Jamaica: Renewable Generation Procurement Guidelines

Task 1: Review of Current Procurement Mechanism

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MRC SI PSR

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LIST OF ACRONYMS

Acronym	Meaning
ADMS	Advanced Distribution Management System
ADO	Automotive Diesel Oil
AGC	Automatic Generation Control
BESS	Battery Energy Storage System
BOO	Build, Own and Operate
BU	Bottom Up
EAF	Equivalent Availability Factor
EFOR	Equivalent Forced Outage Rate
EOI	Expression of Interest
FCR	Frequency Containment Reserves
FLISR	Fault Location Isolation and Service Restoration
FIT	Feed in Tariffs
FRR	Frequency Restoration Reserve
GER	Government Electrical Regulator
GHI	Global Horizontal Irradiance
GOJ	Government of Jamaica
GPE	Generation Procurement Entity
HDVC	High-Voltage, Direct-Current
ICB	International Competitive Bidding
IRP	Integrated Resource Plan
JAMALCO	Jamaica Aluminum Company Limited
JEP	Jamaica Energy Partners
JPPC	Jamaica Private Power Company
JPS	Jamaica Public Service Company Limited
LNG	Liquified Natural Gas
MSET	Ministry of Science, Energy and Technology
NGO	Non-Government Organizations

Acronym	Meaning
OUR	Office of Utilities Regulation
PPA	Power Purchase Agreement
PV	Photovoltaic
RE	Renewable Energy
RES	Renewable Energy Sources
RfI	Request for Information
RfP	Request for Proposal
RfQ	Request for Qualification
RoCoF	Rate of Charge of Frequency
ROFR	Right of First Refusal
RR	Replacement Reserve
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SPV	Specific Purpose Vehicle
TD	Top-Down
T&D	Transmission and Distribution
TOR	Terms of Reference
TSO	Transmission System Operator
VRE	Variable Renewable Energy

1 INTRODUCTION

1.1 Background and objectives

In 2009, the Government of Jamaica (GOJ) identified energy conservation and efficiency, energy diversification and increased renewable energy penetration as key objectives in its National Energy Policy (NEP) 2009-2030. Similarly, the GOJ established a target of 20% renewables on the national grid by 2030. Following the completion of the Integrated Resource Plan (IRP) 10 years later, the GOJ increased its target for renewable energy penetration to 50% by 2037.

In this context, the GOJ has created the Generation Procurement Entity (GPE) through the Electricity Act, 2015, with responsibility for procuring new generation and managing the replacement of generation to meet the national generation demand prescribed by the IRP. In executing its mandate, the GPE is entitled to develop the competitive procurement bidding process and protocols to commence the activities in an open and transparent manner. Therefore, to facilitate the appropriate tasks and decisions by the GPE, the Entity requires international expertise to strengthen its technical capacity to understand best practices and drafting the procurement rules and protocols to attract the requisite investments in generation to meet the national electricity demand.

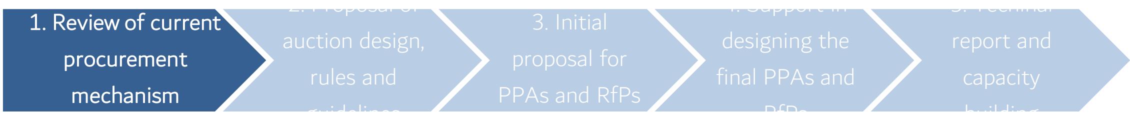
In this sense, the GOJ has requested the IDB support to strengthen the GPE's technical capacity and project management skills, as well as assist the GPE and its legal counsel with the drafting of generation procurement rules, undertaking renewable energy procurement, and engineering support services aligned with the IRP. The general objective of this assignment is to support the Generation Procurement Entity (GPE) in developing general guidelines for generation auctions and rules for renewable power plants in line with Jamaica's Integrated Resource Plan (IRP), following international best practices and their necessary adaptations to the Jamaican context.

PSR has over thirty years of experience and a highly international client base. PSR is a globally leading provider of advanced analytical tools and consulting services in electricity and gas; and an active contributor to applied research on cutting-edge optimization solutions, energy policy and power system economics. MRC Spain is part of the MRC Group of companies, a family of ten sister companies that share a common history and operate internationally as a single organization, combining their human resources, technical skills, and geographical presence to better serve clients worldwide. MRC is focused on energy, water, and sustainable growth. Sigla, also part of MRC Group, is specialized in the different aspects of planning, regulations, restructuring, power tariff surveys and engineering works for transmission and distribution and for water and sanitation, including work site inspections. Altogether, the Consulting Team presents a strong experience in auction design and regulation, as well as extensive knowledge of different systems worldwide.

The proposed scope of services comprises five phases, namely (i) Task 1: review of current procurement mechanism; (ii) Task 2: proposal of auction design, rules and guidelines; (iii) Task 3: initial proposal for PPAs and RfPs; (iv) Task 4: support in designing the final PPAs and RfPs; and (v) Task 5: technical report and capacity building.

1.2 The present task: Review of the Jamaican reality

In the first phase, the Consultants will undertake a review of Jamaica's current auction mechanism, identifying possible gaps in the current mechanism.



In this phase, the Consultants will carry out the following activities:

- Review of the current generation procurement mechanisms in Jamaica, regulations governing the electricity sector and roles of the Generation Procurement Entity (GPE), which is the entity responsible for procuring new generation capacity in Jamaica that wishes to interconnect with the grid as an Independent Power Producer (IPP) in order to meet the national electricity demand.

- Identify relevant gaps in Jamaica's current auction mechanism and electricity sector regulations and make recommendations for improvements in the auction design, based on international experiences adapted to Jamaica's reality, to assist the GPE team in preparing the country's generation auction design.
- Review of existing renewable energy resources maps/databases, together with the review of existing inter-connection capacity to the distribution/transmission grid.

The report is organized as follows:

- A detailed description of the current regulatory framework of Jamaica is presented in Chapter 2;
- An analysis of Jamaica's electricity sector physical reality is presented in Chapter 3;
- Chapter 4 describes in detail the Jamaican procurement processes carried out recently in terms of design elements and outcomes;
- Chapter 5 presents a table summarizing the gaps identified in previous sections and critical risks;
- Chapter 6 presents the main conclusions of the report.

2 REGULATORY FRAMEWORK

2.1 Introduction

The objective of this chapter is to perform a review and an analysis of the current regulatory framework of the Jamaica Electricity Sector, identifying key strengths and weaknesses that may have an impact in the design of the new procurement framework for RES capacity building. It also presents an overview of the recent energy policies, some still in draft mode, that frame the energy matrix diversification strategy for the next 20 years planning horizon.

2.2 The Electricity Sector

The electricity sector is regulated by The Electricity Act (the Act). In July 2015, Jamaica passed a new Electricity Act simultaneously replacing the 1890 Electric Lighting Act, the Electricity Frequency Conversion Act, and the Electricity Development Act.

This new regulation clarifies and codifies the roles and responsibilities of the main actors in the electrical sector, including the Government, the Regulator, the Electric Utility and the Independent Power Producers (IPP). In addition, it prescribes the required standards in the electricity sector.

The main objective of the Act is to consolidate and modernize the laws related to the generation, transmission, distribution, supply, dispatch, and use of electricity.

The following authorities have relevant roles and responsibilities in the development and implementation of the regulatory framework of the electricity sector:

- The Minister of Science, Energy and Technology (MSET) that carry out Integrated Resource Planning activities and issue licenses for the sector,
- The Generation Procurement Entity (GPE) that procures new generation capacity,
- The Government Electrical Regulator (GER) that regulates electricity works, and
- The Office of Utilities Regulation (OUR) that regulates the electricity sector in general, including the operations of the Single Buyer

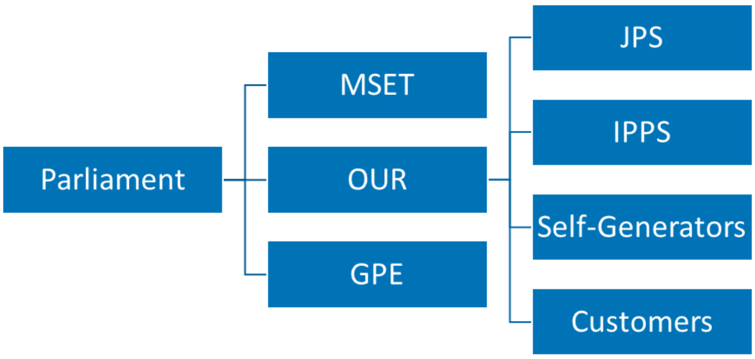


Figure 2-1 – Overview of the electricity sector institutions.

2.2.1 The Ministry of Science, Energy and Technology (MSET)

The key and most relevant task of planning the electricity sector is done by the MSET. In addition, it issues licenses to operate in the sector.

Electricity licenses are granted by the MSET either a) through a bidding process initiated by the GPE; b) pursuant to an application in the prescribed form for the license, with respect to net billing, wheeling arrangements or other arrangements; or c) when the Cabinet has determined it under the specific circumstances as specified in the Act. No license is required for electricity generation for self-consumption.

The electricity license granted under a competitive bidding process (a), or by decision of Cabinet (b), shall be a non-exclusive license for the generation of electricity for all or part of Jamaica; or it may be an exclusive or non-exclusive license (as the case may be) for any or all electricity transmission, distribution, supply or dispatch services for all or part of Jamaica.

The MSET may also revoke or suspend the licenses granted under the circumstances provided in this Law, including for any instance pursuant to a recommendation of the OUR either for violation of the license, any of the Codes, or any of the terms of the Act.

2.2.2 The Generation Procurement Entity (GPE)

The Act introduced the Generation Procurement Entity (GPE) as the responsible entity to procure new generation capacity pursuant to implementation of the Integrated Resource Plan (IRP).

The GPE was established in January 2020 by Cabinet Decision No. 1/20 with the purpose of developing new generation capacity and managing and administering the purchase process through competitive means by which IPPs wish to sell electricity to the Single Buyer.

Also, the GPE is envisioned to become the implementation entity for the IRP as set out in the Act regarding the methodology to procure new generation capacity (renewable energy in particular). The GPE is also responsible for overseeing the implementation plan for the replacement of generation base load capacity that is scheduled for retirement.

2.2.3 The Government Electrical Regulator (GER)

Part X of the Act describes the functions of the GER. This entity regulates the work of electricians and electrical inspection activities. In performing its functions, the GER or its agent shall have the right of entry to any premises or property, and any person who so obstructs his activities shall be penalized.

The Single Buyer shall not connect any premises, facility or apparatus to the system unless it has been duly certified by a licensed electrical inspector as fit to be connected to the system.

2.2.4 The Office of Utilities Regulation (OUR)

The OUR, established by an Act of Parliament in 1995, was created to regulate the operations of utility companies.

The OUR regulates the electricity sector, which includes the Jamaica Public Service Company Limited (JPS) and Independent Power Producers (IPPs) by the provisions of the *Electricity Law of 2015* and the *Electricity License of 2016.*

The role includes:

- Developing the framework within which regulated public services operate (the Codes)
- Establishing rates and tariffs as well as service standards for the relevant regulated sectors.
- Operating in a fair, independent and transparent manner in fulfilling its obligations to all interested parties.

While the OUR has incumbency over a few regulated services, this analysis is focused on the electricity sector. In that regard, the OUR has regulatory remit over the generation, transmission, distribution, dispatch, and supply of electricity. In addition, and to the request of the Cabinet, the OUR was asked to procure energy as seen for example in the RFPs from 2015, 2013 and 2008. Those RFPs developed by the OUR included detailed requirements and information for the complete process of purchase of conventional and renewable energy by the Single Buyer. The analysis of these RFPs is addressed in Section 4 of this Inception Report.

2.3 The Role of Single Buyer

The Act introduced the *Single Buyer* as the licensee responsible for purchasing the electricity, either generated by independent power producers (IPP) at the transmission level and through net billing arrangements at the distribution level. The Single Buyer can also build and own its own generation capacity. In addition, the Single Buyer provides the services of transmission, distribution, and supply and acts as the "System Operator" for the dispatch of energy. In essence, the electricity sector is comprised of a vertically integrated company, and this company is the Jamaica Public Service Company Limited (JPSCo.).

The current structure of the JPS is 80% ownership by private investors, 19.9% owned by the Government of Jamaica, and the remaining 0.1% in the hands of a group of minority shareholders.

Today, the JPS as the Single Buyer has been given by the Act the right of first refusal (ROFR) to replace its aged generation capacity as described below. This clause could become a boundary condition in the design of the new procurement process to have it more competitive.

The Single Buyer safeguards the integrity of the electrical network. In this regard, the Single Buyer is not obliged to connect an independent power producer's generated electricity output to the system unless both the Single Buyer and the Government Electrical Regulator (GER) agree that the independent power producer's connection will not compromise the safety and protection of the system.

Tariffs charged by the Single Buyer are subject to approval and control of the Office of Utilities Regulation (OUR).

2.4 ROFR clause under the Act.

The Right Of First Refusal (ROFR) is the critical clause in the regulatory scheme applicable in the replacement of the obsolete generation owned and operated by the Single Buyer under its license.

The Act establishes that, if the Single Buyer, as the owner of the generation unit within the licensed service issued to it, does not exercise its right of first refusal; or in exercising its right, proposes to exceed the avoided cost, then that replacement generation capacity may be procured through a competitive bidding process or such other process as the Cabinet determines to be in the public interest.

As stipulated by the Act, the time for the exercise of the right of first refusal will commence as of the date specified in the letter of notification from the Minister stating that the generation unit has come to the end of its useful life, considering all the retrofits that have been made over time. This notification also establishes the deadline for the exercise of the right of first refusal. Also, the Single Buyer could initiate the process, if they believe that the unit need to be replaced.

The replacement capacity cannot be exceeded and similarly, the replacement cost should not exceed the generation avoided cost, which will be updated and published every two years in the context of an updated IRP by the MSET.

2.5 Transmission, Distribution and Supply Activities under the Act

These activities are regulated in Part VI of the Act and in the Codes defined in Section 2 of the Act as the Generation Code, Transmission Code, Distribution Code, Supply Code and Dispatch Code. These Codes are issued by the OUR and are reviewed every three years.

The Act establishes that the Single Buyer or a self-generator shall not place or move any transmission line or distribution line above ground, underground, along, over or across any street, without the express written consent of the local authority.

The Single Buyer and the owner or occupier of any land can enter into an agreement for laying, placing or carrying on, under or over such land, any supply line, posts or apparatus ("wayleave agreement"). This wayleave agreement shall be registered under the provisions of the Registration of Titles Act conferring rights and obligations over the land depending on the activities being carried.

2.5.1 The Codes

The codes regulate the different activities of the electricity sector and are issued and controlled by the OUR.

The Generation Code covers the Generator Interconnections to the Transmission or Distribution Systems. The responsibility boundary between the Generator and the System Operator will normally be the bushing at the High Voltage side of the Generating Unit transformer.

The Transmission Code covers the Transmission System including electric power lines operating at 69 kV and above (including138kV and 69kV systems) and including the secondary circuit breakers and up to the outgoing Isolators at Transmission Substations transforming to 24kV, 13.8kV and 12kV.

The Distribution Code covers the Distribution System from the point of the outgoing Isolators on the Transmission Substations to the point of Interconnection with the Customers system.

The Supply Code covers the sale of electricity to customers by the Supply Licensee.

The Dispatch Code controls the Dispatch Licensee in their activities involved in the central management and direction of Generating Plants and other sources of supply to the Grid.

The Codes therefore introduce detailed provisions to assure the smooth integration of the renewable energy and energy efficiency initiatives envisioned by the National Energy Policy 2009-2030. These provisions address minimum technical conditions in line with international best practices and standards, planning and operational responsibilities and requirements related to feasibility studies and system studies. These studies will become a fundamental piece of background information in the Call for Tender set of documentation as it addresses the system´s capacity to integrate the new RE volumes being tendered, and the capacity of the Single Buyer, in its role of dispatcher, to guarantee priority of dispatch of the energy produced by the RE IPPs.

It is envisioned by the OUR that those requirements will evolve over time, responding to technological advances and supporting increasingly higher levels of renewable energy penetration and innovative use of energy efficiency initiatives.

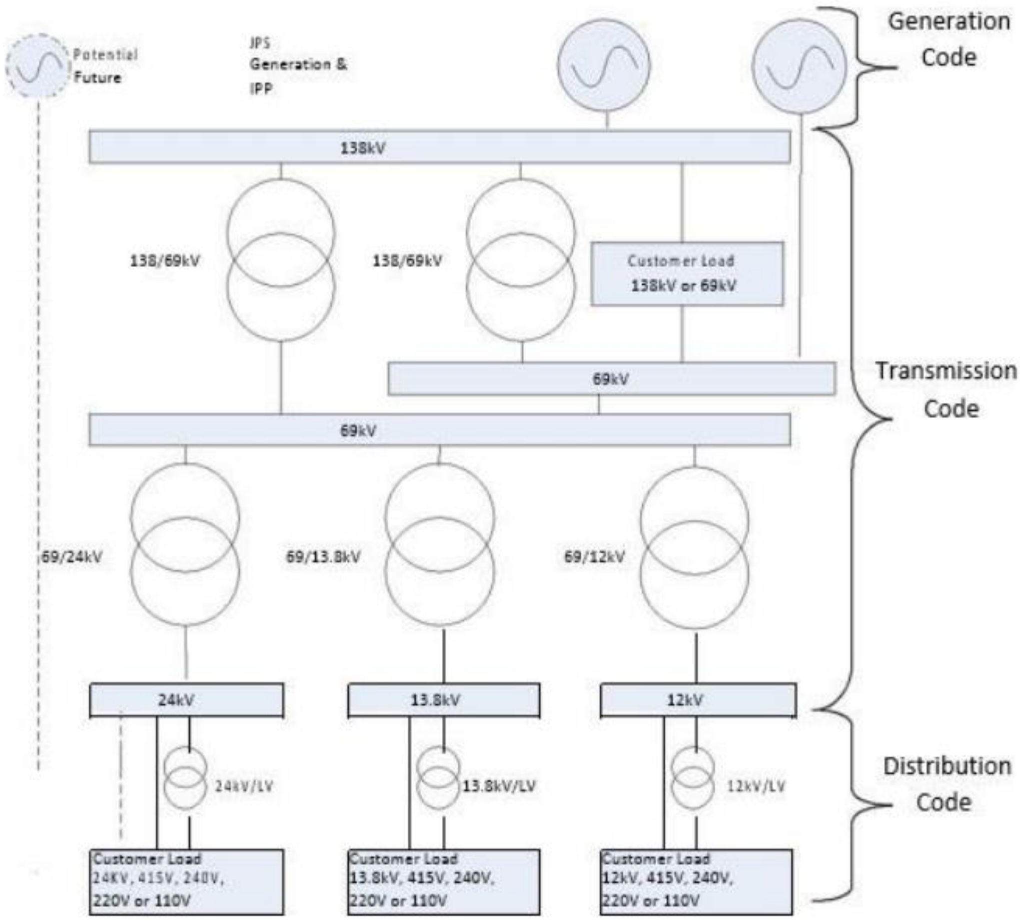


Figure 2-2 - Boundaries between the Transmission, Distribution and Generation Codes. Source: Jamaica Electric Utility Sector Book of Codes 2016.

2.6 The System Operator

The Act obligates the Single Buyer, as the System Operator, to ensure that any information concerning its dispatching activities that it provides to any generation licensee is also made available to every other generation licensee whose generation capacity is included in the dispatching activity. Also, shall develop and maintain a plan for restoring the system to normal operating levels in the event of a major system failure due to failure of any part of the system howsoever caused.

The Second Schedule (Section 45) of the Act (Merit Order Dispatch) establishes the rules of the dispatch activities. This schedule becomes a key consideration for bankability in the Power Purchase Agreement (PPA) and shall be expressly stated in the contract providing assurance to IPPs of the priority of dispatch for the renewable electricity or a compensation mechanism otherwise.

2.7 Renewables Energy in the Act

Article 21 refers to **Renewable Energy** as follow:

> *(1) The Minister may, by order, after consultation with the Office, prescribe renewable energy targets which may include a* ***feed in tariff*** *set by the Office*[1] *for each source for renewable energy.*
>
> *(2) The electricity generated from renewable sources to be injected into the transmission lines or distributions lines shall be granted access* ***when available and shall only be denied by the system operator*** *on the ground of technical reasons which shall be communicated in writing to the licensee within forty-eight hours thereafter with a copy of the reasons to the Minister and Office.*

In relation to the energy injection to the grid, the Act does not necessarily guarantee network access, however the Generation Code establishes that licensed renewable energy systems, regarded as "energy only" plants have priority of dispatch. Whenever there is available energy, the grid operator (JPSCo) is obliged to take the energy except for technical reasons which must be demonstrated.

2.8 The National Environment and Planning Agency (NEPA)

The National Environment and Planning Agency (NEPA) is an Executive Agency of the Ministry of Economic Growth and Job Creation. The Agency became operational on April 1, 2001 as an Executive Agency under the Executive Agencies Act.

It was founded to carry out the technical (functional) and administrative mandate of three statutory bodies:

- The Natural Resources Conservation Authority (NRCA)
- The Town and Country Planning Authority (TCPA)
- The Land Development and Utilization Commission (LDUC).

[1] Office of Utilities Regulation (OUR)

NEPA is the lead government agency with the mandate for environmental protection, natural resource management, land use and spatial planning in Jamaica.

NEPA operates under the following Acts:

- Executive Agencies Act;
- The Natural Resources Conservation Authority Act;
- The Town and Country Planning Act;
- The Land Development and Utilization Act;
- The Beach Control Act;
- The Watersheds Protection Act; and
- The Wild Life Protection Act
- Endangered Species (Protection, Conservation and Regulation of Trade) Act

One of the main functions of this agency is the approval of the **Environmental Impact Assessment (EIA)** necessary for the development and construction of a RE project.

The vision and contributions of this government office are considered important during the development of this consultancy.

2.9 The Policies

The Jamaican Constitution (1962) Chapter III 13(2l) states that all Jamaicans *have the right to enjoy a healthy and productive environment free from the threat of injury or damage from environmental abuse and degradation of the ecological heritage.*

In this sense, the *preservation of the environment is a right with constitutional status*, and is the starting point for the drafting of laws, plans, programs and projects of the energy sector.

2.9.1 Jamaica National Energy Policy (NEP) 2009-2030

The Jamaica NEP was developed in response to global trends and issues related to energy and the environment.

In this sense the policy states that: "*The burning of fossil fuels is the single largest contributor to emissions of greenhouse gases (GHG) such as carbon dioxide and nitrous oxide that contribute to global warming and climate change*."

The implementation of a national energy policy is an important point to achieve a sustainable national development and reduce the dependence on hydrocarbons in its energy matrix.

In this order, the government has developed other sub-policies as listed below but such have not been finalized or fully implemented at the time of writing this report.

