# Standard for Power Quality and Reliability in Electric Power Systems

Consultation Document

ES 06/2023

Issue Date: 27 September 2023

Response Date: 27 October 2023

# Contents

# 1 Introduction

The Utilities Regulation and Competition Authority ("URCA") is the independent regulator for the Electricity Sector ("ES") in The Bahamas. URCA is responsible for the licensing of all generation, transmission, distribution and supply of electricity within, into, from or through The Bahamas. URCA regulates the ES through the Electricity Act, 2015 ("EA 2015"), which sets out, inter alia, URCA's powers and obligations in relation to the regulation of the ES.

The electricity sector policy and objectives as set out in the EA 2015 mandate that the production of electricity be subject to a regime that ensures the supply of safe, least cost, reliable and environmentally sustainable electricity throughout The Bahamas. URCA's primary role is the regulation of the electricity sector in accordance with the goals, objectives and principles underpinning the national energy and electricity sector policies.

URCA believes that a reliable supply of electricity is one that is both consistently available and of good quality. Such a supply is one that will lead to consumer confidence and trust.

In fulfilling the EA mandate, URCA is cognizant of the fact that the production of electricity inherently carries the risk of variations in the ideal (nominal) value that is intended to be produced by the electricity supplier (quality) as well as variations in the consistency of supply (reliability). URCA also notes that these variations can have disruptive effects on equipment, connected to the electricity grid; such as motors and timers or other frequency or voltage sensitive devices In order to mitigate this risk, URCA proposes to implement rules that outline the minimum technical standards for electricity supply.

Section 78 of the EA 2015 repealed The Electricity Act (Ch. 194) and the Out Islands Electricity Act (Ch. 195). The legislation at that time included supply standards for voltage and frequency. These standards were not explicitly included in the legislation that replaced it – the EA 2015. Hence this consultation document is intended to reestablish and expand on those standards. In accordance with section 38(3)(g) of the EA 2015 URCA proposes under this consultation process to exercise its powers to issue standards which are encapsulated in the Standards annexed to this consultation document. Specifically, these standards cover;

1. Power quality – the parameters (voltage, current, and frequency) within which the electricity supplied to consumer must comply.
2. Reliability – the consistency of electricity for the consumer to utilize.

## 1.1 Objectives of this Consultation

As service quality regulation is still evolving, a lighter touch to service standards is being adopted in those sectors where competition is maturing. However, in those sectors where industries are operating in monopolistic markets such as The Bahamas, the service standards being imposed by [URCA] are intended to ensure that the customer is supplied with a high-quality service that provides value for money.[1]

This Consultation Document is being issued to advance the following core objectives:

- To support the electricity sector policy of, inter alia the provision of "a safe reliable supply of electricity" and the advancement of the EA 2015mandate to, inter alia, promote good utility practice and to ensure that PES operate in accordance with consumer protection standards.
- In compliance with the requirement of the EA 2015 for URCA to issue regulations on the standard of service and quality of electricity supply systems and equipment.
- To provide guidance to PESL and APSEL with respect to the provision of service standards in accordance with section 29 of the PESL and 28 of the APESL licenses.
- To protect the interests of consumers connected to the grid and provide guidance on the expected voltage, frequency and other technical deviations that may be expected when connecting to the grid.
- To reestablish standards for the supply of electricity which were applied under legislation prior to the 2015 ES regulatory regime.

[1] Regulated Industries Commission of Trinidad and Tobago, "*Quality of Service Standards"* (Jan 2008) p8 para 3.2

## 1.2 How to Respond

URCA invites and welcomes written submissions and comments from interested parties, including members of the public and licensees, with sufficient interest in the subject matter of this Consultation Document and the Annex included herein.

Written submissions and comments must be received by URCA within thirty (30) calendar days from the publication of this Consultation Document.

The deadline for receiving written submissions and comments is 5:00 p.m. on 25 October 2023.

The written submissions and comments should be submitted to URCA either:

i. by hand to the Chief Executive Officer, Utilities Regulation and Competition Authority, Frederick House, Frederick Street, Nassau, Bahamas;
ii. by email to info@urcabahamas.bs;
iii. by mail to P.O. Box N-4860, Nassau, Bahamas; or,
iv. by facsimile to (242) 393-0237.

As soon as reasonably practicable after the close of the response date for this consultation, URCA intends to publish all responses on the URCA website at www.urcabahamas.bs.

## 1.3 Structure of the remainder of this document

The structure of the remainder of this document is as follows:

Section 2: *Background* provides the background to this consultation document.

Section 3: *Regulatory Framework* sets out the regulatory framework under which URCA has exercised its powers to issue this Consultation Document.

Section 4: *Overview of the Rules and Technical Standards* provides an overview of the components of the proposed Rules and Technical Standards

Section 5: *Next Steps* sets out the next steps to be taken by URCA in establishing the set of Rules and Technical standards governing the supply of electricity to consumers by PESLs and APSELs.

Annex A: *Draft Public Electricity Supply Rules and Technical Standards* contains the draft conditions for the proposed Technical Standard for the Production, Transmission Distribution and Supply of Electrical Energy.

Annex B: *List of questions posed by URCA* provides a complete list of the questions included in the document as part of the consultation.

## 1.4 Confidentiality

URCA believes that, as a matter of transparency and good regulatory practice, it is important for the public and interested parties to this consultation process to have sight of the views and positions expressed by all respondents. As such, as soon as reasonably practicable after the close of the response date for this consultation, URCA intends to publish all responses on the URCA website at www.urcabahamas.bs. However, URCA may treat as confidential responses that are clearly marked (in part or full) as being confidential. An explanation should be provided to justify any information that is submitted on a confidential basis. In such circumstances, a redacted version should also be submitted to URCA. URCA has the sole discretion to determine whether to publish any submission marked as confidential.

## 1.5 Intellectual property

In submitting their responses, URCA assumes that persons are expressly permitting URCA to use those responses as part of the consultation process. Where this does not apply, persons should indicate so in their response so that they may be redacted by URCA.

## 1.6 Interpretation

Except insofar as the context otherwise requires, words or expressions shall have the meaning assigned to them in this consultation document and otherwise words and expressions shall have the same meaning assigned to them under the Electricity Act, and otherwise the Interpretation and General Clauses Act, Chapter 2.

