INVITATION FOR COMMENTS AND CONTRIBUTIONS ON: BATTERY STORAGE INTEGRATION

ES 03/2023

Publication Date: 28 April 2023

Response Date: 28 May 2023

Contents

Invitation For Comments and Contributions On: Battery Storage Integration

1. Introduction

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

The EA establishes that 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. In particular, section 6(2)(g) and 6(2)(h) respectively list as principles and objectives governing the ES to include the promotion of energy efficiency in the generation, distribution and consumption of electricity throughout the economy and promotion of the use of renewable energy. Moreover, the main goal and objective of the electricity sector policy in accordance with section 6(1) EA is creation of a regime for the supply of safe, least cost, reliable and environmentally sustainable electricity throughout The Bahamas.

Having regard to the sector policy which mandates that URCA inter alia promote the use of renewable energy and environmentally sustainable electricity, URCA remains cognizant of developments in renewable energy technology and their application to the ES.

Battery storage systems have the capacity to advance the electricity sector policy and objectives as they enable renewables like solar and wind to be stored and then released when needed. Additionally, advances in battery storage technology have made this system of grid stability and energy coordination an important part of the management of the electrical system on a utility scale. Moreover, URCA has received several inquiries from stakeholders in relation to the facilitate and regulation of battery storage technology in the Bahamian ES.

URCA is in the process of developing its position as it relates to what regulatory measures (if any) would be most appropriate to develop in relation to Battery Storage Integration.

In accordance with URCA's Standard Consultation Procedures (ES 05/2021), URCA's consultation in relation to battery storage technology at this time will follow an informal consultation process. That is, URCA is seeking to receive input from stakeholder to inform URCA's development of a formal consultation document.

URCA accordingly invites licensees, consumers and interested parties to submit viewpoints, comments and/or contributions prior to URCA developing a position, as to the extent (if any) to which regulations are required for the emerging technology of battery storage and to determine the nature and type of those regulations, through input from stakeholders.

1.2 Objectives

In issuing this document, URCA seeks to:

- Provide the public, licensees and interested parties with an overview of technical and economic issues and key requirements for the integration of Battery Energy Storage Systems (BESS)

- To receive input from interested stakeholders, inclusive of licencees with respect to proposed guidelines for Battery Energy Storage Systems integration into GTDS systems.

In particular, in receiving viewpoints, comments and considerations from interested stakeholders, and without limiting the scope of feedback sought, URCA is in particular interested in the following:

- The extent of URCA's regulatory involvement (if any) in relation BESS and the possible regulatory impact.
- Grid interconnection arrangements with relevant licensees;
- Specific technical requirements for BESS;
- Financial implications, compensation and impact on the tariff;
- Whether the adoption of BESS should be incentivised and if so to what extent; and
- Barriers to BESS and regulatory opportunities.

1.3 Provision of Comments, Contributions and Viewpoints

Comments and submissions can be shared on any aspect of this. Persons may deliver their written comments or submissions to URCA's Director of Utilities and Energy either:

- by hand, to URCA's office at Frederick House, Frederick Street, Nassau, Bahamas; or
- by mail, to P. O. Box N-4860, Nassau, Bahamas; or
- by fax, to (242)-393-0237; or
- by email, to info@urcabahamas.bs .

All comments and submissions should be **submitted on or before 28 May 2023**. URCA will acknowledge receipt of all responses.

URCA's preferred format for written responses is as follows:

- Respondent's name;
- Name of organization (or state whether respondent is a consumer);
- Email address or other address of respondent;
- Comments, considerations and viewpoints;
- Any other matters that you believe URCA should consider under the instant Preliminary Consultation process.

Copyright and all other intellectual property that form any part of a response will be assumed to be licensed to URCA for its use during any subsequent consultation process.

1.4 Overview of Technical and Economic Considerations

In order to assist licensees, consumers and interested parties in providing URCA with comments, considerations and viewpoints, URCA has prepared an overview which sets out an explanation of battery storage technology in addition to technical and economic considerations in relation thereto.