- Draft National Renewable Energy Policy (2010 – 2030)
- Draft National Energy-from-Waste Policy (2010 – 2030)
- Draft National Biofuels Policy (2010 – 2030)
- Draft National Trading of Carbon Credits Policy (2010 – 2030)
- Draft National Energy Conservation and Efficiency Policy (2010 – 2030)

The Strategic Framework underpinning this National Energy Policy is comprehensive and will be sustained to 2030 and beyond. The framework includes the short-to medium-term as well as long-term strategic directions for the government, private sector and industry as well as civil society.

The policy presents seven goals:

Goal 1 is focused on e**nergy conservation and efficiency.** This goal implies Improving efficiency in the key energy consuming areas, the bauxite/alumina production, transportation and building design and construction. This focus gives more aware of energy conservation practices and will be helped in reducing its consumption.

Goal 2 is focused to **modernized and expanded energy infrastructure.** This goal implies energy-efficient plants and distribution systems including a protocol for replacing old and inefficient generating plants and a refinery of petroleum in order to replace imports and compensate for the potential switch from oil-fired to natural gas power plants.

Goals 3 is focused on the use of the country's **renewable resources**. In this sense, it establishes that "Jamaica realizes its energy resource potential through the development of renewable energy sources and improves its international competitiveness and energy security while reducing its carbon footprint". The implementation of this goal will be increasing the percentage of renewable energy in the renewable electricity matrix to 34% by 2030 and 50% by 2037.

Goals 4 is focused on **energy security**. It states that "Jamaica's energy supply is secure and sufficient to support long-term economic and social development and environmental sustainability." Given this, the country intends to gradually reduce its dependence on oil (92%) to avoid interruptions in its supply and price volatility. The introduction of standards and regulations on vehicle emissions is also a strategy in this sense.

Goal 5 is focused on establishes a **governance, institutional, legal and regulatory framework** for the energy sector that facilitates stakeholder involvement and engagement. This will permit to remove policy inconsistencies and provide a coherent policy and regulatory framework to facilitate competition in the energy supply system, enable the introduction of diverse sources of energy into the system, and provide integrated monitoring and enforcement of regulations, all overseen by agencies and organizations with the capacity and tools to guide the energy sector.

Goal 6 is focused on that Government and **its agencies became to be a model/leader** in energy conservation**,** efficient of energy and environmental stewardship, providing a stimulus for private sector and community action.

Goal 7 of the NEP focuses on Eco-Efficiency in Industry as the priority area. The goal was developed in response to, a lack of energy management programs in the private sector, low levels of energy efficiency and conservation and the need to move towards a green economy. A key strategy identified by the NEP to achieve this goal, is for emission standards to be established, implemented and enforced.

2.9.2 Draft National Renewable Energy Policy (2009 – 2030)

The Draft National Renewable Energy Policy (REP) is a sub-policy under the NEP which aims to lead Jamaica into a new and sustainable energy future.

At present, the energy generated from renewable sources stands at 13% of net electricity generation. In 2016, an additional 80 MW of generating capacity was connected to the national grid: 24 MW from the Wigton III wind farm, 36.3 MW from Blue Mountain Renewables (BMR) and 20 MW from Content Solar.

Also, in 2016, the government selected Eight Rivers Energy Company (EREC) to construct and operate a 37.0 MW solar PV plant, which added to the pre-existing projects, 165 MW of energy from renewable sources connected to the national grid.

However, in order to achieve the ambitious objectives as set forth by the NEP and its sub-policies, public-private articulation and the revision of the existing regulatory framework are necessary; in order to identify the mechanisms needed to attract *new players* to the Jamaican electricity market, promoting investments in a transparency and competitive way.

In this sense, the role of the National Environment and Planning Agency (NEPA) is important in ensuring that *environmental considerations* and the *use of land* are included in renewable energy projects.

Draft National Energy-from-Waste Policy 2010 – 2030

The Draft National Energy-from-Waste (EFW) Policy was developed in response to the NEP with the main objective being to provide affordable and clean energy from waste in an effort to ensure Jamaica's sustainable future.

The EFW policy outlines the importance of managing gases released from landfills. The main gases produced are methane (CH_4) and carbon dioxide (CO_2), both of which are considered to be the most potent, heat-trapping greenhouse gases. The amount of gas produced by the landfill is directly proportional to the total quantity of organic material contained in the landfill. Therefore, the methane recovered from waste can be used as an energy supply.

A key component **of Goal 2 of the EFW** policy is the exploration and development of systems and mature EFW technologies that will meet or exceed national environmental standards.

Draft Biofuels Policy

The Policy notes that biofuels, which are derived from renewable biomass resources, are able to satisfy energy needs.

A key strategic action of the Biofuels Policy is the use of bioethanol (fermentation of sugar components from plants such as sugar cane) for fuel in vehicles. Although it can be used in its pure form, in Jamaica it is used as a gasoline additive to produce E10 – a mixture of 10% ethanol and 90% gasoline.

The policy also highlights that through replanting cane fields with the intention of creating biofuels, thus reducing the greenhouse gas effect.

The National Environment and Planning Agency (NEPA) will have the responsibility of ensuring that the facilities engaging in biofuels production are operating in a manner that causes no harm to human health and the environment is protected from harmful emissions.

Draft Trading of Carbon Credits Policy

The Draft Trading of Carbon Credits (TCC) Policy is a sub-policy of the NEP that is important in Jamaica's climate change strategy that facilitates reductions in the country's GHG emissions.

The mitigation projects which qualify for carbon credits fall into three categories:

- Renewable Energy that replaces/reduces fossil fuel consumption,
- Energy Efficiency
- Afforestation/Reforestation.

The policy is developed to facilitate Jamaica's fulfillment of its commitment to the UNFCC and to create the necessary framework for generating carbon credits. Under this policy, the majority of the GHG mitigation projects are initiatives that develop renewable energy sources and energy efficiency programs.

Potential carbon emissions reduction projects in Jamaica were listed in the TCC as:

- Renewable energy (wind, solar, hydro, biofuels)
- Alternative fuel sources (liquefied natural gas, compressed natural gas)
- Energy-from-Waste
- Energy Efficiency
- Land Use, Land Use Change and Forestry

Through the renewable energy, energy efficiency and energy-from-waste projects, the TCC Policy forms linkages with the REP, the EFW and the ECEP (Energy Conservation and Efficiency Policy).

2.10 Integrated Resource Plan (IRP) 2018 - 2037

In February 2020, the Government approved a new Integrated Resource Plan (IRP). This plan is the roadmap for Jamaica's energy sector for the next 20 years and contemplates the diversification of its energy matrix.

The key elements of the IRP include:

- A 20-year planning period, considering the existing Jamaica resource.
- The identification of the preferred portfolio of supply-side and demand-side resources to meet this planning.

- An Action Plan that identifies the steps to be taken during the 20-year timeframe.

The following table shows the government agencies involved in the IRP and their roles and responsibilities.

Integrated Resource Planning – a team effort

Responsibility	MSET	JPS	OUR	GPE
Objectives and Metrics	Develop	Inform	Inform	Inform
Transmission & Distribution Planning Studies	Approve	Develop	Review for rates	Inform
Load Forecasting: Assumptions/Inputs supplied by MSET	Approve	Develop	Inform	Inform
Stakeholder Process: communication & policy	Develop	Inform	Inform	Inform
Supply Technologies and Feasibility Studies	Develop	Review for Technical Meeting	Review for rates	Inform
Third Party Supply/Demand Contracts	Agree/ Review	Develop	Approve	Inform
Sales Forecasting	Approve	Develop	Approve Rates	Inform
Energy Efficiency and Demand Programs	Develop	Inform	Approve Rates	Inform
Policy Action Plans	Develop	Inform	Inform	Inform
Environmental Impacts – NEPA compliance management interface with JPS	Develop	Inform	Inform	Inform
Generation Expansion Plan	Develop	Inform	Review for Rates	Inform
Procurement of Generation Capacity	Inform	Inform	Inform	Develop

Figure 2-3 - Agency Role in IRP. Source: Integrated Resource Planning.

By 2030, the objective is to have 34% of renewable electricity from different technologies, more than doubling the current share of 13%, and by 2037 to reach a goal of 50%. The specific goals of the IRP and their impact on Jamaica's physical system will be addressed in section 3.4.

3 THE PHYSICAL REALITY OF JAMAICA'S ELECTRICITY SECTOR

3.1 Introduction

The Jamaica energy matrix is currently dominated by fossil fuels resources, as the general trend in the Caribbean. Despite this, as stated in several reference documents as the IRP , the NEP and others, Jamaica has in its strategy to move towards significant deployment of renewable energy, representing a reliable and cost-effective solution for the short term, due to its quick deployment and decreasing costs.

The key characteristics of the Jamaica energy situation are very well depicted by the recent study conducted by the MSET for the Integrated Energy Plan of Jamaica, that helps unveiling the following elements and issues related to the energy system of Jamaica, which is worth noting.

Table 1 - Jamaican energy system key issues and mitigation actions. Source: Jamaica IEP, 2021.

Key Issues	Possible Actions
Dominance of oil products in the system	*Diversification of the mix*
Import dependency (primary[2] and secondary commodities[3])	*Reduction of (financial and supply) exposure*
Low share of renewable energy in the total primary energy supply (contribution of renewable energy in electricity generation accounts for around 10% according to the published energy balance for 2020).	*Exploitation of domestic renewable resources*
Transport and Industry are the major sectors of energy consumption	*Sectoral transformations and advanced technologies*
Significant electricity T&D losses (even greater than the electricity household consumption).	*Non-technical losses reduction strategy.*

The Government of Jamaica adopted a National Energy Policy in 2009, which established a goal of 20% of renewable energy in the energy mix by 2030 (further enhanced to include 30% of RES in the electricity mix).

Besides, the Government Strategic Framework also addressed both the supply and demand energy-related issues that the country faces. In 2018, a more ambitious target was announced, with a target to reach 50% of the electricity generation being from renewables by 2030, but not yet adopted.

Jamaica remains committed to making its contribution as the world moves to address the challenge of climate change. The target to reduce emissions in 2030, relative to business-as-usual by 25.4% as an unconditional target and 28.5% as a conditional target, covers the energy sector (supply and end-use) and land-use change and forestry and is part of the updated Nationally Determined Contribution (NDC) of Jamaica.

The Jamaican IRP also describes the "preferred" resource mix for the power sector over the next 20 years. The IRP is an important reference document that represents the electricity investment roadmap for Jamaica over the period 2018 – 2037 and provides information concerning the process followed in developing and analyzing the "preferred" electricity resource mix and how this electricity resource mix meets the objectives stated. As per the IRP, RES share of the generation mix is foreseen to be at 34% by 2030 and 50% by 2037.

[2] Jamaica has no proven fossil fuel reserves.

[3] Output from the refineries is lower than the consumption. Extremely high dependency for gasoline and LPG.

In line with those targets, the IRP stated plan is to have 320 MW in solar or wind projects, 120 MW of liquefied natural gas (LNG) and 74 MW of other renewable generation capacity (including hydropower, waste-to-energy, and/or biomass power) by 2025.

In general terms, the IRP aims to increase generation capacity by 1,664 MW by 2037 as follows:

- Solar or Wind Energy 1270 MW
- Liquefied natural gas 330 MW
- Biomass or hydrogen-based sources as waste materials in 74MW

As a result of this, an approximate investment of 2.8 US Billion Dollars is expected throughout the life of the IRP, aimed at modernizing the electrical infrastructure and diversifying the energy matrix. Also, an amount of 2.3 US Billion Dollars of the IRP budget will be allocated for the replacement of obsolete and inefficient plants

In 2020, the Government approved the need to procure 513MW of new generating capacity by 2025.

- 171.5 MW of fixed and intermittent technology to replace the old plants owned by JPSCo (ROFR)
- 246 MW -268 MW solar and Wind
- 36MW Hydro
- 18 MW – 40 MW of Energy from Waste (public-private articulation)
- 20 MW Biomass.

A successful implementation of this government strategic plan should enable a stronger participation of private IPPs in the energy sector complementing the strong presence of JPSCo, developing clean low-carbon technologies, and producing a change of sustainable growth for the country.

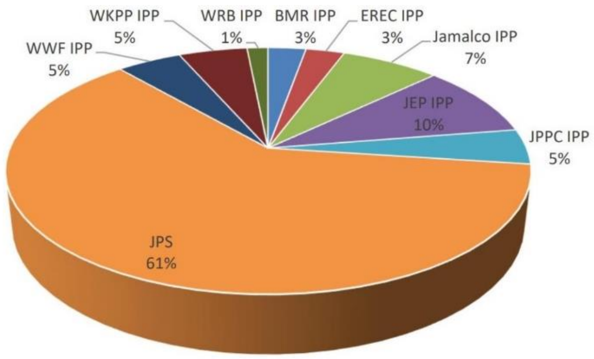


Figure 3-1 - 2018 Installed power in Jamaica by Owner. Source: Integrated Resource Planning.

Reference:

- JPSCo (Jamaica Public Service Company Limited)
- JPPC IPP (Jamaica Private Power Company)
- Jamalco IPP (Jamaica Aluminum Company)
- EREC IPP (Eight Rivers Energy Company)
- BMR IPP (Blue Mountain Renewables)
- WRB IPP
- WKPP IPP (West Kingston Power Partners)
- WWF IPP (Wigton Wind Farm)

3.2 Overview of the electricity generation sector in Jamaica

3.2.1 The electricity supply

Jamaica continues to rely heavily on fossil fuel-based electricity generation (see Figure 3-2 and Figure 3-3 below), reporting an energy supply mix depending on fossil fuel for the 89%, as of 2020.

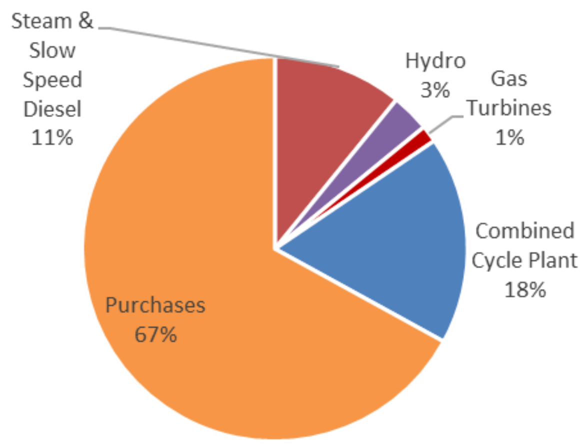


Figure 3-2 - JPSCo net generation and purchases. Source: JPSCo Annual Report, 2020.

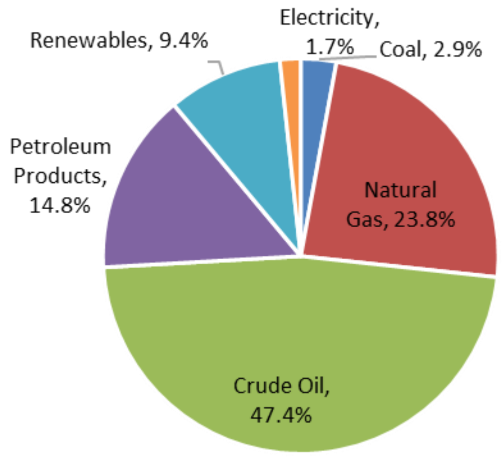


Figure 3-3 - Share of total supply. Source: National Energy Balance, 2020.

3.2.2 JPSCo power plants

JPSCo is the sole electric utility with exclusive rights for all island supply of electricity. JPSCo owns the grid and generates approximately two thirds of Jamaica's power generation capacity.

It owns and operates 4 major power stations:

- Rockfort;
- Hunts Bay;
- Old Harbour; and
- Bogue

9 hydroelectric plants:

- Maggoty;
- New Maggoty;
- Upper White River;
- Lower White River;
- Roaring River;
- Rio Bueno A;
- Rio Bueno B;
- Rams Horn; and
- Constant Spring

and 1 wind farm:

- Munro wind farm.

It also purchases power from a few Independent Power Producers. Among them Jamaica Energy Partners (JEP), Jamaica Private Power Company (JPPC), NFE Jamalco, and Wigton Wind Farm.

Figure 3-4 - JPSCo hydro and fossil-fuel generation sites. ***Source: JPSCo, 2022.***

3.2.3 The generation fleet status and performance

Looking at generation assets, as reported by JPSCo, the fossil fuel assets, are reported in good conditions, although a lot of capacity is saved for peak hours. The upgrade of the Automotive Diesel Oil (ADO) and Heavy Fuel Oil (HFO) burning plants to Liquefied Natural Gas (LNG) fueled plants has already happened at Bogue, Old Harbor and at Hunts Bay replaced with the new 190MW LNG-powered plant. These changes should increase the efficiency (conversion of fuel to electricity) for the system.

Regarding hydro, Jamaica's assets have been refurbished in the recent past, and their capacity factors are quite high in most of the cases (above 75%). This allows a higher penetration of other intermittent sources of energy, as wind and solar PV generation power plants. Most of the units provide power factor in the inductive side, around 0.9-0.95, going forward reactive power management is crucial to the operation of the grid. Supporting the grid infrastructure with investments to be done in the reactive power regulation.

In line with the objective of this assignment, it is important to highlight that the system has limited low voltage ride through capabilities, in terms of plants that could cope with a low voltage fault. This has proven to be an issue in other island markets[4], and low interconnected systems, especially on the ones in which renewable power plants, such as photovoltaic plants or wind farms, does not have these capabilities.

Heat rate

During the last years, JPSCo, have been retooling its generation fleet for efficiency through fuel conversions, rehabilitation, and expansion of the hydro system and executing on its program of preventative maintenance. The result was the achievement of record strides in improving its efficiency in converting fuel to electricity as measured by heat rate. JPSCo' thermal Heat Rate improved from 12,034 kJ/kWh in 2013 to 10,226 kJ/kWh in 2020. This resulted in a reduction in the quantity and cost of fuel used to generate electricity and therefore lower costs charged to customers.

In 2016 the Heat Rate performance deteriorated to 11,570 kJ/kWh from 11,332 kJ/kWh in 2015. This was due to the combined cycle being offline for approximately three months to facilitate the Bogue Plant gas conversion implementation project. The performance was also impacted by higher-than-normal forced outages on other key base-load steam units during that year.

[4] Challenges of island and isolated market with high penetration of RES are explained in Appendix 2 of this Report.

Performance

Unplanned outages in JPSCo generating fleet measured by equivalent forced outage rate (EFOR) fell to the lowest levels in 15 years during the last regulatory period, from 17% in 2013 to 6% in 2019 and worsened in 2020, at 11%. An improvement was recorded in the equivalent availability factor (EAF) which measures the availability of the plants for generating electricity. This moved from 75% in 2013 to 84% at the end of 2020.

There was a slight deterioration in EFOR during 2015 due to challenges at the Bogue Power station in relation to the operation of the gas turbines and an extended planned major overhaul on OH unit#3. However, performance recovered with steady improvements up to 2019, as reported in Figure 3-5 below.

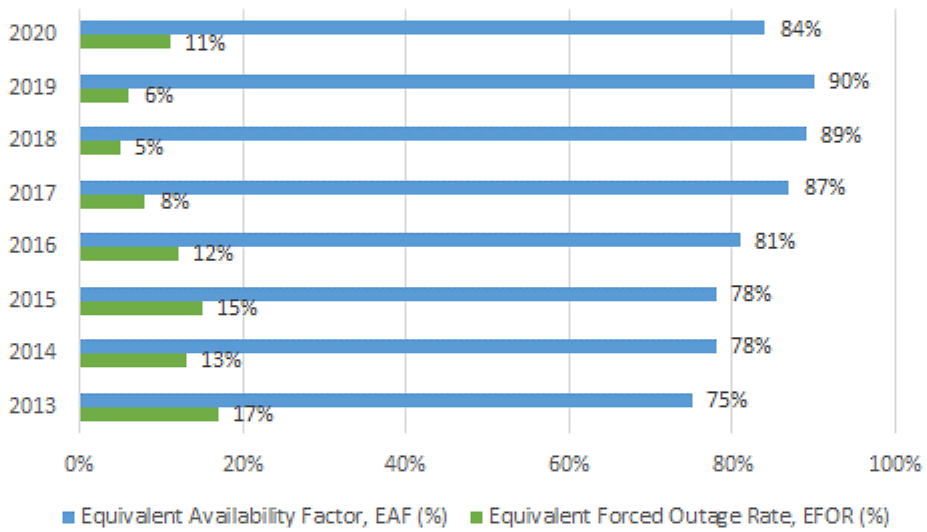


Figure 3-5 - Equivalent Availability Factor and Equivalent Force Outage Rate. *Source: JPSCo Annual Report, 2020.*

3.2.4 Independent power producers

Jamaica Energy Partners (JEP)

Jamaica Energy Partners is an Independent Power Provider (IPP) which began commercial operations in October 1995, with the Doctor Bird Power Plant. This Plant encompasses the company's production facilities and is located at Old Harbour Bay, in the parish of St. Catherine. JEP is currently the largest IPP in Jamaica and owns and operates two power barges, Doctor Bird I and Doctor Bird II, with outputs of 74.2 MW and 50.2 MW respectively; or a combined output of 124.4 MW. Doctor Bird II's generating capacity was added in March 2006, and this barge is located approximately 300 yards from the original.

With the introduction of WKPP (see details below) in July 2012 and the acquisition of JPPC in March 2019, JEP's total generating capacity has increased to approximately 250 MW, making the company one of the major suppliers of electricity in Jamaica. In fact, among the three facilities, JEP, JPPC and WKPP supply approximately 40% of the energy requirements of the national grid. JEP, JPPC and WKPP are owned by the InterEnergy Group.

West Kingston Power Partners (WKPP)

West Kingston Power Partners is a JEP's affiliate company, and is a land-based, 65.5 MW Heavy Fuel Oil (HFO) power plant located in the Western Kingston area.

Jamaica Private Power Company Ltd

Jamaica Private Power Company Ltd. is an IPP, which from 2007 operates as a subsidiary of Inkia Energy Limited. It owns and operates two 29.8 MW slow speed diesel generation units, two heat recovery steam generators, and a 4.2

MW steam turbine generator at a plant located in Kingston, Jamaica. The plant achieved Commercial Operations in 1998 with a 20-year PPA with JPSCo.

South Jamaica Power Company

South Jamaica Power Company (SJPC) is a JPSCo affiliate which was formed to develop the new Old Harbour power plant. It is a 194 MW combined cycle power plant, burning natural gas, which replaced the old generators at the same plant as well as at Hunts Bay power station, which burned HFO. The plant was commissioned at the end of 2019.

New Fortress Energy (Jamalco)

A gas fired combined heat and power plant was commissioned by NFE in March 2020 at the Jamalco refinery in Halse Hall, Clarendon. The plant, fires natural gas from the floating storage regasification terminal in Old Harbour. The plant, with an installed capacity of 100 MW, supplies up to 94MW of generating capacity of the power to JPSCo through a PPA and produces around 280,000 pounds of steam per hour, which are used in Jamalco processes.

Wigton Wind Farm Ltd.