# 2 Background

Early electric supply and communications systems were isolated systems serving a specific town or area. They were constructed without standardization of clearances, strengths of materials, construction methods, or operation. As a result of the lack of standardization between systems and across systems, problems occurred for users of those systems.

The early usage and operability problems encountered were further compounded as consumer use increased after 1900 and smaller systems were linked together to take advantage of economies of scale. An action by the public or an electrical worker that would be safe in one area might not be safe in another. In addition, some electrical utility and factory installations were constructed, maintained, or operated in a less than desirable manner.

In response to these problems, in the United States and other jurisdictions, electrical safety codes and standards were established to bring consistency and safety to the design, construction, operation, maintenance, and use of electrical energy and communications. The requirements of the original code were based upon sound engineering theory and generally accepted good practice. They were codified after extensive research and public review, a practice that continues today. In the United States in particular, The National Bureau of Standards brought together representatives of the major players: electric utilities, telephone utilities, railroads, and factory owners to identify and discuss commonalities between systems, common problems, and potential solutions that were practical to achieve. The result was a practical, unified, national code that addressed potential problems that might be found in any area and on any kind of electrical or communication system.[2]

URCA believes that the experience gleaned from early use and adoption of codified standards for electric grids in other jurisdictions are no less relevant to the Bahamas and that the establishment of appropriate standards are necessary to the proper operation and use of electricity, particularly since prior to the establishment of the EA 2015, the electricity sector was governed by the now-

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[2] National Electric Safety Code ANSI (C2 Http//ethw.org//National Electrical Safety Code)

repealed Electricity Act and Out Islands Electricity Act which along with their subsidiary legislation included, albeit limited, rules and technical standards for the supply of electricity.

The electricity sector reform of 2016, saw the enactment of the new EA of 2015, establishing URCA as the independent regulator of the electricity sector, defining the role of URCA and giving URCA the authority to establish regulations to govern the sector. While the new act broadened the scope of for the regulation of the sector, the complete subsidiary legislation regarding the technical standards required for the Electricity Sector were not contained in the relevant Savings and Transitional provisions of the EA. One instance of this was the technical standards to which electricity suppliers were to adhere when supplying their service territory with electricity.

This became apparent to URCA in the course of its review of the ES legislation and its investigations into several ES complaints. Notwithstanding any codification or inclusion of these standards in internal licensees' Consumer Protection Plans, a void still exists for the application of technical standards for public electricity supply licensees (PESLs) and authorized public electricity supplier licensees (APELs) in the electricity sector.

URCA believes that the standards proposed herein are in the interest of good operational practice of GTDS (Generation Transmission Distribution and Supply) licensees as well as consumers due to the rapid technological advancement in consumer electronics and the sensitivity of those devices to abnormal and/or unhealthy perturbations in the supply of electricity.

URCA now issues this Consultation Document to invite submissions and comments from interested parties prior to making a Final Decision on the proposed technical standards, so as to remove any ambiguity that may exist for licensees with respect to the technical standards that will apply to the electricity sector in The Bahamas.

# 3 Regulatory Framework

URCA undertakes various roles and duties in the ES in The Bahamas with the primary role being that of the regulation of the electricity sector in accordance with the goals, objectives and principles underpinning the national energy and electricity sector policies[3].

## 3.1 Policy Objectives

The National Energy Policy 2013 established a Strategic Framework with priority attention on inter alia:

The "Development of a comprehensive governance/regulatory framework to effectively support the advancement of the energy sector to be effectively able to facilitate the introduction of renewables and the diversification of fuels" [4]

Goal two of the National Energy Policy establishes that:

"The Bahamas will have a modern energy infrastructure that enhances energy generation capacity and ensures that energy supplies are safely, reliably, and affordably transported to homes, communities. And [sic] the productive sectors on a sustainable basis."[5]

URCA maintains that the 'safe' production and supply of electricity necessitates that the electrical energy so supplied be done in such a way that minimizes and mitigates, to the extent possible, damage to person, equipment, or property.

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[3] Electricity Act 2015 para 37(1)

[4] National Energy Policy 2013 para 5

[5] National Energy Policy 2013 Section 2, page 16 para 1

## 3.2 Electricity Act 2015

Section 6 of the EA 2015 establishes that the main goal of the electricity sector policy is the creation of a regime for the supply of safe, least cost, reliable and environmentally sustainable electricity throughout The Bahamas.

Section 7 of the Electricity Act mandates that, in creating regulatory and other measures that introduce or amend a significant government policy or regulatory measure, including but not limited to the national energy policy, URCA shall "(i) specify the electricity sector policy objective that is advanced by the policy or measure."

Section 22 of the EA 2015 establishes URCA as the independent regulator of the ES and empowers it to exercise and perform its functions and power in accordance with the provisions of the EA 2015 and the URCA Act.

Section 37 of the EA 2015 provides that the role of URCA is to, inter alia:[6]

> "promote good utility practice and continuous improvement in all regulated activities"; and to,
>
> "hold regulated entities accountable for operating in an environmentally responsible manner"; and to,
>
> "engage inspectors as required, at the costs of the licensees, to conduct inspections of public electricity suppliers for compliance with the terms and conditions of their licenses.

Section 38(3)(g) of the EA 2015 empowers URCA to issue technical rules and standards and enforce standards for the purpose of carrying into effect the sector policy objectives, which includes but is not limited to, the protection of electricity consumers. Section 38 also requires every public electricity supplier (PES) to "within three months of the date of this act comes into operation, submit to URCA for approval a plan proposing standards for the protection of

[6] Electricity Act 2015 Section 2(i, k, n)

electricity consumers[7] which shall include, inter alia, standards of service, quality and safety of electricity service and equipment provided.

Section 40 of the EA 2015 further empowers URCA to "issue regulatory or other measures relating to the protection of consumers including measures regulating the standard of service and the quality and safety of electricity supply systems and equipment"[8]. Section 40 also empowers URCA to issue regulatory standards of service, quality and safety for electricity supply systems and equipment.

Under the terms of section 41 URCA has a duty to consult with the public on matters which, in the determination of URCA, are of public significance.