URCA's comprehensive analysis of the Battery Energy Storage Systems and Discussion on technical and economic implications are annexed to this document.

1.5 Next Steps

After the period for responses closes, URCA will publish on its website responses received. URCA will thereafter consider the viewpoints received and develop its position in relation thereto which will be included in a Consultation Document (if appropriate) which URCA intends to action as a part of its T1 2024 projects for the ES.

URCA reserves the right to further liaise with respondents informally as it relates to the subject of this consultation.

ANNEX A: Technical Analysis of Battery Energy Storage Systems

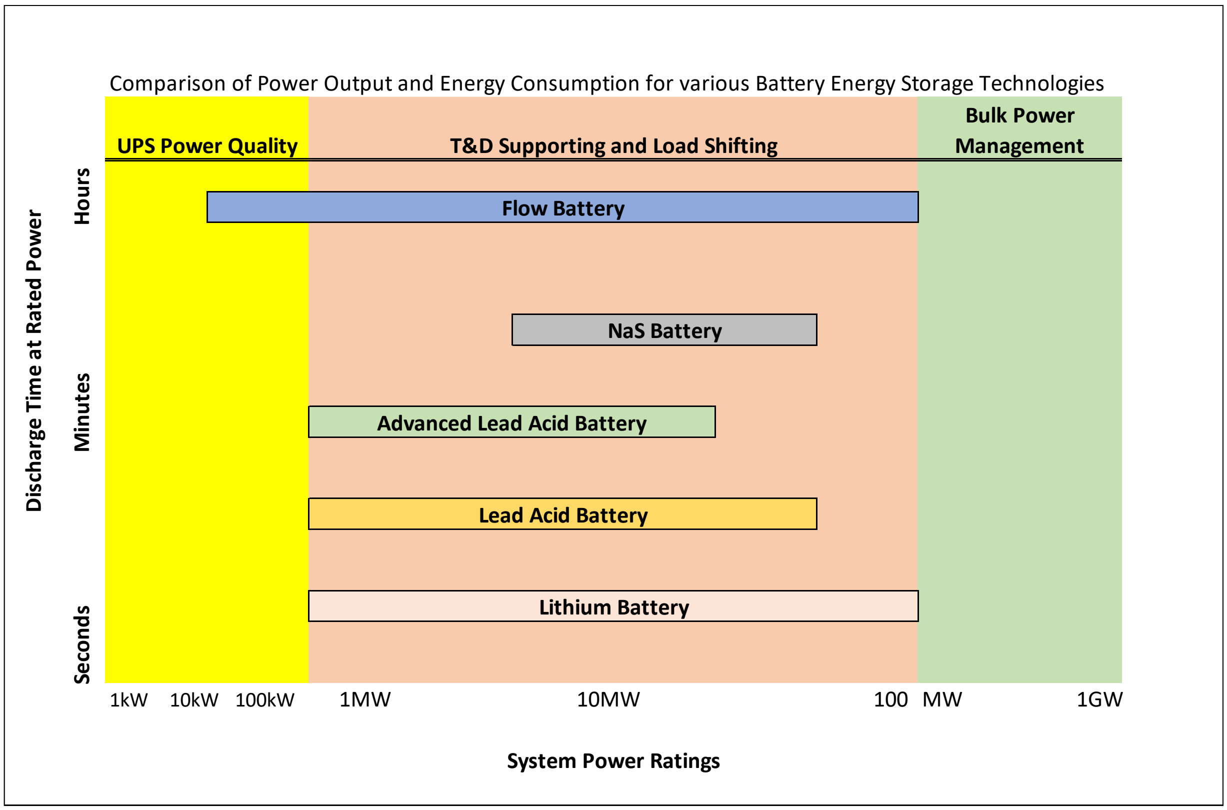
Battery energy storage technologies can be differentiated on the basis of energy density, charge and discharge (round trip) efficiency, life span and eco-friendliness of the devices. Energy density is defined as the amount of energy that can be stored in a single system per unit volume or per unit weight.

A Battery Storage Energy System may be defined as follows:-

"A Battery energy storage system is an electrochemical device that charges (or collects energy) from the grid or power plant and then discharges that energy at a later time to provide electricity or other grid service (such as stabilization) when needed."