Wigton Windfarm Limited, formerly a subsidiary of the Petroleum Corporation of Jamaica (PCJ), owns the largest wind energy facility in Jamaica. Located in Rose Hill, Manchester, the wind farm currently comprises three plants: Wigton I (20.7 MW started in 2004), Wigton II (18 MW commissioned in 2010) and Wigton III (24 MW commissioned in 2016). The Plant was privatized in May 2019 when 100% of its shares was sold to the local market through the Jamaica Stock Exchange (JSE).[5]

BMR Energy

BMR Energy is a subsidiary of Virgin Group. In 2016 commissioned a 36.3 MW wind project. It has operation in other Caribbean countries, with a total installed capacity of 126 MW in wind and solar projects.

Content Solar

Content Solar Ltd., owned by WRB Serra, commissioned its 20 MW solar photovoltaic (PV) power plant in Content Village, Clarendon, Jamaica in 2016. It operates under a power purchase agreement (PPA) with JPSCo.

Eight Rivers

Eight Rivers Energy Company Limited (EREC) is a Jamaican power joint venture led by French company Neoen, with stakes held MPC Capital AG and UK power developer Rekamniar Frontier Ventures. The company commissioned the Paradise Park solar plant, in 2019 with an installed capacity of 37 MW, in Westmoreland Parish. It operates under a 20-year PPA with JPSCo.

3.3 Overview of the Jamaican electricity transmission sector and RES integration

3.3.1 Overview of the electricity transmission grid in Jamaica

In Jamaica more than 97% of the whole population is electrified. JPSCo is the sole transmission and distribution company and it is the owner and operator of the national electricity grid, which includes around 1,200 km of 138 and 69 kV lines, as well as 55 substations (of which 44 provide distribution supply) with a total capacity above 1,800 MVA.

[5] https://www.wwfja.com/wp-content/uploads/2020/09/CORP-GOVERNANCE-STRUCTURE.pdf

There are nine bulk power 138kV transmission substations connecting the 138kV system to the 69 kV voltage level by twelve interbus transformers with a total capacity of 798 MVA. Except for two, Old Harbour and Bellevue, these nine substations also provide distribution supply.

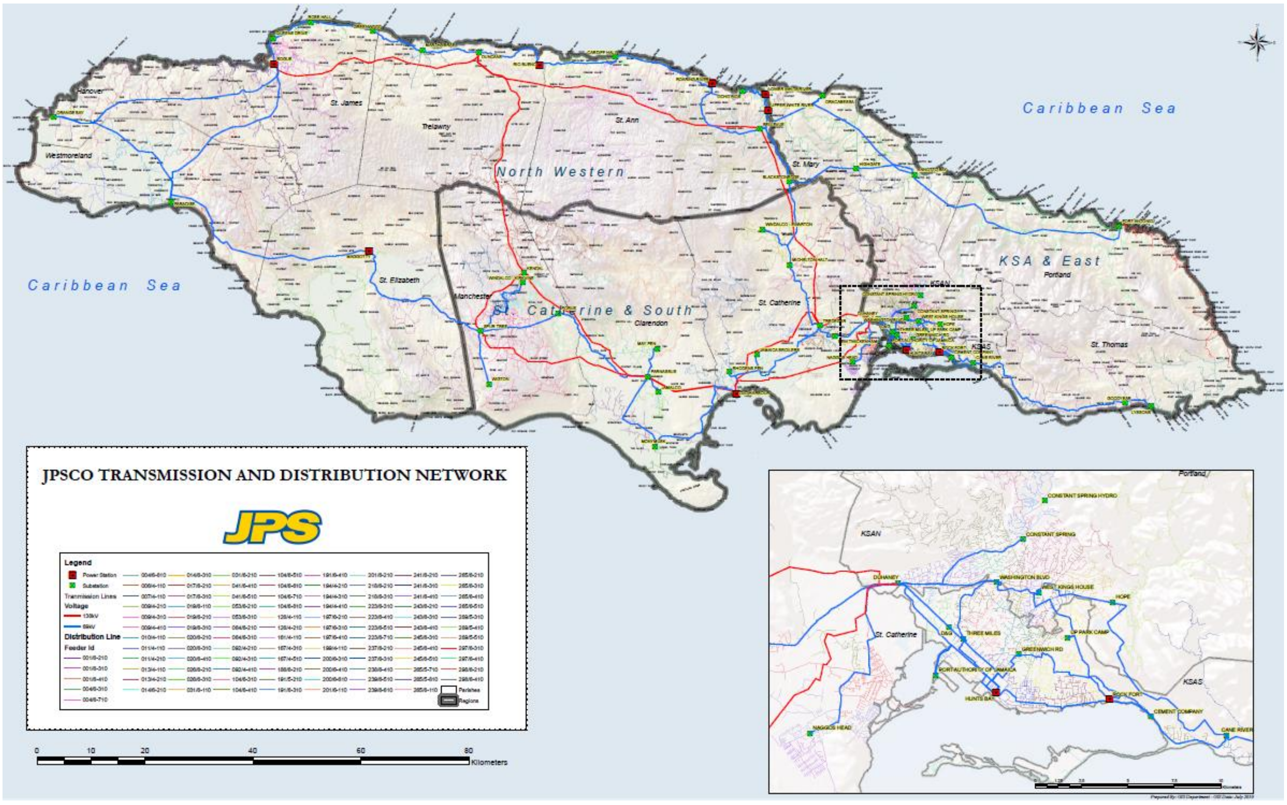


Figure 3-6 - The transmission system as of 2018. ***Source: JPSCo, 2022.***

Transmission lines at the Old Harbour area

The Old Harbour Power Station which is the largest on the grid and the site of the largest base load facility has four 138kV lines and two 69kV lines emanating from that station. The total MVA capacity of the 138kV and 69kV lines is 740 MVA and 37.5 MVA respectively.

About 90% of the power generated at Old Harbour will flow on the four 138kV circuits coming from that station. The Old Harbour to Duhaney and the Old Harbour to Tredegar 138kV lines, which take the bulk of this power to supply the North Central and Eastern sections of the island, are usually loaded to about 40% and 35% of their capacity respectively.[6]

The Old Harbour to Parnassus 138 kV line is a double circuit, steel tower construction that supplies the central and western sections of the Island. These lines are usually 30% loaded and provide backup for each other should either be out of service[7].

Transmission line at the Corporate Area

The Corporate Area, which is marginally the second largest zone of generation, is the island's largest load center. Within this region there are five 69kV lines emanating from Hunts Bay power station switchyard with a capacity of 337 MVA,

[6] Integrated Resource Plan – A 20 Year Roadmap to Sustain and Enable Jamaica's Electricity Future (version 21/02/2020).

[7] Ibidem.

while at the Rockfort power station switchyard there are five 69kV circuits from that location with a capacity of 377 MVA. The generating capacity at Hunts Bay and Rockfort are 122.5 MW, 63.8MW, 65.5 MW and 40MW. At Hunts Bay 68.5 MW was provided by based load generation and which was recently retired, while the remaining 54 MW is provided by gas turbines, which are mainly peaking units. All the generating capacity at the Rockfort Power Plant is provided by base load diesel units. The three most heavily loaded lines are the Hunts Bay to Three Miles and Rockfort to Up Park Camp 69kV and Duhaney to Washington Boulevard 69kV lines. These lines experience loading in excess of 40% of their thermal capacity, during either the day or evening peak period. However, the Duhaney to Washington Boulevard 69kV, which is the most heavily loaded during the day period, will experience loading in excess of 60% of its thermal capacity.[8]

One of the major constraints on the existing transmission system in this region is that there is only one transmission substation (the Duhaney substation) importing bulk power into the Corporate Area, which is the island’s major load center. Duhaney is a 138/69/24 kV substation with three interbus transformers of total capacity 280 MVA. Two 138 kV transmission lines and six 69 kV emanate from this station, of which four 69kV lines take power into the Corporate Area (inclusive of Naggo’s Head substation). The Old Harbour to Duhaney 138kV line provides the main link between the Old Harbour Power Station and the Corporate Area (via Duhaney).

Transmission lines at Bogue area

At Bogue, there are four 69kV circuits; each with a thermal rating of 61MVA, and a 155 MVA rated 138kV line, which is limited to 100 MVA due to the rating of the 138/69kV interbus transformer. The two most heavily loaded circuits are the two Bogue to Queen’s Drive 69kV lines, which are loaded to about 35 % of their thermal capacity under normal dispatching condition.[9]

Industrial customers supplied at transmission voltage

There are no customers currently supplied at the 138kV level however the following customers are supplied directly from the 69kV network:

- Cement Company: Cement manufacturer
- Port Authority of Jamaica (PAJ): Shipping Port Administrator
- Jamalco (Halse Hall): Bauxite Processing Facility
- Windalco (Kirkvine): Bauxite Processing Facility
- Windalco (Ewarton): Bauxite Processing Facility

3.3.2 System reliability

As per the JPSCo annual records, the reliability and stability of the transmission and distribution grid is constantly improved. To this end, JPSCo has made substantial investments to replace defective structures and equipment, voltage standardization and upgrade of the network including leveraging of various grid technologies. This resulted in an improved and more resilient grid and a reduction in the frequency and duration of outages as reflected in the SAIDI and SAIFI performance highlighted in Figure 3-7.

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[8] Ibidem.

[9] Ibidem.

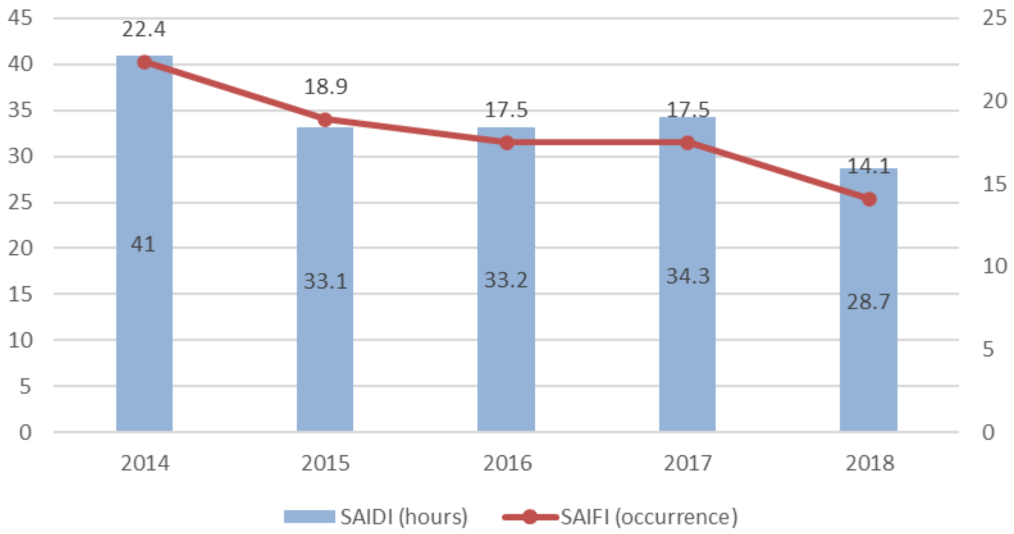


Figure 3-7 - Total system SAIDI and SAIFI. Source: JPSCo 2020.

Customers in Jamaica are currently experiencing fewer and shorter outages, as reflected in the SAIDI and SAIFI performance indexes. Total system reliability SAIDI hours showed improvement from 40.99 hours in 2014 to 28.66 hours in 2018 (i.e., 12.33 hours or 30%). In 2017 and 2018, the system was impacted by a number of severe weather impacting events, including flooding, severe winds and freak storm conditions that affected the level of improvement experienced. This contributed 6.66 hours to outage duration (5.1 hours in 2017 and 1.6 hours in 2018).

Customers are also experiencing reduction in the frequency of outages. Total System SAIFI showed improvement over the five-year period from 22.4 occurrences in 2014 to 14.1 in 2018 (i.e., 8.3 occurrence or 37%).

System losses

System Losses continue to be an area of significant concern for JPSCo. Losses performance showed reductions over the five-year period but was incommensurate with the effort and investment reported by JPSCo. At the end of 2013, system losses were at 26.6%, after which it deteriorated by 0.36 percentage point to 27% in 2015 before progressively improving each year to 26.3% at December 2018 representing a 0.73 percentage point movement.

At the end of 2018, technical losses represented 8.2% of total losses and non-technical losses represented 18%. The non-technical losses performance was greatly impacted by poor socioeconomic conditions existing in the environment over which JPSCo had very little control. Despite this, JPSCo reports to have employed various strategies, including working with various Government agencies and Non-Government Organizations (NGOs) and using relevant technology to mitigate the high level of system losses.

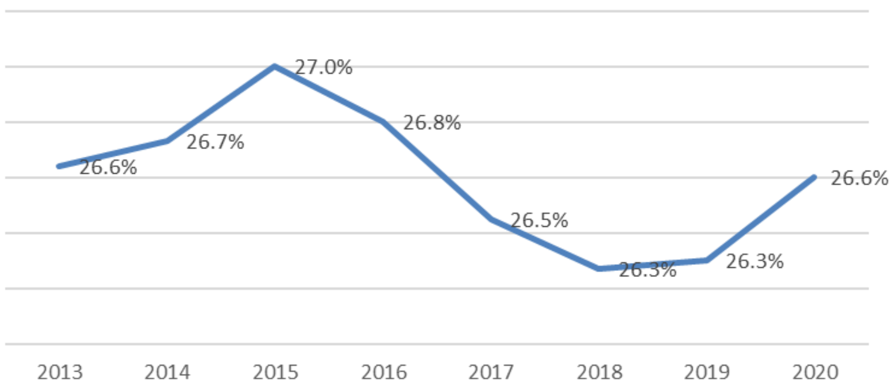


Figure 3-8 - Jamaica system losses (%). Source: IRP and JPSCo 2020.

To reduce systems losses, JPSCo has undertaken some initiatives including the installation of over 144,000 Smart Meters, and the installation of 685 Check Meters in 2018, specifically designed for industrial and large commercial customers, installation of RAMI and total meters in various middle-income communities.

3.3.3 Transmission asset performance

JPSCo has recently upgraded the protection system and installed new substation transformers and upgraded Duncans Interbus; expanded the Spur Tree Substation and voltage standardization of Roaring River and Ocho Rios feeders. These which were formerly 12 kV feeders, were converted to 24 kV.

Substations

There was a marked decrease in forced outages in substations over the past five years. Equipment failure contributed to over 70% of faults in the substations. This was due mainly to the failure of transformers and their component parts. Transformer related faults contributed approximately by 23% to equipment failures while the contribution from breakers, insulators, arresters, protective devices and conductors ranged between 5% and 9%.

Transmission

Transmission Line Trip: an average of 90 transient and 120 sustained trips per year has been experienced. This is well above the industry standard of six trips per 100km per year. JPSCo line length of 1,207.6km, would give an equivalent of 73 interruptions per year.

Transmission Fault: Equipment failure contributed approximately by 54% to transmission line faults. Other major contributors were lightning and other weather-related events which accounted for the 25%. Public trespass/encroachment events, which were mainly motor vehicle accidents accounted for 9%. The leading causes of forced outages over the period were failures involving insulators - 30%, shield wires - 18%, conductors (jumper included) - 18% and cross arms - 10%.

Reinforcement and Rehabilitation of the T&D Network

This included:

- The installation of over 300 km of #2/0 medium voltage covered conductors to reduce the impact of vegetation
- Fuse coordination on over 10 distribution feeders to reduce the extent of outages online sections
- Routine maintenance activities such as detailed and hazard patrol using ultra-sound and infrared technology to identify and correct defects on transmission and distribution circuits.
- Lightning mitigation installations to reduce the impact of severe lightning strikes; structural integrity improvement including pole replacement and rehabilitation; pole and pad mounted transformer replacement; and intensified vegetation control.

In 2014, JPSCo started its transition from a traditional grid to a more modern grid with smart capabilities. During the period JPSCo installed components of an advanced distribution management system (ADMS) with fault location isolation and service restoration (FLISR).

In 2017, JPSCo began the implementation of an enterprise asset management system (EAM) with the aim of improving the way in which the Company's assets are maintained, thereby improving system reliability and further affecting control on cost. JPSCo is committed to continue expanding EAM across the business to facilitate full coverage of generation, transmission and distribution assets in an integrated manner to improve the lifecycle management of these assets.

System Shutdown

During 2016, the system suffered two major incidents in April and August, both of which resulted in system shutdown of 230 minutes and 337 minutes respectively. Following on investigations, JPSCo submitted a comprehensive report to the OUR with an action plan, outlining lessons learnt, corrective actions, cost and timelines. The OUR, received periodic updates on the progress of the implementation of the action plans.

3.3.4 Grid interconnections advantages towards RES integration

In general, increased grid interconnection at regional, national and international level would enable more flexibility in power transmission from regions with an ample availability of renewables to other regions with high electricity demand.

Another advantage is the integration of variable renewables with conventional power and the possibility for variable renewables to complement each other at different times (e.g., solar power during the day, wind power overnight) and/or in different regions (South, North).

Higher interconnection and transmission capacity also enables the optimal use of surplus generation, alleviates the problem of daily and seasonal demand peaks, reduces the requirements for regulation reserves, enhances congestion management and reduces the need for new (and back-up) generation capacity. Modern, high-voltage, direct-current (HVDC) transmission lines for long distances are highly efficient, though their implementation takes time and involves significant upfront investment. Grid interconnection also requires full integration of the grid management systems.

The technology implemented to achieve grid interconnection allows grid operators to optimize their control energy use through intelligent communication between the grid operators' load-frequency controllers. Moreover, there are some market-based mechanisms that facilitate the efficient operation of grid interconnection, such as market coupling, market splitting and market balancing between neighboring operating areas. However, this is not the case for Jamaica being an island, where an energy market for exchange do not exist and the electricity system is organized around JPSCo as single utility company.

Regional interconnection is thus a key recommendation for RES integration and is indicated not to be only a solution for the issues.

3.4 Grid Planning

3.4.1 Intro / General considerations

When wind and solar resources, capable of being utilized economically, are located far from load centers, developing sufficient transmission capacity to move renewable energy to consumptions centers is critical to their integration. The disparities in generation capacity, transmission location and load size between locations can make the development of transmission for RE contentious and complex, particularly with respect to cost allocation. On the other hand, distributed energy resources provide for an alternative vision of the future grid, where energy is generated and used locally, avoiding the cost of line losses and the high capital cost of transmission lines. In such a scenario, the electricity grid could be conceptualized as a collection of independent micro-grids with vastly reduced long-distance energy transmission needs. In any case, this change in the paradigm may take some time to develop and, up to now, distributed generation only represent a small percentage of the total generation in many countries, including Jamaica.

Jamaica shows tremendous solar potential. Annual average global horizontal irradiance (GHI – the most useful measure for solar PV power generation) ranges from 5 to 7 kWh/m2/day. Even more promising, the solar resource is particularly strong in the southern part of the country, which is also where the most populous cities – Kingston, Portmore, and Spanish Town – are located.

Jamaica is located just to the north of the region of highest wind speeds generated by the Caribbean "Low-Level Jet", and thus wind speeds are moderate. Hence, as per the sun, most of the wind potential is located in the southern areas of the island. The following figures report the solar global horizontal irradiation, the wind speed and the main lines of the JPSCo grid with circled load centers.

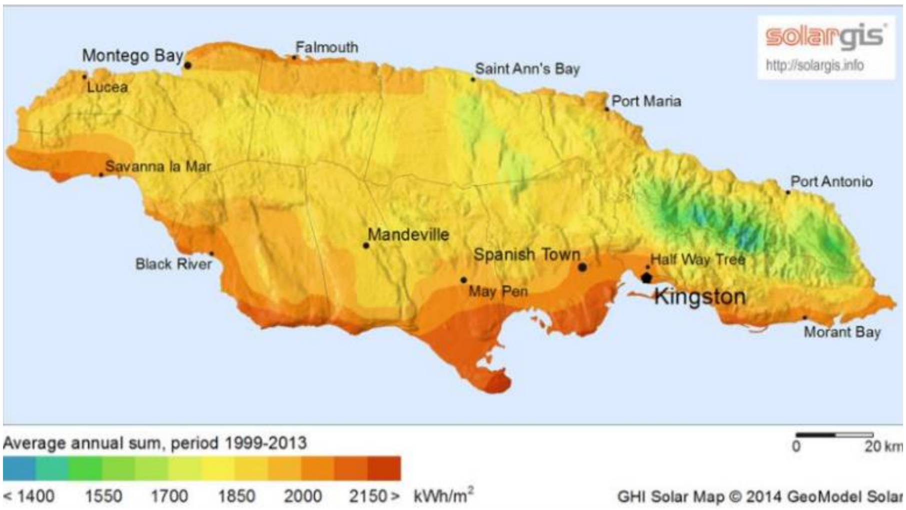


Figure 3-9 - Global Horizontal Irradiation (Source: Solargis 2021)

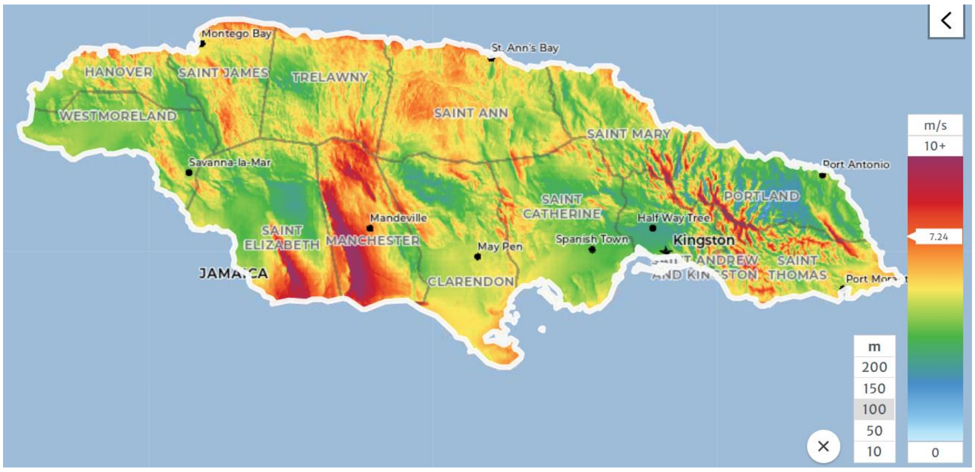


Figure 3-10 -Mean wind speed (Source: Global Wind Atlas, 2022)

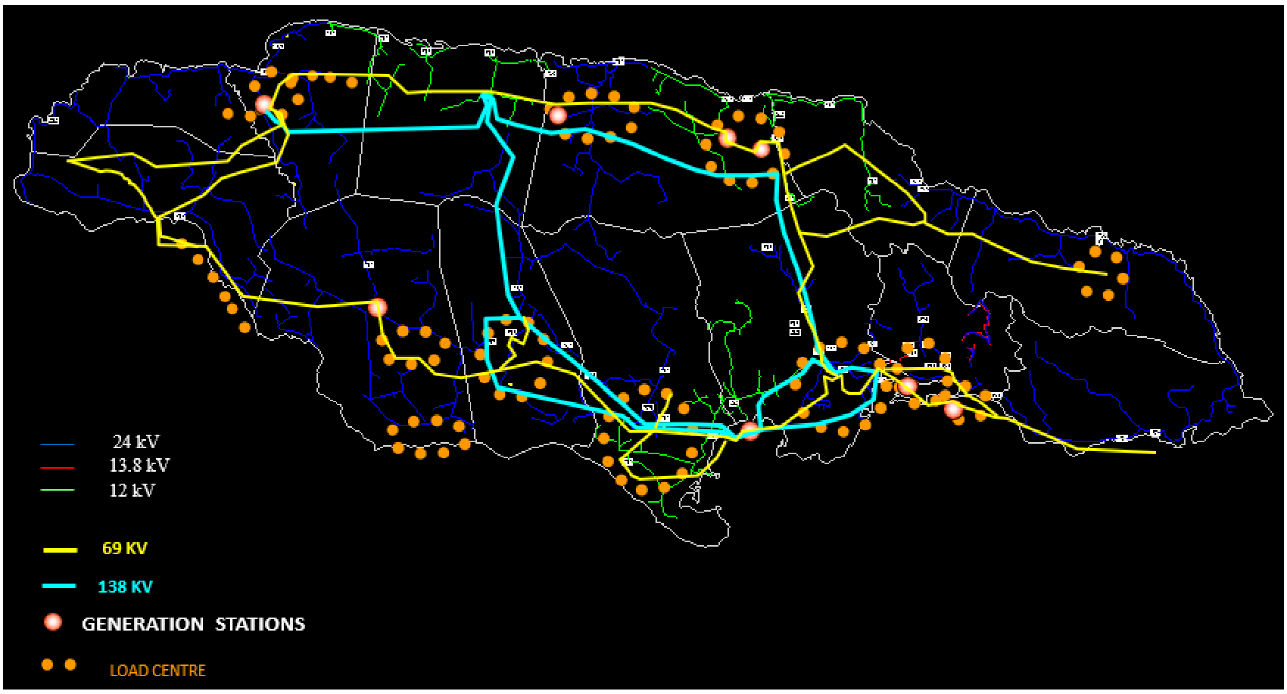


Figure 3-11 - JPSCo grid and load centers. (Source: JPSCo 2022)

According to the Electricity Act, 2015, Part XI, *"System Planning, etc."*, the Ministry of Science, Energy & Technology (MSET) is responsible for:

"(1) the planning the development of the system, which planning shall include
(a) the collection of data from electricity sector participants.
(b) consultations with the Office, the single buyer and other electricity sector participants; and
(c) the conduct of any relevant forecast.
(2) The planning process for transmission and distribution shall specifically consider the location of renewable energy resources and other generation sources, taking into account the potential for electrification of rural areas.
(3) A licensee shall comply with a request made by the Minister for information for the purposes of executing his planning responsibility under this section and failure to comply with a request under this subsection, without reasonable cause, shall be an offence."