## 3.3 License Condition

Section 29.1 of the PESL provides that:

"URCA shall set service standards based on the Licensee's approved Consumer Protection Plan. The standards shall include Guaranteed Service Standards, Overall Standards and/or other standards approved by URCA. These standards will be set considering the reasonable cost of meeting them and any trade-offs with affordability"[9]

The cumulative effect of the foregoing, therefore, allows URCA to conduct this public consultation and to exercise its regulatory powers under the Electricity Act to intervene in the electricity market to the extent of establishing technical standards for electricity supply in The Bahamas.

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[7] EA 2015 Section 40(1)

[8] EA 2015Section 40 (8)

[9] Section 29 Public Electricity Supplier License.

## 3.4 Regulatory Impact Statement

In evaluating the proposed technical standards against the requirements of section 7 of the EA, URCA considers that the proposed action is made with a view to implementing the main goal and governing principles and objectives of the sector policy and the electricity supply regime. Specifically, URCA considers that the objectives set out in section 6(2)(a, b, c, and g) and section 40 of the EA 2015 are advanced by the introduction of technical rules and standards for the supply of electricity to consumers. These objectives respectively relate to:

- The provision of safe, least cost electricity supplies to all consumers,
- Advancement of The Bahamas' economic growth and development of international competitiveness,
- The enhancement of the energy security of The Bahamas,
- The promotion of energy efficiency in the generation, distribution, and consumption of electricity throughout the economy.

More particularly, URCA considers that benefits would accrue to suppliers and consumers if provided with technical standards and rules that outline the minimum level for the parameters described herein relating to the supply of electricity to consumers.

# 4 Overview of the Rules and Technical Standards

The following electromagnetic parameters of electric grids, which are within the control of electricity suppliers have the potential to impact the quality of electrical energy being consumed by customers of electricity suppliers:

Table 1[10] —Characteristics of power system electromagnetic parameters

[10] IEEE Std 1159™-2019 (Revision of IEEE Std 1159-2009)

| Item | Parameter | Description |
|---|---|---|
| 1 | Transients | Sudden, nonpower frequency change from the nominal condition of voltage, current, or both |
| 2 | Oscillatory/Frequency (Low, Medium High) | Sudden, nonpower frequency change in the steady-state condition of voltage, current, or both, that includes both positive and negative polarity values |
| 3 | Short Duration (RMS) Variations | Usually caused by fault conditions – the energization of large loads that require high starting currents, or intermittent loose connections in power wiring. *(Includes Sags, Dips and Swells.)* |
| 4 | Long Duration RMS Variations (Under and Over voltages) | Long-duration variations encompass rms deviations at power frequencies for longer than 1 minute. |
| 5 | Imbalance (Voltage, Current) | The ratio of the magnitude of the negative sequence component to the magnitude of the positive sequence component, expressed as a percentage |
| 6 | Waveform Distortion (Noise, Harmonics) | Steady-state deviation from an ideal power frequency sinusoid |
| 7 | Voltage Fluctuations | Systematic variations of the voltage envelope or a series of random voltage changes.<br>The term flicker is derived from the impact of the voltage fluctuation on lighting intensity. |

| | | |
|---|---|---|
| 8 | Power Frequency Variations. | Deviation of the power system fundamental frequency from its specified nominal value (e.g., 50 Hz, 60 Hz). |
| 9 | Supply Reliability | Operational reliability is the ability of the power system to balance supply and demand in real time by managing variability, ramping constraints, and flexible loads—including immediately following an "event" like a large power plant or transmission line failure.[11] |

The Consultation Document seeks to establish acceptable levels for items 3 (Short Term RMS Variations), 5 (Imbalance), 6 (Waveform Distortion) and 7(Voltage Fluctuation) and 9 (Supply Reliability) only, however URCA signals its intent to develop further standards in relation to the remaining electromagnetic phenomena at a later date and to consult on that process.

The technical standards contained in the Consultation Document relate to the physical factors affecting power quality in an electrical system, including allowable voltage, phase imbalance, frequency and harmonic distortions deviations in the supply of electricity to consumers of that service, where:

**Frequency** means the rate of oscillation of the electrical waveform every second. Frequency only applies to systems that use alternating current. The Bahamas' electricity system operates on a nominal frequency of 60 Hertz (Hz). Deviations from this value can cause issues with clocks and other time dependent devices.

Electricity that is supplied at a constant frequency is important for several reasons:

[11] Madeline Geocaris *"Assessing Power System Reliability in a Changing Grid, Environment" (Aug. 10, 2022*)

- accuracy in timekeeping. Constant frequency is vital in systems that rely on time keeping to perform functions l (e.g. a timed lock).
- Motor speed control: in fan motors, the torque is proportional to the speed, hence the power is proportional to the square of the speed. This means that small changes in frequency lead to large changes in power.
- At the generation point, abnormal frequencies make it difficult for generators to stay synchronized and can damage windings and other components.

Electrical frequency is one of the electrical system parameters that was included in the Out Islands Electricity Act (Ch. 195) and omitted from successor legislation. In the preceding legislation, electrical frequency was mandated to be maintained within a range of plus or minus 2 of the nominal frequency.

**Phase Imbalance (Unbalance).** The IEEE in its 1159-2019 (002) standard defines voltage imbalance (or unbalance) to mean in a three-phase system as the ratio of the magnitude of the negative sequence component to the magnitude of the positive sequence component, expressed as a percentage represented mathematically by the following equation:[12]

$$\%\ Imbalance\ = \frac{|Vneg|}{|Vpos|} X100\%$$

For the purpose of these technical standards a phase imbalance will mean a mismatch in the line-to-line voltage of one or more conductors in that system.

Three phase systems are intended to operate with phases balanced. Phase imbalances can cause unbalanced current in motor windings; unbalanced current means an increase in current to at least one winding raising that winding’s temperature which can reduce motor or equipment life.

**Voltage** means the amount of electrical pressure required or employed to effect the transfer of electrons (electrical current) from one region to another. Both high and low voltage levels can

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[12] IEEE Recommended Practice for Monitoring Electric Power Quality Std 1159™-2019

lead to issues with electrical and electronic equipment. For example, low voltages will cause higher currents in the circuit than the equipment is designed, leading to overheating, insulation breakdown and other issues. High voltages can lead to leakage currents, dielectric breakdown, and insulation failure.

