 8.9.2** The connection to the premises shall be done using a support bracket attached to the external wall of the premises.
- 8.9.3** If meter installation is not required, the service entrance cable may lead directly indoors to the customer's distribution board, double throw switch or junction box main breaker.

8.10 Customer's Internal Wiring

- 8.10.1** A customer shall be responsible for the wiring inside the customer's premises. The Service Provider must inspect the quality of the internal wiring and may refuse providing the service under unsafe conditions. The Service Provider shall inform the customer about the unsafe conditions detected and advise on the necessary actions to be taken in order to proceed with the connection.
- 8.10.2** The wiring of a customer's premises shall emanate from a service entrance box with a single main breaker protecting all the consumer premises wiring. The main breaker shall have a current rating no greater than that of the meter or the service entrance conductor.
- 8.10.3** Depending on the complexity of the installation, there may be additional branch breakers connecting from the main breaker to protect individual circuits, but the input of the single main breaker shall be the point of interconnection for the meter.
- 8.10.4** Despite section 8.10.1 and to accelerate the pace of initial household connections, a Service Provider may arrange with the customer and carry out internal wiring of the customer's premises with an agreement for reimbursement by the customer, or otherwise, over a reasonable period during operations. The additional costs arising from such an arrangement shall not be considered as part of a Service Provider's cost during tariff determination.

8.11 System of Earthing

- 8.11.1** Electric services, including, but not limited to, service equipment, raceways, service distribution enclosures, junction boxes, enclosures, and any service conductor to be grounded/bonded shall be grounded/bonded in accordance with the NEC (*National Electrical Code of USA*) 2020 and with earthing conductors having ampacities adequate for the available fault current over the operating time of the fault-protective device.

8.11.2 If the circuit has no overcurrent or fault protection, the earthing conductor ampacity shall be determined by the design and operating conditions of the circuit. If the conductor enclosures and attachments to equipment enclosures are continuous and adequate, the circuit path formed by these metallic surfaces may constitute the equipment earthing conductor.

8.11.3 Earthing conductor wires shall be connected via a suitable lug, terminal, or device that is not disturbed during normal operation, inspection, or maintenance.

8.11.4 A Customer's electrical installation must comply with the multiple earth neutral system of earthing. Each service connection shall be earthed by connecting the neutral at the consumer's service entrance box to an earth electrode consisting of a driven rod 12mm in diameter and 1.5m long driven fully into the earth. The electrode shall be connected to the neutral via a bare grounding/bonding conductor.

8.11.5 The grounding/bonding conductors for all service connections shall be soft annealed copper clad steel or galvanized steel only, with a minimum size of 6mm diameter.

AC conductor earthing

8.11.6 System electrical earthing shall only occur on the AC side of a system, where the AC neutral conductor is connected to the consumer earth conductor, at a single location at the generation facility site, typically within the system's main AC distribution panel. The location of the neutral/earth bonding shall be clearly labelled and indicated on the installations' single line diagram.

8.11.7 Alternating current conductors shall be earthed in accordance with standards used by the national grid.

DC conductor earthing

8.11.8 DC systems, or the DC portion of mini grids with AC may remain unearthed.

8.12 Lightning Protection

Mini grids in lightning-prone areas shall be protected against lightning through the installation of a surge protection device that can provide protection for least 100 kA surge current (8/20 μ s). If the mini grid has both an AC and DC sides, each side shall be protected with a separate surge protection device.

8.13 Fault Current

A Customer's electrical installations must be designed to withstand, without damage and under fault conditions, a maximum current as defined by the Service Provider.

8.14 Alternative Power Supply Installed by Customer

8.14.1 If a customer installs an alternate supply source for auxiliary or emergency generation, the connections of such alternate generating plant shall be arranged

so that they can never be connected in parallel with the Service Provider's network. Service to the load from the alternate generation source shall be made through an open-before-close multi-pole, double-throw transfer switch arrangement to prevent such paralleling.

8.14.2 The Service Provider may define additional requirements to ensure the safe changeover operation of the alternative source of electricity supply.

PART C: RULES OF PRACTICE

Introduction

The Rules of Practice, in this Part C, details the technical requirements and interconnection requirements for a Mini Grid system, arrangements for operations and safety considerations.

SECTION 9: GENERAL PROVISIONS

9.1 Liability

9.1.1 A Service Provider shall only be liable to a customer and a customer shall only be liable to a Service Provider for any damages which arise directly out of the willful misconduct or negligence of the:

- (a) Service Provider in providing mini grid services to the customer;
- (b) customer in being connected to the Service Provider's network; or
- (c) Service Provider or Customer in meeting their respective obligations under this Code, their licenses or permits and any other applicable law.

9.1.2 The Service Provider shall educate its customers on the use of appropriate equipment to control loss or damage, which may result from poor quality or reliability of electricity supply within its Mini Grid system.

9.1.3 A customer shall be liable to the Service Provider for any loss or damage resulting from the use of electricity in a manner that will make the Service Provider's Mini Grid system unsafe.

9.2 Force Majeure

9.2.1 Neither party shall be held to have committed a breach respect of any obligation under this Code if prevented from performing that obligation, in whole or in part, because of a force majeure event.

9.2.2 The Mini Grid Code contains procedures for the management of day-to-day technical situations on the Mini Grid system, considering a wide range of operational conditions likely to be encountered under both normal and abnormal conditions.

9.2.3 The Mini Grid Code cannot foresee all the possible operating conditions in the Mini Grid system. Actors must therefore understand and accept that a Service Provider may be required, in such unforeseen circumstances, to act decisively to discharge its obligations under the License or Permit condition(s), within the following general principles and priorities:

- (a) firstly, to preserve or restore the integrity of the Mini Grid system, including the avoidance of breakdowns or situations leading to partial or total collapse of the system;
- (b) compliance by the Service Provider with the Law, and conditions in its License or Permit or Concession, as may be applicable;
- (c) preserving the safety of equipment, to prevent damage to plant or equipment, and public safety to prevent personal injury; and
- (d) the achievement of objectives specifically identified in the Mini Grid Code.

Customers and other service providers shall therefore provide such reasonable cooperation and assistance as a Service Provider may require in such operational circumstances.

- 9.2.4** If circumstances not envisaged by the provisions of the Mini Grid Code should arise, the Service Provider shall, to the extent reasonably practicable in the circumstances, consult promptly and in good faith with RREA and all affected parties in an effort to reach agreement as to what should be done.
- 9.2.5** If agreement between the Service Provider and RREA or the affected parties cannot be reached in the time available, the Service Provider shall determine what shall be done in accordance with the Mini Grid Code.
- 9.2.6** The Service Provider shall promptly refer any unforeseen circumstance identified, together with the determinations and interpretations made, to the RREA for their consideration.
- 9.2.7** A customer shall comply with all instructions given to it by the Service Provider following a determination for an unforeseen circumstance or a difference in interpretation, provided that such instructions are consistent with the principles established in the Mini Grid Code
- 9.2.8** The provisions of the Mini Grid Code may be suspended in whole or in part during a Security Period, or in accordance with an emergency declaration arising from external conditions affecting provision of the service as may be initiated by the RREA, LERC or other competent GoL Authority.

SECTION 10: CONDITIONS OF SERVICE & ASSET MANAGEMENT

10.1 Establishment

- 10.1.1** A Service Provider shall have Conditions of Service which must be consistent with the provisions of this Code and all other applicable Codes, regulations, and legislation.
- 10.1.2** The Conditions of Service shall describe the operating practices and the connection policies of the Service Provider. Subject to this Code and other applicable laws, a Service Provider shall comply with its Conditions of Service but may waive a provision of its Conditions of Service in favor of a customer or a prospective customer and expressed as Customer Charter with the approval of the RREA or LERC.
- 10.1.3** A Service Provider shall
- (a) file a copy of its Conditions of Service with the RREA and LERC;
 - (b) paste its Conditions of Service on a notice board at its offices;
 - (c) publish its Conditions of Service on its website and application form for services; and
 - (d) make copies of its Conditions of Service and the various forms of Customer Charter available to customers upon request.
- 10.1.4** A Service Provider's existing Conditions of Service shall meet the standards set out in this Code within a period of one year following the coming into force of this Code after which date the Service Provider must fully comply.
- 10.1.5** A Service Provider's Conditions of Service may be subject to review by RREA or LERC as part of the assessment of the Service Provider's performance-based rates plan.
- 10.1.6** A Service Provider's Conditions of Service shall include, at the minimum, a description of the following:
- (a) the types of connection services rendered by the Service Provider for each customer class, and the conditions under which these services will be performed including the daily service hours;
 - (b) the Service Provider's basic connection service that is recovered through its revenue requirements;
 - (c) the demarcation point at which the Service Provider's ownership of distribution equipment ends at the customer connection point;
 - (d) the billing cycle period and the payment requirements by a customer;
 - (e) basic design requirements for connection to the mini grid network;
 - (f) levels of service (voltage, quality and reliability) at which the Service Provider provides electricity supply and the corresponding maximum current or load thresholds;
 - (g) metering services provided by the Service Provider;
 - (h) type of meters required by customer class;

- (i) Quality of Service standards to which the Mini Grid system is designed and operated;
- (j) conditions under which supply may be unreliable or intermittent;
- (k) conditions under which service may be interrupted;
- (l) conditions under which the Service Provider may disconnect a consumer;
- (m) policies for planned interruptions;
- (n) the business process the Service Provider uses to disconnect and reconnect consumers, including means of notification and timing;
- (o) the Service Provider's rights and obligations with respect to a customer;
- (p) the rights and obligations that a consumer has with respect to the Service Provider;
- (q) the Service Provider's limitations in accordance with this Code;
- (r) Customer relations and complaints handling procedure of the Service Provider; and
- (s) the Service Provider's dispute resolution procedure.

10.2 Good Asset Management

10.2.1 A Service Provider must:

- (a) ensure that the records of an equipment that affects the integrity of the Mini Grid system are maintained for reference, for the duration of the operational life of the plant; and
- (b) make available relevant information requested about its assets within a reasonable time.

10.2.2 A Service Provider must use its best endeavors to:

- (a) assess and record the nature, location, condition, and performance of its Mini Grid system assets;
- (b) develop and implement plans for the acquisition, creation, maintenance, operation, refurbishment, repair, and disposal of its Mini Grid assets to:
 - (i) comply with the laws and other performance obligations which apply to the provision of the Mini Grid services including those contained in this Code;
 - (ii) minimize the risks associated with the failure or reduced performance of the assets;
 - (iii) minimize cost to customers through reduction in system losses; and
- (c) develop, test, or simulate and implement contingency plans (including where relevant, plans to strengthen security of the supply) to deal with events which have a low probability of occurring, but are realistic and would have a substantial impact on customers.

10.3 Customer's Electrical Installation and Equipment

10.3.1 A customer must use best endeavors to ensure that:

- (a) the customer's electrical installation and any equipment within it:
 - (i) complies with this Code;
 - (ii) is maintained in a safe condition; and
- (b) protection equipment in the customer's premises/installation is always effectively coordinated with the electrical characteristics of the Mini Grid system.

10.3.2 A customer must use their best endeavors to:

- (a) ensure that the customer's actions or equipment do not adversely affect the Mini Grid and reliability and quality of supply to other customers;
- (b) not allow a supply of electricity to its electrical installation to be used other than at the customer's premises;
- (c) not take electricity supplied to another supply address from the customer's supply address; and
- (d) not allow electricity supplied to the supply address to bypass the metering device installed by the Service Provider;

10.4 Service Provider's Equipment on Customer Premises

10.4.1 A customer must:

- (a) not interfere, and must use best endeavors not to allow interference with the Service Provider's Mini Grid system including any of the Service Provider's equipment installed in or on the customer's premises; and
- (b) provide and maintain on the customer's premises any reasonable or agreed facility required by its Service Provider to protect any equipment of the Service Provider.