Hence, in Jamaica, the MSET together with JPSCo, the OUR and GPE are the main institutions in charge for the electricity system planning. With JPSCo developing transmission and distribution network planning studies and the MSET giving the final approval. More details are reported in the below table as per the Jamaican IRP.

Responsibility	MSET	JPS	OUR	GPE
Objectives and Metrics	Develop	Inform	Inform	Inform
Transmission & Distribution Planning Studies	Approve	Develop	Review for rates	Inform
Load Forecasting: Assumptions/Inputs supplied by MSET	Approve	Develop	Inform	Inform
Stakeholder Process: communication & policy	Develop	Inform	Inform	Inform
Supply Technologies and Feasibility Studies	Develop	Review for Technical Meeting	Review for rates	Inform
Third Party Supply/Demand Contracts	Agree/ Review	Develop	Approve	Inform
Sales Forecasting	Approve	Develop	Approve Rates	Inform
Energy Efficiency and Demand Programs	Develop	Inform	Approve Rates	Inform
Policy Action Plans	Develop	Inform	Inform	Inform
Environmental Impacts – NEPA compliance management interface with JPS	Develop	Inform	Inform	Inform
Generation Expansion Plan	Develop	Inform	Review for Rates	Inform
Procurement of Generation Capacity	Inform	Inform	Inform	Develop

Figure 3-12 - Jamaica's institution roles in planning activities (Source: IRP, 2020)

3.4.2 JPSCo transmission and distribution planning process

Transmission Planning

In Jamaica, long-term transmission planning is done by JPSCo as per the mandate of the Electricity Act and as detailed by the Jamaica Electric Utility Sector Transmission Code TC 3.2

"The System Operator shall follow a planning process divided into major activities as follows:
a. Identification of the need for expansion or modification of the Transmission System;
b. Formulation of alternative options to meet this need;
c. Study of these options to ensure compliance with agreed technical limits and justifiable reliability and quality of supply standards;
d. Costing of these options and determination of the preferred option on the basis of procedures consistent with Prudent Utility Practice;

e. Approval of the preferred option in line with OUR tariff, JPS Business Plan, and License authorization levels and initiation of execution."

Transmission planning is performed over the scenarios created by the generation planning carried by the MSET and the OUR. So, the transmission system links new generation facilities to the existing interconnected system, reflecting the financial and primary resource allocation and utilization policies. JPSCo evaluates the network reinforcements and new developments required to serve the projected demand (at each load center and substation). Power system studies (load-flows, contingency analysis, stability evaluation, etc.) are performed to assure the planned network is enough adequate and robust. Compliance with the Transmission Code prescriptions is also checked at this stage.

Connection related planning studies are undertaken outside the above process, but new load information will be used to inform the demand forecasts. The timescales required to undertake the new connection studies necessary to plan the system vary depending on the driver for the studies and the ability to obtain consented routes.

Hence, to guarantee safety, reliability, security and stability of the system and the grid, JPSCo is required, by the Transmission Code, to conduct transmission network planning studies as:

"a. Preparation of the Transmission Least Cost Expansion Plan for submission to the OUR;
b. Evaluation of Transmission System reinforcement projects; and
c. Evaluation of any proposed User Development, which is submitted to the System Operator in accordance with an application for an Interconnection Agreement or an Amended Interconnection Agreement."

Distribution planning

JPSCo is responsible for Distribution System planning including:

"a. Analysing the impact of changes to an existing Users Systems;
b. Analysing the impact of the connection of new Users Systems;
c. Analysing the impact of new generation connections;
d. Analysing the impact of the connection of Rural Electrification Projects;
e. Planning the network to meet forecast Demand and forecast generation capacities; and
f. Identifying and correcting areas of non-conformance with planning criteria related to Voltage Drop, System Capacity, Fault Level, System Loss and Power Quality."

JPSCo follows a distribution planning process divided into major activities as follows:

"a. Identification of the need for expansion or modification of the Distribution System;
b. Formulation of alternative options to meet this need;
c. Study of these options to ensure compliance with agreed technical limits and justifiable reliability and quality of supply standards;
d. Costing of these options and determination of the preferred option on the basis of procedures consistent with Prudent Utility Practice ;
e. Approval of the preferred option in line with JPS financial authorisation levels and initiation of execution."

Normally, this analysis has a time scale as indicated in the below figure (valid for transmission and distribution planning).

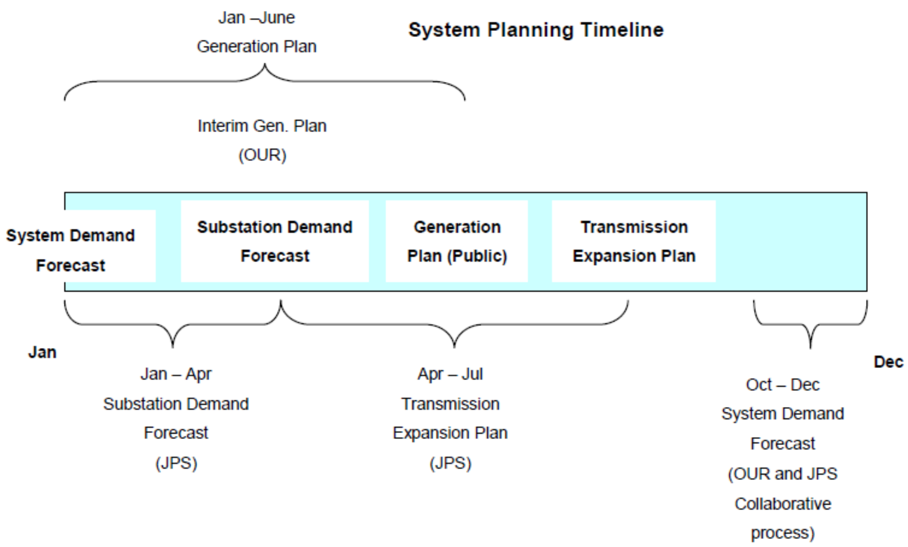


Figure 3-13 – Transmission and Distribution planning timescale (Source: Transmission and Distribution Codes).

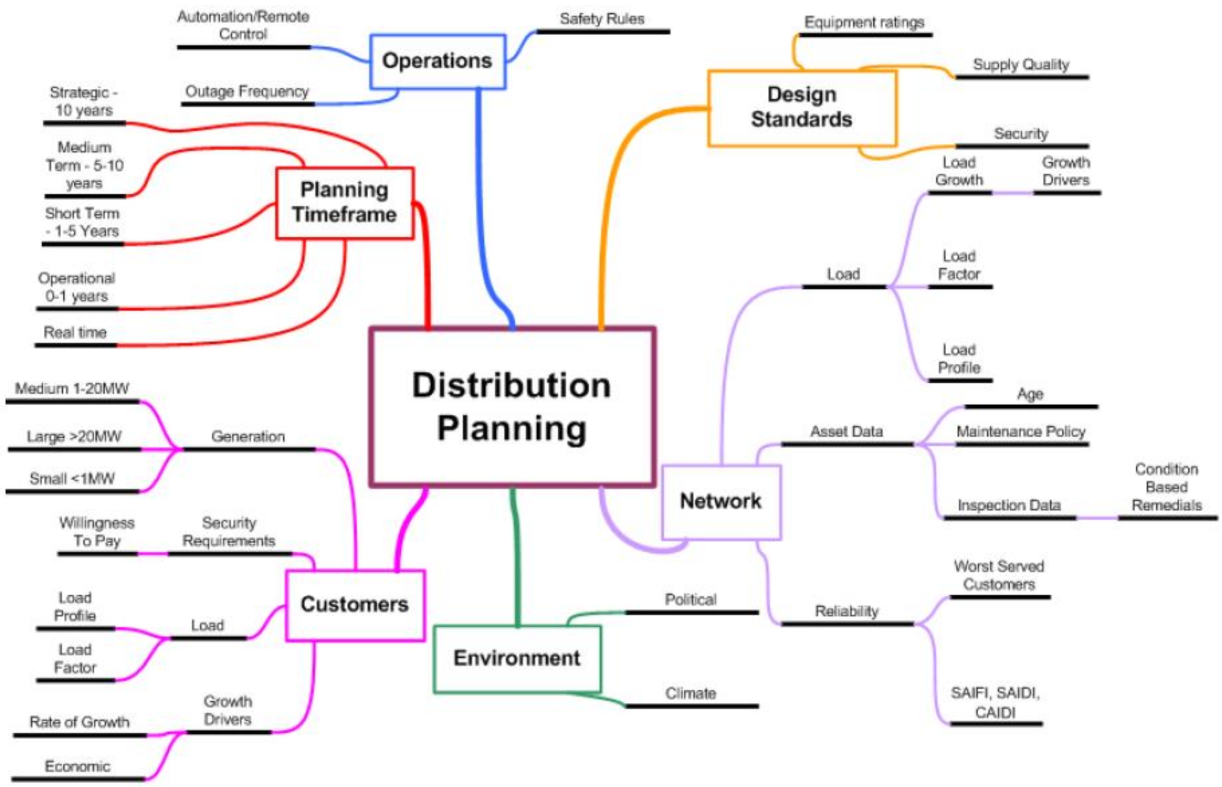


Figure 3-14 - Key distribution planning details (Source: Distribution Code)

Demand Forecast

As stated in the Transmission Code, power system analysis studies shall be conducted by JPSCo or third-party consultant pre-approved by JPSCo, according to the Study Guidelines outlined in the Transmission Code and using a suitable power system software such as PSS/E and DIgSILENT.

According to the Transmission Code, to carry out load flow studies, substation loads can be represented by *their constant real (MW) and reactive (MVAR) power requirements*.

Demand forecast is then required to enable the network *to be developed in a coordinated and economic manner*. *A consumption forecast using an econometric regression methodology is considered suitable for this.* This forecast of unit consumption is then to be developed into a peak demand forecast for each substation: this demand data shall then be used in the system studies outlined in the Transmission and Distribution Codes.

The overall process for development of the grid wise forecast is illustrated below. This process is undertaken on an annual basis.

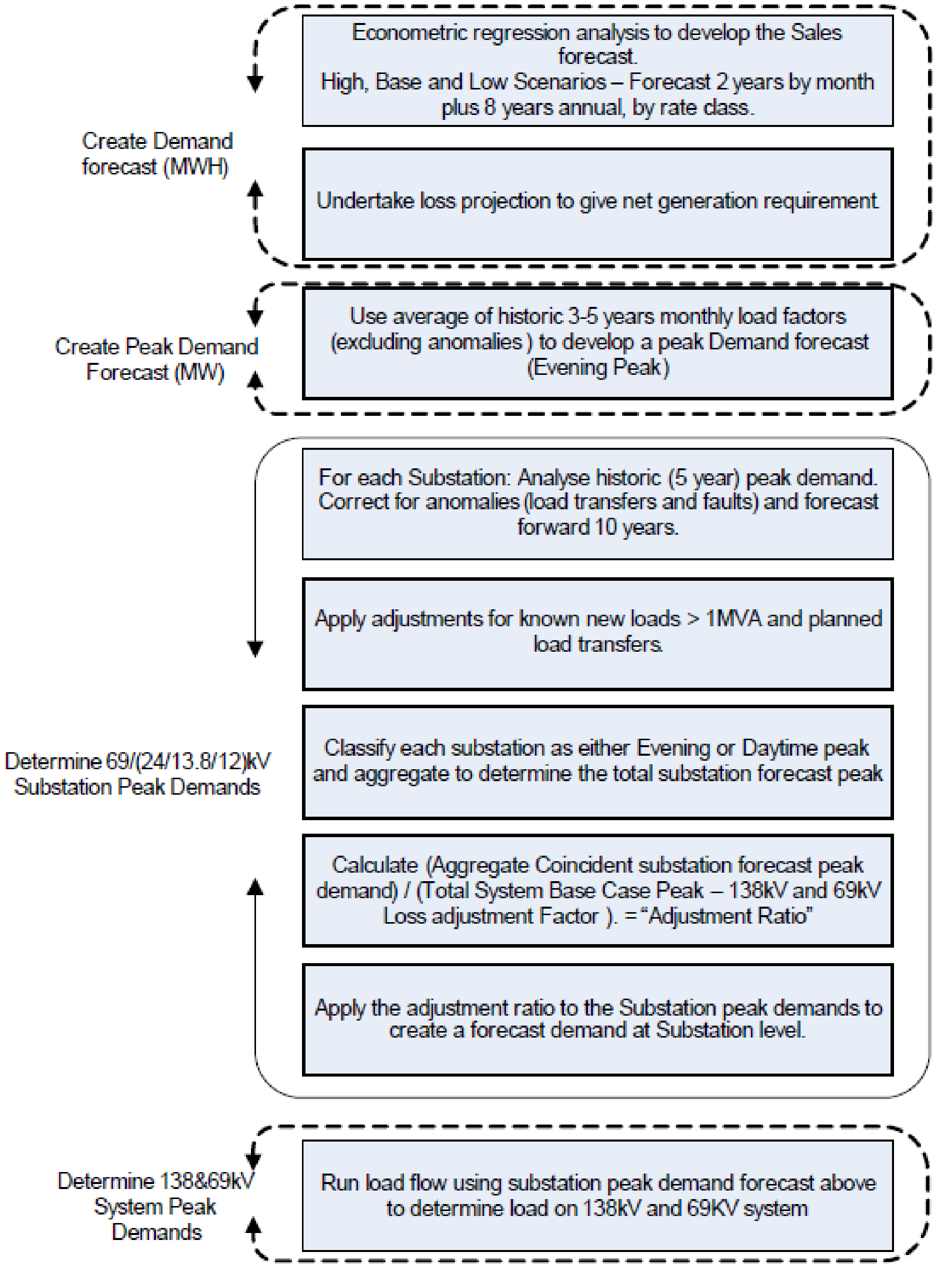


Figure 3-15 - System and substations demand forecast process (Source: Transmission and Distribution Code)

3.5 Procedures for access and connection to the grid

3.5.1 Intro / General considerations

The access and connection to the transmission grid denote the processes by which non-transmission agents (developers or owners of generation plants, consuming facilities or distribution networks) apply to incorporate into the power system new facilities or reinforce the integration of the existing facilities, and eventually the non-transmission agents gain connection to the transmission grid and with it the ability to import or export power from the grid. Generally, the access process is associated to or integrated within system planning and development processes.

For generation, access is the process by which generators apply to connect new plants (or up-rating or modifying the conditions for the existing ones) to the entity responsible for assessment and obtain connection solutions or offers, and eventually the corresponding license or authorization to operate. In the case of Jamaica, the responsible entity is JPSCo.

From the power system perspective, generation is needed to comply with the prescribed levels of supply reliability and efficiency as well as social-environmental requirements. However, different approaches may be used to define which generation must or can be installed and to assess the acceptability of access and connection applications.

To this respect, two approaches may be present, either exclusively or in some degree of combination, for a power system:

- Top-Down (TD): in which a global strategy is established, or a global optimization procedure is carried out, and, consequently, a number of general guidelines are drawn, or detailed decisions are made in terms of what amount and which sort of generation (technology, fuel type, renewables, indigenous, …), in which area (even in which bus or substation), in which time horizon should be installed.

  In this approach, therefore, there are figures concerning capacity of connection, what may be compatible with competitive mechanisms for assignation to generators the contingents decided by type, location, time.

  The established capacity of connection would constitute the reference for the system operator assessment of the access to the grid applications.

- Bottom-Up (BU): in which the general strategy – if any – is translated into regulatory incentives or mechanisms by which generation promoters develop or try to develop their projects considering regulatory signals which incentivize/penalize technology, type of fuel, connection point (location, voltage) commissioning year, etc.

  In this approach, the generation to be connected are assessed by the system operator mainly on technical grounds and generally on an individual basis.

3.5.2 Right of access and management of production constraints

The access to the grid may be regulated (according to procedures) or negotiated by the grid responsible entity who has been given the function of providing the necessary generation. In many power systems, nowadays, the access to the transmission grid is open in principle to every agent, subject to conditions and technical requirements and the corresponding fares, but the approach and the procedures may be significant for the practical application of that guideline.

For generation, a significant difference among systems may be located in whether there are limits for connection – of any sort – which is related with the way the system guarantees to the generators the “transmission capacity”.

Depending on the scheme in place in the country, it will be possible to deny connection or guarantee unconstrained access to new generation applicants.

In general, access is a regulated process and is considered a basic and important pillar for liberalization (as well as for other objectives as RES integration). In terms of priority for some generators, for instance, in European systems (according to the RES European Directive) there is a priority (or guarantee, depending on the system) for dispatching the production from RES plants. Furthermore, in some systems there is a hierarchy for different types of RES (Ireland, Spain). Priority for physical connection is less common according to the contributions to the survey (Spain for RES generation whenever RES and a non-RES generator are in condition to sign the Connection Contract).

3.5.3 Process to connect to the grid in Jamaica

As stated in the Electricity Act, no person is allowed to engage in the generation, transmission, distribution, dispatch and supply of electricity, unless authorized to do so by an electricity license.

The license is granted by the Ministry and, in the case of independent power producers, JPS is not obliged to connect an independent power producer's generated electricity output to the system unless both, JPS and Chief Electrical Regulator agree that the independent power producer's connection will not compromise the safety and protection of the system.

The requirements for connection to the transmission network of licensed RES generators is governed by the prescriptions stated in:

- The Generation Code
- The Transmission Code.
- The Distribution Code
- OUR Document Ele. 2005/08.1 "Guidelines for the addition of Generating Capacity to the Public Electricity Supply System (2006)" and
- the "JPS Guide to the Interconnection of Distributed Generation".

The Generation Code specifies the normal method of connection and the minimum technical, design and operational criteria which must be complied with by any generator in Jamaica.

Additionally, as specified in the Generation Code, details specific to each generator's connection may be set out in a separate Connection Agreement or in some cases, the relevant Power Purchase Agreement. Hence, the connection conditions set out in the Generation Code shall be read in conjunction with either or both agreements as relevant.[10]

The voltage level at which the generators are connected to the transmission or distribution system depends on, but are not limited to, the size and number of units and the other factors that determine the connection point. Subject to other technical considerations,

- generators with a rated capacity of 10 MW or above shall be connected to the transmission system at 69 kV or 138 kV.
- Generators with a rated capacity of below 10 MW may be connected to either the transmission System at 69 kV or 138 kV or the primary distribution system at 24 kV or less
- The chosen method of connection is determined by JPS on the grounds of system security, stability and safety.

As reported by the Transmission Code, all substations have the capability to disconnect or separate, from the transmission system, any transmission line and/or generating unit which is interconnected to the substation.

DCC 2.4 of the Distribution Code regulates connection of generators at low and medium voltage.

> *"In accordance with the Generation Code, Generators with a rated capacity of 10MW or below may be connected to the Distribution System where technical conditions allow. The design of connections between any Embedded Generating Unit and the Distribution System shall be as set out in the Generation Code. The design of connections between the Distribution System and Customers shall be consistent with the License".*
> *"Embedded Generation Units shall be required, as a minimum, to meet following performance standards:*

[10] As reported in the Generation Code, in the event that, there is any conflict between the provisions of the generation code and any connection agreement and/or Power Purchase Agreement and the said connection agreement and/or Power Purchase Agreement was signed before the Generation Code came into effect, then, the provisions of the connection agreement and/or Power Purchase Agreement will supersede the Generation Code.

> *a. Sustained Operation at any Load within the loading limits and within the System frequency range 49.5 Hz to 50.5 Hz.*
> *b. Emergency Operation at any Load within the loading limits within the System frequency range 48.0 Hz to 52.5 Hz during exceptional conditions.*
> *c. Maintain normal rated output at the voltages specified in DPC 2.2.1.*
> *d. Sustained Operation at the rated Power Factor set out in the* Interconnection Agreement."

3.5.4 Minimum Performance Required for the Connection to the transmission network

Minimum performance requirements, also applicable to RES power plants, are established in the Jamaican Transmission Code.

These criteria, applicable to wind and solar PV power plants with 10 MW or more of installed capacity, are connected to the transmission network (69 kV or 138 kV), were developed by JPS and approved by MSET. The objective of these requirements is to assure that the incorporation of this type of facilities into the grid do not adversely impact the overall performance of the network.