Electricity voltage is one of the electrical system parameters that was included in the Out Islands Electricity Act (Ch. 195) and omitted from successor legislation. In the preceding legislation, the declared voltages were mandated to be maintained within a range of plus or minus 6% of the nominal voltage.

**Harmonic Distortion** the interference in an AC power signal created by frequency multiples of the sine wave. Total Harmonic Distortion (THD) is used as a measure of the amount of harmonic distortion in the system. The non-linear characteristics of many industrial and commercial loads such as power converters, fluorescent lamps, computers, light dimmers, and variable speed motor drives (VSDs) used in conjunction with industrial pumps, fans, compressors, and air conditioning equipment have made harmonic distortion a common occurrence in electrical power networks. Further, large industrial converters and variable speed drives can generate significant levels of distortion at the point of common coupling (PCC), where other users are connected to the network equipment. [13]

Harmonics are undesirable in an electrical system because they create losses in distribution networks and within customers installations. They also reduce the life expectancy of electrical devices such as transformers and motors and can cause circuit overloads leading to nuisance tripping, and power disruptions.

Harmonics are undesirable from a cost perspective. They have been estimated to cost the European Union (EU) more than 10 billion euros per annum with less than 5% of that figure being spent on preventative measures.[14]

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[13] https://powerside.com/knowledge

[14] Chapman. (2001). The Cost of Poor Power Quality. Brussels: Copper Development Association

Although current distortion levels can be characterized by a THD as described previously, this can often be misleading. For instance, many ASDs exhibit high THD values for the input current when they are operating at very light loads. This is not a significant concern because the total rms magnitude of harmonic current is low, even though its relative distortion is high.[15]

IEEE Std 519-2014 defines the total demand distortion (TDD) to characterize harmonic currents in a way that is more meaningful. This term is similar to THD with the exception that distortion is expressed as a percent of current selected load current such as the peak demand, rather than as a percent of the root mean square (rms) fundamental current magnitude.

For the purposes of this technical standard, URCA will base the technical standard on THD as this term is well represented in literature and may be more familiar to licensees, recognizing that the conversion between the two terms is not arithmetically complex.

These standards also define and regulate electrical power reliability by defining *reliability supply indices* for the distribution network for GTDS licensees.

**Reliability of Supply:** Electricity Supply Utilities must have accurate information about system performance to ensure that maintenance dollars are spent wisely and that customer expectations are met.

To measure system performance, the electric utility industry has developed several measures of reliability. These reliability indices include measures of outage duration, frequency of outages, system availability, and response time[16].

The IEEE-2022 standard "*Guide for Electric Distribution Reliability Indices"* defines the following reliability events in the supply of electricity:

[15] IEEE Recommended Practice for Monitoring Electric Power Quality Std 1159™-2019

[16] Layton, L *"Electricity System Reliability Indices, 2004"*

- *Momentary Interruption:* A single operation of an interrupting device that results in zero voltage. It is also defined as the brief loss of power to one or more customers caused by the opening and closing operation of an interruption device(s)
- *Momentary Interruption Event:* An interruption of duration limited to the period of time required to restore service.
- *Sustained Interruption:* An interruption that lasts more than five minutes.

While these defined events are useful in describing and monitoring interruption events (particularly in the definition of a major outage or major event -$T_{MED}$,) in a the most detailed way, URCA does not propose to utilize this more detailed standard in determining reliability indices, due to the administrative burden that such a requirement would place on licensees at this time.

URCA therefore proposes to continue to use the following definitions as contained in its consultation document on major outage definition (ES 01/2023):

**Interruption** means the total loss of electric power on one or more normally energized conductors to one or more customers connected to the distribution portion of the system; and,

**Major outage** means (a) the loss of the ability of a component to deliver power which results in the total loss of electric power on one or more normally energized conductors to a significant customer base, for a duration of two consecutive hours or more; and/or (b) the loss of the ability of a component to deliver power which results in the total loss of electric power on one or more normally energized conductors to the customer base, for any duration

In this standard, URCA therefore proposes to require the monitoring, recording and reporting of the following indices:

**System Average Interruption Duration Index (SAIDI)**

SAIDI refers to "System Average Interruption Duration Index." It is calculated by multiplying the average duration of customer interruptions by their total number and then dividing it by the total number of customers in the system.

SAIDI describes the total duration of the average customer interruption. The most direct way to improve SAIDI is to improve the utility's response to outages.. Strategies to reduce the frequency of interruptions will also help improve SAIDI.

**Customer Average Interruption Duration Index (CAIDI)**

CAIDI refers to "Customer Average Interruption Duration Index." It is calculated as total minutes of customer interruption divided by the total number of customers interrupted.

CAIDI describes the average time required to restore service. Unlike SAIDI or SAIFI, CAIDI includes only customers who actually experienced an interruption. This makes it useful for measuring response to interruptions, but not the prevention of interruptions.

CAIDI improvement strategies include automated call-out of troubleshooters and crews to more quickly resolve outages and increased staffing for troubleshooting.

**System Average Interruption Frequency Index (SAIFI)**

SAIFI refers to "System Average Interruption Frequency Index." It is calculated by dividing the total number of customers interrupted by an outage by the total number of customers in the system.

In short, SAIFI describes how often the average customer experiences an interruption.

SAIFI can be improved by reducing the frequency of outages through better preventative maintenance. Improved equipment maintenance and tree-trimming, for example, can limit the number of service interruptions.

**Average System Availability Index Average System Availability Index (ASAI)**

The Average System Availability Index (ASAI) measures the percentage of time a customer receives an electricity service over a defined period (e.g. monthly/yearly).

ASAI directly measures the distribution system adequacy and complements the other reliability indices. Additionally, the ASAI measure requires no additional information for computation. Together, these indices provide comprehensive indicators of the reliability performance of the electricity network.

URCA also recognizes the usefulness of tracking Momentary Average Interruption Frequency Index **(MAIFI),** and Customers Interrupted per Interruption Index **(CIII),** because of the greater accuracy that these indices can give in measuring the reliability of a utility's entire system. URCA does not, however, propose monitoring recording and reporting of these indices at this time, because of the administrative burden that these measurements, recording and reporting can place on licensees.

The use of electricity supply reliability indices provides a view of distribution system performance which is useful to both the licensee and the customer. To adequately measure performance, both the duration and frequency of customer interruptions must be examined at various system levels.