10.4.2 Provided official identification is produced by the Service Provider's representatives on request, a customer must always provide to the Service Provider representatives convenient and unhindered access:

- (a) to the Service Provider's equipment for any purposes associated with the supply, metering or billing of electricity; and
- (b) to the customer's electrical installation for the purposes of:
 - (i) carrying out an inspection or testing of the customer's electrical installation to assess whether the customer is complying with this Code; or
 - (ii) connecting, disconnecting, or reconnecting supply, to ensure safety within the customer's premises for the purposes described in this section 10.4.2.

10.4.3 If necessary, the customer must provide safety equipment and appropriate safety instructions to representatives of the Service Provider to ensure safe access to the customer's premises.

10.4.4 In cases other than emergencies, a Service Provider must use best endeavors to access a customer's premises at a time, which is reasonably convenient to both the customer and the Service Provider.

OPERATIONS SUB-CODE

SECTION 11: MINI GRID SYSTEM TECHNICAL REQUIREMENTS (or FRAMEWORK)

11.1 Purpose

11.1.1 The purpose of this section is to outline the minimum technical specifications and requirements that must be followed in the development, installation, and operation of a Mini Grid system in Liberia.

11.1.2 The technical specifications and requirements presented in this Sub-Code are developed with the purpose of ensuring safety and reliability of mini grids.

11.2 Mini Grid Distribution Network Requirements

General

11.2.1 A Mini Grid supply system that intends to possibly interconnect with the national grid sometime in the future shall design and build its distribution network in accordance with the standards of the national Distribution Grid. For the avoidance of doubt, the distribution network in such cases shall conform with the LEC design and construction standards for medium voltage, low voltage, and service connections.

Medium voltage (MV) distribution standard

11.2.2 A **medium voltage** distribution system, if used for a Mini Grid, must be designed, and constructed at 33 kV nominal voltage and below for all locations not in the proximity of the Monrovia grid, using conductors selected to minimize life cycle cost. For the most part, 50 mm² Aluminum Conductor Steel Reinforced (ACSR) shall be the conductor of choice. While the main lines will of necessity be three phase, liberal use of single phase, two-wire 19kV laterals with 25mm² ACSR conductors, are recommended.

11.2.3 **Poles** shall be treated in accordance with the KS 516 standard titled "*Wood poles for Power and Communications Lines*" and must be of length between 10 to 11 meters as defined by the final engineering design. Centrifugal concrete or Pre-stressed Centrifugal Poles of length between 10 -11 meters are also appropriate.

11.2.4 **Pole-top structures** shall follow the LEC design & construction standards for 33kV voltage levels.

11.2.5 The **average span** between 33 kV poles will be 100 meters in open country and 50 meters in communities where it is expected that low voltage (LV) lines will be constructed. Pole-by-pole location shall be specified in the final engineering design documents. The design shall carefully observe principles of cost minimization while maintaining safety clearances.

- 11.2.6 Distribution transformers** must be dimensioned to meet load that will be served. Wherever possible, single-phase transformers shall be used in 5kVA, 10kVA and 25kVA capacities.
- 11.2.7** Three phase transformers may be used for large single customers such as hospitals or colleges but shall be not less than 50 kVA in capacity with larger capacity transformers used when justified by the size of the customer.
- 11.2.8** The use of MV for a Mini Grid with an inverter in the system should be carefully considered, since the 33kV line generates a significant amount of reactive power which will have to be absorbed by the inverter if no other reactive power consuming load is available. It may be necessary for the Service Provider to consider the use of distribution reactors to consume excess reactive power which decision must be based upon specialist design review.
- 11.2.9** The MV system shall be designed to ensure that voltage drop from the nominal value does not exceed the operational limits specified in Technical Schedule TS-A. 10% of the nominal value.]
- 11.2.10** The **low voltage (LV) windings** of single-phase transformers used for a mini grid with an MV network may be split to provide 230/460volts supply. The LV feeders emanating from these transformers will consist of three conductors made up of a neutral and two “phases”. A single-phase 230-volt service will be available between the neutral and each phase wire.
- 11.2.11** The **LV conductor** shall be 3x25mm² Aerial Bundled Cable (ABC), installed so that the line length from the transformer to the furthest consumer shall be no more than 275 meters.

Low voltage (LV) distribution standard

- 11.2.12** A Mini Grid system that (is without a MV network and which) relies only on a LV network shall be designed as 400/230V three-phase four-wire systems equipped with three-phase main feeders from the generating station and single-phase laterals.
- 11.2.13** **LV overhead lines** shall all be ABC-type, that is, with three insulated All-Aluminum (AA) phase wires wrapped around an insulated All-Aluminum-Alloy (AAA) neutral and conforming to the latest editions of the IEC standards applicable to their construction, including but not limited to the following:
- (a) IEC 60104: Aluminum-magnesium-silicon alloy wire for overhead line conductors
 - (b) IEC 61089: Round wire concentric lay overhead electrical stranded conductors
 - (c) IEC 60228: Conductors of Insulated Cables

(d) IEC 60502-1: Cables for Rated Voltages of 1kV ($U_m=1.2kV$) and 3KV ($U_m=3.6kV$)

(e) ICEA S-76-474: Neutral-Supported Power Cable Assemblies with Weather Resistant Extruded Insulation Rated 600 Volts.

11.2.14 Based on economic design principles, $4 \times 50mm^2$ ABC may be preferred for the main lines and $2 \times 25mm^2$ ABC for the lateral lines.

11.2.15 LV network lines shall be mounted on **poles** of length between 8 to 9 meters with an average span of 40-50 meters. Wood Poles shall be treated in accordance with the KS 516 standard and pole locations will be defined through a final design process to –

(a) maximize the number of consumers that can be connected;

(b) observe safety clearances specified in this Code and other safety regulations or codes approved by the LERC or other relevant GoL authority; and

(c) ensure that voltage levels do not drop below 90% of nominal values.

11.2.16 The total length of any LV feeder, including laterals shall not exceed 1000 meters from the generation station to the last consumer.

11.2.17 Service poles may be used to connect houses that are more than 30 meters from the LV line alignment. Customer service (connection) wires shall not exceed 50 meters in length.

11.2.18 Consumers must be connected through an appropriate metering device as provided under section 16 of this Code – Metering.

House wiring

11.2.19 House wiring will follow the LERC house wiring safety and quality requirements unless a ready board is used. Ready boards will follow quality standards established by *South African standard SANS 1619:2015 Small power distribution units for single phase 230V service connections*.

11.3 Solar PV Generation Design Parameters

General

11.3.1 A solar-based generation system shall be dimensioned to serve, at a minimum, the maximum energy requirements, including battery, charger, and inverter losses in accordance with the projections prescribed under section 7.2 - System Planning Requirements.

11.3.2 A Solar PV AC-based generation system shall include a *solar photovoltaic array, battery storage*, and for a Mini Grid that has more than 550 consumers, one or more diesel generators that will be used in a hybrid configuration in association with the solar photovoltaic/battery storage system.

11.3.3 Solar PV DC-based generation supply systems with battery storage may be used for smaller Mini Grid systems in communities with smaller number of consumers or stand-alone-supply systems for consumers technically beyond the reach of the mini-grid network installed in those communities.

Solar PV array rack (mounting structure)

11.3.4 The solar photovoltaic array shall be designed to sit on a fixed-tilt racking system that is capable of withstanding windspeeds of up to 140 kilometer per hour and oriented to maximize generation potential over the course of the solar year.

11.3.5 A solar PV mounting structure shall conform to the below standards and as may be amended and have the following characteristics:

- (a) It shall be made of corrosion-resistant material such as aluminium alloy or hot dip galvanized steels, in which case, thickness of galvanization shall exceed 80 microns.
- (b) It shall be constructed as earth mounted, top-of-pole, or roof-mounted type.
- (c) Mounting components such as bolts, nuts, fasteners, panel mounting clamps including joining sections of the structure shall be made of galvanized or stainless-steel fasteners or by welding and with bolts secured with locking washers or locknuts.
- (d) In case of a welding structure, galvanization shall be done after the fabrication work.
- (e) Any contact between unlike materials shall be avoided by using insulation between any aluminium and galvanized sections; and
- (f) Meet the ANSI UL 2703 requirements for PV mounting system, grounding device safety (includes system level fire tests for PV module + mounting system combination).

Photovoltaic (PV) modules

11.3.6 Solar panels shall be STC-rated with a minimum of 20 years warranty for quality and service life.

11.3.7 Despite section 11.3.6, a Solar PV panel shall conform to the below standards and as may be amended and have the following minimum characteristics:

- (a) **Solar modules** shall conform to the following standards:
 - (i) IEC 61215-2:2021 Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval.
 - (ii) IEC 61730-2:2016 Photovoltaic (PV) modules safety qualification – Requirements for construction and requirement for testing.

- (iii) IEC 62804: for the detection of potential-induced degradation (PID)
- (b) Solar modules shall have a junction box with ingress rating IP65 or higher mounted at the back of the panel with at least 4 mm² cross sectional conductor area output cables.
- (c) **PV modules** shall all have the following product warranty levels:
 - (i) Manufacturing warranty (material and workmanship) - must have at least a ten-year warranty on physical manufacture of module itself,i.e; the frame, encapsulant, glass, module junction box etc.
 - (ii) Power output (performance) warranty: ten years warranty for 90% rated output and 25 years warranty for 80% rated output.
- (d) **Bypass diodes** shall be installed in each module to prevent hotspots in modules, which occur often because of partial shading of modules.
- (e) The **label of the PV module** shall have the following details:
 - (i) Name of the manufacturer,
 - (ii) model number,
 - (iii) serial number,
 - (iv) short-circuit current (I_{sc}),
 - (v) open-circuit voltage (V_{oc}),
 - (vi) current at maximum power (I_{mp}),
 - (vii) voltage at maximum power (V_{mp}), and
 - (viii) power rating of panel at standard test condition (STC)

Solar photovoltaic array Dimensioning

11.3.8 Dimensioning panel capacity shall consider a derating factor of 5% to cover degradation over time. Dimensioning the solar PV array must be performed by accessing and using solar irradiation data from a recognized meteorological source using flat plane irradiation figures, provided on an hourly basis over a full calendar year. The array capacity shall be dimensioned to meet the daily energy peak demand during the lowest solar insolation month at the tenth project year.

11.3.9 Demand must be evaluated on the basis of a daily load curve that distributes residential, commercial, water supply, school, health clinic and other point demands in line with expected diurnal consumption patterns. That is, a load curve shall be developed using a recognized historic data-set to predict the load shape and to predict peak demand.

Solar PV Batteries

11.3.10 The preferred battery chemistry shall be lithium ion with a minimum expected life of 6 years.

11.3.11 Despite section 11.3.10, the minimum qualifications for batteries to be used with the Solar PV generation system for a mini grid shall include the following:

- (a) Cycle life: The rated cycle life of the battery shall be not less than 1,500 cycles when discharged to 50% DOD (Depth of Discharge).
- (b) Warranty: All batteries shall have at least two years warranty under the operational conditions on site, to 80% of original rated capacity.
- (c) batteries shall comply with following standards and as may be amended:
 - (i) IEC 62485-2:2010 - Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries
 - (ii) IEC 62933/UL 9540 – Safety requirements for Energy storage systems
 - (iii) IEC 60417- Graphical symbols for use on equipment
- (d) Labelling conditions: Each battery/cell shall be –
 - (i) engraved with the date of manufacture.
 - (ii) labelled indicating
 - the battery type,
 - the manufacturer,
 - model number and serial number,
 - voltage and
 - capacity (Ah).