Types of Technology for BESS

The table below illustrates the various types of technologies currently being used in Battery Energy Storage and shows applicability to system size as well as discharge time at rated power for the various technologies:



Lithium batteries have the highest commercially available energy density.

1.1.1 Lead Acid (PbA) Battery

Lead-acid batteries are widely used in vehicles and other applications requiring high current values for relatively short duration. The main advantages of this technology are low cost, maturity of the technology and end of life treatment.

1.1.2 Nickel-Cadmium (Ni-Cd) Battery

Nickel Cadmium batteries are widely used for computers, hand-tools and other small battery-operated devices that require even power discharge characteristics.

1.1.3 Nickel-Metal Hydride (Ni-MH) Battery

Ni-MH batteries combine sealed electrode chemistry of the Ni-Cd battery with the energy storage features of metal alloys. They are widely found in high-end portable electronics where run-time is important in the purchase decision.

1.1.4 Lithium-Ion (Li-Ion) Battery

Li-Ion battery chemistry has the highest energy density; they do not require memory cycling to prolong battery life. They are widely used in electronic devices and in electric mobility applications.

1.1.5 Sulphur-Sodium (Na-S) Battery

The sulphur-sodium (Na-S) battery or liquid metal battery is a type of molten metal battery made from sodium and sulphur. It has a high energy density, high efficiency and discharge and a long cycle life and is made from inexpensive materials.

Its major disadvantage is that it has a high operating temperature of (300^{o}C to 350^{o}C). It is primarily used for electric-grid energy storage.

1.1.6 Redox Flow Battery (RFB)

RFBs are charged and discharged by means of the oxidation-reduction reaction of ions of vanadium or similar metals.

1.2 Battery Energy Storage System Applications

BESS can provide various services to public electricity suppliers:

- **Load Shifting or Load Levelling:** System Operators charge batteries during periods of excess generation and discharge batteries during periods of excess demand to coordinate the dispatch of generating resources more efficiently. This time shifting necessarily involves arbitrage whereby energy is stored during times when the cost of production are lower (say during the evening low and base-load plant is operational) and discharged during times when marginal cost of production are higher (say during day-time peaks).

- **Firm Capacity or Peaking Capacity**: system operators must ensure that the have sufficient resources to meet the highest demand periods in a given year (peak demand). This peak is typically met with less efficient (highest cost) generators, however depending on the load curve and size of the storage system, BESS can be used to ensure adequate peaking generation capacity.

- **Operating Reserves and Ancillary Services:** The reliability of power systems depends on the match of generation output to electricity demand. There are various categories of operating reserves and ancillary services that operate on different timescales, from microseconds to hours, all of which are needed to ensure system reliability.

BESS can rapidly charge and discharge in fractions of a second, faster than conventional generating plants.

- **Transmission and Distribution Upgrade Deferrals:** Deploying BESS can help delay the need for new grid investments by meeting peak demand with energy stored from lower demand periods, thereby reducing congestion and improving overall transmission and distribution asset utilization.

- **Black Start:** In an island-wide blackout, BESS can provide the necessary on-site power needed to restore power to larger conventional sources of generation.

- **Relief to Transmission Grid:** In those cases (especially during high demand) transmission grids may become overburdened. Battery energy systems can provide some relief from these situations. There is presently no transmission congestion differential pricing in BPL billing system, but BESS can provide relief to the operator under these conditions.

- **Power Quality:** Storage can protect customer loads downstream against events that are of short duration but that affect the quality of power being delivered to the customer.

- **Electricity Supply Regulation:** Electricity Supply regulation is used to moderate differences caused by perturbations in generation and system connected loads.

2 Placement of Battery Energy Storage Systems

It is important when siting BESS to analyse the costs and benefits of each potential siting possible to ensure that the optimum location is selected.

2.1 In the transmission network

Connection in the Transmission network allows the BESS to support the Transmission facilities and provide temporary (rather than long-term) relief from Transmission issues. Transmission placement for BESS is distinct from distribution placement in size and frequency response time.