These metrics provide decision-makers at the utility with the information they need to:

- Improve system reliability.
- Pinpoint and resolve chronic trouble-spots in the system.
- Integrate incoming customer outage reports and service requests with outage data.
- Minimize the frequency and impact of customer outages.
- Respond quickly and effectively to storms or other major outage events.
- Improve service restoration process.[17]

For the purposes of this standard URCA proposes to establish minimum acceptable service levels for SAIDI, SAIFI, CAIDI, and ASAI and signals its intent to develop minimum acceptable levels for the additional aforementioned performance indices at the *customer* level at a later date and to consult on that process.

[17] SAIDI, CAIFI, & SAIFI: A Guide to Utility Reliability Metrics (hexstream.com)

# 5 Applicability of the Proposed Technical Standards.

As stated in section 2 of this consultation document, the proposed technical standards for the GTDS of electrical energy are informed by the technical standards published by other regional jurisdictions and by international standard setting bodies such as the IEEE (*The Institute for Electrical and Electronic Engineers*).

URCA is therefore satisfied that the proposed technical standards for the Generation Transmission Distribution and Supply (GTDS) of electrical energy are appropriate and consistent with standards established in other jurisdictions, that they have attained widespread adoption and that they have led to improvements in electricity supply quality and system maintenance.

These standards shall apply to anyone engaging in GTDS services in the Bahamas and who in accordance with the EA 2015 are required by the EA 2015, to provide such services.

URCA considers it important to emphasize that the technical standards proposed for GTDS of electrical energy in this consultation document are the minimum standards and signals its intent to monitor the requirement for proposing additional standards, where appropriate, and to consult on that process.

As the technical standards contained in the Consultation Document were included in prior legislation, URCA proposes that licensees shall have up to 6 months to comply with the requirements of these standards.

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| Question 1: Are there any other relevant standards not included in this consultation document, which URCA ought to include?<br><br>Please provide reasoning to support your answer.? |

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| Question 2: Is this a reasonable time for the implementation of the standards contained herein? |

# 6 Next Steps

This section sets out the next steps to be taken in this consultation process by URCA towards issuing the proposed supply technical standards.

After the period for responses closes, URCA will carefully consider all submissions and shall issue its Statement of Results and Final Decision, of the Standard for Power Quality and Reliability in Electric Power Systems, within thirty (30) calendar days from the close of responses by interested parties.

After the issuance of the Statement of Results and Final Decision, URCA will notify the relevant ES licensees of the new requirements for the supply of electricity. The standards will apply to the relevant licensees' consumer protection plans and shall be referenced therein.

At an appropriate time, URCA intends to revisit these technical standards for the electricity sector to develop broader rules and standards that apply to various aspects of the GTDS in the electricity sector.

# Annex A: Standards for Power Quality and Reliability in Electric Power Systems

## 1 Regulatory Title

This regulation may be cited as “Standard for Power Quality and Reliability in Electric Power Systems”.

## 2 Definitions

**APESL** means Approved Public Electricity Supplier Licensee as defined in Section 46(1)(a)(ii) of the EA.

**Abnormal Circumstances** means acts of force majeure where the usual operation of the electricity supplier is disrupted by factors beyond the control of the supplier such as during an extreme weather event.

**Consumer** means any person who uses or may use or requests or may request, a supply of energy for business or residential purposes, As defined in Part I, Preliminary, of the Electricity Act 2015.

**Customer** means, in relation to a licensee, the person –

(a) to whom energy is supplied in the course of any business carried on as such by the licensee;

(b) to whom the licensee is seeking to secure that energy is provided;

(c) who wishes to be supplied with energy, or who is likely to seek to become a person to whom energy is supplied; and includes any of them whose use or potential use of energy is for the purposes of, or in connection with a business; as defined in Part I, Preliminary, of the Electricity Act 2015

**EA** means the Electricity Act of the Bahamas, enacted in 2015.

**Electrical Grid** or ***Electricity Grid*** means the electrical lines, conduits, or cables of any voltage level, providing electrical energy to a customer of the PESL or APESL and has the same meaning as "electricity supply system" as defined in *Part I, Preliminary*, of the Electricity Act 2015.

**Frequency** means the rate of oscillation of the electrical waveform every second. Frequency only applies to systems that use alternating current.

**Grid** means:

(a) any BPL power system, inclusive of transmission and distribution, wherever located within The Bahamas;

(b) the power system, inclusive of transmission and distribution, of any public electricity supplier within The Bahamas other than BPL; as defined in Part I, Preliminary, of the Electricity Act 2015

**GTDS** means generation, transmission, distribution and supply *(of electrical energy);*

**Harmonic Distortion** means the interference in an AC power signal created by frequency multiples of the sine wave. Total Harmonic Distortion (THD) is used as a measure of the amount of harmonic distortion in the system.

**PCC** means the **point of common coupling**. PCC is normally taken as the point in the power system closest to the user where the system owner or operator could offer service to other users. For all classes of customers, this shall mean at the customer side of the service meter.

**PESL** means Public Electricity Supplier Licensee as defined in Section 2 (Interpretation), of the EA.

**Phase Imbalance** means, in reference to a three-phase system, a mismatch in the line-to-line voltage of one or more conductors in that system. Three phase systems are intended to operate with phases balanced.

**Power Quality** means the condition of the electricity supply such that is in within the parameters specified in this consultation document and of such a condition so as to be safely and consistently used by customers without undue risk of damage to person or property.

**Voltage** means the amount of electrical pressure required or employed to effect the transfer of electrons (electrical current/energy) from one point in a conductor to another.

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|---|
| Question 3: Do you agree with the definition of the Point of Common Coupling? If not, please provide an alternate definition with justification. |

# 3 Measurement and Enforcement

The term *power quality* refers to a wide variety of electromagnetic phenomena that characterize the voltage and current at a given time and at a given location on the power system. In specifying limits of power quality that may be supplied by a PESL or APESL, it is necessary to ensure compliance with those limits through the establishment of an adequate monitoring program. URCA hereby signals its intent to establish a formal monitoring and verification at a later date utilizing the following equipment and measuring regime:

## 3.1 Measurement Regime

The characteristics of the electrical system will be measured using the equipment described herein for the purpose of establishing ongoing and continued compliance of the electrical grid with the requirements of these regulations. The power quality parameters listed in this standard shall apply to, and be measured at, the point of common coupling.