Inverters

11.3.12 Solar PV inverters or battery inverters are acceptable to be used for mini grids under this Code provided they meet the following standards and certifications and as may be amended:

- (a) IEC 62109-1:2010 (Safety of Power Converters for Use in Photovoltaic Power Systems – Part 1: General Requirements)
- (b) IEC 62109-2:2011 (Safety of power converters for use in photovoltaic power systems - Part 2: Requirements for inverters)
- (c) IEC 62109-3: Safety of power converters for use in photovoltaic power systems - Part 3: Requirements for electronic devices in combination with photovoltaic elements
- (d) CE or UL 1741; and
- (e) IEC 62477-1: - Safety requirements for power electronic converter systems and equipment - Part 1: General

11.3.13 Despite section 11.3.12, the following additional qualifications are required for inverters to be used with the Solar PV generation system for the Mini Grid system:

- (a) Warranty: All inverters shall have at least 5 years warranty against manufacturing defects
- (b) Efficiency: the minimum acceptable efficiency for inverters operating within over 75% of the rated power range shall be:
 - (i) 95% for solar PV inverters; and
 - (ii) 90% for battery inverters.
- (c) Inverter protection: All inverters shall have
 - (i) protection for over temperature and excessive DC voltage
 - (ii) minimum IP54 ingress protection rating for outdoor installations
- (d) Labelling: Each inverter device shall be labelled with at least the following information:
 - (i) name of manufacturer;
 - (ii) model number & Serial number;
 - (iii) frequency;
 - (iv) input and output voltage; and
 - (v) rated power.

PV charge controllers

11.3.14 If PV charge controllers are used, they shall conform to the below standards and as may be amended and shall have the following characteristics:

- (a) Maximum Power Point Tracking (MPPT) or Pulse Width Modulated (PWM)
- (b) PV charging efficiency at least 90% based on IEC 61683: Photovoltaic System-Power Conditioners - Procedure for Measuring Efficiency
- (c) Rated current at 50° C must be at minimum 120% of peak array current (Isc)
- (d) Protected from dust ingress (IP54 or higher).
- (e) Controllers to be certified to meet at least one of the following standards:
 - (i) CE or UL 1741 Marking
 - (ii) IEC 62509 Battery charge controllers for PV systems - Performance and functioning

- (iii) IEC 62093: Balance of system components for PV systems – Design qualification natural environments

Battery storage and inverters - design & Dimensioning

- 11.3.15** Battery storage shall be dimensioned to ensure a minimum of 24 hours of autonomy during periods of low solar insolation conditions.
- 11.3.16** If the batteries are not equipped with inverters, the grid interactive solar photovoltaic (PV) inverter shall be dimensioned using the inverter DC-rated input power to accommodate the required DC-rated PV output.
- 11.3.17** The system output voltage shall be 230/400 volts three-phase and at a frequency of 50 Hertz (Hz). The battery bi-directional inverter and charger shall be rated to charge the battery bank at least at one third (C/3) of the battery capacity and shall have an inverting rating sufficient to cover the estimated peak demand of the system.
- 11.3.18** If the grid interactive PV Inverter and the battery bi-directional inverter and charger are not equipped with integrated DC surge arrestors, integrated surge arrestors should be provided separately.
- 11.3.19** Positive cables between batteries and inverters shall be protected with DC-rated *over-current protection and disconnect* (either circuit breaker or fused disconnect) of appropriate rating to protect cables in the event of a short circuit.

Solar Home System – Technical Specifications

- 11.3.20** Renewable energy and hybrid systems including solar home system products packaging with power rating less than or equal to 350W for rural electrification shall be designed and deployed in accordance with the standard LS/IEC TS 62257-9-8.

11.4 Hydropower Generation Design Parameters

General

- 11.4.1** The requirements in this section 11.4 of this Code shall apply to hydropower facilities that employ a weir, canal, and penstock.
- 11.4.2** If a developer chooses to employ other technologies that do not require these structures, then the LERC and RREA must apply an appropriate subset of requirements listed herein and may impose other requirements that pertain to the proposed configuration and equipment employed.

Powerhouse

- 11.4.3** The hydro generation powerhouse of a Mini Grid shall have the following minimum characteristics:

- (a) The powerhouse shall be located above the maximum 25-year flood levels as observed by residents near the site.
- (b) The floor area of the powerhouse shall be sufficient to safely place the equipment and carry out routine maintenance work conveniently. Adequate spacing and easy access to the electrical and electromechanical equipment from all sides shall be maintained for ease of operation and maintenance.
- (c) Window areas of the powerhouse shall be equivalent to at least 10% of the powerhouse floor area to ensure adequate passive ventilation in the absence or failure of automatic temperature control equipment.
- (d) The minimum height between floor and ceiling shall be 3 meters or 10 feet. Roofing material shall be made of fire-resistant materials such as tile or corrugated sheets. In case of corrugated sheets, the minimum thickness shall be 0.47mm. The roof shall be watertight and shall extend at least 1 meter or 3 feet over walls to prevent water from entering through window portals.
- (e) The power-house door shall be designed with adequate spacing for easy installation and removal of equipment. For safety reasons, the door shall be outward opening.
- (f) Workers' quarters or rest house with basic facilities such as bathroom/washroom and essential living furniture shall accompany the powerhouse design as it is necessary for an operator to be present all the times during normal system operation.

Civil works – concrete and steel

11.4.4 Concrete mixtures in hydropower civil works structures shall follow the ratios of cement, sand, and gravel (C:S:G) as described below for:

- (a) base (screed) concretes – 1:2:4 (Grade 15)
- (b) foundations and other structures – 1:1.5:3 (Grade 20)
- (c) water-bearing structures such as the forebay tank, weir, and channel of a hydropower facility – 1:1:2 (Grade 25)
- (d) Tor steel or rebar (reinforcing bar) used for construction shall comply with *BS 4449-2005* and bends shall comply with *BS 8666*.

Weir & intake

11.4.5 The weir and intake structures of the powerhouse of a hydro generation Mini Grid system shall have the following minimum characteristics:

- (a) The weir should be located at a river section with short width, with an exposed bedrock or where depth to the bedrock is minimum, along with considerable upstream storage (in the case that flows are restricted during the dry season).
- (b) Intake shall be selected such that minimum debris will enter the system during flooding period.
- (c) Intake shall be equipped with a trash rack to prevent clogging; a control gate to control the water flow to the channel and flood barrier wall to make the control gate operations possible during high flow periods. Trash rack shall have
 - (i) preferably iron rods or flat iron;
 - (ii) welded with a gap, decided based on the turbine supplier's recommendation; and
 - (iii) rod orienting upward (vertical) direction without cross bars, making it easy for the plant personnel to clean efficiently with a rake.
- (d) The intake shall be located such that it can be accessed during high flood period.
- (e) A sluice gate (flush gate) shall be designed based on the maximum silt load of the stream and shall be located at the lowest point of the weir with a proper controlling mechanism.
- (f) Erosion and deepening of downstream riverbed, due to scouring action, of weir and spillways shall be considered in the design phase and shall be protected with suitable mechanism or structures incorporated in weir design.

Channel

11.4.6 The design considerations for the channel of a Mini Grid hydropower station shall include the following:

- (a) Freeboard allowance of 30% shall be kept when designing the channel dimensions.
- (b) To limit erosion in the channel, maximum channel velocity shall conform to the specifications in Table 2. In case of silty water, channel velocity shall be maintained at the minimum velocity of 0.3 m/s to prevent clogging of the channel.

Table 2: Maximum channel velocity for different types of hydro channels

Type of channel	Maximum velocity (m/s)
Concrete channels with no internal plaster	2
Rubble and masonry channel with smooth plaster	1.8
Clay channel	1.5
Earth Channel	0.7

Forebay

11.4.7 The forebay of the powerhouse of a Mini Grid hydropower station shall comprise of the following sections and characteristics:

- (a) The settling tank section shall settle and filter particles above 0.3 mm in diameter.
- (b) A manually operated sluice gate (flush gate) and spillway shall be incorporated to the settling section to flush the silt collected from time to time.
- (c) A second trash rack shall be included in the forebay section with rod spacing at similar proportions to the weir intake trash rack.
- (d) The penstock penetration through the forebay shall be deep enough to avoid vortex formation but must be positioned at least 150 mm above the forebay tank floor to prevent silt and small stones from entering the penstock.
- (e) A vent pipe with a sufficient diameter shall be fixed to the penstock or bell mouth section to prevent implosion of the penstock due to surge pressure.

Penstock and Supports

11.4.8 The penstock and support structures of the powerhouse of a Mini Grid hydropower station shall have the following characteristics:

- (a) Penstock shall ideally have constant gradient in each section (i.e. straight from one anchor to the next).
- (b) An air release valve shall be fitted to the highest point if air is likely to be trapped due to the layout of the penstock.
- (c) Penstock material and thickness shall consider pressure due to normal operation as well as any surge that might occur due to blockage, with a safety factor of at least 2.

- (d) Penstocks laid above ground shall be supported at 6m intervals with a slide block or support block. In the event of support blocks, minimum of 120 degrees of the penstock circumference shall be firmly in contact with the support block. These supports and slide blocks may be made with concrete, rubble, and masonry.
- (e) In all bends, an anchor block made of reinforced concrete shall be constructed to counterbalance the forces that occur because of change of momentum of water. Possible penstock failing scenarios like toppling, sliding, sinking/lifting forces shall be considered when sizing the anchor blocks.
- (f) Underground steel and PVC penstocks shall be buried at least 300 mm beneath the ground and shall be on a sand bed. No slide or support blocks apart from anchor blocks at the bends are required in underground penstocks.
- (g) Rubber sheets or tar sheets (graphite asbestos sheet) of minimum thickness of 3 mm must be placed between a steel penstock and supports to prevent abrasion due to thermal expansion and contraction.
- (h) Expansion joints are required in steel penstocks to minimize the stress created due to thermal expansion and contraction.
- (i) A tailrace shall be constructed with reinforced concrete and shall create a safe passage of water back to the stream downstream of the power-house. Steps or rock protuberance shall be incorporated to break the water speed and to minimize erosion.

Micro-hydropower generator and controls

11.4.9 The turbine of a hydropower Mini Grid station shall have the following characteristics:

- (a) The turbine shall be able to operate at runaway speed or loss of load condition for two hours without mechanical failure.
- (b) The water flow through the turbine must be able to be fully stopped by a valve or guide vanes to allow for turbine maintenance. The valve shall be a slow-closing (at least 10 seconds) type to prevent build-up of a pressure wave in the penstock pipe.
- (c) The turbine shall have a sealing mechanism to prevent water from flowing along the shaft and entering the generator.

- (d) In configurations where the turbine is coupled directly to the generator, a flexible coupling is advised to protect against bearing failure from misalignment.

11.4.10 The generator and controls of a hydropower Mini Grid station shall have the following characteristics:

- (a) The generator must have the means of controlling voltage and frequency that are within the limits specified in Technical Schedule TS-A under all conditions from 0% to 100% load.
- (b) If the generator is the *induction* type, excitation capacitor banks shall have an over-current device to stop the generation of excessive voltage and damage to the alternator in the case of turbine overspeed or runaway speed.

11.5 Electricity Supply Stations

Safety and Protective arrangements

11.5.1 A Service Provider shall take all necessary precautionary measures and arrangements in the layout of its plant and equipment to ensure safety at its electricity supply stations.