Fault ride through capability

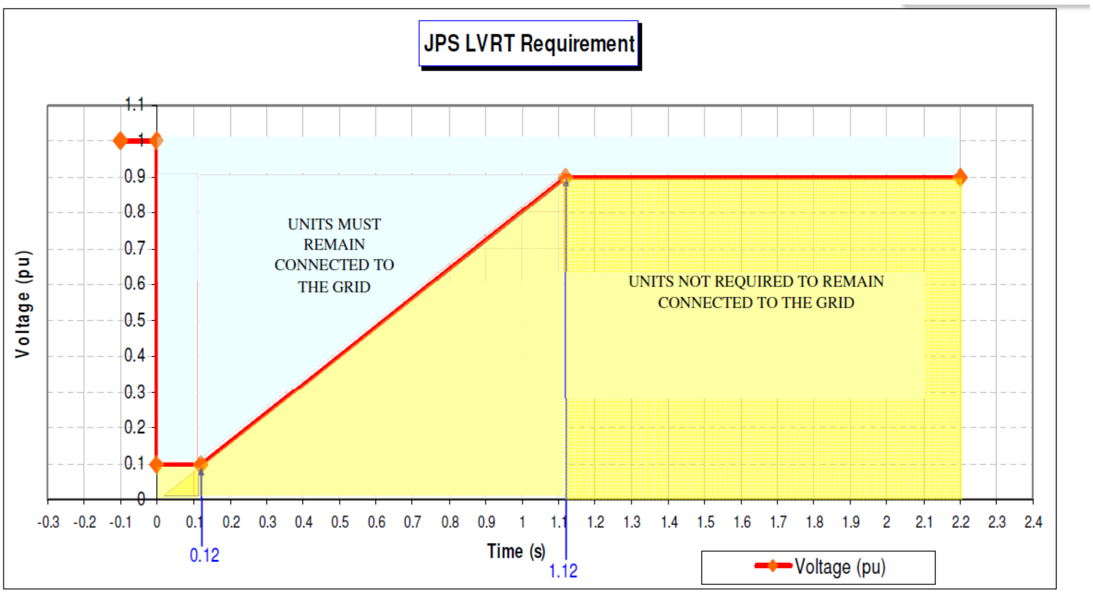
As reported in section 3.2.3, the Jamaican electricity system has limited low voltage ride through capabilities, in terms of plants that could cope with a low voltage fault.

The fault ride through capability is calculated as a percentage of nominal bus kV with system operation parameters of 10% to 90%, sees

> *"the generating unit to remain stable and connected to the system without tripping or losing synchronism for transmission voltage dips less than or equal to 120ms in duration."*

For transmission voltage dips, occurring due to system disturbances greater than 120ms (6 cycles) in duration the generating unit:

> *"During Voltage Dip*
> *1. Remain transiently stable and connected to the system for at least 1 second without tripping/losing synchronism.*
> *2. Provide Active Power output during voltage dips at least in proportion to the retained balanced voltage at the Interconnection Point.*
> *Immediately After Voltage Dip*
> *3. Restore Active Power output at the Interconnection Point to 90% of nominal levels (available immediately before the occurrence of the dip) within 1 second of restoration of steady state voltage conditions. That is, within the normal voltage operating band of 69kV ± 5%."*



Generating Units must remain connected to the grid in the region above the Low Voltage Ride-Through (LVRT) curve.

Figure 3-16 - Low Voltage Ride-Through (LVRT) Curve (Source: Generation Code, Schedule F)

Reactive power requirements

As reported into the Jamaican Transmission Code, at the network connection point, the VRE power plants shall be capable of continuous operation injecting/absorbing reactive energy within the region defined with the bold lines in the diagram below. There is no differentiation between wind and solar PV.

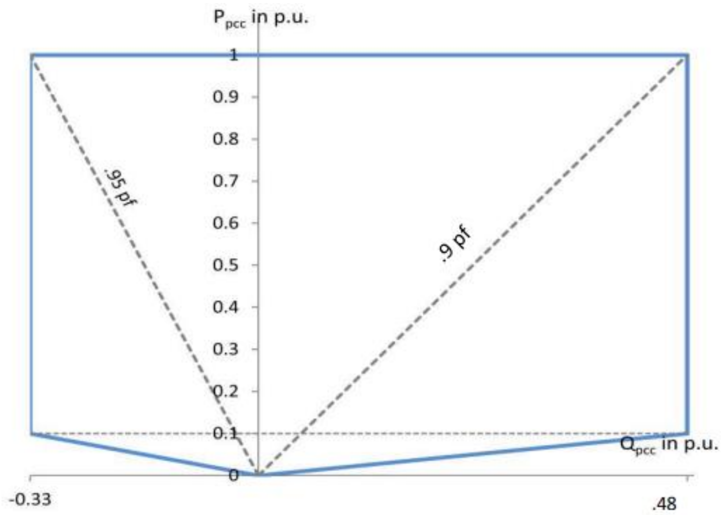


Figure 3-17 - TC 9.2 “Minimum PQ Diagram to be Fulfilled by VRPP plant” (Source: Transmission Code TC9.2)

Frequency and voltage control

An important figure for these kinds of activities related to the system security and reliability is the one foreseen by the Generation Code, the System Control Engineer, identified as a

> *“Person appointed by the Grid Operator and on duty at System Control Center with responsibility for controlling the generation, transmission and distribution of electrical energy”*
>
> *“To each Generator the required Dispatch Instructions for both Real Power (MW) and Reactive Power (MVAR) output or absorption in the case of Reactive Power, in accordance with the declared operating*

limits of each Generating Unit as agreed upon between the Grid Operator and the Generators to ensure adherence to these operating standards.
Automatic Generation Control (AGC) can be used to perform frequency control by sending signals to generator to adjust output. …, each new Generator shall ensure that the Generating Units are AGC enabled and can, without human intervention, accept and respond to a signal to adjust load. Additionally, the SCADA/EMS system shall have the capability to facilitate the use of AGC. The range of control afforded by the implementation of AGC shall be the subject of the Generator's PPA."

According to the Generation Code, the System Control Engineer is then responsible for issuing any instruction necessary to:

"i) Maintain the voltage on the Transmission System in accordance with the normal operational limits of +/- 5%;
ii) Maintain, or enable others to maintain, the voltage of supply to consumers within the limits of +/- 5% of the Nominal Operating Voltages;
iii) Supply the Reactive Power requirements of the System as economically as possible, and to organize the disposition of Reactive Power reserves for proper control of the System voltage in accordance with the requirement of i) and ii) above;
iv) Maintain frequency within the limits of 50 Hz +/- 0.2 Hz."

3.6 Critical assessment of the Jamaican Transmission and Generation Code

The most crucial factors for the stability of a power system are its mechanical inertia – provided by the rotating masses of all the turbines and the electricity generators – and its capability to damp any perturbation. The physical characteristics of wind and solar PV plants are substantially different from those of thermal plants – including concentrated solar power units – which consist of a boiler producing high pressure steam that drives a turbine rotating in the same shaft with a synchronous generator.

The ability to regulate frequency and arrest any sudden rise and decline of system frequency is provided by the inertial response of the generators connected to the system and the speed droop governors in conventional generators. In principle, most wind turbine generators are often isolated from the grid by power electronic converters, and their inertial response to the overall power system is almost negligible. Solar PV plants, also, have no contribution to the inertia of the power system. Therefore, an increased penetration of wind turbines and solar PV plants may result in significant changes on the dynamic performance of frequency after a disturbance (faster frequency declines) and additional burden is put in the conventional synchronous machines.

The knowledge that large levels of penetration of wind and solar PV are anticipated to take place in many countries, lead to two major conclusions.

- First, the operation of power systems with a strong presence of intermittent generation should be profoundly reconsidered and grid codes must be adapted to this new situation.
- Second, wind and solar PV plants can no longer be regarded as passive units, shutting down when system faults occur and with local control of regulation.

In this new context, they must behave as much as possible as ordinary power plants, which can provide reactive power support and/or voltage control, remain connected during system faults and increase the amount of control effort required to stabilize system frequency.

Soon it is expected that intermittent renewable generation will actively participate in maintaining system stability through varied control capabilities such as:

- primary frequency regulation,
- power curtailment and ramping,
- voltage/VAR control/regulation,

- voltage ride through, and
- inertial response.

As the wind penetration increases, these features on power wind facilities will be essential for the operation of the system, in particular during post contingency system restoration, peak generation during low demand periods, and unexpected ramp up generation at times when demand drops.[11]

The requirements incorporated into the Jamaican Generation and Transmission Codes, for wind and solar PV generators are considered, in general, appropriate and substantially aligned with the prescriptions contained into the Grid Code those countries with important VRE penetration.

In Europe, grid code prescriptions for wind and solar PV generators need to be aligned with the prescriptions contained into the "ENTSO-E Network Code. Requirements for Grid Connection Applicable to all Generators".

It should be mentioned that the prescriptions included in the code should be classified by generator. For instance, the ENTSO-E network Code classifies the generators in 4 categories (A through D) regarding the capacity of the plant connected. Hence, in the Jamaican case, it would be necessary to expand the code to cover all types (and capacities) of generation once the amount of VRE increase.

3.7 RES integration to the transmission grid

3.7.1 Intro / General considerations

In general, the challenges imposed by VRE into the power system can be divided into two major groups (see Figure 3-18**Error! Reference source not found.**):

- Challenges associated with the variability of the primary resource: Related with fact that it is impossible to completely control the production of VRE generation. The primary resources (wind or sun) vary (pseudo)randomly with time, and it is not possible to generate above their availability at each moment. These characteristics, in turn, requires that adequate amounts of reserve (and reserve types) will be incorporated into the system, production be properly and accurately forecasted and, eventually, part of the energy spilled.
- Challenges associated to technological aspects: These challenges are not related with the inherent variability of the primary resource, but with the type of machines/systems that are normally utilized for this type of generation. Most of the potential problems associated with technological aspects can be solved if proper requirements are included in the Grid Codes and/or connection agreements.

[11] NERC, 2009; Holttinen H., et al., 2011.

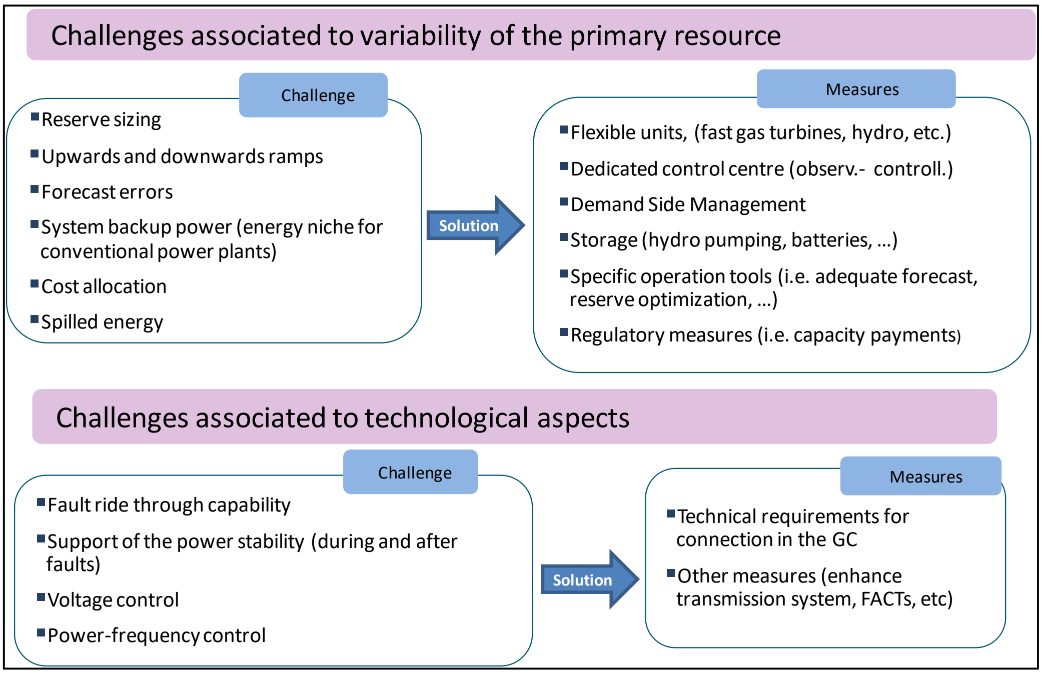


Figure 3-18 - Challenges to integrate VRE in power systems (Source: Consultants' elaboration)

A critical issue in power system operation with a large volume of intermittent production is the number of operating reserves that will be needed to maintain reliable and efficient power system operation. The practical implications are:

- more expensive operation, as a number of plants have to be maintained in a state of readiness and kept from being used normally to generate electricity, regardless of the regulatory framework;
- a long-term impact on the generation mix, as appropriate investments have to be made to have these plants installed and ready when the level of penetration of intermittent generation makes these plants necessary.

As previously investigated by studies on VRE penetration into the Jamaican system,[12] from a technical point of view, VRE sources can have significant impacts on the dynamics of the system and should not be underestimated, as they could put the operation of the system at risk if they were insufficiently anticipated. However, these impacts should not be overestimated, because an overly conservative approach would lead to a waste of valuable natural resources of the country, being aware that any potential hurdle has technical solutions

3.7.2 Ancillary service management

When the variability of generation resources is small relative to that of load, the system uses generation resources that can quickly match their output to the varying demand above base load levels. On the smallest time scale of second to second or minute to minute, certain generators are interconnected to the grid in such a way that they automatically respond to those varying demand levels by providing frequency control and regulation services.

Primary frequency control involves the autonomous, automatic, and rapid action (i.e., within seconds) of a generator to change its output to compensate large changes in frequency. Primary frequency control actions are especially important during the period following the sudden loss of generation, because the actions required to prevent the interruption of electric service to customers must be initiated immediately (i.e., within seconds).

[12] Grid Impact Analysis and Assessment for Increased Penetration of Renewable Energy into the Jamaican Electricity Grid Final report November 2013. MSET – EDF, Hinicio.

In addition to primary frequency control, the grid operator must have the capability to provide secondary frequency control. Secondary frequency control involves slower, centrally (i.e., externally) directed actions that affect frequency more slowly than primary control (i.e., in tens of seconds to minutes). Secondary frequency control actions can be initiated automatically or in response to manual dispatch commands.

On the time scale of generation and transmission scheduling, blocks of energy may need to be dispatched up or down to supplement the wind and solar energy that are used on a must-take basis. Together, one can think of these compensations as balancing services needed to maintain system equilibrium and reliability. Balancing services can come from some of the existing generation fleet and demand-side resources. However, planning requires a fresh look at what that optimal mix would be for the coming decades as renewable generation becomes a significant and possibly dominant resource on power systems.

Electric systems have always had to accommodate continuously changing customer loads and some variability in generator output, including planned and unplanned generator and line outages. A portion of renewable integration costs is simply the result of higher levels of variability in operating generator output than previously experienced.

3.7.3 Influence of RES in reserve determination

Renewable energies, in particular variable renewable energies (wind and solar PV) have a significant influence in the amount of reserves required to properly operate the power system. This impact, however, is heavily dependent on the:

- The amount of VRE connected to the system;
- The variability of the aggregated injected power of all the VRE generation in the area (which may be higher if most of the VRE generation is located within a relatively reduced area[13]); and
- The magnitude, relatively to the overall generation, of the deterministic Dimensioning Incident[14]

Although no general rules can be established, the European experience in countries with significant amount of VRE may be helpful to extract some lessons:

- **Primary reserves requirements are not affected by a significant amount of RES connected to the system.** The primary reserve requirements for each TSO are not excessively demanding and, in any case, not affected by the RES.
- **Secondary reserves requirements have increased (in relation with the situation without RES), but not significantly.** The dimensioning incident and random variability of demand and VRE generation seems to have not heavily impacted the amount of secondary reserves requirement. In the case of Germany, for example, in the latest 15 years, the amount of VRE (solar + wind) has grown from less than 10,000 MW to more than 80,000 MW. However, the requirements of secondary and tertiary reserves have maintained constant (even declined)[15].

Similarly, Figure 3-19, extracted from a Red Eléctrica (Spanish TSO) presentation, shows that the amount of primary, secondary and tertiary reserves was not significantly influenced by the large amount of wind generation installed in Spain in the period 2000-2012.

[13] Compensation effects are less if most of VRE generation is affected by similar metrological conditions.

[14] In cases the dimensioning incident is large, the variability of VRE generation is less important

[15] The decline in reserves requirements since 2010 was caused by better forecasting tools and the decision of sharing reserves among the different TSOs in Germany.

System Balancing Reserves	Definition	Influence of Wind Power on Reserve
Primary Regulation	Action of speed regulators from generator units responding to changes in system frequency (<30 s to 15 minutes)	Not influenced by wind power
Secondary Regulation	Automatic action of central algorithm and AGCs in the generation units that provide this service responding to changes in system frequency and power deviations with respect to France. (≤100 s to 15 minutes)	Only slightly affected by wind generation ramps when these ramps are opposite to system demand. Presently, no need to contract further reserve bands.
Tertiary Regulation	Manual power variation with respect to a previous program in less than 15 minutes. (<15 min to 2 hours)	Only slightly affected by wind generation ramps when these ramps are opposite to system demand.
Running Reserves or Hot Reserves	Dispatchable generation reserves that can be called upon within 15 minutes to approximately 2 hours. Include tertiary reserves and consist on the running reserves of connected thermal units and hydro and hydro pump storage reserves. (15 min-2 hours to 4 hours)	Significant influence of wind power. Reserve provision must be increased to take into account wind power forecast errors. Reserves are checked from day D-1 once market results are received until real time.

Figure 3-19 - Influence of Wind Generation in the required Reserves (Spain) (*Source: Wind Power Integration in Spain. The view of the TSO. REE. 2012*)

In other countries, the deployment of VRE generation has increased the required amount of Frequency Restoration Reserve (FRR) and Replacement Reserve (RR). In a study published in 2013, Elia (the Belgium TSO) estimated that the deployment of about 2,800 MW of wind plus 2000 MW of PV generation in the following 5 years will require about 300 MW of additional reserves "up" and 600 MW of additional reserves "down". However, only ± 50 MW of this additional reserves need to be automatically controlled (through the Automatic Generation Control - AGC), while the remaining part could be manually activated.

- **Requirements of "Down" Reserves have significantly increased.** Historically, secondary, tertiary and additional reserves were calculated considering, significant incidents in the network. These incidents, in most of the European countries were associated with the trip of large generators[16,17]. Therefore, even if the band for secondary reserve were usually symmetrical, all other reserves were determined considering only additional generation. The situation dramatically changed with the introduction of large amounts of VRE generation. The variability associated with VRE generation added to its partial unpredictability of VRE generation (particularly wind generation) creates unbalances caused by the errors associated with the forecasting models. It is necessary, therefore, to have enough resources capable to rapidly decrease generation in amounts that, in many cases, were larger than the requirements associated with the increase in generation. This, in turn, requires dispatching enough flexible generation capable to produce such adjustments.
- **Tertiary and Supplementary reserves are significantly impacted by large amounts of solar and/or wind generation.** One of the characteristics of VRE, and particularly wind energy, is that can experience increasing and/or decreasing ramps lasting few hours, which don't impose significant impacts in secondary reserves but requires to have enough conventional generation to compensate the unbalances. The amount of reserves required is very much dependent on:
    - The accuracy of the forecasting models and the frequency these forecasts are updated. Less accurate models and/or less frequently updated, imply larger values of supplementary reserves; and

[16] The loss of a large demand was, normally, much smaller than the trip of the largest generator.

[17] In some cases, the trip of an HVDC while exporting power to another countries requires also significant down reserves.

- The residual curve (“Duck curve”[18]). Although not directly linked with the amount of reserves required to securely operate the power systems with large penetration of VRE, a “side effect” of the increase of these types of energies is the reduction of the “room” to accommodate the other technologies which are necessary to regulate the system. In some cases, the residual conventional load-curve (the load that should be covered by conventional generation, once deducted from the actual load curve the energy generated by VRE generators and inflexible power plants) have very important ramps, which are outside the ramping capabilities of the existing conventional units. This is particularly important in case of significant amounts of solar generation. It is possible that additional thermal generation needs to be dispatched, simply to have enough machines capable to quickly ramp-up, and, eventually, some VRE generation curtailed. The following figure shows the situation in Germany on Sunday 7th 2013. Ramps of up to 5,000 MW/hour had to be managed by the TSOs.

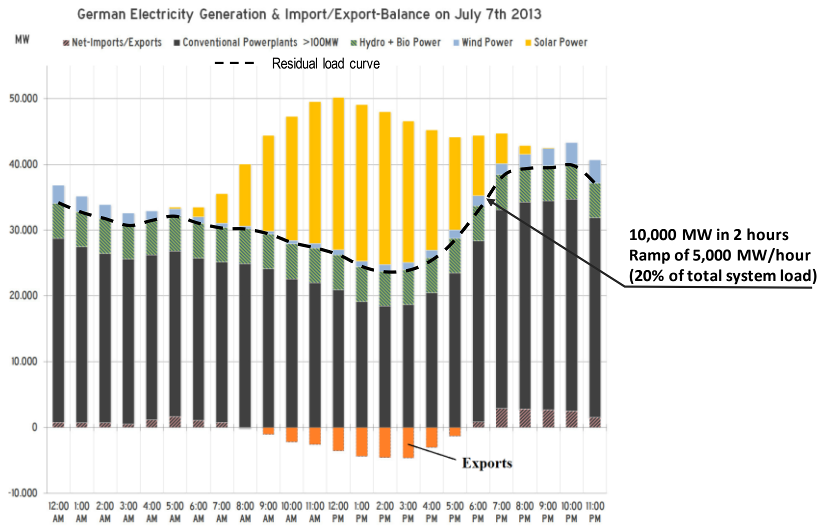


Figure 3-20 - Daily dispatch in Germany on July 7th, 2013. Source: Fraunhofer ISE.

3.7.4 RES generation forecast

Wind and solar PV generation are, basically, energy resources that can’t be dispatched like conventional generation. In more traditional utility operations, predictions of system load for the next hour, day, week, etc. are essential for programming supply resources according with the market results while maintaining system reliability and security. Incremental costs due to the uncertainty in the timing and quantity of energy delivery from wind/solar generation facilities in operational time frames can be reduced with better short-term wind generation forecasts and appropriate use of those predictions by control area operators and power markets in scheduling functions and real-time operating practices.

As the penetration of VRE energy continues increasing, becoming a central piece of the total energy mix, it is increasingly important to consider ways to more efficiently operate power systems to accommodate significant amounts of such a variable resource. In situations where resource decisions are made according to various market signals, prediction of wind and solar generation will be important for those who operate the markets and are in charge of system security and reliability.

Whether by direct action of an operating entity or responding to market signals, electric supply resources in an electric power control area must be managed, scheduled, and operated to provide the desired levels of system reliability and security. Meeting such objective and at the same time honoring the countless constraints on individual generating units

[18] “Duck curve” is an expression, started to be utilized by the California ISO, to represent the part of the load curve that has to be supplied by conventional generation, assuming that all VRE generation is totally dispatched.

and resulting from contractual obligations requires the ability to continually assess the present state of the system and predict probable states hours or days in advance.

Uncertainty in the operational planning time frame can lead to defensive operating strategies and higher costs. Wind/solar generation can only increase the uncertainty in the short-term forecasts utilized to commit and schedule generation and may lead to higher operating costs. In real-time operation, additional reserves shall be allocated to cover the uncertainty in the hours-ahead time frame, again with higher costs.