BESS can store energy during times of peak renewable energy generation and release them to the network during times of off-peak demand.

2.2 In the distribution network

Connection in the Distribution network allows the BESS to support the Distribution facilities and provide temporary (rather than long-term) relief from distribution issues. These issues include management of power quality issues in Distribution Networks.

2.3 Co-located with VRE Generators

Electricity generation from R/E sources is affected by natural conditions which can lead to variability and intermittent production of electrical production. In the case of small systems with a reasonable penetration of R/E's grid instability can become a real problem without alternative load support from BESS.

3 Sizing of BESS

Frequency regulation and black start BESS for grid applications are sized according to power converter capacity (in MW).

Sizing Methods for Power and Energy Applications

Sized by power converter capacity (MW)	Sized by power storage capacity (MWh)
Frequency regulation	Renewable Integration
Black Start Applications	Peak Shaving
	Load Leveling

Various mathematical models for sizing of BESS exist. Energy Storage providers will be required to engage a suitably qualified engineering firm to assist with sizing of the intended BESS at the proposed location, given the use of BESS in the system.

4 Key Barriers to BESS Deployment

4.1 Regulatory Barriers: Lack of rules to clarify the regulation of BESS.

4.2 **Restrictions or lack of clarity regarding how storage can be used across GTD:** Because of the flexible nature of storage, it has a cross-cutting application in multiple markets.

4.3 **Market Barriers:** The market for implementation of BESS is small in most major markets and even smaller for grids that typical of island nations.

5 Safety Issues Related to Utility Scale Battery Storage

Licensed GTDS operators who have BESS must obtain from the manufacturer safety recommendations for routine operation as well as information that can be used to inform first responders about proper protocols to deal with these systems in emergency conditions.

This is because an electricity storage application is different from other electrical equipment because it is always energized and cannot easily be switched off. This will require unique procedures on the part of the workers, operators, linesmen to ensure proper safety measures and procedures are in place for installation, commissioning and operation.

In many cases electricity storage equipment contains exotic material that may require special handling and disposal in routine operation and specialized response in emergency conditions such as in a fire or natural disaster.[1]

6 Reserve Capacity

Normal Grid operations will require some kind of reserve capacity that can be switched on or made operational in the event of the failure of a generating set or in the event of loss of output from VRE systems.

Reserve Capacity is categorized into three broad categories:

i) Spinning (synchronized) This is generating capacity that is online but unloaded and can respond within 10 minutes to compensate for generation or transmission outages. Frequency responsive spinning reserve responds within 10 seconds of an outage.
ii) Non-Spinning Reserve (Non synchronized) Generation capacity that may be offline but can be brought online within 10 minutes.
iii) Supplemental Reserve is generation that can be brought online within an hour.

Storage generation capacity must be online and operational if it is to be used as reserve capacity or included in the inventory of reserve capacity.

7 Voltage Support

URCA requires that GTDS operators maintain voltage (target service levels) within specified limits (PESL s.34.1, 35.1, 36.1, 37.1) In most cases, this requires management of reactance. To manage reactance at the grid level, system operators need voltage support resources to offset reactive effects so that the transmission system can be operated in a stable manner.

Strategically placed energy storage within the grid at central locations can offset the need for designated power plant to generate reactive power (VAR). Alternatively, multiple VAR-support storage systems could be placed near large loads in a distributed approach.

All modern power control systems (PCSs) have the capability to operate at a non-unity power factor, to source and sink reactive power or volt-ampere reactive (VARs) Real power is not needed from the battery in this mode of operation and thus discharge duration and minimum cycles per year are not

[1] DOE/EPRI 2013 Electricity Storage Handbook Abbas A Akhil et al

relevant in this case.[2]

Energy storage systems used for Transmission support can improve the transmission system performance by compensating for electrical anomalies and disturbances such as voltage sag, unstable voltage and sub-synchronous resonance.[3]

8 Advantages of BESS over other Storage Technologies

Some of the advantages of BESS include:

i) Small footprint.