11.5.2 The Service Provider shall at the minimum identify the following key safety issues and concerns and establish the necessary procedures and safety measures to address them:

- (a) Spaces in which electric supply conductors or equipment are installed shall be protected from entrance of unauthorized persons.
- (b) Floors shall have even surfaced and secure footing.
- (c) Each room with working electrical equipment shall have the means of exit that is kept clear of obstructions.
- (d) Mechanical parts such as pulleys, belts, or other parts that transmit mechanical power shall have guards installed to prevent injury.
- (e) Suddenly moving parts of equipment that operate in such a way that persons in the vicinity are likely to be injured by such movement shall be guarded or isolated.
- (f) Electrical Danger warning signs must be installed at all access points to the yard and building.
- (g) Fire extinguishers of appropriate type must be installed and maintained in the building.
- (h) The name of the plant must be displayed clearly on the front of the building.

- (i) Sufficient lighting must be installed to do safe work on any equipment by day or night.

Battery installations (where applicable)

11.5.3 A Service Provider shall provide for appropriate safety and protective precautionary measures in the design and layout for battery installations when required at the electricity supply station and at the minimum, address the following concerns:

- (a) Provide for adequate space around batteries to allow for safe maintenance, testing, battery replacement, and inspection. Space shall also be provided above the cells to allow for operation, taking measurements, adding water (if cells are flooded type), and for lifting equipment when required.
- (b) Storage batteries shall be in an area accessible only to qualified persons or within a protective enclosure such as a fence, battery room, case, or cage that limits the chances of contact with energized parts.
- (c) The battery area shall be ventilated either by a fan or by a natural ventilation system to limit hydrogen accumulation and explosion risk in flooded lead-acid batteries.
- (d) Racks that support battery cells shall be firmly anchored, preferably to the floor. Racks made of metal shall be earthed.
- (e) The floor material in battery areas shall be of a material that resists corrosion from electrolyte. Provision shall be made to keep spilled electrolyte from leaking to areas where it can cause damage.
- (f) Battery areas shall be provided with goggles or face shield, acid-resistant gloves, protective aprons, first aid kit and water to use to rinse skin in case of contact with electrolyte.

On-site fuel storage

11.5.4 A Service Provider shall take appropriate safety and protective precautionary measures at the electricity supply station where on-site fuel storage is required, including the following design considerations at the minimum:

- (a) All tanks, pipes, valves, and pipe fittings shall be designed and built, in accordance with an approved standard and shall have a safety factor that is adequate for the condition of the services.
- (b) The storage facility shall incorporate spillage control such as
 - (i) remote impounding,
 - (ii) impounding around tanks - bunding or

(iii) by a combination of both (i) and (ii).

11.5.5 In both types of impounding provided in section 11.5.4 (b), the Service Provider shall ensure that the impoundment area is protected by adequately designed systems to prevent the contamination of ground water, if such a risk exists.

11.6 Classification of Levels of Service

11.6.1 The levels of service that define the standard technical specifications for power quality, reliability, and availability supported under this Mini grid Code for different end-user services shall be as provided in Table 3 based on the SE4All Tier rating system.

11.6.2 A Mini Grid system operating under this Code shall adhere to the quality of supply and service standards equivalent, at the minimum, to:

- (a) Tier 1 under the SE4All rating system as the base level for a DC-based mini grid system and
- (b) Tier 2 under the SE4All rating system as the base level for an AC-based mini grid system.

Table 3: SE4All Levels of Service classification

Level of Service →		Base		Standard		High
Supply type →		DC	AC	AC/DC	AC	AC
Attributes		Tier-1	Tier-2	Tier-3	Tier-4	Tier-5
Peak Capacity	Power (W)	≥ 3 W	≥ 50 W	≥ 200 W	≥ 800 W	≥ 2000 W
	Wh/day	≥ 12 Wh	≥ 200 Wh	≥ 1000 Wh	≥ 3400 Wh	≥ 8200 Wh
Energy Use	kWh/year	≥ 4.38	≥ 73	≥ 365	≥ 1250	≥ 3000
Availability	Hrs/day	≥ 4 hrs	≥ 4 hrs	≥ 8 hrs	≥ 16 hrs	≥ 23 hrs
	Hrs/evening	≥ 1 hr.	≥ 2 hrs	≥ 3 hrs	≥ 4 hrs	≥ 4 hrs

11.7 Quality of Supply

11.7.1 The quality of supply standard under this Code is specified for each level of service in terms of the nominal voltage, voltage variations, voltage imbalance, harmonic voltage distortion effects and frequency of the supply at the connection point.

11.7.2 A Service Provider shall follow good utility practice in managing the power quality of the Mini Grid system through monitoring of the parameters set out in section 11.7.1 of this Code. The Service Provider must define in its Conditions of Service, the quality of supply standards and the minimum service levels to which its Mini Grid system is designated and operated.

Nominal Voltage

11.7.3 The standards for nominal voltage levels and allowed tolerance limits for steady state operations at a connection point of the Mini Grid system are as specified in Technical Schedule TS-A of this Code.

Transient voltage variations

11.7.4 Under fault (such as lightning strikes) and circuit switching conditions the rated frequency component of voltage may fall or rise transiently. The fall or rise in voltage will be affected by the method of earthing of the neutral point of the Mini Grid system, and voltage may fall transiently to zero at the point of fault. The transient voltage variation limits allowed at a connection point in the Mini Grid system must be as specified in Technical Schedule TS-A of this Code.

11.7.5 The mini grid system or any other connected network or equipment shall be designed and operated to include devices that will mitigate the effects of transient over voltages within the Mini Grid system and the Service Provider shall take into account the effect of electrical transients when specifying the insulation of its electrical equipment and any other connected equipment to match the quality requirements for the level of services provided in accordance with the classification in Table 3.

Voltage imbalance

11.7.6 Voltage imbalance defines the degree to which the three phases of the electrical supply at a connection point are not identical either in magnitude or displacement (or both) [for a 3-phase Mini Grid system]. Voltage imbalance can be described in terms of the contribution of zero sequence voltages and the contribution of negative sequence voltages.

11.7.7 Phase voltage imbalance in the mini grid system shall not exceed the limits as specified in Technical Schedule TS-A for operations corresponding to the three levels of service considered under this Code (base, standard & high) respectively.

Frequency

11.7.8 The nominal frequency of operation for an AC Mini Grid system under this Code shall be 50 Hz and the permissible limits of variation shall be as specified in the Technical Schedule TS-A. A Service Provider and customers shall ensure that their Equipment including the generators can operate reliably and safely within the specified supply frequency limits during the service hours and can withstand the limits specified under System Stress and extreme System fault conditions.

Total Harmonic Distortion (THD)

11.7.9 Total harmonic distortion (THD) of the AC waveshape within an AC Mini Grid and at a PoCC of a customer connection shall not exceed the limits specified in Technical Schedule TS-A for each level of service.

11.8 Availability of Supply

- 11.8.1** The standard for availability of supply under this Code is specified for each Level of Service in terms of the power capacity and energy generation supply adequacy at the connection point, and the hours of service per day provided to a customer as specified in Table 3 under section 11.6.
- 11.8.2** The power capacity delivery capability of a Mini Grid system shall be established by the Service Provider in accordance with the Level of Service classification specified in Table 3. The Service Provider shall ensure that the power generation capacity provides supply at a value that is consistent with the peak of the ten-year forecast value based upon the projected average consumption of all customer categories as stated in Table 1 under section 7.2.3.
- 11.8.3** The service hours capability of the Mini Grid shall be established by the Service Provider in accordance with the Level of Service to be provided as specified in Table 3. A Service Provider shall endeavor to adhere to the committed minimum hours of service established for day and nighttime services, respectively.

11.9 Supply Reliability

- 11.9.1** Power supply reliability represents how consistently the Mini Grid provides power, specifically between the defined levels of service and the actual service that is provided. The standard for reliability of supply under this Code is specified for each Level of Service in terms of assessment of two indices, System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI), considering the frequency and duration of electrical outages due to interruptions of supply to customers.

- 11.9.2** The SAIFI measures the average number of power outages that an average customer experiences in defined period, typically a year, and is defined as:

$$SAIFI = \frac{\textit{Total Number of Customer Interruptions}}{\textit{Total Number of Customers Served}}$$

- 11.9.3** The SAIDI measures the average number of minutes (or hours) that an average customer is without power over the defined period, typically a year, and is defined as:

$$SAIDI = \frac{\textit{Total Minutes (or Hours) of Customer Interruptions}}{\textit{Total Number of Customers Served}}$$

- 11.9.4** The SAIFI and SAIDI values for a Mini Grid operating under this Code shall be adjusted or normalized to reflect the percent of planned service hours for the period, corresponding to the Level of Service provided. This is required to ensure a meaningful basis for comparison of reliability of supply between different Mini Grids as the use of these indices normally assumes 24/7 daily supply.

11.9.5 The indices shall be calculated separately for planned interruptions (P-SAIFI_{xx}, P-SAIDI_{xx}) and unplanned interruptions (SAIDI_{xx}, SAIFI_{xx}) with the annotation which must reflect the number of hours per day service expected to be provided.

SECTION 12: MINI GRID INTERCONNECTION REQUIREMENTS

12.1 Purpose

The purpose of this section is to present the requirements and procedures for the safe, reliable, and efficient interconnection of a Mini Grid system with the national grid infrastructure.

12.2 Liberia Power System characteristics

12.2.1 The characteristic voltage levels and frequency of power supply in Liberia are as provided in Table 4.

Table 4: Characteristics of the Liberia power supply system

Segment	Characteristic	Operating values
a) Transmission	Voltage (V)	225kV & 132kV
b) Sub-transmission	Voltage (V)	66kV
c) Distribution	Voltage (V)	≤33kV
d) Utilization	Voltage (V)	230V/415V
e) System Frequency	Hertz (Hz)	50Hz

12.3 Interconnection Requirements

12.3.1 Interconnection requirements for any isolated power station that has the plan to connect with an infrastructure at any connection point within the supply segment of the national grid (i.e., transmission or distribution segment) will be required to comply with minimum technical, design and operational conditions provided in this section 12 of this Code and shall be consistent with the obligations, procedures and provisions in the Liberia Electricity Distribution Code and the Grid Code.

Generation

12.3.2 Mini Grid generation stations that may include small hydroelectric plants, solar photovoltaic arrays, biomass gasification stations, and other conventional and renewable power stations will be required to employ adjustable frequency regulators capable of operating at full output over a frequency range as specified in the Liberia Electricity Grid Code.

12.3.3 All hydropower plants must be fully commissioned, complete full load testing and all safety tests before an interconnection application will be considered.

12.3.4 The interconnection station between the Mini Grid and the national grid must be equipped with isolation/protection devices as described in the following sections and must also be equipped with a revenue-grade metering station to meter imported and exported power. The precision and accuracy of the metering station shall be in accordance with the Liberia Electricity Grid Code.

Synchronization

12.3.5 To perform manual paralleling of AC generators, the Service Provider must use appropriate devices such as:

- (a) voltmeters with voltage matching window of + 2.5% or less;
- (b) synchrosopes with phase angle acceptance window of + 5 deg. or less;
and
- (c) frequency meters with frequency matching window of 0.1 Hz or less.

12.3.6 Generators with greater than 1 MW nameplate power rating must have automatic synchronizing relay or automatic synchronizer.

Voltage

12.3.7 Voltage levels used for a Mini Grid by a Service Provider shall comply with the standard voltages used in the Liberia power system. No equipment should be acquired and connected to the Mini Grid whose nameplate voltage varies from the operating voltage of the Mini Grid as specified in Technical Schedule TS-A.

Active and reactive power

12.3.8 Following the premise that the reactive power should be controlled as well as real power, the non-beneficial exchange of reactive power between the Mini Grid and the national grid shall be minimized. The responsibility for installation of reactive power correction equipment shall lie with the partner generating the objectionable reactive power.