In control areas with multiple wind generation facilities, forecasts must be generated for each plant on schedules appropriate for real-time management of the control area as well as short-term operational planning activities such as unit commitment or reliability monitoring. Given that the plants in a single control area are exposed to the same general meteorological conditions, a wider geographical perspective on VRE (especially wind) resources conditions for forecasting is essential.

Because VRE generation is intermittent and has priority dispatch, the installation of multiple large VRE plants in regions where the primary resources are abundant is significantly affecting all system operations, reliability, power quality, and ancillary service requirements. As a result, wind and solar PV energy forecasting has become an essential function in planning the daily operation of electric power systems.

3.7.5 Current situation in Jamaica

Based on the Jamaican Transmission Code, the following security system standards are used in such a manner that the operating safety, and integrity and reliability of the Jamaican electricity system are ensured and to operate the system in compliance with the criteria related to the supply quality and operating conditions as set out in the Transmission Code regulation:

- Setting of system normal and contingency conditions
- Load power factor
- Thermal Loading
- Spinning reserve
- Fault levels
- Frequency criteria
- Network stability
- Transmission system resiliency

Relevant frequencies for a generator are those reported in the below table:

50.5 Hz < Freq	.5s
49.5 Hz ≤ Freq ≤ 50.5 Hz	**Continuous Operation**
48.0 Hz < Freq <49.5 Hz	20s
Freq ≤ 48.0 Hz	.5s

TC 4.8.3. describes the Primary Frequency Control (PFC).

Generators that have capacity available to either increase output or decrease output in real-time must provide PFR, which may make use of that available capacity response to system frequency deviations. The PFR shall be similar to the droop characteristic of the governor system used by conventional steam generators. The governor droop shall be set by system operator and be in the range of 0% to 5%, with a default of 5%.

In Primary Frequency Response mode, the PFR control system shall have the capabilities as displayed in the Power-Frequency Response Curve in Figure 3-21, where the power and frequency ranges required for points A, B, C, D, and E shall be defined by JPS.

Important step is that all generators in operation must reduce their instantaneous active power output when the system frequency is more than 50.03 Hz.

From Figure 3-21, points A, B, C, D and E therefore may be adjusted by system operator to accommodate requirements for system reliability which will be communicated to and agreed upon with the generator, on a case-by-case basis. In this figure the only defined power output point is maximum available power (100%) of the generator; the Active Power Set Point could be in any value between 100% and down to 10%. The Active Power Set Point shall correspond to system operator's operator designation of this value.

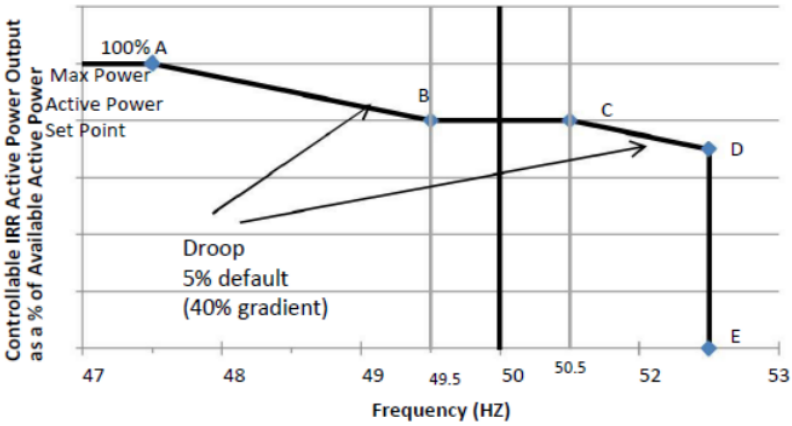


Figure 3-21 - Curve 1, power-frequency response curve (*Source: Transmission Code*)

Also, under the prescription of the Generation Code, VRE are required to perform specific tests and continuously provide data due to their variable generation nature as:

- Meteorological data for PV and Wind Farms
- Maximum reactive power capability test
- Voltage flicker measurement
- Harmonic distortion measurement

VRE Generation forecast and dispatch

As reported in the Jamaican Generation Code, all VRE generation units are required to cooperate with System Control Center by providing generation forecasts that JPS uses to schedule the demand energy and dispatch the necessary units to operate the system reliably.

The Generation Code, under Variable Resource Forecasting section states:

> *"JPS requires the VRPP to provide quality resource forecast from reputable and industry proven methods, and or in accordance with requirements that will be dictated by JPS in the transmission Interconnection Agreement or other agreement between JPS and the VRPP. The forecast should provide the following information:*
> *Medium-Term Forecast: a rolling hourly resource forecast submitted to JPS for the next 168 hours. The rolling hourly forecast means the forecast must be provided on an hourly basis.*
> *Short-Term Forecast: JPS reserves the right to also request a rolling 5-minute resource forecast to be submitted to JPS and/or the centralized forecasting vendor for the next 6 hours.*

The System Operator is required to consolidate forecasting functions in a single provider to assure uniformity of quality and improved forecasting prediction capacity, and to share the costs among the users.
The forecasts shall be provided to the System Operator through web service or ftp (File Transfer Protocol) site delivery in a format to be agreed upon with the System Operator. The System Operator reserves the right to request a specific file format that the VRPP must accommodate".

Dispatch and Disconnection of VRE units

According to the Generation Code, JPS retains the right to disconnect any generating facility (through phone or SCADA) from the system grid thereby isolating equipment, without prior notice under the following circumstances:

"i) in cases of System Emergency;

ii) during system restoration following partial or complete loss of power;

iii) if at any time the Generating Facility is being operated outside acceptable operating parameters in a manner which violates the Connection Conditions set out in the Code or which is likely to cause any of the following:

a. A safety risk to personnel;

b. Risk to stability or security of the System Grid or Other Generating Units;

c. Any behavior causing sustained operation outside the normal System Grid operating frequency and voltages as stated under Sub-section 2.3.

Notwithstanding the forgoing in the event of any material breach of Connection Conditions which prevents the System Operator from meeting its Licence obligations, the System Operator may disconnect after using best commercial efforts to give notice to the Generator."

The Generation Code gives the right to JPS to send dispatch instructions to VRE units, via radio, phone or SCADA as per the VRE unit SCADA signals list, to reduce their output due to system reliability. In particular,

"On-Line VRPPs must be able to commence their shutdown sequence within five (5) minutes of receipt of a Dispatch Instruction from JPS. The shutdown sequence shall be completed as soon as practical, but no longer than ten (10) minutes from the receipt of a Dispatch Instruction from JPS.

If the JPS Transmission System condition requires breaker or switch operations to disconnect a non-MW producing VRPP from the system, the disconnection shall be completed as soon as practical, but no longer than ten (10) minutes from the receipt of a Dispatch Instruction from JPS. Once disconnected from the JPS Transmission System, a VRPP shall wait for instructions from System Control Center before reconnecting the system to the network. The VRPP shall complete as soon as practical, but no longer than ten (10) minutes, the required switching to return the system to a normal configuration after receiving the new Dispatch Signal from JPS to do so.

After providing prior notice to JPS, a VRPP plant may disconnect from the Transmission System at any time, if reasonable and practical, in the case that the condition or manner of operation of the JPS Transmission System poses an immediate threat of injury or material damage to any person or equipment of the VRPP Units and/or project substation."

3.8 New trends in RES integration

The current evolution of electricity grids is mainly aimed at differentiating primary energy sources with a fast-growing share of renewable energies with a substantial positive impact on political aspects (safety and security of energy sources availability), economic advantages (better control of energy source costs) and environmental desires (sustainable energy sources with low-carbon content with reduced impact of the eco-systems and health).

These modifications are driving a strong grid model change with a challenging role of novel enabling technologies able to allow for a more efficient and intelligent control of the energy and power flows.

The renewable energy sources characteristics are mandating this model shift for its own peculiar features to be non-programmable and randomly available. The new electricity grids must be able to smooth out and reduce the intermittent nature of the renewable energy sources to make them compatible in time, location, dimension and costs with the technical and economical requirements of the final users. In this context, flexibility is the ability to maintain continuous service in the face of rapid and wide swings in supply or demand.

The need to ensure supply that matches demand under all circumstances poses particular challenges for variable renewable power options such as wind and solar generation, whose supply heavily depends on season, time and weather conditions.

Generally speaking, all power systems have some inherent level of flexibility designed to balance supply and demand at all times. Variability and uncertainty are not new to power systems because loads change over time and in sometimes unpredictable ways, and conventional resources could fail unexpectedly.

Main issues when facing huge share of renewable generation are:

- Steeper Ramps - the rate of increase or decrease in dispatchable generation to follow changes in demand. Ramps can be steep if renewable generation is decreasing at the same time that demand rises.
- Lower Turn-downs - operation of dispatchable generators at low levels. High wind output during periods of low demand creates a need for generators that can turn down output to low levels but remain available to rise again quickly.
- Shorter peaks – periods where generation is supplied at a higher level. Peaks are shorter in duration, resulting in fewer operating hours for conventional plants, affecting cost recovery and long-term security of supply.

Hence wind and solar generation can create the need for more flexibility.

3.8.1 Energy storage and BESS usages

Energy storage systems has widely been considered a potential solution for improving grid flexibility through ancillary services, expediting renewables' integration, and enhancing grid reliability. Below use cases are listed:

- Transmission Investment Deferral,
- Ancillary Services,
- Load Management in Balancing Market/Mechanisms,
- RES Capacity Development and Integration,
- Behind the Meter Applications: Load Shifting
- EV Charging: PV + Storage

In the below sections, we dig-deep on a few items as find them useful to the Jamaican reality.

Transmission Investment Deferral

Energy storage systems can be used to delay or replace capital-intensive transmission extension and/or upgrade investment. Specific nodes within the transmission system may operate near their designed capacity and may be inadequate to serve the additional demand and/or generation requested. In such cases the thermal limits of the transmission assets are usually exceeded for a very short time period, a few hours or a single day per year. A much smaller investment in storage systems can provide a solution to this problem and can further assist to extend the lifetime of transmission assets operating close to their operational limits. Similarly, BESS can be used to store excess generation that causes transmission congestion for later use.

The Transmission grid upgrade deferral objectives are:

- To use energy storage to defer or avoid transmission infrastructure upgrades and solve transmission congestion issues by installing energy storage systems instead of new lines and/or transformer.
- To use energy storage as a transmission grid component in order to decrease the "traditional" grid size during the grid planning process by basing its design on a peak shaving means.

Besides grid upgrade deferral objective, an energy storage can be used to provide capacity/voltage support in order to reduce the impacts of the loss of a major grid component and support the grid in case of contingency. The energy storage can also be used to improve the performance of the transmission system by compensating for electrical anomalies and disturbances such as voltage sag, unstable voltage, sub-synchronous resonance, and power quality.

Ancillary Services

Ancillary services, such as fast FCR (Frequency Containment Reserves), FCR, aFRR, mFRR regulation, voltage support, capacity reserve, and spinning reserve, among others, will grow in significance as the penetration of intermittent renewable energy increases, although they have different dynamics in terms of performance, varying by market and time of year. Some applications require high power for short durations (e.g., fast FCR regulation response), while others call for power over longer periods (e.g., firm capacity supply). These different services imply various charge/discharge cycles of BESS. In some cases, uniform charge and discharge cycles are likely to be the norm (e.g., in electricity time shift), while highly variable charge/discharge patterns could be the standard in others.

This has implications for which BESS technologies are most economically suited to provide this array of services[19].

BESS is even more successful than the synchronous machines for the FCR control, as seen from the following Figure. Therefore, the TSO may preferentially prefer storage systems in the FCR and be evaluated in a different market structure such as Fast FCR.

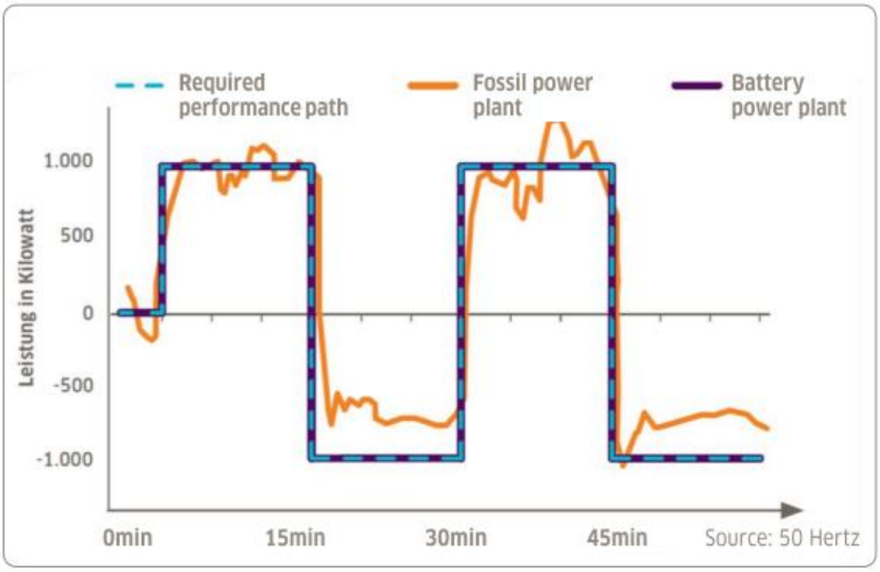


Figure 3-22 - FCR Response Success Graph (BESS vs. Fossil Fired Power Plants)

Increasingly countries begin to identify market reforms to support higher shares of intermittent renewable energy sources, new and more transparent markets for ancillary services are emerging, often at a very granular level (e.g., fast FCR, FCR, aFRR, mFRR, firm capacity, etc.). This will open up new opportunities for BESS deployment, given that BESS will increasingly offer competitive services to these markets.

[19] JPS has implemented a 24.5MW lithium-ion battery Hybrid Energy Storage System (HESS) + flywheels

RES Capacity Development and Integration

As is known, the large-scale integration of renewable energy sources such as photovoltaic and wind energy can be done effectively only if system operators have the necessary tools to handle their inherent variability. The development of a strongly interconnected power system with high renewables penetration requires the implementation of advanced solutions by TSOs to overcome the technical challenges. A disadvantage of variable renewable energy sources is their fluctuations in time and space with an associated uncertainty, especially for wind, and lower capacity factors in comparison to conventional technologies. In this respect, TSOs should have emerging power technologies and ICT to increase system flexibility and develop suitable market models allowing small scale, widely distributed resources, such as storage devices and demand response units, to provide flexibility services. TSOs should also develop a portfolio of new technologies for system development and new tools for the optimal exploitation of flexibility sources along with the sizing and positioning of storage systems to cope with the needs and demands of a high proportion of variable RES system.

The storage, as a flexibility measure, responds to these fluctuations and meet the demand at all times, specifically to deal with their temporal component. Storage can provide both upward and downward flexibility, storing energy either when there is generation surplus or lower demand and discharging in the opposite case. Depending on the time scale from msec. up to months, there are different roles that storage can play thus avoiding curtailment of running RES.

TSOs can also use the non-synchronous energy storage, which have a grid connection power converter, to provide near instantaneous active power output, replicating the effects of inertia, in case of frequency change in the system within a timeframe of up to 5 msec. The control could be derivative or proportional[20].

Applications:

- Dynamic Stability and Requirements on Minimum Inertia
- RES + BESS use case
    - Regarding RES + BESS use case an important detail is that, in systems with organize market, wind and solar power plants produce electricity based on the availability of their resource and this availability may not coincide with the market prices. For this reason, BESS can be used to shift the generation to the highest price hours in a day to generate more income.

      From this perspective, in fact RES + BESS use case is an option for price arbitrage. A wind farm will store its energy at nighttime and sell it at peak hours, which is similar to buying the energy at nighttime and selling at peak hours. Moreover, there can be a restriction for the RES + BESS scenario where, power given to the system at any hour cannot exceed the installed capacity of the RES. Therefore, for example if a RES has 10 MW installed capacity and producing at maximum at an hour, it cannot sell power from the stored energy even if the price is the highest at that hour. Therefore, feasibility of RES + BESS use case is always lower than the standalone BESS for arbitrage purposes.
    - Another benefit of RES + BESS use case is the minimization of imbalance costs due to unpredictable generation.

EV charging (PV + BESS)

As an integrated system, solar energy + storage + EV charging can be considered as a use case for the BESS. To explain this use case, we can divide it into below sub use cases:

- Off grid: PV + BESS + EV Charging
- On Grid: PV + BESS + Private EV charging

[20] EASE, Energy Storage Applications Summary. Brussels, June 2020.

- On Grid: BESS + Private EV charging
- On Grid: PV + BESS + Public EV charging
- On Grid: BESS + Public EV charging

For the off-grid case, BESS is not an option but a necessity. Because otherwise the PV generation is lost when the EV is not charging.

In terms of the feasibility study, private and public charging points are not different. They can both generate their own energy via PV and get the remaining need from a supplier. In fact, this case is a specialized version of the above-mentioned price arbitrage (corresponding to the so called behind the meter application, which is a sub case, where the BESS will be charged at the minimum prices and discharged at the highest prices in a day). Whether there are PV panels installed or not, it does not change the feasibility of the BESS. The energy is stored at the minimum hour prices and used in the highest price hours, regardless of the PV installation. Besides, most of the time PV generation will not be stored in the BESS because the cheaper energy at nighttime on grid will be stored when the PV generation is not available.

3.8.2 VRE power plants control

The SCADA system is the core of JPS power system control. It is used to collect real time information about the key system parameters and to monitor, control and optimize the operation of the generation and/or transmission systems.

SCADA present in JPS's system is the last receiver of the information collected and where the national range decisions are to be taken and JPS is charged with the maintenance and backup for the complete SCADA system.

Wind and solar PV power facilities, regardless they are connected to the transmission or distribution system, are obliged to send power plant's data details to JPS as per the prescriptions of the Transmission Code.

The approaches used to control RES generation may take different forms, mainly depending on the characteristics of the involved systems and the particularities of the facilities to be controlled.

For instance, Italy and Spain have a long tradition in RES integration and also different approaches used to control VRE power plants:

- Italy, as the number of facilities to be controlled is high and their individual installed capacity is low, has chosen that the interlocutor of the TSO are the DSOs. These DSOs, in turn, issues the required commands to the generators or, eventually, take direct control over the facilities' breaker opening it if required.
- In Spain, it was decided that the TSO should not have direct tele-control over any power plant and/or its associated equipment. It was necessary, therefore, to introduce an interface between the TSO and the generators, which are the delegated control centres. The DSO plays a relatively limited role in this type of control. In addition, the amount of RES generation connected at the MV, and LV level is relatively small. Therefore, it has not been necessary, up to now, to implement a TSO direct control over such kind of facilities.

In Jamaica, the amount of RES generation currently commissioned is very small. Most of it is connected to the HV network, although it is foreseen a rapid growth of facilities connected at transmission and distribution levels in following years. In sight of a greater introduction of VRE in the Jamaican electricity system, it is reasonable to think about the necessity of adaptation of the control tools at both levels, being sure that this aspect does not constitute a barrier for their actual deployment.

3.9 Conclusions

Jamaica electricity supply system is currently characterized by a low presence of renewable energy sources in the total primary energy supply and by a significant share of electricity losses at transmission and distribution level.

According to reference documents, Jamaica attributes high importance to the provision of energy from renewable energy sources with a view to diversify energy resources, reduce the use of fossil fuel resources and reduce greenhouse gas emissions. In this context, the supply of electricity from renewable sources has a key role.

From the electricity generation point of view, the Jamaica's electricity supply system is characterized, on the one hand, by fossil fuel assets, reported in good conditions, with a lot of capacity saved for peak hours, being ADO and HFO power plants recently replaced by LNG fueled power plants. With massive Sola PV load that in the future may replace conventional load, the risk of creating very important ramps, which might be outside the ramping capabilities of the existing conventional units needs to be considered. On the other hand, the Jamaica's electricity supply system is characterized by a recently refurbished hydro generation assets, with high-capacity factors (above 75%) that could allow a higher penetration of intermittent sources of energy as wind and solar PV. However, the system has limited low voltage ride through capabilities, in terms of plants that could cope with a low voltage fault. A key issue when dealing with increasing VRE generation capacity.

From a network operation and planning point of view, the requirements incorporated into the Jamaican Generation, Transmission and Distribution Codes, for wind and solar PV generators are considered, in general, appropriate and substantially aligned with the prescriptions contained into the codes of those countries with important VRE penetration.

It should be mentioned however, that the prescriptions included in the codes, in the future, should be classified by generator and by capacity of the plant connected to the system once the amount of VRE increases. Also, grid codes must be shaped in regard to control and curtailment of VRE resources.

It is recommended to consider in the future the possibility to operate generation facilities in synchronous mode. Considering however, BESS technology as a more successful option than the synchronous machines for primary reserves and FCR control.

Batteries deployment could help mitigate variability and may act as transmission investment deferral. Jamaica has to consider, as part of the future procurement strategy, batteries deployment as hybrid solution or stand-alone projects (acting as power grid assets).

Finally, actions on smart-grids, storage techniques and network development must be planned in a coordinated way to avoid future problems. An assessment of the electricity market design, and transmission and distribution system planning and operation in view of increased VRE integration is also suggested.

4 ANALYSIS OF JAMAICAN PROCUREMENT PROCESSES

4.1 Overview of the electricity generation procurement

Independent Power Producers

For those entities that are looking to generate electricity for use primarily by the public, i.e., Independent Power Producers (IPPs) or JPS; the Act through section 20 has designated an entity called the Generation Procurement Entity (GPE) to procure all new generating capacity. This procurement is done through a competitive bidding process, except under the following circumstances:

- An emergency exists such as to make a competitive bidding process impractical
- The grant of the licence is necessary to accommodate an offer from a foreign government to the Jamaican Government that will benefit the electricity sector
- Due to exceptional circumstances or the prevailing economic and financial conditions in Jamaica, it is in the public interest to grant the license.

Self-generation

The Electricity Act, 2015 outlines the procedures for the addition of new generation assets into the Jamaica's system. Part IV "Electricity Licences" indicates that self-generators, i.e., persons or entities that generate electricity for their own onsite consumption; are not required to apply for any license or seek permission from any agency to install and operate their generation assets. However, any interconnection with the grid for the purpose of transmission, distribution or supply of electricity; requires an electricity license.

Examples of interconnecting to the grid that a self-generator may be interested in, are net billing and power wheeling. The application guidelines and forms are all available at MSET's site. Self-generators that wish to interconnect with the grid are required to comply with additional standards outlined in this Act and the Generation Code, to ensure safe and efficient interconnection.

Renewable Energies

There is no separate entity for the regulation of electricity generated by renewable sources; nor is there any separate or specific legislative piece. The Electricity Act 2015, The Office of Utilities Regulation Act, and the JPS Electricity License 2016 all have specific sections that support and promote the integration of renewable energy into the national grid.

4.2 Results of past auctions

Since the mid-1990s the Government of Jamaica (GOJ) has pursued the inclusion of private sector participation in the electricity sector. The framework was updated and codified with the promulgation of the OUR Act in 1995 and between 2004 and 2015 the OUR had the mandate to administer the procurement of generating plants for system expansion on the basis of International Competitive Bidding (ICB). In carrying out this responsibility, the OUR issued several Request for Proposals (RfP) for the supply of generating plants on a "Build, Own and Operate (BOO) Basis". Nevertheless, in 2015 the Generation Procurement Entity (GPE) was established through the Electricity Act, with the responsibility for procuring new generation and managing the replacement of old plants that are owned by JPS to meet the national generation demand. The Electricity Act also mandates the GPE with the responsibility to manage and administer the process for procurement via competitive bidding of generation capacity by potential Independent Power Producers (IPPs).