BESS can be installed in a higher capacity density that other storage technologies, thereby occupying a smaller footprint than other technologies.

ii) No Restrictions on geographical location

There are no real restrictions on the geographical location of BESS, as it can be installed wherever the need for the technology arises. Other types of storage, such as pumped hydro or compressed air energy storage are only suitable for limited geographical locations.

9 Disadvantages of BESS

Some of the disadvantages of BESS include:

i) Relatively High Cost

BESS requires a relatively higher initial capital outlay than some other forms of energy storage.

ii) Increased maintenance

BESS can require marginally higher maintenance

iii) Battery Life

Battery life is a limiting factor to the operational life of the BESS.

10 Business Models for Energy Storage Systems

There are various models through which grid energy storage can be implemented within electrical girds in the Bahamas for utility-scale systems they can be:

- Utility owned and installed and operated
- Independent Operator owned and installed

Behind the meter systems will of necessity be installed and operated by the customer. Regulations may be to support the successful integration of BESS.

[2] DOE/EPRI 2013 Electricity Storage Handbook Abbas A Akhil, G. Huff et al
[3] DOE/EPRI 2013 Electricity Storage Handbook Abbas A Akhil, G. Huff et al

11 End of Life Considerations for BESS

Battery recycling is intended to reduce the number of batteries that end of in a landfill permanently. Batteries reach an end of life (EOL) of around 80% of initial capacity. This 80% capacity can provide utility for other uses such as in small electric transportation devices (carts, scooters, etc.)

KEY CHARACTERISTICS OF BATTERY ENERGY STORAGE SYSTEMS [4]

- **Rated power capacity** is the total possible instantaneous discharge capability (in kilowatts [kW] or megawatts [MW]) of the BESS, or the maximum rate of discharge that the BESS can achieve, starting from a fully charged state.
- **Energy capacity** is the maximum amount of stored energy (in kilowatt-hours [kWh] or megawatt-hours [MWh])
- **Storage duration** is the amount of time storage can discharge at its power capacity before depleting its energy capacity. For example, a battery with 1 MW of power capacity and 4 MWh of usable energy capacity will have a storage duration of four hours.
- **Cycle life/lifetime** is the amount of time or cycles a battery storage system can provide regular charging and discharging before failure or significant degradation.
- **Self-discharge** occurs when the stored charge (or energy) of the battery is reduced through internal chemical reactions, or without being discharged to perform work for the grid or a customer. Self-discharge, expressed as a percentage of charge lost over a certain period, reduces the amount of energy available for discharge and is an important parameter to consider in batteries intended for longer-duration applications.
- **State of charge**, expressed as a percentage, represents the battery's present level of charge and ranges from completely discharged to fully charged. The state of charge influences a battery's ability to provide energy or ancillary services to the grid at any given time.
- **Round-trip efficiency**, measured as a percentage, is a ratio of the energy charged to the battery to the energy discharged from the battery. It can represent the total DC-DC or AC-AC efficiency of the battery system, including losses from self-discharge and other electrical losses. Although battery manufacturers often refer to the DC-DC efficiency, AC-AC efficiency is typically more important to utilities, as they only see the battery's charging and discharging from the point of interconnection to the power system, which uses AC (Denholm 2019)

[4] NREL Gris Scale Battery Storage Frequently Asked Questions

APPLICATIONS OF BATTERY ENERGY STORAGE[5]

Table 1: Applications of Utility-Scale Energy Storage			
Application	**Description**	**Length of Time Needed**	**Applicability to Bahamas Grid Systems**
Arbitrage	Purchasing low-cost off-peak energy and selling it during periods of high prices	Hours	No
Firm Capacity	Provide reliable capacity to meet peak system demand.	4+ Hours	Yes
Operating Reserves			
Frequency Response	Very fast response to variations in demand and generation.	Seconds	Yes
Demand Regulation	Fast response to random, unpredictable variations in demand and generation.	15 Minutes to 1 Hour	Possible
Spinning Reserve	Fast response to a contingency such as a generator failure	30 Minutes to 2 Hours	Yes
Generation Replacement	Units brought online to replace spinning units.	Hours	Possible
Load Ramping	Follow longer-term (hourly) changes in electricity demand.	30 Minutes to Hours	Possible
Transmisssion and distribution Replacement and Deferral	Reduce loading on T&D system during peak times	Hours	Possible
Black Start	Units brought online to start system after a system-wide failure (blackout).	Hours	Yes