Isolation

12.3.9 When a Mini Grid is connected to the national grid, a disconnect switch shall be installed at the point of interconnection and shall provide physical and visible isolation from the national grid. Such a device shall:

- (a) simultaneously open all phases (gang operated) to the connected facilities;
- (b) be accessible by operator of the national grid and may be under the jurisdiction of the grid System Operator;
- (c) be lockable in the open position by the operator of the national grid;
- (d) Not be operated without advance notice to either party, unless an emergency condition requires that the device be opened to isolate the interconnection facilities; and
- (e) be suitable for safe operation under the conditions of use.

12.3.10 The Mini Grid must be designed to include as many switching devices as economically viable to isolate faults. They will include, at the minimum, two switches to isolate every one third of load.

12.3.11 A distribution feeder must be protected from line-side faults through different devices:

- (a) Circuit breaker – A breaker with the capacity to interrupt maximum available fault current. The breaker settings will allow for the feeder to be disconnected before the damage curve of the cable is reached.
- (b) Fuses – A safety device including a strip of wire that melts when the current exceeds a determined level.

12.3.12 Protective devices in the distribution feeders shall isolate faults or equipment and protect other components of the network within the specified fault clearance time. The maximum fault clearance time in the user's side shall not exceed 3 seconds.

Quality

12.3.13 A Service Provider shall design and operate the interconnected Mini grid system in such a way that voltage and frequency are maintained under normal conditions within the limits prescribed in Technical Schedule TS-A.

12.3.14 Generating units must withstand mechanical stress due to line-side faults with clearing time of up to 3.0 seconds.

SECTION 13: MINI GRID OPERATIONS

13.1 Purpose

13.1.1 The purpose of this section is to provide guidelines, criteria and procedures required to facilitate safe, reliable, and efficient supply of power from the Mini Grid to customers under normal and emergency conditions.

13.1.2 The provisions under this section of the Code shall apply to all Mini Grid Service Providers.

13.2 General Responsibilities of a Mini Grid Service Provider

13.2.1 A Service Provider must operate the Mini Grid system to achieve the highest degree of reliability practicable given the circumstances and take appropriate remedial action promptly to relieve any abnormal condition that may jeopardize its operations.

13.2.2 A Service Provider must co-ordinate and monitor the voltage operating on the Mini Grid to ensure safe, reliable, and efficient operation of the system. The Service Provider must operate the system in such a way as to minimize adverse effects of disturbances on customers.

13.2.3 A Service Provider is responsible for efficient restoration of the Mini Grid system after supply interruptions.

13.2.4 In the event of a partial or total system shut down because of a disturbance on the Mini Grid system, the Service Provider must investigate and carry out the necessary restoration operations to minimize the outage time of customers.

13.2.5 A Service Provider must:

(a) establish and implement operating instructions, procedures, standards, and guidelines to cover the safe operation of the Mini Grid system under normal and abnormal system conditions; and

(b) maintain a database (or record) with version control of all the documents, relating to the establishment and implementation contemplated in paragraph (a), in compliance with license conditions.

13.2.6 The Service Provider must operate the Mini Grid system, as far as reasonably possible, within the defined technical standards and equipment ratings.

13.2.7 The Service provider must manage constraints on the Mini Grid system through the determination of operational limits.

13.2.8 A Service Provider must ensure adequate and reliable communications between its power station, control center and substations to achieve the degree of service reliability agreed with its customers.

13.2.9 A Service Provider must determine and review on a regular basis the relay settings for main and backup protection on the Mini Grid system.

13.2.10 A Service Provider must develop, implement, and maintain adequate communication strategy and links with its customers to assure a high degree of customer service relations in accordance with the LERC's Customer Service and Quality of Service and Supply Regulations.

13.2.11 A Service Provider shall engage the services of qualified and certified operators and technicians with appropriate training to minimize human errors during operations and maintenance of the Mini Grid system.

13.3 Mini Grid Operating States

13.3.1 The operating states of a Mini Grid system under this Code are defined as Normal, Contingency (Alert) or Emergency when the following operating conditions exist:

- (a) **Normal:** Refers to the operation of the network in the condition as originally planned and designed to satisfy load and voltage including the following:
 - (i) the system frequency is within the specified limits for normal operations of an AC Mini Grid system;
 - (ii) maximum voltage drop is within the specified limits of sending voltage and within the specified normal operational limits;
 - (iii) the normal conductor loading of all distribution feeders and other equipment are below 85% of their continuous ratings (50% ampacity of conductors required in Year-1 of operation to provide for reserve to assist adjacent faulted feeders);
- (b) **Contingency:** Refers to operation of the network outside the limits of normal operation where critical control parameters start to creep out of range including the following:
 - (i) the system frequency is outside the limits for the Normal operating condition for an AC Mini Grid system;
 - (ii) the network voltage drops exceed the limits from sending end voltage resulting in connecting point voltages falling outside the stipulated operational limits;
 - (iii) there is critical loading or imminent overloading of feeders and other system equipment; and
 - (iv) a weather or switching disturbance that affects the operations.
- (c) **Emergency:** Refers to the network condition resulting in any of the following occurrences:
 - (i) permanent fault on a feeder;
 - (ii) network switching to isolate a fault;
 - (iii) operation of switching equipment to allow for some back-feeding; or
 - (iv) partial or total system collapse.

13.3.2 A Service Provider shall:

- (a) establish through technical studies and operating experience the capability of components of the Mini Grid system for both normal and emergency conditions; and
- (b) ensure that Mini Grid system equipment is operated within the established normal rating except for temporary conditions after a contingency has occurred.

13.3.3 When line (or feeder) loading, equipment loading, voltage levels or frequency deviate from normal operating limits or can be expected to exceed emergency limits following a contingency, and reliability of bulk power supply is threatened, the Service Provider shall take immediate steps to relieve the conditions.

13.4 Mini Grid System Monitoring and Control

13.4.1 A Service Provider shall monitor the voltage, frequency, and power factor on the Mini Grid system at identified critical points at peak and off-peak hours and take reasonable measures for improvement when required.

13.4.2 Important data such as Voltage, Current, Power Factor, Power (kW), Transformer data such as tap position, oil/winding temperature, etc. shall be logged periodically (*typically on hourly basis*) at substations and for supply feeders and appropriate records maintained in addition to the following:

- (a) Operation and maintenance manuals for Equipment and the entire supply system (consisting of details of system operation and maintenance of Equipment),
- (b) Maintenance registers for the Equipment and station batteries,
- (c) Interruption Registers,
- (d) Line Fault Clearance Register, and
- (e) Equipment registers.

13.4.3 A Service Provider shall operate the network and equipment within their normal rating values, allowing overload only for a short period of time during major contingencies.

13.4.4 A Service Provider is responsible for keeping a log of all the data and events in the network and shall submit the record monthly to RREA and LERC.

13.5 Operations Plan, Procedures and Manuals

13.5.1 A Service Provider shall be responsible for developing operational plans to manage the system operations to ensure a safe and reliable delivery of power supply to customers, including the following plans:

- (a) Generation and distribution operation plan;
- (b) System maintenance plan; and

(c) Emergency and contingency response plans.

13.5.2 A Service Provider shall develop and periodically update a logical plan for each power generating unit operator to re-establish the system in a stable and orderly manner in the event of a partial or total collapse of the system.

13.5.3 A Service Provider shall develop manuals detailing procedures that must be followed to ensure a systematic response to operational issues affecting the delivery of safe and reliable services including manuals and procedures for:

- (a) Switching equipment and network switching devices;
- (b) Disconnection and reconnection of supply;
- (c) Restoration of supply following an outage; and
- (d) Emergency response & management procedures.

13.6 Service Provider's Right to Interrupt Supply

A Service Provider may interrupt supply at any time for any of the following reasons:

- (a) planned maintenance, repair, or augmentation of the Mini Grid system;
- (b) unplanned maintenance or repair of the Mini Grid system in circumstances where, in the opinion of the Service Provider, the customer's electrical installation or the system poses an immediate threat of injury or material damage to any person, property or the Mini Grid system;
- (c) to shed load/energy because the total demand for electricity at the relevant time exceeds the total supply available;
- (d) the installation of a new supply to another customer;
- (e) in the case of an emergency; or
- (f) to restore supply to a customer.

13.7 Planned Interruptions

13.7.1 In the case of a planned interruption or outage, the Service Provider must provide affected customers with information relating to the expected date of the outage, time and duration of the outage and must establish reasonable means of communication to the affected customers for outage related enquiries.

13.7.2 The information and communication requirements expected from a Service Provider to affected customers of a planned interruption shall be in accordance with procedures prescribed in LERC's Customer Service and Quality of Supply Regulations.

13.7.3 A Service Provider's policies and procedures with respect to planned outages shall be described in the Conditions of Service.

13.8 Unplanned Interruptions and outages

13.8.1 For unplanned interruptions to power supply or an emergency arising from any system contingency or breakdown of a Mini Grid equipment, leading to either a partial or total system blackout, a Service Provider must:

- (a) upon being advised of the interruption or emergency make the necessary efforts, as soon as practical, to inform customers through a convenient means of communication as established in its Customer Charter on the nature of the interruption and an estimate of the time when supply will be restored or when reliable information on restoration of supply will be available;
- (b) provide options for customers who call the service to be directly connected to a telephone operator if required; and
- (c) use best endeavors to restore the customer's supply as soon as possible making allowance for reasonable priorities such as hospitals, clinics, and other essential community services.

13.8.2 The Service Provider must fall on its established Emergency Response and Management Plan which must allow for safe and orderly recovery from a partial or complete system collapse, with minimum impact on customers.

13.9 Disconnection and Reconnection

13.9.1 A Service Provider may disconnect supply to the supply address of a customer if the customer fails to comply with the written notice of non-compliance issued by the Service Provider or breaches any arrangement entered into between the Service provider and the customer including non-compliance with the applicable standards and payment obligations of the customer.

13.9.2 A Service Provider shall establish a process for disconnection and reconnection that specifies timing and means of notification consistent with the LERC's Customer Service and Quality of Supply Regulations.

13.9.3 In developing physical and business processes for disconnection and reconnection, a Service Provider shall consider safety and reliability as a primary requirement and document same in its Customer Charter.

13.10 Unauthorized Energy Use

13.10.1 A Service Provider shall use its discretion in taking action to mitigate unauthorized energy use. Upon identification of possible unauthorized energy use, a Service Provider shall disconnect the supply and investigate.

13.10.2 A Service Provider shall monitor losses and unaccounted for energy use on a quarterly basis to detect any upward trends that may indicate the need for management policies to moderate unauthorized energy use.

13.10.3 A Service Provider may recover from the customer responsible for the unauthorized energy use all reasonable costs incurred by the Service Provider arising from unauthorized energy use by the Customer.

13.11 Illegal Supply and/or Power Theft

A Service Provider may disconnect supply to a customer's supply address immediately and may proceed further to take any other appropriate legal action if:

- (a) the supply of electricity to a customer's electrical installation is used other than at the customer's premises, except in accordance with the Law;
- (b) a customer takes at the customer's supply address electricity supplied to another supply address;
- (c) a customer tampers with, or permits tampering with, the meter or associated equipment; or
- (d) a customer allows electricity supplied to the customer's supply address to bypass the meter.

SECTION 14: Safety, Health & Environment

14.1 Purpose

14.1.1 This section establishes the principles and arrangements that ensure safe working conditions for personnel working on or near Mini Grid system equipment or personnel who may have to work on or use equipment at the Connection Points.

14.1.2 The concern is necessary and considered very important because the electromechanical systems that constitute the Mini Grid system are designed so that when operated normally, they are safe for workmen and the environment, but they contain inherent dangers hence the need to operate them in accordance with Safety Rules and Procedures.

14.1.3 This section of the Code presents minimum safety guidelines and standards for Mini Grid design, construction, and operation to contain any of the inherent dangers posed.

14.2 Safety Coordination

14.2.1 A Service provider shall follow good utility practice in operating and maintaining the Mini Grid system and shall abide by safety rules and regulations that apply to routine utility work.