Since 2008, three renewable auctions were carried out. However, only the latest one was able to fulfil the entire demanded capacity. In 2012, the context of rising oil prices and the desire to reduce Jamaica's high dependence on oil imports, OUR in support of the NEP issued the RfP for 115MW of generation projects based on renewable energy resources – 78 MW of energy only and 37 MW of firm capacity. Although the energy part was successfully fulfilled, the process wasn't able to contract the demanded firm capacity. Some agents argued that the lack of proposals was due to the clause of Proposal Security, which required a 1-year guarantee in the amount of 1% of the expected total capital cost of the proposed project. A couple of years later, in 2015, the OUR launched a new auction for the unattended 37 MW, but this time not restricted to any capacity type (firm or energy only). It is worth mentioning that the Proposal Security clause was kept the same. The auction was successful, but only contracted "energy only" projects.

YEAR	CAPACITY REQUIRED (BOO)	# OF PROPOSALS	AWARD(S) /AWARDEE(S)	YEAR IMPLEMENTED
2008	Up to 80 MW (Renewables Technologies)	5	6.6 MW Hydro/Jamaica Public Service Company Limited	2010
			3.0 MW Wind/ Jamaica Public Service Company Limited	2014
2013	Up to 115 MW (Renewables Technologies)	20	34 MW Wind/ Blue Mountain Renewable Limited.	2016
			24 MW Wind/ Wigton Windfarm Limited.	2016
			20 MW Solar/ WRB Limited	2016
2015	Up to 37 MW (Renewables Technologies)	19	37.0 MW/ Eight Rivers Energy company Limited	2019

Since 2015, no auctions were held under GPE mandate. Nevertheless, GPE must establish new protocols and rules governing critical aspects of procurement to ensure appropriate transparency and continuity to attract the level of investment needed. Therefore, for the analysis of the following sections, the auctions from 2012 and 2015 will be used.

4.3 Call for auction (Review of Process Prior to May 2015)

General

Jamaica did not have an official auctioning program, in such a way that auctions were only called when deemed needed. The responsibility for calling and coordinating the auctions was entitled to the Office of Utilities Regulation (OUR). Although there isn't an auction program in place, auctions are not only called if there is need of new capacity to meet demand, but they may as well be driven by national goals and policies. For example, the National Energy Policy 2009–2030 (NEP) has identified fuel diversification and the development of the country's renewable energy sources as two of its main objectives, and this has driven the two latest auctions carried out in the country. The main reason was the rising oil prices and a desire to reduce Jamaica's high dependence on oil imports. Additionally, Jamaica had set the target to increase renewable participation in the energy matrix to 20% by 2030, as detailed in Section 2.9.1.

In 2015, the Electricity Act (EA2015) was promulgated, and the OUR Act was amended to give it more enforcement powers. In 2016, JPS' All Island Electricity License was re-negotiated. The new License gave JPS the Right Of First Refusal (ROFR), which allows the company to replace its aged generating capacity subject to a GOJ approved retirement schedule and an assessment against the latest Integrated Resource Plan (IRP) developed by the Ministry of Science Energy and Technology (MSET). Should JPS' replacement proposal be deemed to be non-competitive with respect to the market, then the capacity gap caused by the need for retirement shall be filled through competitive bidding.

Auctions are typically exclusive for a set of technologies – usually dividing conventional and renewable technologies in different auctions. Nevertheless, different technologies from the same category may compete among each other. The process starts with the issuing of the Request for proposal, which is followed one month later by a pre-bid meeting. Then, candidates have around five months to submit their proposals. The evaluation process takes three months and then there are six months destined for negotiations on the Project Agreements. All together leads to a total length of almost 1.5 years from the Request for Proposal to the announcement of the winner, which is a very long period when compared with other systems. The commissioning date is set in two different targets, two years ahead for energy only and three years for capacity, counting from the end of the process.

Product and Bids

There are two products offered in the Jamaican energy auctions: energy only and firm capacity with associated energy. For proposals offering energy only, bids must be totally represented on USD /kWh. In terms of the amount, all energy injected into the grid is absorbed by the contract and the project will be accepted on the grid as available. Therefore, the offered tariff shall be based on the proposed capacity of the project and its expected capacity factor. For proposals offering firm capacity, the bid should be divided into a Capacity Price, a Fixed O&M, a Variable O&M and a Renewable Fuel Feed Stock Price. The Capacity price and the Fixed O&M should be in USD/kW-month, while the Variable O&M and the fuel price should be in USD/kWh. The energy portion is based on the Dependable Capacity of the project, expected availability and economic dispatch by JPS.

Regarding indexation, each component of the economic offer is linked to an index. All components, with the exception of the fuel price, are indexed to the exchange rate and O&M components, besides the FX, are also indexed to the US CPI. For the fuel component, the index may vary according to the fuel type. Furthermore, in support of its tariff calculations, the Applicant shall submit a functional electronic copy of a Tariff Model in an Excel spreadsheet. This model should include fixed and variable costs that incorporate the input costs, financing and output assumptions from which the proposed tariffs are derived. The model should also be able to do sensitivities and should be accompanied by user guide. Although the tariff shall be quoted in USD, all payments are made in equivalent Jamaican Dollars.

It is worth mentioning that applicants are permitted to submit more than one proposal, which may be independent or alternatives. In the case of multiple independent proposals, each one shall be submitted separately and shall be evaluated independently of each other. In the case of alternative proposals, the applicant must clearly identify the preferred one.

Furthermore, another relevant matter that merits highlight is that JPS, the sole utility of the electric market, is allowed to submit proposals in response to the RfP, competing with other applicants. This has been raised as a point of concern by other agents, since it may have a competitive advantage over other participants.

Bid submission

The proposals were to be submitted in sealed envelopes or boxes to the OUR office, in Kingston. Applicants may modify or withdraw their proposals after submission, provided that the modification or notice of withdrawal was received in writing by the OUR prior to the deadline for submission of proposals.

Each Applicant shall furnish, as part of its proposal, a Proposal Security in the amount of 1% of the expected total capital cost of the proposed project. In the case of multiple proposals, each one shall be accompanied by the required Proposal Security. Nevertheless, in the case of alternative proposals, the Proposal Security is valued at 1% of the highest total capital cost alternative included in the set. The Proposal Security shall, at the Applicant's option, be in the form of a certified cheque or an unconditional letter of credit issued by a reputable financial institution.

All Proposals, as well as its Proposal Security, shall remain valid for a period of one year from the deadline for submission. Prior to expiry of the proposal's validity period, the OUR may request one or more of the Applicants to extend the validity of their proposal and the Proposal Security for a specified period. Withdrawals before the expiration date will result in the forfeiture of the Proposal Security. It is worth mentioning that this request was pointed out by some agents as the main reason for the lack of offers in the 2013 auction. Nevertheless, this clause was kept in the 37MW auction, called out to fulfil the capacity not acquired in the previous one.

Additionally, all proposals and alternatives must be accompanied by a non-refundable processing fee of USD 8,000. The fee may be payable by certified cheque issued by a reputable bank. However, Applicants whose proposals are disqualified based on the terms governing submission requirements at the proposal opening will be refunded.

Furthermore, one month after issuing the RfP, a Pre-Bid Meeting is carried out in order to answer any questions prospective Applicants may have concerning the RfP. Additional questions are still allowed after the meeting, as long as they are sent up to thirty days before the deadline for Submission of Proposals.

Opening and evaluation of proposals

Right after the end of the deadline for submissions, the OUR opens all proposals. Applicants are invited to attend the event and all persons present shall sign a register evidencing their attendance. For each proposal opened, the OUR announces:

- The name of the Applicant
- Whether there is evidence of payment of the processing fee
- The amount of the Proposal Security
- The proposed generating capacity
- The type of renewable energy technology proposed
- The total project cost

The OUR will evaluate and rank only Proposals determined to be substantially responsive to the requirements of the RfP. During the examination, evaluation and comparison of proposals, the OUR may ask the Applicants for clarifications. Requests for clarifications and responses shall be in writing and no change in the tariff or substance of the proposal shall be sought, offered or permitted by the Applicant.

It is worth mentioning that, acting in its sole discretion, the OUR reserves the right to accept or reject any proposal, as well as not to recommend any Applicant for grant of Licence - then terminating the selection process at any time without thereby incurring any liability. Additionally, after opening of the Proposals, the OUR is not obliged to disclose to Applicants any information relating to the examination, clarification, evaluation and comparison of proposals.

4.4 Demand

The auction demand is centrally defined and is always determined in terms of installed capacity. This is a point that merits attention when engaging in renewable contracts since the energy generated by different technologies vary substantially. In the 115 MW auction, demand was defined in specific tranches for each product; nevertheless, in the 37 MW auction, there was one single demand tranche that could be fulfilled by any of the products.

The offtaker of the contract is JPS, the sector's sole utility who may also be a bidder in the auction. JPS is an integrated electric utility company, engaged in the generation, transmission and distribution of electricity, and also responsible for purchasing power from a number of Independent Power Producers. Most of its shares is owned by two private companies: Marubeni Corporation and Korea East-West Power Company Ltd., each with a 40% share - a minor part (less than 1%) is held by private shareholders. The remaining 19.9% is owned by the Government of Jamaica.

Regarding the credibility of the offtaker, it is tightly linked with the financial health of the company and varies from country to country. For example, utilities can be considered a credible contract counterparty in some countries and not in others. Countrywise, Jamaica's Long-Term Foreign Currency Issuer Default Rating (IDR) is rated at 'B+' by Fitch Ratings. In the company's point of view, CariCRIS grants 'good creditworthiness' ratings to JPS.

4.5 Qualification process

The Jamaican auction design does not involve a prequalification process; rather, the first stage of the project evaluation process involves a strict and long analysis of the bidders' credentials. Along with the proposal, the applicant must submit an extensive list of documents and information, as detailed below:

- Proposal Letter, according to pre-specified form
- An affidavit (a written statement that all information in the proposal is true), according to pre-specified form
- Basic information on the applicant's Organization (name, country, contact information, stockholders, board of directors, etc.), according to pre-specified forms
- Basic information on associated organizations, according to pre-specified forms
- If applicants form a joint venture, a copy of the agreement entered into by the joint venture partners
- Articles of Incorporation and by-laws, or other organizational documents
- Certificate of registration with the relevant companies' registration authority.

- Curriculum Vitae of key personnel who will be responsible for developing, managing and operating the Project
- literature/brochures describing Applicant's facilities and accomplishments and information on technical personnel resources.
- List of similar projects undertaken by the applicant within the last ten (10) years.
- audited "Financial Statements" for the last three years.
- Credit report covering at least three years (this was required only in the 2015 auction)
- All Applicants who are registered or resident in Jamaica are required to submit a tax compliance certificate valid as at the deadline for submission of Proposals
- general description of related projects and operations that the applicant are currently implementing.
- Specific project description and data, including general plant specifications, description and explanation of the technology to be used, major systems and equipment description, availability, capacity factor, efficiencies, and net power output after transformer losses
- Location of site, interconnection arrangement, description of access route to site, evidence of ability to secure use of site and (in the case of the 2015 auction) potential grid impact
- Evidence that the necessary site investigations have been done
- Site ambient conditions and expected impact on plant output
- Technical feasibility study
- Proposed arrangements for supply and installation of facilities, with evidence that there are no impediments to successful delivery and installation of the Facilities
- Plan for use of local labor
- Letters from the service providers/regulatory agencies proving adequate arrangements will be made to secure potable water, sanitary and sewer facilities, and construction power
- Evidence that adequate arrangements have been made to ensure that the necessary inputs for the implementation of the Project will be available and are adequate for the proper implementation.
- Environmental impact report, with evidence that the standards of all relevant regulatory and statutory agencies will be met
- Proposed tariff, splitting into capacity price, fixed o&M price, variable O&M price and renewable fuel feed stock price, according to pre-specified forms
- Cost data in support of tariff (describing development, construction, insurance and other costs), according to pre-specified forms
- Financial data in support of tariff (describing the amounts and sources of equity and debt financing, fees, interest rates, etc.), with letters from the sources of financing and supporting documentation to verify that the sources are capable of meeting the commitments.
- A tariff model for the project in Excel or compatible format, incorporating input costs, financing terms and energy assumptions. The model should be able to do sensitivities and have a user guide
- Detailed breakdown of the construction cost by major components of the project
- Organization chart and resumes of key personnel of the company during pre-construction, construction and operation stages. This should include requirements for operations and maintenance.
- Listing of proposed subcontracts for the major elements of the Project
- Applicant's proposed training program for Jamaican Nationals
- Applicant's proposed Project insurance plan to meet the insurance coverage required under the Project Agreements.
- Equipment experience including past performance data for three (3) continuous years of reliable commercial operation
- Facilities' available designs and drawing, with detailed specifications (manufacturer, model, codes, ratings) for the major systems and equipment
- detailed Project implementation schedule in a functional electronic Gantt chart compatible with Microsoft Project
- Disclosure letter

- For the 2015 auction, it was also required a detailed project interconnection schedule, showing the proposed interconnection configuration, and costs associated. Applicants shall also provide a Dynamic Model and Data of their Plant in an electronic format that is fully compatible and that can be imported into with PTI PSS/E and DIgSILENT PowerFactory power systems software.

It is also important to mention that one of the first points of the qualification process is ensuring that bids respect the price caps. One price cap is established for each technology that is able to participate in the procurement process. Any proposal that presents a price above the cap is immediately disqualified from the process.

Moreover, the applicant must furnish a *proposal security*, in an amount equivalent to 1% of the expected capital cost of the project, for each submitted proposal. In the case of alternative proposals (when the applicant indicates a preferred and alternative proposals), the 1% amount refers to the alternative with highest capital cost. This security can be either in a form of a cheque or an unconditional letter of credit from a reputable financial institution. Proposals must be valid for at least one year, as well as the proposal security.

The proposal security will be returned to the bidder after the evaluation process, unless the applicant withdraws its proposal[21] (during the period it is still valid), if the proposal contains false statements, or if the applicant wins the auction but fails to execute the project agreements or to deposit the *performance security*. The *performance security* is a deposit that winner applicants must furnish once they receive a PPA. It must amount to 5% of the expected capital cost (in the 2015 auction exceptionally, energy only projects could deposit only 1% of the expected capital cost) and be valid until the beginning of construction – when it is replaced by a *construction security*. The OUR will retain the performance security if it identifies any false representation, or failure to comply with the RFP, or with the provisions of project agreements.

After bid reception, there is a pre-qualification phase, in which the OUR determines the responsiveness of the proposals to the requirements of the RFP. The OUR may waive minor deviations in proposals, but material deviations or reservations will lead to the rejection of the proposal. Among the reasons that may disqualify a proposal are:

- Failure to submit proposal and supporting documentation within the required timeframe;
- Failure to submit all forms completed and all information required;
- Material inconsistencies in the information submitted;
- The proposal is not accompanied by the proposal security deposit required;
- The proposal is not valid for an entire year (starting from the deadline for proposals submission);
- The proposal proposes a tariff above price ceilings.

Proposals determined to be substantially responsive but that present arithmetic errors will be corrected by the OUR. All corrections are considered binding on the applicant even when they may affect the comparative ranking on proposals – the applicant may choose between accepting the correction or having its proposal refused.

Not rejected bids will pass to the qualification process, which is done in two stages. In Stage 1, applicant's ability to implement the project is evaluated, considering its (i) experience; (ii) ability to raise financing; (iii) technical capability and qualifications; (iv) ability to implement the project in a timely manner; and (v) ownership of similar installations and/or related technologies and equipment. All these five criteria are further detailed in the RFP and in of this report. The applicant receives a score for each of these five criteria and is approved for Stage 2 if achieves pre-specified target scores.

In Stage 2, a detailed technical evaluation is done for applicants approved in Stage 1. Proposals are given scores for each of the following eight criteria: (i) proposed renewable plant technology; (ii) renewable energy source data and/or arrangement for provision of renewable fuel feed stock; (iii) availability and suitability of proposed site; (iv) design of project facilities; (v) proposed arrangements for construction of project facilities; (vi) proposed arrangements for

[21] If the applicant withdraws its proposal *before* the deadline to submit proposals, then he can still have its proposal security back.

operation and maintenance of facilities; (vii) compliance with environmental and statutory requirements; and (viii) ability to provide services to the grid[22]. All these eight criteria are further detailed in the RFP and in Appendix 1: Stages 1 and 2 Scores. The applicants that achieve pre-specified target scores in Stage 2 are deemed technically feasible and will be then subject to economic comparison in order to select the tender winners, in the so-called Stage 3 (see section 4.5 for a description of the economic comparison process).

The weights given to each of the above criteria for Stages 1 and 2 are shown in Appendix 1: Stages 1 and 2 Scores. It is noteworthy that there were some differences between the tenders held in the 2012 and 2015, mainly in Stage 2. These changes include:

- The 2015 tender reduced the weight given to the "ability to raise financing" criterion in Stage 1. Moreover, it did not distinguish between the ability to provide equity from own sources and from other sources, as had been done in the 2012 tender.
- Starting in 2015, the extent to which plants require network modification to the grid (apart from interconnection modifications for suitable grid operation) passed to negatively affect the score for "availability and suitability of proposed site", in Stage 2, with high weight.
- Weight given for local content (that affects both "arrangements for construction" and "arrangements for operation and maintenance" criteria in Stage 2) was reduced by more than half.
- The 2015 tender started evaluating the project's "ability to provide services to the grid" in Stage 2.
- The weight given to the "proposed renewable plant technology" criterion in Stage 2 reduced significantly, mainly because of the removal of the sub-criterion "proposals offering firm capacity must be dispatchable and meet a minimum capacity factor 60%". Instead, the 2015 auction simply imposed that firm capacity proposals guaranteed an availability of at least 90% for being approved already in Stage 1 (without no scores being given to this criterion).

Both tenders adopted the same target scores. Regarding targets for Stage 1, proposals needed to achieve a minimum of 50% of the total score, and a minimum of 60% in the "ability to finance project" category for being approved to Stage 2. Additionally, the 2015 tender required that proposals for firm energy had a 90% availability, as described above. In Stage 2, both tenders required that proposals achieved at least 50% of the maximum score for each of the eight criteria, and a 60% overall score.

4.6 Winner selection process

The winner selection process concerns the rules and criteria to translate bid information (and mainly the prices contained in it) into a decision on which bidders will receive PPAs. In the context of Jamaican auctions, it is possible to identify the winner selection process with the Stage 3 of the evaluation process (called "economic evaluation of project"). The RFPs state that the proposals approved in stages 1 and 2 that result in the least cost to consumers are selected as winners. To calculate these costs, many factors are considered, such as grid impact[23], expected plant output parameters, plant availability and proposed tariffs. However, it is not clear in the RFP how exactly these parameters are considered (there are no explicit formulas, and no description of the calculations needed). The RFP from the 2012 auction informs that proposals with firm capacity will be given priority and ranked highest, but also does not specify what kind of priority will be given.

There is also no mention to the problem of handling non-divisibility, that is how the "marginal bid" should be handled in case its acceptance would cause to surpass the total requested demand. For example, if in the latest auction

[22] The "ability to provide services to the grid" criterion was considered only in the 2015 auction (that procured 37 MW). Moreover, this auction evaluated the "compliance with environmental and statutory requirements" criterion in a yes/no basis, instead of attributing a score, as done in the 2012 auction (that procured 115 MW). For more details, see Appendix 1: Stages 1 and 2 Scores.

[23] Grid impact was included as a factor in stage 3 only in 2015 tender. The RFP indicates only that this evaluation uses PTI PSS/E and DIgSILENT PowerFactory *softwares*, with input data (plant models) sent directly by the applicants in their proposal.

demanding 37MW of capacity the cheapest bids were two 20 MW projects that would be the best option for the system. The documents do not specify what happens in such a scenario. Some alternatives are (i) accepting both bids in totality with a total contracting of 40 MW (higher than the original demand), (ii) contracting only 17 MW of the second-best bid (to ensure the demand is met exactly, (iii) initiate negotiations with bidders. It is also worth mentioning that the possibility of alternative bids may help in these cases, but still a complicated situation may happen.

Final winners are awarded in a pay-as-bid manner. That is, the tariff included in the PPA to be signed between the winner and the grid operator is equal to the tariff proposed in the winner's bids. Although this implementation seems intuitive, there are implications regarding bidders' behavior: bidders will not seek simply to win the auction, but rather to win it while submitting the highest possible bid, as this will increase its revenue during the plant's operation. Thus, they will try to estimate the tariff other bidders will propose and submit bid prices marginally lower than these estimations (provided this value is still enough to support the plants' lifetime costs and provide sufficient returns to stakeholders). There are some alternative designs (namely, *marginal pricing schemes*) in which bids are less dependent on other bids' estimation and may be more coherent with real plant's costs.

4.7 PPA design and Ensuring performance

The contract has a main body of 19 articles and 10 Schedules that contemplate mainly: (a) technical, logistical and operational items between the Parties; (b) Operations Log that the Company has to comply with; (c) indexation and adjustment of economics issues under the contract. The Parties under this contract is JPS (as a Buyer) and the Company (as a Seller). The following sections explains how the principal terms in the contract are regulated.

4.7.1 Contract duration and indexation

The initial term of this Agreement is for 20 years. Nevertheless, it may be extended for an additional period (not specify) and on terms and conditions mutually agreeable by the Parties, subject to the evaluation and approval of the OUR.

Clause 9 (compensation, payment and billing) establishes the payment mechanisms can be in US Dollars or Jamaican Dollars. All prices, charges and amounts are in US Dollars, however, JPS may make payments in equivalent Jamaican Dollars by applying the Acting Exchange Rate as defined in Schedule 1 of the Agreement.

Schedule 6 (Indexation and Adjustment) defines the principles of indexation and adjustment of the payments and other monetary values in the Agreement.

Section 1.2 of this Schedule are established the adjustment for liquidated damages for Delay in Commissioning, and Section 1.3. the adjustment for the Security Deposits to be performed by the Company (Construction Security Deposit, 1% Capital Cost of Project).

It is specified that the Company shall be solely responsible for maintaining the adjusted level of this Security Deposit, and the payments by JPS to the Company shall not be adjusted to support this obligation.

4.7.2 Settlements

Under clause 17, the Company may not assign or transfer its rights or obligations under the Agreement or discharge any of the facilities necessary for the Energy Plant to meet the net energy output without the prior written consent of JPS.

JPS may not assign or transfer its rights or obligations under the Agreement without the prior written consent of the Company and the approval of the OUR.

Nevertheless, the Company for the purpose of financing the construction, operation and maintenance of the Project, may assign or create security over its rights and interests under the Agreement for the benefit of the Lenders, without the prior consent of JPS (Granting of Security).