URCA envisions that equipment described herein will, where necessary be permanently installed at various points on the electrical grid and monitored and read by URCA and/or the licensee at regular intervals but at any case not less that once per month or on receipt of a specific complaint by URCA.

## 3.2 Equipment

For the purposes of monitoring and reporting, the licensee will be required to utilize its own equipment to monitor compliance and act where necessary. It should also provide the data to URCA in the manner and format specified herein. URCA may inspect the licensee's equipment to verify its accuracy and/or request the licensee to do the same and provide the results of such inspection to URCA.

As a check of the reported values, URCA will establish a contemporaneous monitoring programme utilizing, inter alia, the following tools and equipment to monitor licensee electrical power quality:

**Power Quality Analyzers**

Power quality analyzers are devices that measure and record power quality parameters such as voltage, current, harmonics, and transients.

**Power Quality Meters**

Power quality meters are used for long-term monitoring of power quality parameters and will be installed at a specific location to monitor the electrical signals continuously.

**Data Loggers**

Data loggers are used for monitoring voltage variations, current fluctuations, and other power quality parameters at high speed and with high accuracy.

**Power Quality Monitoring Systems**

These tools provide a comprehensive approach to power quality monitoring and will include sensors and analyzers to monitor and track the quality of the power supply.

**Other Special tools**

URCA will use any other tool or equipment device, or process not specifically referred to in this document to ensure compliance with the power quality levels described herein.

### 3.3 Enforcement

Enforcement is an on-going regulatory obligation and a necessary outflow of the establishment of technical standards. When implementing enforcement measures, URCA will do so for the benefit of all stakeholders to enforce regulated sector laws, encourage competition, and to ensure that licensees are compliant with the license conditions and other technical rules and regulations published by URCA.

Enforcement is a necessary component of regulation to ensure the integrity of the electrical supply system. The enforcement framework therefore includes both ex-ante and ex-post regulatory measures intended to allow URCA to prevent, detect and investigate electrical supply issues.

### 3.4 Inspections

URCA, acting in accordance with section 40(6) of the Electricity Act, has the right to monitor and enforce the consumer protection conditions in licenses and, in this regard, URCA may from time to time appoint in writing one or more suitably qualified electrical inspectors to inspect –

- (a) any electrical installation or apparatus of BPL or of any other public electricity supplier; or,
- (b) the wirings, fittings or apparatus used by any consumer.

This statutory provision provides URCA with the legislative underpinning to ensure that electrical systems are established, operated, and maintained in a manner that is consistent with regulatory standards.

## 4 Nominal Supply Levels

Public Electricity Supplier Licensees (PESL) and Approved Public Electricity Supplier Licensees (APESL) shall supply their service at the following voltages and frequencies, unless alternative levels are agreed between the licensee and customer.

Table A1 Allowable Supply Voltages and Frequencies

| Transmission | Voltage (Volts) | Phases | Frequency (Hz) |
|---|---|---|---|
| Distribution | | | |
| Level A | 120 | 1 | 60 |
| Level B | 120/240 | 1 | 60 |
| Level C | 120/208 | 3 | 60 |
| Level D | 277/480 | 3 | 60 |

Question 4: Do you agree with the supply voltage limits proposed by URCA? Please give reasons why you do or do not agree with these limits and provide alternative limits.

Please provide full reasoning in support of your response

# 5 Allowable Deviation to Nominal Supply Levels

## 5.1 Voltage Deviation

The steady state supply voltage shall be maintained within plus or minus six percent (+/- 6%) of the nominal supply level.

Question 5: Do you agree with the allowable voltage deviation limits proposed by URCA? Please give reasons why you do or do not agree with these limits and provide alternative limits.

Please provide full reasoning in support of your response

## 5.2 Allowable Voltage Phase Imbalance

The maximum phase imbalance, measured under no load conditions, shall be limited to plus or minus three percent (+/- 3%).

$$Percent\ volage\ unbalance = \frac{\mathrm{V\,max}\,dif - Vav\ 3\ ph}{\mathrm{Vav\ 3\ ph}} *\ 100\%$$

Where:

Vmax dif = the phase voltage with the largest difference from the average of the three phases.

Vav 3 ph = the average voltage of the three phases

## 5.3 Frequency Deviation

The steady state supply frequency shall be maintained within plus or minus two percent (+/- 2%) of the nominal supply level.

| |
|---|
| Question 6: Do you agree with the allowable frequency deviations proposed by URCA? Please give reasons why you do or do not agree with these limits and provide alternative limits.<br><br>Please provide full reasoning in support of your response |

## 5.4 Harmonic Deviation

Harmonics are produced both by the system operator and the end user. The harmonic currents produced by the end user flow through the owner's or operator's system which leads to voltage harmonics in the voltages supplied to other users. Both the licensee and the customer have a responsibility to limit harmonic currents.

URCA recognizes the impact that the addition of harmonic adding equipment can have on the system and encourages system operators to advise consumers of these effects and to not add equipment that affects the impedance characteristics in a way such that the voltage distortions are increased. Also, system operators shall make every effort to minimize the harmonics produced and supplied to end users and transmitted to the grid from end users.

At the PCC, system owners or operators shall limit line-to-neutral voltage harmonics as follows:

- Daily 99th percentile very short time (3 s) values shall be less than 1.5 times the values given in Table 4.
- Weekly 95th percentile short time (10 min) values shall be less than the values given in Table 4.

All values shall be in percent of the rated power frequency voltage at the PCC. Table 4applies to voltage harmonics whose frequencies are integer multiples of the power frequency up to and including the $50^{th}$ harmonic.

The limits in this clause are based on the fact that some level of voltage distortion is generally acceptable [18]and the underlying assumption of these limits is that by limiting harmonic current injections by users, voltage distortion can be kept below objectionable levels. In the event that limiting harmonic currents alone does not result in acceptable levels of voltage distortion, system owners or operators should take action to modify system characteristics so that voltage distortion levels are acceptable. The acceptable voltage distortion levels form the basis of the harmonic voltage limits in table 4.