14.2.2 A Service Provider must in accordance with the relevant legislation governing health and safety in the workplace establish a *health and safety management plan* and *implementation guidelines* to ensure the health and safety of personnel working on the Mini Grid system or any equipment connected to it.

14.2.3 The implementation guidelines and procedures for the health and safety management plan required in section 14.2.2 must have a set of rules and instructions for implementing safety precautions on Medium Voltage and Low Voltage equipment and must contain, at the least, the following details:

- (a) safety coordination procedures;
- (b) appointment of safety coordinators or authorized safety personnel;
- (c) safety logs and record of safety precautions;
- (d) location of safety precautions;
- (e) implementation of safety precautions;
- (f) environmental safety issues; and
- (g) documentation control.

14.2.4 Workmen must adopt the implementation guidelines as a rule of practice for any work that is to be done on the Mini Grid system or on an installation of the customer.

14.2.5 Safety procedures will be always observed, and proper personal protective equipment will be used to guarantee safety of workmen and safe operations of energized networks.

14.3 Safety Code

Minimum Working Clearances from Energized Overhead Electric Utility Lines

14.3.1 Medium voltage clearances for 33 kV distribution line will be constructed with a minimum vertical clearance of 6.5 meters from phase to ground, and a minimum horizontal clearance of 2.8 meters.

14.3.2 Low voltage clearance for 400/230 Volt distribution line will be constructed with a minimum vertical clearance of 5.5 meters from phase to ground, and a minimum horizontal clearance of 1.7 meters for bare lines and 0.5 meters for insulated conductors.

14.3.3 Operation of line trucks including cranes, bucket trucks, digger-derricks, and similar equipment, any part of which is capable of vertical, lateral, or swinging motion is forbidden **by law** to operate within 3 meters, of energized overhead distribution lines with bare conductors. Lines shall be de-energized prior to construction or maintenance activities when using maintenance vehicles with cranes, elevation buckets or other equipment with similar features.

14.3.4 The owner, contractor, or association responsible for temporary work in the vicinity of medium voltage or low voltage distribution lines must notify the Service Provider at least 48 hours before the work begins. No work shall begin until the persons responsible for the temporary work and the Service Provider have made satisfactory arrangements to de-energize and ground, move, or relocate the line to prevent accidental contact.

14.3.5 In situations where work or maintenance on nearby signs, buildings, bridges, and any such other work would require persons unqualified in electrical line construction, maintenance or repair to place themselves or any conductive object within **3 meters** of uninsulated energized medium or low voltage electric lines, it shall be the responsibility of the owner, the contractor, and/or the association performing the work to ensure before work begins that the appropriate arrangements with the Service Provider have been made and that any required arrangements have been completed to prevent accidental contact.

Construction site signaling

14.3.6 All construction and remodeling activities regardless of size and/or scope must be fenced, barricaded, or otherwise protected to restrict public entrance and to ensure the safety of those in the general area. The owner, contractor, or association performing any works in the Mini Grid system or network are responsible for the isolation of the construction area.

14.4 Health Safety and Environment

14.4.1 A Service Provider shall abide by the health safety rules and regulations that apply to routine work.

14.4.2 A Service Provider shall implement an industry recognized health safety program that includes training and regularly conducted audits. This program also will include Public Education and Public Health Safety Initiatives.

14.4.3 Any problems that a Service Provider identifies as part of the audit shall be remedied as soon as possible or in accordance with the Service Provider's health safety program.

14.4.4 The Service Provider shall prepare and implement an environmental corporate policy program [such as the Service Provider's *Technical and Safety Management Plan (TSMP)* and *Health and Environmental Management Plan (HEMP)*] supporting procedures and appropriate training to ensure compliance with environmental regulations and indicate a proactive approach to environmental damage avoidance.

PART D: STANDARDS OF PERFORMANCE

Introduction

The Standards of Performance, in this Part D. states the indicators and benchmarks for quality and reliability of supply for each level of service provided. The Part also contains the sub-code for metering which describes the applicable standards and installation arrangements for metering.

SECTION 15: BENCHMARKS AND INDICES FOR STANDARDS OF SUPPLY: QUALITY AND RELIABILITY

15.1 Purpose

- 15.1.1** The purpose of this Section of the Mini Grid Code is to:
- (a) specify the various indices used by LERC and RREA to monitor the performance of the operations of the Service Provider;
 - (b) define minimum levels of quality of supply to customers;
 - (c) define minimum reliability standards and benchmarks for the different levels of service operations of the Mini Grid system; and
 - (d) guide Service Providers to design, operate and maintain their systems and equipment to fit the environment and limitations within which they operate.
- 15.1.2** A Service Provider shall monitor and report to RREA and LERC the performance of operations of the Mini Grid system in terms of –
- (a) the quality and reliability of supply; and
 - (b) the quality of customer service.

15.2 Standards for Power Quality and Reliability

- 15.2.1** Subject to the Level of Service classification of Mini Grid system operations provided under section 11.6 of this Code, the quality of power supply in the Mini Grid network for a particular Level of Service for any period shall be acceptable when all the controlling parameters and indices stated under section 11.7 are within the limits specified in Technical Schedule TS-A of this Code.
- 15.2.2** The reliability of power supply in the Mini Grid system for any period is considered acceptable when the total duration of unacceptable quality of supply resulting in interruptions to customers is maintained within the acceptable limits.
- 15.2.3** Using the reliability of supply indices defined under section 11.9, a Service Provider shall design and operate the Mini Grid system to meet the reliability of supply benchmarks established for unplanned and planned interruptions corresponding to each Level of Service as specified in Technical Schedule TS-B.

15.3 Reliability of Supply Targets

- 15.3.1** Subject to section 15.2.3 and in consultation with RREA, the LERC is responsible for setting the performance targets for indices to be reported on periodically by a Service Provider as part of its operational performance reporting obligations in accordance with the Customer Service and Quality of Supply Regulations.
- 15.3.2** The RREA and LERC shall evaluate the Service Provider's reliability performance indices annually against the unique targets set for that year and publish same as performance results.

- 15.3.3** A Service Provider must use best endeavors to meet targets required in accordance with the provisions of the Customer Service and Quality of Supply Regulations and this Code or otherwise meet reasonable customer expectations of reliability of supply.

SECTION 16: METERING

16.1 Purpose

- 16.1.1** The purpose of this section of the Code is to establish the minimum standards for metering and recording the electricity consumption of a customer that purchases power from a Service Provider.

- 16.1.2** All electric service supplied by a Service Provider under this Code shall be metered at the point of connection (PoC) with the consumer's facility.

16.2 Ownership

- 16.2.1** Despite section 8.5.2, a Service Provider shall be the sole owner of the revenue meter. Any metering installations in the premises of the customer, regardless that equipment is annexed to the customer's premises, shall remain the property of the Service Provider.

- 16.2.2** Provided official identification is produced by the Service Provider's representatives on request, a customer must always provide to such representatives convenient and unhindered access:

- (a) to the Service Provider's equipment installed on the customer's premises for any purposes associated with the supply, metering, or billing of electricity; and
- (b) to the customer's electrical installation for the purposes of:
 - (i) inspection or testing of the customer's electrical installation in order to assess whether the customer is complying with this Code;
 - (ii) connecting, disconnecting, or reconnecting supply; or
 - (iii) removal of the meter in case the service is no longer required.

16.3 Customer responsibility

- 16.3.1** A customer must:

- (a) not tamper with, or permit tampering with the meter or associated metering equipment installed by a Service Provider; and
- (b) not interfere and must use best endeavors not to allow interference with the Service Provider's network including any of the Service Provider's equipment installed in or on the customer's premises.

- 16.3.2** A customer must provide and maintain on the customer's premises any reasonable or agreed facility required by its Service Provider to protect any equipment of the Service Provider.

16.4 Technical Characteristics

Meter Type/Accuracy

- 16.4.1** The Service Provider shall determine the type of metering system to employ, considering –
- (a) the type of customer,
 - (b) accessibility,
 - (c) economy, and
 - (d) required features or capabilities.
- 16.4.2** Despite section 16.4.1, a Service Provider that intends to possibly interconnect later with the national grid shall use meters that comply with the minimum requirements established in the Metering Sub-code of the Liberia Electricity Grid Code.
- 16.4.3** When a Service Provider has no intention of connecting the Mini Grid system later with the national grid there is no need to follow the metering requirements of the Grid Code, but meters used must have at least 2% accuracy (*i.e maximum allowed error*) at full load conforming to the requirements of *IEC accuracy Class 2*.
- 16.4.4** Subject to section 16.4.1, single phase prepayment meter shall be used for residential customers. Commercial customers may use single-phase prepayment meter or three-phase meter. Three-phase meters may be AMI (smart meters) or the conventional post-payment meters.
- 16.4.5** The accuracy of the various items of measuring equipment shall conform to the relevant IEC standard² (*2- IEC 62055-31 Particular Requirements-Static Payment meters for Active Energy (Cl 1 & 2)*).

16.5 Meter Installation/Reading/Testing

Customer Access & Installation

- 16.5.1** A Service Provider's meter installer shall, after providing official identification, gain access to a customer's premises to install the meter in an accessible location. There must be no splices, connections, or customer-accessible enclosure between the point of service (or service draw point) and the meter.
- 16.5.2** The customer shall guarantee access to the premises to a Service Provider's representative, subject to official identification, for any purpose associated with the supply, metering services including meter reading, or billing of electricity.
- 16.5.3** The customer shall inform the Service Provider whenever there is a change in the premises that affects access to the meter.
- 16.5.4** The meter may be enclosed in a cabinet or otherwise installed in a manner that shall conform to the manufacturer's stated environmental conditions.

16.5.5 The installation shall provide protection from moisture and dust ingress and from physical damage, including vibration. In addition, the cabinet or Meter must be sealed to prevent unauthorized access.

Meter Sealing

16.5.6 The Service Provider shall install a seal to protect the meter from tampering. The Service Provider will track the seal number in a database to control when the seal needs to be replaced for the meter's calibration, resets, or any other purpose. If a seal is found broken, an investigation must be initiated to determine responsibility.

Meter Testing

16.5.7 Upon request from a customer, the Service Provider shall provide a meter testing service free-of-charge once a year. Any additional meter test request in a year shall be done at the customer's expense.

16.6 Metering Data

16.6.1 A Service Provider shall keep metering data (*preferably in a central database*) and use reasonable measures to protect and preserve the confidential nature of the metering data.

16.6.2 The Service Provider shall not permit any unauthorized third party to have access to the metering data with the exception of RREA and the LERC, upon request.

16.6.3 Despite section 16.6.2, an official metering data of a customer must be made available by the Service Provider upon request by the customer in a format agreed on by the parties. The Service Provider may levy a charge for the provision of that data and that levy/charge shall relate to the cost of providing the data.

SECTION 17: INFORMATION EXCHANGE AND REPORTING

17.1 Purpose and Scope

17.1.1 The Service Provider has an obligation to ensure that the Mini Grid system is operated in a reliable and secure manner. To achieve this, a Service Provider needs to identify information it has to provide to or requires from its customers or any other service provider connected to the Mini Grid for the maintenance of system security.

17.1.2 This section specifies some guidelines for cooperation in the exchange of data and information to enable Service Providers and customers carry out their obligations in a sound business environment.

17.1.3 This section also establishes the monitoring framework and reporting guidelines for Service Providers to get them to remain accountable for their performance in the delivery of services to customers.

17.2 General Principles for Implementation of Information and Data Exchange

17.2.1 A Service Provider shall educate its customers on the Service Provider's rights and obligations as well as the rights and obligations of customers relating to established Conditions of Service and in accordance with the expected Level of Service to be provided.