[5] NREL Grid Scale Battery Storage Frequently Asked Questions

ANNEX B: Battery Energy Storage Integration Economic Considerations

Generally, from a broader perspective, Battery Energy Storage has matured faster than rates, regulations and utility business models needed to support them as core components of the electric grid. Energy storage systems have the potential to economically provide benefits to all stakeholders in the electricity market space. URCA's remit is to assess the economics of BESS from a societal standpoint whereby the benefit /cost will be the ultimate driver for the decision making. This policy-cost tool presents cost-effectiveness from the perspective of the participants, showing the impact of policy designs on customer cash flows, and calculates what, if any, customer rate increase or subsidy is needed to recover fixed utility costs.

Table 1 below shows what each of these tests considers as a cost or benefit.

Test	Perspective	Costs	Benefits
Jurisdiction-Specific Cost Test	Regulators or decision-makers	Administrative costs, tariff rate payments, applicable policy goal impacts	Energy-related and capacity/transmission and distribution (T&D)-related costs avoided by the utility, applicable policy goal impacts
Utility Cost Test	The utility[a]	Administrative costs	Energy-related and capacity/T&D-related costs avoided by the utility
Societal Cost Test	Society	Administrative costs, installation costs, incremental measure costs (O&M, replacement, etc.)	Energy-related and capacity/T&D-related costs avoided by the utility, non-monetized benefits (such as cost of carbon)
Participant Cost Test	Participants	Installation costs, incremental measure costs (O&M, replacement, etc.)	Tariff rate payments, avoided retail payments
Ratepayer Impact Test	Non-participating ratepayers	Administrative costs, tariff rate payments, lost revenue to utility due to reduced consumption	Energy-related and capacity/T&D-related costs avoided by the utility

[a] The Utility Cost Test does not include utility revenue impacts such as tariff rate payments or avoided fuel charges, since these revenue impacts are passed through to utility customers through increased rates. Rather, the test focuses on direct costs and benefits experienced immediately by the utility.

Implications for Stakeholders to consider

For URCA

Consider whether to develop a Cost Effectiveness Tariff and policy tool, consistent with Government ES policies that will enable Renewable resources such as battery energy storage supplying electricity for self-use and to the grid that benefit all stakeholders, including customers of the utilities and the utilities.

URCA remit allows for distributed energy resources (including storage) be considered as alternative, potentially lower-cost solutions to problems typically addressed by traditional "wires" investments and/or centralized peaking generation investments for the Family Islands.

For Utilities

- Adopt utility business models and tariff to reflect the value that storage can provide to the grid. This will depend on the location, and the functionality of the distributed generation. URCA believes that the tariff that URCA should allowed/approved should make utilities indifferent to the distinction between distributed and centralized resources.

- Prior to considering new centralized assets, utilities should first look for opportunities to leverage existing assets, such as storage, provide education so that distribution planners, grid operators, and rate designers can work together to leverage battery storage full potentials.

For the Government, Advisors and Research Community (GARC)

- develop a widely recognized modelling tool or a consistent methodology and approach capable of comparing, on an equal basis, the net cost of services provided by energy storage and other distributed energy resources as compared to incumbent technologies such as combustion turbines and traditional infrastructure upgrades.

- Develop a detailed roadmap that specifically identifies policy and regulatory changes that must be adapted or revised to enable widespread integration of energy storage and other distributed energy resources.

For Battery and Distributed Energy Resources Developers

Project sponsor may:-

- pursue business models that fully utilize the battery.
- Pursue cost reduction efforts for all elements of energy storage system, that is, all $/kW components
- Collaborate with utilities and URCA to help bring awareness of what values distributed energy storage can provide and what new utility business model will be needed to scale battery storage.