Table A2: Allowable Harmonics[19]

| Level | Bus Voltage at PCC | Individual Harmonic (%) h ≤ 50 | Total Harmonic Distortion THD (%) |
|---|---|---|---|
| A | V ≤1.0 kV | 5.0 | 8.0 |

[18] IEEE Std 519 – 2022 Clause 5 para 1

[19] IEEE Std 519 – 2022 table 1 – voltage distortion limits (V≤1.0kV)

Question 7: Do you agree with the allowable harmonics limits proposed by URCA? Please give reasons why you do or do not agree with these limits and provide alternative limits.

Please provide full reasoning in support of your response

# 6 Reliability

## 6.1 Definitions, acronyms, and abbreviations

### 6.1.1 Definitions

For the purposes of this standard reliability indices shall mean those parameters when measured, recorded, and reported track the *consistency* of supply of the electrical grid. And the following event definitions shall apply.

**Interruption**: An interruption is the total loss of electric power on one or more normally energized conductors to one or more customers connected to the distribution portion of the system.

**interruption duration:** The time period from the initiation of an interruption until service has been restored to the affected customers.

### 6.1.2 Acronyms and Abbreviations

The following parameters are used in the calculation of performance indices:

**CI** Customers Interrupted

**CMI** Customer Minutes of Interruption

**K** Number of interruptions experienced by an individual customer in the reporting period.

**$L_i$** Connected kVA load interrupted for each interruption event

**$L_T$** Total connected kVA load served

**$N_i$** Number of interrupted customers for each sustained interruption event during the reporting period

**$N_{mi}$** Number of interrupted customers for each momentary interruption event during the reporting period

**$N_T$** Total number of customers served for the area

$r_i$ Restoration time for each interruption event

$T_{MED}$ Major Event Day threshold

## 6.2 Recording and Reporting of Indices

A recordable event is any interruption that lasts more than 5 minutes

The indices shall be measured, recorded and reported to URCA by PESL and APESL as referenced in the licensees' reporting requirements e.g. outage reporting and biannual reports.

| |
|---|
| Question 8: Do you agree that a recordable event should be any interruption that lasts more than 5 minutes? If not, please provide an alternative value with justification. |

| |
|---|
| Question 9: As a licensee how will you comply with this requirement? For example, where and how will the event be recorded? |

## 6.3 Reliability Indices

### 6.3.1 System Average Interruption Duration Index (SAIDI)

SAIDI indicates the total duration of interruption for the average customer during a pre-defined period of time. It is commonly measured in hours of interruption. A sample calculation of SAIDI is shown below:

$$SAIDI = \frac{\Sigma \text{ Customer Minutes of Interruption}}{Total\ Number\ of\ Customers\ Served}$$

To calculate SAIDI, the following formula is used:

$$SAIDI = \frac{\Sigma \mathrm{r}_i \mathrm{N}_i}{N_T} = \frac{\mathrm{CMI}}{\mathrm{N}_T}$$

### 6.3.2 System Average Interruption Frequency Index (SAIFI)

The System Average Interruption Frequency Index (SAIFI) indicates how often the average customer experiences a sustained interruption over a predefined period of time as represented in the equation below.

$$SAIFI = \frac{\Sigma \text{ Total Number of Customers Interrupted}}{Total\ Number\ of\ Customers\ Served}$$

To Calculate SAIFI, the following formula is used:

$$SAIFI = \frac{\Sigma \mathrm{N}_i}{N_T} = \frac{\mathrm{CI}}{N_T}$$

### 6.3.3 Customer Average Interruption Duration Index (CAIDI):

The Customer Average Interruption Duration Index (CAIDI) represents the average time required to restore service. It is represented by equation 5 below:

$$CAIDI = \frac{\Sigma \text{ Customer Minutes of Interruption}}{Total\ Number\ of\ Customers\ Interrupted} = \frac{\mathrm{CMI}}{CI}$$

To Calculate CAIDI, the following formula is used:

$$CAIDI = \frac{\Sigma r_i \mathrm{N}_i}{\sum N_i} = \frac{\mathrm{SAIDI}}{\mathrm{SAIFI}}$$

### 6.3.4 Average System Availability Index (ASAI):

The Average System Availability Index Average System Availability Index (ASAI) measures the percentage of time a customer receives an electricity service over a defined period (e.g. monthly/yearly). It is calculated as follows:

$$ASAI = \frac{Customer\ Hours\ of\ Service\ Demanded}{Customer\ Hours\ of\ Service\ Provided}$$

ASAI can also be calculated numerically from either of the following equations:

$$ASAI = 1 - \left(\frac{\Sigma(r_i * N_i)}{(N_T - T)}\right) * 100 = \left(\frac{8760 - SAIDI}{8760}\right) * 100$$

Where

T = Time Period being monitored (hours)
$R_i$ =restoration time (hours)
$N_i$ = total number of customers interrupted
$N_t$ = Total number of customers served.

ASAI directly measures the generation and system adequacy and complements the other reliability indices. Additionally, the ASAI measure requires no additional information for computation. Together, these indices provide comprehensive indicators of the reliability performance of the electricity network.

### 6.3.5 Major Event Day (MED) Definition

It is important to define a further term which is useful in tracking of reliability indices in the supply of electrical power. That term is a Major Event Day. A Major Event Day is a day in which the daily system SAIDI exceeds the threshold value, TMED. The SAIDI index is used as the basis of this definition since it leads to consistent results regardless of utility size, and because SAIDI is a good indicator of operational and design stress. Even though SAIDI is used to determine the MEDs, all indices should be calculated based on removal of the identified day.[20]

URCA does not propose that Major Event Days be tracked by PESL and APESL, at this time, but intends by introducing the terminology to make licensees aware of the term, and its utility in conjunction with SAIDI as an indicator of operational and design stress.

[20] IEEE Std 1366-2022 IEEE Guide for Electric Power Distribution Reliability Indices

A major event day can also be used as a classification of major outages. URCA notes that such a definition was recently determined by URCA (ES 01 /2023) but signals its intent to introduce the new definition once licensees have attained necessary familiarity of and facility with the terms introduced in this consultation process, and to consult on the new definition.

## 6.4 Sample Calculations of SAIFI, SAIDI and CAIDI

To table below is used to calculate the referenced indices. In the example the utility serves 2000 customers in the geographical area.