17.2.2 Where the Mini Grid is interconnected with another distribution network both service providers shall keep readily available, complete, and accurate records of all data required for the proper administration of the Mini Grid Code.

17.2.3 Service Providers will provide open and timely exchange of relevant information to facilitate the secure and reliable operation of their networks or systems.

17.2.4 The information exchanged between the Service Providers may be either confidential (bilateral) information or public information intended for all parties. The provider of the information shall indicate whether the information being provided should be considered confidential or public.

17.2.5 Service Providers shall make available critical data to each other to allow for rational and informed decisions to be made regarding their respective operations.

17.2.6 In the case of electronic data sharing, access to the system or network information shall be provided on read-only basis.

17.3 Planning Information

17.3.1 A Service Provider that has its Mini Grid system connected to another network or system shall provide on a regular basis such information as may be

reasonably required by that other Service Provider for the purposes of planning and development to meet statutory or regulatory obligations.

17.3.2 The Planning Information to be provided shall be as specified in Section 7 of this Mini Grid Code and any other information which may from time to time be required.

17.3.3 The Service Provider shall keep an updated technical database of its Mini Grid system for purposes of system technical studies to support the National Electrification Master Plan (NEMP).

17.4 Network/System Information Exchange

17.4.1 Customers or any other service provider connected to the Mini Grid must exchange information with the Service Provider within an agreed lead time on all operations on their (customer) installations which may have an adverse effect on the Mini Grid system including any planned activities such as plant shutdown or scheduled maintenance.

17.4.2 A Service Provider shall communicate network/system information as required to customers for safe and reliable operation of customer plant and equipment as may be required.

17.4.3 The network information exchange may be both electronic and paper based and within an agreed time frame.

17.4.4 The necessary communication facilities and procedures shall be established between the parties to allow for the timely transfer of information.

17.5 Time Standard

The time standard used shall be the Coordinated Universal Time (UTC) Standard and every time information shall be referenced to it. To maintain synchronization, it is recommended that each Mini Grid system node shall be provided with a connection to GPS satellite receivers that enable all relevant devices to maintain time synchronization.

17.6 Data Retention and Archiving

17.6.1 A Service Provider shall maintain sufficient records to support audit and verification requirements and to support monitoring of compliance with the provisions of the Mini Grid Code. The Service Provider shall also maintain necessary data and records, in sufficient detail, to support event diagnostics and trouble shooting.

17.6.2 A Service Provider shall maintain a complete and accurate record of all Operational Data supplied or maintained under this Code for a period of at least three years from the date the Operational Data was first supplied or created.

17.6.3 An audit trail of all changes made to archived data must:

- (a) be maintained;
- (b) identify every change made and the time and date of the change; and
- (c) include both pre and post values of all content and structure changes.

17.6.4 The RREA or LERC may at any time audit the data retention and archiving systems of a Service Provider.

17.7 Mini Grid Performance Data Reporting

17.7.1 Subject to the election of roles under sections 4.4 and 4.5 of this Code, the following Mini Grid system Key Performance Indicators (KPIs) and operational information shall be made available by the Service Provider to RREA and LERC in the format/template presented in Appendix A:

- (a) Daily:
 - (i) Daily record of power and energy produced by each mini grid generating facility;
 - (ii) Hourly actual demand of the previous day in kW;
 - (iii) Reserve amounts during the morning and evening peaks of the previous day in kW
- (b) Monthly:
 - (i) Average number of service hours delivered;
 - (ii) Energy balance indicating total generation, energy available for sale and losses;
 - (iii) Generating plant Availability;
 - (iv) Number and total duration of frequency excursions outside the statutory limits and proportion resulting in customer interruptions;
 - (v) Number and total duration of voltage excursions outside statutory limits and proportion resulting in customer interruptions;
 - (vi) Outage time at each mini grid network node.
- (c) Quarterly and Annually:
 - (i) Number of active customers by class or groupings;
 - (ii) Annual energy balance for the period;
 - (iii) Annual peak demand in MW during the period, date and time;
 - (iv) Annual minimum demand in MW during the period, date and time; and
 - (v) Values of SAIFI_{xx} , SAIDI_{xx}, P-SAIFI_{xx} and P-SAIDI_{xx} recorded during period.

17.7.2 A Service Provider shall publish each month a report on the performance of the Mini Grid system for the previous month, including a report on Significant Incidents and operating conditions of the Mini Grid system.

17.7.3 RREA shall review and analyze the performance records and other submissions received from the Service Provider and submit a report on the performance of the mini grid system with any recommendations to the LERC quarterly and annually.

17.8 Events Reporting

17.8.1 In the case of a Significant Incident, which has been notified by the Service Provider, a customer or other third party, the Service Provider shall investigate and submit a written report to RREA and LERC.

17.8.2 The reports referred to in section 17.8.1 shall, where applicable, include at least the following:

- (a) time and date of Significant Incident;
- (b) the location;
- (c) plant and/or equipment involved;
- (d) brief description of the Significant Incident;
- (e) estimated time and date of return to service;
- (f) supplies/generation interrupted and duration of interruption;
- (g) generating unit – frequency response achieved;
- (i) any other information that the Service Provider reasonably considers may be required in relation to the Significant Incident

17.9 Significant Incident

17.9.1 Every case where either or a combination of the following happens shall be treated as a **Significant incident**:

- (a) malfunctioning of Equipment, Apparatus connected to the Mini Grid;
- (b) a person, or animal receives an electric shock, whether mild or serious or suffers an injury or burn, directly or indirectly due to electrical causes.

17.9.2 The personnel of the Service Provider in charge of the concerned Equipment, Apparatus or area shall report the incident immediately to the highest responsible officer of the Service Provider in charge within 12 hours. A designated officer from the affected Service Provider should reach the spot within 24 hours and assess the situation and probable cause of the accident, losses to consumers, and damage to Equipment, Apparatus of the Mini Grid system or customer's appliance.

SECTION 18: COMPLAINTS AND DISPUTE RESOLUTION

18.1 Complaints Handling Process

18.1.1 The Service Provider's Customer Charter must include information on its complaint handling processes which must be in accordance with the LERC's Complaints Handling Guidelines and the Customer Service and Quality of Supply Regulations.

18.1.2 When a Service Provider responds to a customer's complaint, the Service Provider must inform the customer that the customer has a right to appeal to RREA or the LERC if not satisfied with the Service Provider's remedy.

18.1.3A A Service Provider must include information about the LERC disconnection procedures including any disconnection warning issued by the Service Provider.

SECTION 19: BREACH OF THE MINI GRID CODE

19.1 Service Provider's Obligation to Remedy

If a Service Provider breaches this Code, it must remedy that breach as soon as practicable.

19.2 Notification of Non-compliance

19.2.1 If a Service Provider becomes aware of its failure to comply with any obligation under the Code, which can reasonably be expected to have a material, adverse impact on a customer, it must:

- (a) notify the customer likely to be adversely affected by the non-compliance within 5 business days;
- (b) undertake an investigation of the non-compliance as soon as practicable but in any event within 20 business days; and
- (c) advise the customer of the steps it is taking to comply.

19.2.2 If a Service Provider becomes aware of a breach of this Code by a customer or any other service provider connected to the Mini Grid system, which is not of a trivial nature, the Service Provider must notify the customer or the other service providers, in writing and as far as possible using plain English, of:

- (a) details of the non-compliance and its implications, including any impact on the system;
- (b) actions that should be taken to remedy the non-compliance.
- (c) a reasonable time in which compliance must be demonstrated;
- (d) any consequences of non-compliance; and
- (e) the Service Provider's procedure for handling complaints.

19.3 Customer's Obligation to Remedy

A customer must use best endeavors to remedy any non-compliance with this Mini Grid Code within the time specified in any notice of non-compliance sent by a Service Provider or face disconnection of the services for non-compliance as provided under section 13.9 of the Code.

PART E: DEFINITIONS

In this Code:

-10%	Means 0.90 times the relevant voltage
+5% ...	Means 1.05 times the relevant voltage
+50% ...	Means 1.5 times the relevant voltage
-100%.....	Means 0 Volts
+20%.....	Means 1.2 times the relevant voltage
+80%.....	Means 1.8 times the relevant voltage
Accident...	Means any unplanned event that results in damage to property, the natural environment or affect the distribution network operation's relationship with the community,
Active Energy	Means a measure of electrical energy flow, being the time integral of the product of voltage and the in-phase component of current flow across a connection point, expressed in Watthours and multiples thereof (Units: Wh, kWh, MWh):
Active Power	Means the rate at which active energy is transferred. (Units: W, kW, MW)
Ancillary Service	Means a service required for the secure operation of an electricity system including frequency regulation, voltage support, provision of reserve plant and black start
Apparent Power	Means the square root of the sum of the squares of the active power and the reactive power
Black Start	Means the process of restoring the power system after a total or partial failure and where no external electricity supply is available
Business Day	Means a day, other than a Saturday or Sunday, or a Public Holiday
Calendar day (or day)	Means any day, including a Saturday or Sunday, or a Public Holiday
Complaint	Means a written or verbal expression of dissatisfaction about – <ul style="list-style-type: none"> (a) an action, (b) a proposed action, (c) a failure to act or (d) a failure to observe published practices or procedures, by – <ul style="list-style-type: none"> (i) a Service Provider, (ii) its employees or (iii) contractors.
Confidential Information	Means any information about a customer or information provided to the Service Provider under an obligation of confidence
Connect	Means the making and maintaining of contact between two electrical systems allowing for the supply of electricity between the two systems and reconnect has a corresponding meaning

Connection Point	<i>In relation to a customer</i> , means the point at which the customer's wiring and the Service Provider's network are connected; or <i>In relation to another service provider</i> , means the point at which the networks or systems of both service providers are interconnected
Customer	Means a person whose electrical installation is connected to the Service Provider's network or who may want to have its electrical installation connected to the Service Provider's network or Mini Grid system, and includes an embedded generator
Customer Charter	Means a code of practice instituted to improve access to an organization's services and to promote quality by telling the customer the levels and standards of service to expect and what to do if something goes wrong
Demand	Means the active power or apparent power (expressed in kW and kVAr) consumed by a customer in respect of an electrical installation integrated over a fifteen or thirty-minute period
Earthing	Means the process of providing a connection between a conductor and ground using the approved device.
Electrical Installation	Means any electrical equipment at a customer's site that is connected to, but not part of, a Mini Grid system
Emergency	Means an actual or imminent occurrence of an event which in any way endangers or threatens to endanger the safety or health of any person or which destroys or damages, or threatens to destroy or damage any property
Emergency Response Plan	Means a comprehensive document that plans for probable emergencies which involves Mini Grid system employees, contractors, properties, plants, and equipment and prescribes appropriate response or actions
Energize	
Energy	Means active and reactive electrical energy
Event	Means an unscheduled or unplanned (although may be anticipated) occurrence on a system including, without limiting that general description to, faults, incidents, and breakdowns
Feeder	Means an electric line and associated equipment at a normal voltage supply level (33kV & below) which a Service Provider uses for bulk electricity supply
Force Majeure Event	Means an event outside the reasonable control of a Service provider or a customer, as the case may be
Frequency Variation	Means a departure of the actual system frequency from the nominal value of system frequency
Generating Unit	Means a single set of apparatus that generates electricity
Generation	Means activities pertaining to a generator including the production of electricity and its delivery to the electricity system
Generator	Means a person or company who engages in the activity of owning, controlling, or operating generating units and who generates electricity under a License

Good utility practice

Incident	Means any unplanned event that has the potential to damage property, the natural environment or affect the Mini Grid system operations
Interruption	Means the temporary unavailability of supply from the Mini Grid network to a customer, but does not include disconnection
Isolation	Means the process of achieving electrical separation of a conductor (or supply apparatus) from the remainder of the system
Load	Means a customer's demand for electricity at a supply point
Metering Installation	Means the equipment required for measuring the flow of active or reactive power or energy located between the metering point and the point of connection to the consumer's system
Metering Code	Means the set of requirements made up of standards, procedures, and guidelines for metrology applicable to a particular customer
Mini Grid System	Means a small electricity supply system with its own power generation capacity or source of supply, supplying electricity to customers and can operate in isolation (Isolated Mini Grid) from or be connected to a distribution or transmission network (Interconnected Mini Grid)
Network	Means the electrical sub-transmission and/or distribution system
Non-technical Losses	Means losses that occur due to unidentified, misallocated, or inaccurate energy flows or can be thought of as electricity that is consumed but not billed
Official Identification	Means document issued by the Service Provider that identifies its employee, workmen or agents as authentic representative of the Service Provider.
Outage	Means interruption resulting from the planned or unplanned removal of an item of plant and/or apparatus from service availability
Off -grid	Means a stand-alone power system designed to function without the support of another electricity network, and includes a solar home system (SHS)
Point of Connection (PoC)	Same as "Connection Point"
Power Factor	Means the ratio of active power to apparent power
Power System	Means the whole of the infrastructure of electricity systems, generators and other users connected to the system.
Public Holiday	Means a public holiday appointed
Quality Of Supply	Means the measure of the ability of the Mini Grid system to provide supply that meets the voltage quality requirements of this Code
Reactive Energy	Means the time integral of the product of voltage and the out-of-phase component of current flow
Reactive Power	Means the rate at which reactive energy is supplied
Reliability Of Supply	Means the measure of the ability of the Mini Grid system to provide supply to customers
Rural Area	Means an area supplied electricity by an electric line which:

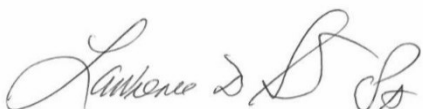
- (a) forms part of a distribution system; and
- (b) is a single feeder the length of which measured from the relevant zone substation is at least 15 km

Safety Management	Means the process of ensuring that the HV system is in a state so that it is safe for personnel to carry out work and/or testing
Safety Rules	Means Service Provider’s mandatory rules that seek to ensure that persons working on plant and/or apparatus to which the rules apply are safeguarded from hazards arising from the system
Service Provider	Means a legal entity registered and licensed/permitted to generate and sell, or buy, distribute and supply electricity to customers. A Service Provider. in this context, could refer to the ‘Developer’ or ‘Operator’ as used in RREA Act.
Supply	Means the delivery of electricity
Supply Address	Means the address where the customer is being supplied with electricity
System	Means the network for Mini Grid generation, distribution and supply of electricity in Liberia
System losses	Means total losses in the Mini Grid system comprising Technical and non-technical losses
Technical losses	Means losses due to energy dissipated in conductors, equipment used for the distribution system and including magnetic losses in transformers.
Total Harmonic Distortion (THD)	Means the ratio of the root-mean-square of the harmonic content to the root-mean-square of the fundamental quantity, expressed as a percent of the fundamental
Tor steel	Means cold-worked low-compound prepares that are utilized for fortifying cement
Unauthorized energy use	Means using electricity that was illegally obtained or a legally obtained service that is not used for the required purpose or used in a manner that interferes with the supply of other customers.

**THE COMMON SEAL OF
LIBERIA ELECTRICITY REGULATORY COMMISSION**

Was affixed pursuant to the ORDER OF THE COMMISSION

On this 13th day of June 2022.



**Dr. Lawrence D. Sekajipo, CPA, CFE, DBA
CHAIRMAN
BOARD OF COMMISSIONERS**

TECHNICAL SCHEDULES

TECHNICAL SCHEDULE TS-A: QUALITY OF SUPPLY STANDARDS/BENCHMARKS

Description	Standard/ Category	BASE Level of Service	STANDARD Level of Service	HIGH Level of Service
AC Mini Grid Power Condition		BENCHMARK		
Nominal Voltage ($V_{nominal}$)	Low Voltage	230V (1-Ph) 415V (3-Ph)	230V (1-Ph) 415V (3-Ph)	230V (1-Ph) 415V (3-Ph)
	Medium Voltage	$\leq 33kV$	$1 \leq 33kV$	$\leq 33kV$
Steady state Voltage Variation		$\pm 10\%$	+5%/-10%	+5%/-10%
Transients	Phase to Earth: +50% to 100%	No protection required	Surge protection required	Surge protection required
	Phase to Phase: +20% to 100%			
Short duration voltage variation	$1.1V_n < V < 0.9V_n$ for < 1 minute	<5/day	<1/day	<1/week
Long duration voltage variation	$1.1V_n < V < 0.9V_n$ for > 1 minute	<10/day	<5/day	<1/week
Voltage Imbalance	Only in 3-ph systems	< 10%	< 5%	< 2%
Frequency variation		50 +4%/-6% (47-52Hz)	50 +4%/-4% (48-52Hz)	50 +2%/-2% (49-51Hz)
Harmonic Distortion Limits	Total Harmonic Distortion (THD)	$\leq 10\%$	$\leq 8\%$	$\leq 5\%$
DC Mini Grid Power Condition		BENCHMARK		

Nominal Voltage		≤48V	≤48V	≤48V
Resistive voltage drop		<10% (within 30% of sending end voltage)	<5% (Within 20% of sending end voltage)	<2% (Within 10% of sending end voltage)
Short voltage variation	1.1Vn<V<0.9 Vn for < 1 minute	<5/day	<2/day	<1/day
Long voltage variation	1.1Vn<V<0.9 Vn for > 1 minute	<5/day	<2/day	<1/day
Maximum Allowed Percent ripple (peak-to-peak)		50% pk-pk (Rec 20%)	20% pk-pk (Rec 10%)	10% pk-pk (Rec 5%)
DC ripple & switching noise		Unfiltered	Transient noise minimized	Transient & ripple noises minimized
Transients		No protection	Surge protection required	Surge protection required
Faults allowed / day		5	2	1

**TECHNICAL SCHEDULE TS-B: RELIABILITY OF SUPPLY
STANDARDS/BENCHMARKS**

Interruptions (Assuming 24hr- service)	Benchmark (by Levels of Service)		
	BASE Level of Service	STANDARD Level of Service	HIGH Level of Service
Unplanned-SAIFI ₂₄	<52 per year	<12 per year	<2 per year
Unplanned-SAIDI ₂₄	<876 hours per year (90% reliability)	<438 hours per year (95% reliability)	<1.5 hours per year (99.9% reliability)
Planned-SAIFI ₂₄	No requirement (but should be defined)	No requirement (but should be defined)	<2 per year
Planned-SAIDI ₂₄	No requirement (but should be defined)	No requirement (but should be defined)	<30 minutes per year (100% reliability)
<p><i>SAIFI and SAIDI are typically assumed for power systems that are specified to provide full time, 24 hours/day of energy service. A subscript is used in this report for systems that provide partial hours/day service since the number of planned and unplanned interruptions and length of any interruptions should be normalized by the percent of hours of service.</i></p>			

APPENDIX A: PERFORMANCE REPORTING INDICATORS TEMPLATE

1. Technical Performance Reporting Template

Performance Indicator	Current recorded	Previous achieved	Regulatory Benchmark
1. Power Production			
Solar PV generation (kWh)			
Diesel Generation (kWh)			
Diesel fuel consumption (for generation) in litres			
2. Power quality			
Voltage surveys for small system			
Renewable energy contribution (kWh)			
3. Cost of production per unit sales			
Energy production (kWh)/Energy sales (\$/kWh)			
4. Power availability			
Duration of daily service			
Hours per day electricity provided daily			
Percent of days service provided below contracted value			
Percent of days service provided above contracted value			
Average number of hours of service provided during the day (6 a.m./6 p.m.)			
Average number of hours of service provided during the evening (6 p.m./12 p.m.)			
5. Efficiency			
System losses (energy sales (kWh)/energy production (kWh))			
Battery efficiency (%)			
Diesel system efficiency (kWh/liter)			
6. Unplanned power outages (adjusted to reflect average hours of service per day)			
Number of unplanned service events			
System Average Interruption Frequency Index (SAIFI)			
System Average Interruption Duration Index (SAIDI _{xx})			
Planned power outages (adjusted to reflect average hours of service per day)			
Number of planned service events			
Planned System Average Interruption Frequency Index (P-SAIFI)			
Planned System Average Interruption Duration Index (P-SAIDI _{xx})			
7. Operation, maintenance, and safety			

Number of O&M events with short description of event and root-cause analysis			
Number of public or worker safety events with short description of event and root-cause analysis			

2. Commercial Performance Reporting Template

Performance Indicator	Current recorded	Previous achieved	Regulatory Benchmark
1. Customers by level of service (Tier 2, 3,4,5)			
New services connected			
Services retired			
Total services in place			
2. Customers by sector (residential, government, commercial)			
New services connected			
Services retired			
Total services in place			
3. Payment collection rate			
% of customers current on payments by level of service			
% of customers that are more than 6 months behind by level of service			
% of customers current on payments by sector			
% of customers that are more than 6 months behind by sector			
Number & % of customers in community electrified with electrical service that meets power quality requirements by sector			
Percent (%) of load by sector			
4. Total service interruptions			
Power supplier			
Extreme weather condition			
Prearranged			
All other			
5. Number and nature of service calls and complaints			
6. Safety issues and workplace injuries			
7. Total number of customers			
8. Total kWh sold			
9. Other electric revenue			
10. Total kWh purchased (if any)			

11. Total kWh generated			
12. Cost of purchases and generation			
13. Revenues by sector (residential, government, commercial)			
14. Revenues by level of service			
15. Average revenues from power sales (\$/kWh)			
16. Average cost of power (\$/kWh) by segment			
Generation (fuel, maintenance)			
Distribution			
Service (office support, insurance)			
17. Total cost of electric service			
18. Expected capacity to sell			
Minimum			
Maximum			
Performance Indicator	Current recorded	Previous achieved	Regulatory Benchmark
19. Annual electricity production during the calendar year (January 1 to December 31)			
20. Annual electricity sales during the calendar year (January 1 to December 31)			
Amount of electricity sold to retail customers			
Amount of electricity sold to distribution network operators (if applicable)			

Appendix B: Customer Service Agreement Template (General)

1. heading/title <Customer supply and sale contract>
2. description/purpose/the service (basically the product/service description) <to supply and sale of electricity to premises of the customer in according to terms and conditions specified hereunder>
3. parties <specify the supplier and customer - including addresses>
4. date <state date of the agreement>
5. territory/geographical coverage <operational jurisdiction of the permit>
6. term - period of agreement
7. responsibilities of provider - include or append details of services
 - receipt & processing of customer application for connection to the supply
 - inspection of premises to ascertain of quality of wiring prior to connection;
 - connection of the premises to supply upon receipt of statutory fees;
 - provision of safe, reliable, and quality supply to a subscribed level of service; and
 - specify metering & billing procedures and cycle
8. responsibilities of client
 - ensuring safety in the use of electricity within premises
 - safeguard and prevent tampering of supplier's installed equipment
 - timely payment of bills and charges
 - submit to established procedures for addressing complaints & dispute resolution
9. electricity tariff, rates & charges (refer if appropriate to attached schedule)
10. payment terms
 - specify mode of payment for services (pre-paid or post-paid)
 - specify allowed period for bill payment (if post-paid)
 - late or defaulting payment actions/procedures (e.g., warning, disconnection etc.)
11. customer complaints procedure, dispute, and arbitration process
 - reporting complaints to specified address/contact in established format
 - following through the established procedure for addressing complaints internally;
 - discretion to pursue alternative dispute resolution mechanism, if not satisfied.