Table A3 Interruption Data for Electric Utility 2022

| Event Number | Date | Time Off | Time On | Duration (min) | Number of Customers Affected | Interruption Type |
|---|---|---|---|---|---|---|
| 1 | Jan 7 | 12:12:20 | 12:20:30 | 8.17 | 200 | S |
| 2 | Feb 2 | 18:23:56 | 18:24:26 | 0.5 | 400 | M |
| 3 | Mar 15 | 00:23:10 | 01:34:29 | 71.32 | 600 | S |
| 4 | May 12 | 23:17:00 | 23:47:14 | 30.23 | 25 | S |
| 5 | Jun 6 | 09:30:10 | 09:31:10 | 1 | 2,000 | M |
| 6 | Aug 15 | 15:45:39 | 20:12:50 | 267.18 | 90 | S |
| 7 | Sep 31 | 08:20:00 | 10:20:00 | 120 | 700 | S |
| 8 | Oct 18 | 17:10:00 | 17:20:00 | 10 | 1,500 | S |

| Event Number | Date | Time Off | Time On | Duration (min) | Number of Customers Affected | Interruption Type |
|---|---|---|---|---|---|---|
| 9 | Nov 21 | 10:15:00 | 10:55:00 | 100 | 100 | S |
| | Note 1: Interruption type S = Sustained; M = Momentary<br>Note 2: Total Customers Served = 2000 | | | | | |

From Table 1: the number of customers who have experienced a sustained interruption is 3, 215. The total number of customers who have sustained a momentary interruption is 2,400.

These technical standards do not require the reporting of momentary interruptions, but they are included here for the guidance of licensees in the calculation of the indices.

Calculation of SAIFI

$$SAIFI = \frac{200 + 600 + 25 + 90 + 1500 + 100}{2000} = 1.61$$

Calculation of SAIDI

$$SAIDI = \frac{(8.17\times200)+(71.3\times600)+(30.3\times25)+(267.2\times90)+(120\times700)+(10\times1500)+(40\times100)}{2000} = 86.11 \text{ minutes}$$

or 1.43 hours

Calculation of CAIDI

$$CAIDI = \frac{SAIDI}{SAIFI} = \frac{86.110}{1.6075} = 53.57\ minutes$$

Calculation of ASAI

$$ASAI = \left(\frac{8760 - SAIDI}{8760}\right) * 100 = (-\frac{8760 - 1.435}{8760})*100 = 99.98\%$$

## 6.5 Proposed Quality of Service Standards for Reliability

Licensees shall incorporate the following quality of service standards into their Consumer Protection Plans:

Table A4 Proposed Reliability Indicator Targets for New Providence

| Parameter | Units (Per Year Per Customer) | Reliability Indicator Targets | | |
|---|---|---|---|---|
| | | 2024 | 2025 | 2026 |
| SAIDI (1) | Hours | 4.25 | 4.16 | 4.07 |
| SAIFI (1) | Outages | 6.24 | 6.12 | 5.99 |
| CAIDI (1) | Hours | 0.68 | 0.68 | 0.68 |
| ASAI (2) | Percentage | 99.951 | 99.952 | 99.953 |

**Notes:**

1) Values for SAIDI, SAIFI and CAIDA are maximum values

2) Values for ASAI are minimum values.

Question 10: Do you agree with the proposed maximum SAIDI, SAIFI, CAIDI and ASAI values for *New Providence* proposed by URCA? Please give reasons why you do or do not agree with these limits and provide alternative limits.

Please provide full reasoning in support of your response

Table A5 Proposed Reliability Indicator Targets for The Family Islands

| Parameter | Units (Per Year Per customer) | Targets | | |
|---|---|---|---|---|
| | | 2024 | 2025 | 2026 |
| SAIDI (1) | Hours | 6.25 | 6.12 | 5.99 |
| SAIFI (1) | Outages | 8.24 | 8.07 | 7.91 |
| CAIDI (1) | Hours | 0.76 | 0.76 | 0.76 |
| ASAI (2) | Percent | 99.928 | 99.930 | 99.932 |

**Notes:**

1) Values for SAIDI, SAIFI and CAIDA are maximum values

2) Values for ASAI are minimum values.

Question 11: Do you agree with the proposed maximum SAIDI, SAIFI, CAIDI and ASAI values for the *Family Islands* proposed by URCA? Please give reasons why you do or do not agree with these limits and provide alternative limits.

Please provide full reasoning in support of your response

# Annex B: List of Questions Posed by URCA

The following questions were posed by URCA in the body of this document.

Question 1: Is this a reasonable time for the implementation of the standards contained herein?

Please provide full reasoning in support of your response

Question 2: Are there any other standards not included in this consultation document, which URCA ought to include?

Please provide full reasoning in support of your response.

Question 3: Do you agree with the definition of the Point of Common Coupling? If not, please provide an alternate definition with justification.

Question 4: Do you agree with the supply voltage limits proposed by URCA? Please give reasons why you do or do not agree with these limits and provide alternative limits.

Please provide full reasoning in support of your response.

Question 5: Do you agree with the allowable voltage deviation limits proposed by URCA? Please give reasons why you do or do not agree with these limits and provide alternative limits.

Please provide full reasoning in support of your response.

Question 6: Do you agree with the allowable frequency deviations proposed by URCA? Please give reasons why you do or do not agree with these limits and provide alternative limits.

Please provide full reasoning in support of your response.

Question 7: Do you agree with the allowable harmonic limits proposed by URCA? Please give reasons why you do or do not agree with these limits and provide alternative limits.

Please provide full reasoning in support of your response.

Question 8: Do you agree that a recordable event should be any interruption that lasts more than 5 minutes? If not, please provide an alternative value with justification.

Question 9: As a licensee how will you comply with this requirement? For example, where and how will the event be recorded?

Question 10: Do you agree with the proposed maximum SAIDI, SAIFI, CAIDI and ASAI values for *New Providence* proposed by URCA? Please give reasons why you do or do not agree with these limits and provide alternative limits.

Please provide full reasoning in support of your response.

Question 11: Do you agree with the proposed maximum SAIDI, SAIFI, CAIDI and ASAI values for the *Family Islands* proposed by URCA? Please give reasons why you do or do not agree with these limits and provide alternative limits.

Please provide full reasoning in support of your response.