4.7.3 Delay penalties

Clause 9.4 (Liquidated Damages for Delays in Commissioning the Facility) is established a penalty to the Company for this delay of Two Hundred and Thirty Dollars ($230.00) (or the Jamaican Dollar equivalent) per kW for each Day or part thereof, provided that the cumulative amount of such payments shall not exceed the Construction Security Deposit (1% Capital Cost of Project). These payments shall be liquidated damages for the detrimental impact of such delay. As a mentioned, the adjustment for these penalties is in Schedule 9.

4.7.4 Contract cancellation

The Agreement establishes specific causes of termination by both Parties. Below are highlighted some of the key causes of default:

Company Events of Default: i) failure to begin construction after One Hundred and Eighty (180) days after signing of this Agreement; ii) abandonment of the construction of the Project without the written consent of JPS; iii) failure to achieve Commercial Operations Date within one (1) Year after the Scheduled Commercial Operations Date.

JPS' Events of Default: i) the passing of a resolution by the shareholders of JPS for the winding up of JPS; ii) the admission in writing by JPS of its inability generally to pay its debts as they become due; iii) the appointment of a provisional manager, trustee or Liquidator in a proceeding for the winding up of JPS, after notice to JPS and due hearing; or iv) the making by the Court of an order winding up JPS.

The contract also establishes remediation periods whereby the defaulting Party shall have ten (10) Business Days within which to cure the Event of Default, accompanied by weekly progress reports on curing the Event of Default.

4.8 Conclusions

Overall, the procurement process is very long and bureaucratic. Furthermore, the auction documents are a little vague and miss some specifications, which may lead to some insecurity of potential bidders. In terms of the contract, the following is concluded and recommended:

(1) The Agreement is highly regulated in technical, operational and logistical matters (Schedules 4, 5, 7 and 10). This could be because this PPA was done before the Codes of 2016 were implemented (Generation, Transmission, Distribution, Dispatch and Supply). In order to simplify it is recommended to make references of these issues in the main body of the PPA to the provisions of the Codes.
(2) The Agreement does not establish a technology change mechanism. Perhaps this is due to the project, from the time is awarded until the start of its construction, having to be approved by JPS. However, it is recommended to provide an update mechanism due to technology changes during the terms of the contract.
(3) There are many provisions in the Agreement of Company's obligation to inform the JPS related to the construction progress of the Power Plant, including a copy of the EPC contract. In order to simplify these controls, it is recommended to establish an Annex or Schedule, with the critical milestones and leave its compliance supervision to JPS, establishing the penalties for delays. In this way, the Company will have flexibility in the execution of the Project, focusing their efforts on the fulfillment of each milestone.
(4) The Agreement should clearly and specifically address what happens to net energy generation above the contracted energy, which is not foreseen in this version.
(5) The Agreement provides dispatch priority and establishes that JPS cannot reduce or curtail the amount of electricity from the facility for any reason during the term of the agreement, except in specific cases provided in the contract. Does not specify the treatment in case of curtailment.
(6) Adjustments should be made to make the contract more attractive in terms of bankability.
(7) As a final comment, it is important to clarify the treatment of contracting under the ROFR, before launching an RfP to make the process more competitive.

5 IDENTIFICATION OF GAPS AND RISK MATRIX

The table below shows the main gaps and risks identified in the current Jamaican power sector framework that may impact auction design and results. The first column (red flag/point of concern) shows the risk/gap category. Each category may be divided into topics, which are described in the second column (description). The column "likelihood" indicates the probability that each risk impacts the results of the tenders (for example, by reducing auction participation, raising bid prices, or changing bidders' strategies), while the fourth column measures the size of this impact. Both "likelihood" and "impact" columns are classified as low, medium, and high. The last column ("mitigation") provides some alternatives to reduce the impact and/or likelihood of each risk. It is worth mentioning that many of these recommendations are not in the scope of this project and should be evaluated in future works, if Jamaican authorities find them adequate.

Red Flag/Point of concern	Description	Likelihood	Impact	Mitigation
Energy Transition planning and monitoring	For an energy transition towards an economy based on low or zero content of CO2 sources, countries usually develop a long-term plan. As RES is an essential element of this kind of plans. Its variability makes indispensable to take into consideration different elements and perspectives. For instance, the assessment to consider storage techniques, interconnections, other generation technologies as natural gas, energy transition policy that shapes generation plan and demand forecast activities.	Medium	High	Develop a clear and unique strategy of progressive involvement of all public and private sectors in a common national project. The last Integrated Energy Plan (2021) illustrates the recommended tools and steps to be taken towards a scenario-based-strategic document that the GoJ should undertake and iterate to define a solid energy plan, maintain a high governance and follow-up of such plan and give maximum legal and temporal stability of the country energy transition.
Network Planning	*RES integration* • The larger the variability of RES is, more difficult is to integrate them, since larger amounts of reserves are needed to compensate such variability. • The larger the amount of spare capacity in conventional power plants, the easier to integrate significant amounts of RES. • The architecture and available capacity of the transmission system makes additional generation to be properly dispatched to compensate their variability.	Medium	High	• JPS to conduct a detailed RES integration study to evaluate the maximum amount of wind and solar PV generation that can be securely incorporated into the system, in the short, medium and long range; • Determine the most critical aspects (parameters) which are limiting (or expected to limit) the amount of RES to connect and propose methods for eliminating them; • Also, performing a cost-benefit analysis.
	RES variability	High	Medium	• Ensure adequate amounts of reserve (and reserve types) to be incorporated into the

Red Flag/Point of concern	Description	Likelihood	Impact	Mitigation
	It is impossible to completely control the production of VRE generation. The primary resources (wind or sun) vary (pseudo)randomly with time, and it is not possible to generate above their availability at each moment. Currently, as reported by JPS, the Jamaican system has limited low voltage ride through capabilities, in terms of plants that could cope with a low voltage fault. A proven issue for system in which renewable power plants, such as photovoltaic power plants or wind farms, does not have these capabilities.			system and production to be properly and accurately forecasted. • List recommendations in relation to the investments that should be carried out to mitigate RES variability. • Batteries deployment could help mitigate variability and may act as transmission investment deferral. • Consider as part of the future procurement strategy batteries deployment as hybrid solution or stand-alone projects (acting as power grid assets).
	Transmission network planning With high-RES integration, JPS transmission planning exercises should be carried out considering a network capable of absorbing large amounts of variable renewable sources. With the need of planning a network capable to securely supply the load, connecting the generation that is expected to be installed according to the indicative generation expansion plan. Dis-alignment between policy plan and transmission network expansion plan, both in terms of capacity and timeframe, could lead to develop a network that is not capable of accommodating the amount of RES expected by the central government.	Medium	High	• Develop a transmission plan aligned, as much as possible, with the policy guidelines issued by key institutions as the Regulator or the central Government. • Generation and transmission plan to have the same timeframe of 10 years aligned with the Government objectives and policy directions
	RES control The approach used to control RES generation is very important in integrating high stake of RES and may take different forms. This mainly depends on the characteristics of the involved systems and the particularities of the facilities to be controlled in	Low	Medium	Shape the Grid Code to higher penetration of VRE (mostly wind and solar), in regard to control and curtailment of these resources. Different methodologies should be investigated regarding centralized and decentralized control, as well as tele-control.

Red Flag/Point of concern	Description	Likelihood	Impact	Mitigation
	the present and under the future development plans.			
	Auctioned product The auction products and system planning do not seem to be closely linked.	High	Medium	• The auction demand and amounts to be contracted of each product (energy and firm capacity) should be determined according to the aforementioned studies. • Define different tranches of demand for each product and in a unit compatible with the product – for example, define the energy demand in MWh.
Single buyer	*Vertically Integrated Market* The Jamaican energy landscape is dominated by the Jamaica Public Service Company (JPSCo), which has a dominant role in generation and monopoly on transmission and distribution and is also the single buyer and system operator. Furthermore, JPS is not barred from participation in the generation market, which can lead to conflict of interests.	High	High	Create rules within the RfP that mitigate JPS conflicts of interest, giving investors' confidence. These rules will emerge during the consulting process.
	Financial Health Credit worthiness of the Single Buyer (who is also the off taker of the auction contract).	Medium	High	Create a robust system of guarantees that protects private IPPs in case the Single Buyer does not meet their offtaker or payment obligations.
	ROFR Clause A right of the Single Buyer that may be perceived by the private sector as a privilege to JPS in detriment of private IPPs.	Medium	Low	• Consider changes to the ROFR clause. • Consider integrating JPS's choice on whether to make the replacements into the auction process itself (this should be explicit in the legislation).
Auction design	*Revision process of RFP* The RFP should be understandable and clear for all potential bidders, even foreign companies. There were many imprecisions and even mistakes in the auction documents (for example, the weights of the evaluation criteria were revised in later addendums).	Medium	Low	More thorough internal revision process before releasing the first version of the RFP.

Red Flag/Point of concern	Description	Likelihood	Impact	Mitigation
	Project evaluation and qualification Complex and very long process for evaluating bids and need for many qualification documents and guarantees.	High	Low	• Simplify the evaluation process, but keeping the key parameters needed to ensure the quality of the development of the project. • Streamline qualification process so the evaluation can take place faster.
	Economic evaluation The auction documents make explicit that the project that implies in the minimal cost for the system will be selected. However, it does not specify explicitly how cost and different products, amounts of energy and generation profiles are taken into account.	High	Medium	• Detail how projects are compared, writing down formulas explicitly and illustrating with examples. • Generation profiles and capacity factors should be taken into account in the evaluation process. • Detail how variable costs are converted to an estimated total amount, if the indexes used are forecasted, etc. • Detail explicitly the role of grid integration costs in bid ranking.
	Handling of non-divisibility The document does not describe what is done in case the marginal project offers a greater amount of capacity than requested. Offer guarantee The rfp establishes a bid guarantee of 1% of the value of the project that must be sustained until the award, which has sometimes taken up to a year with a high financial cost for the bidder.	High High	High High	It is very important to define how the marginal project is defined and what happens in case it is bigger than the total amount needed for the system. Projects may specify up to what percentage they may be reduced. Demand may also have a margin of flexibility. Establish a fixed value of dollars per MWh of the offered project, optimizing the process to award the project.
PPA	*Settlements and penalties* The auction design does not describe what happens in case of lower or greater generation or capacity than specified in the auction. Also, the PPA does not address what happens in case of curtailments	Medium	Medium	• The RFP should specify (with values and/or formulas) penalties and settlements that may apply in case of differences between the offered and the delivered capacity and generation. • Although curtailments may not be a relevant matter nowadays, all long-term contracts should already

Red Flag/Point of concern	Description	Likelihood	Impact	Mitigation
				define implications of such events in energy contracts.
Access to Land	*Lack of information regarding the availability of land where the renewable resource is available and does not compete with other uses of the land.*	High	High	Guarantee investors access to land during the PPA terms, in Sites where there are RE resource and grid connection. According to the strategic objective of National Land Agency (2021-2025), the development of the National Digital Cadastral Map is a priority of the Agency. Makes available to the potential investor access to this National Digital Cadastral Map by regions with their respective private and public owners, and facilitate the necessary paperwork of right of way.

6 CONCLUSIONS

The Government of Jamaica future plans are attributing high importance to the provision of energy from renewable energy sources, to diversify the current energy matrix, reduce the use of fossil fuel resources and reduce greenhouse gas emissions. In this context, the supply of electricity from renewable energy sources has a key role. The IRP goal is to increase, by 2037, solar or wind generation capacity by 1,270 MW, to increase liquefied natural gas generation capacity by 330 MW and biomass or hydrogen-based sources as waste materials by 74MW.

The phase of renewable energy exponential growth in Jamaica is requiring regulatory and administrative changes if Jamaica wishes to use its full potential and accelerate the deployment in support of climate goals.

The Electricity Act of 2015 organizes the electricity sector, assigning roles and responsibilities for the Government Authorities, which is appropriate for the implementation of the regulatory framework.

Any necessary adjustments for a new renewable capacity building program can be made through specific ad-hoc regulations, in line with the IRP and the potential requirements of the electrical system.

Because the structure of the Jamaican electricity sector has a vertical integration of companies and is highly compressed, is vital to prevent conflicts of interest that may be perceived by future investors for the new RE capacity to be contracted. This could be mitigated in the new RE capacity procurement.

In addition, it is necessary to define how the ROFR clause will play out for the replacement of the existing capacity, when the currents RE IPP contracts expire, as well as for the new capacity that is planned to be contracted in the future.

From the electricity generation point of view, the Jamaica's electricity supply system is characterized by a recently refurbished hydro generation assets with high-capacity factors (above 75%) that could allow a higher penetration of intermittent sources of energy as wind and solar PV. However, the system has limited low voltage ride through capabilities, in terms of plants that could cope with a low voltage fault. A key issue when dealing with increasing VRE generation capacity.

From a network operation and planning point of view, the requirements incorporated into the Jamaican Generation, Transmission and Distribution Codes, for wind and solar PV generators are considered, in general, appropriate and substantially aligned with the prescriptions contained into the codes of those countries with important VRE penetration.

It should be mentioned however, that the prescriptions included in the codes, in the future, should be classified by generator and by capacity of the plant connected to the system once the amount of VRE increases. Also, grid codes must be shaped in regard to control and curtailment of VRE resources.

It is recommended to consider in the future the possibility to operate generation facilities in synchronous mode. Considering however, BESS technology as a more successful option than the synchronous machines for primary reserves and FCR control.

Batteries deployment could help mitigate variability and may act as transmission investment deferral. Jamaica has to consider, as part of the future procurement strategy, batteries deployment as hybrid solution or stand-alone projects (acting as power grid assets).

Finally, actions on smart-grids, storage techniques and network development must be planned in a coordinated way to avoid future problems. An assessment of the electricity market design, and transmission and distribution system planning and operation in view of increased VRE integration is also suggested.

The actual procurement process is considered very long and bureaucratic. Furthermore, the auction documents are a little vague and miss some specifications, which may lead to some insecurity of potential bidders. In terms of the contract, the following is concluded and recommended:

(1) The Agreement is highly regulated in technical, operational and logistical matters (Schedules 4, 5, 7 and 10). This could be because this PPA was done before the Codes of 2016 were implemented (Generation, Transmission, Distribution, Dispatch and Supply). In order to simplify it is recommended to make references of these issues in the main body of the PPA to the provisions of the Codes.

(2) The Agreement does not establish a technology change mechanism. Perhaps this is due to the project, from the time is awarded until the start of its construction, having to be approved by JPS. However, it is recommended to provide an update mechanism due to technology changes during the terms of the contract.
(3) There are many provisions in the Agreement of Company's obligation to inform the JPS related to the construction progress of the Power Plant, including a copy of the EPC contract. In order to simplify these controls, it is recommended to establish an Annex or Schedule, with the critical milestones and leave its compliance supervision to JPS, establishing the penalties for delays. In this way, the Company will have flexibility in the execution of the Project, focusing their efforts on the fulfillment of each milestone.
(4) The Agreement should clearly and specifically address what happens to net energy generation above the contracted energy, which is not foreseen in this version.
(5) The Agreement provides dispatch priority and establishes that JPS cannot reduce or curtail the amount of electricity from the facility for any reason during the term of the agreement, except in specific cases provided in the contract. Does not specify the treatment in case of curtailment.
(6) Adjustments should be made to make the contract more attractive in terms of bankability.

As a final comment, it is important to clarify the treatment of contracting under the ROFR, before launching an RfP to make the process more competitive

APPENDIX 1: STAGES 1 AND 2 SCORES

The tables below show the scores given to each criterion in Stages 1 (evaluation of applicant's ability to implement project) and 2 (technical evaluation of project) of the proposals' evaluation process, for both the auctions held in 2012 and 2015.

Stage 1: Applicant's ability to implement project		
Criteria	**2012 auction (115 MW)**	**2015 auction (37 MW)**
Experience	**20%**	**20%**
a) Scale of operations in power generation projects	5%	5%
b) Scope of activities in the development of power generation projects[1]	5%	5%
c) Track record of successfully developing and operating renewable based power generation projects[1]	5%	5%
d) Period of involvement in Scale at a. and Scope at b. above	5%	5%
Ability to Finance Project	**40%**	**35%**
a) Audited financial statements and other supporting data and information for the last three years will be analyzed to determine the financial condition, performance and capability of each Applicant and its associated entities	5%	5%
b) Credit report and capacity to borrow funds	20%	10%
c) Provision of a financial model that shows the relationships between inputs and outputs of the proposal	0%	10%
d) Ability to provide equity[2]	15%	10%
Technical Capability and Qualifications of Key Persons Employed or to be Contracted by Applicant	**20%**	**20%**
a) Competence of key personnel (as evidenced by CVs)	4%	10%
b) Indicated use and/or development of local labour throughout project implementation	6%	2%
c) Existing systems for management of engineering, construction and operations & maintenance of proposed facilities	5%	3%
d) Experience with existing technologies in renewable based power generation	5%	5%
Ability to Implement the Project in a Timely Manner	**10%**	**15%**
Evidence of existing and workable plans and designs for the proposed or similar facilities using the renewable technology on which the proposal is based	10%	15%
Current Ownership of similar installations and/or related renewable technologies and equipment	**10%**	**10%**

[1] The RFP for the 2015 tender added the following at the end: "[…] in the region or places similar to Jamaica".

[2] The 2012 auction scored separately the ability to provide equity from own sources (10%) and from other sources (5%).

Stage 2: Technical Evaluation

Criteria	2012 auction (115 MW)	2015 auction (37 MW)
Proposed Renewable Plant Technology	**20%**	**8%**
a) Years of successful commercial use of proposed renewable technology	5%	6%
b) Applicable current developments which would enhance feasibility of technology	5%	2%
c) Proposals offering Firm Capacity must be dispatchable and meet a minimum capacity factor 60%.	10%	0%
Renewable energy source data and/or arrangement for provision of renewable fuel feed stock	**20%**	**25%**
a1) No. of years of investment/bankable grade data including seasonal, daily, and hourly information	15%	10%
b1) Ability to forecast plant availability	5%	15%
OR		
a2) Agreement for the continuous supply of renewable energy fuel feed stock	20%	25%
Availability and suitability of site	**15%**	**25%**
a) Suitability of proposed site	5%	2.5%
b) Demonstrated ability to secure proposed site	5%	2.5%
c) Ease of interconnection	5%	5%
d) Extent to which Plant will not require network modification to the Grid apart from interconnection modifications for suitable Grid operation	0%	15%
Design of Project Facilities	**10%**	**12%**
a) Suitability of proposed design	5%	10%
b) Commercial experience of similar designs	5%	2%
Arrangements for construction	**15%**	**10%**
a) Proposed arrangements for construction of facilities	4%	5%
b) Experience of proposed supply/construction /installation Contractor(s)	6%	3%
c) Local labour content in project	5%	2%
Arrangements for operation and maintenance	**15%**	**10%**
a) Proposed arrangements for operation and maintenance of facilities	4%	5%
b) Experience of proposed O&M contractor/personnel	6%	3%
c) Local personnel retained	5%	2%
Compliance with environmental and statutory requirements	**5%**	**Yes/No[2]**
a) Proposed regulatory and statutory compliance as per exhibit	5%	
Ability to provide services to the grid	**0%**	**10%**
Ability to provide Grid support in the areas of voltage and frequency control	0%	10%

[2] The compliance with environmental and statutory requirements was not scored in the 2015 auction but evaluated on a base on a yes/no criteria.

APPENDIX 2: POWER SYSTEM CHALLENGES OF ISLANDS AND ISOLATED SYSTEMS WITH HIGH SHARES OF VARIABLE RES[24]

Achieving decarbonisation targets requires the integration of vast amounts of variable renewable energy which increases the complexity of operating an electricity system that has been designed for alternating current and synchronous generation. Islands today find themselves at the forefront of the energy transition, as they have seen rapid increases in variable renewable generation but have no or fewer interconnections to help cope with the associated challenges. This is why they serve as a useful 'test bed' for possible solutions, which can be highly instructive for interconnected energy systems preparing to integrate very high shares of variable renewables in the coming decades.

The cost to operate the system has increased over the last years and this trend is unlikely to change unless technologies such as energy storage are used to their maximum potential. Energy storage can provide a solution to the main challenges posed by the integration of variable renewable energy. It is crucial that the products designed to address these needs can be stacked and that regional needs are properly evaluated and communicated to the market.

To fulfil aspirations of high variable RES penetration and decarbonisation, most power systems will have to deal with operational limitations that can prevent large amounts of non-synchronous generation from being integrated into the energy mix at any given time. These limitations have already been identified by grid operators in islands in Europe, e.g., in Ireland, the UK, French overseas islands, and the Canary Islands; as well as overseas, e.g., in Australia and Texas (isolated system), and these cases are similar to what is found in Jamaica.

Island systems tend to have limited to no interconnections, islands have to rely more on other flexibility options to ensure the secure and cost-efficient operation of their energy system: flexible thermal generation, demand-response, and energy storage. Indeed, islands have seen some of the first commercial deployments of energy storage systems, due to a clear business case.

The table below presents an overview of the challenges faced by islands and isolated system when integrating a high share of variable RES, consequences imposed by these, their effects, how energy storage can help solve or alleviate their negative effects and current routes to market for the delivery of these services. As can be seen, storage has a key role to play in ensuring the operation of the system is cost effective by addressing systematic issues.

[24] EASE, Study on Power System Challenges of Islands and Isolated Systems with High Shares of Variable Renewables. Brussels, March 2020.

Challenge	Consequence	Effect	Storage's Role	Route to Market
Decreasing levels of synchronous generation	Reduction in the level of synchronous inertia and system stability	• Greater rate of charge of frequency (RoCoF) increasing risk of load shedding, embedded generation tripping and system collapse • Renewable curtailment to ensure regional system stability, increasing cost to operate the system • Increased risk of system split	• Synchronous storage technologies increase synchronous inertia levels • Non-synchronous storage provides synthetic inertia	• Stability product for grid services (e.g., Network Development Roadmap in the UK) • Grid services market for static and dynamic reactive power • Enhanced frequency (balancing services). • Dispatch of synchronous generation to real time to secure service availability (risk of energy market distortions)
	Reduction in sources of reactive power	• Increase in transmission losses. • Triggers frequency disturbances as a result of changes in power flows • Reduce ability to maintain statutory voltage limits	• Storage can act as a dynamic reactive power source	
	Reduction on the level of Fast Fault Current infeed	• Affects the ability of network protection equipment to detect and clear network faults • Non-synchronous generation operates with a higher risk of instability	• Synchronous storage provides fast fault current infeed (aka Short Circuit Level), Voltage Regulation	
Increase in distribution connected generation and changes in demand patterns	Large swings in power angles following a network disturbance.	• Triggers frequency disturbances as a result of changes in power flows • Affects the ability of power system protection to detect and clear a network fault	• Storage can act as a dynamic reactive power source • Synchronous storage technologies can increase synchronous inertia levels	• Stability product for grid services (e.g., Network Development Roadmap in the UK) • Grid service market for static and dynamic reactive power.
	Regional excess renewable generation due to network constraints	• Systemic curtailment of low carbon energy compensated through balancing actions, increasing the cost to operate the system	• In the exporting side of a congested boundary storage can absorb excess energy • In the importing side of a congested boundary storage can operate as replacing reserve	• Grid service market for constraint management (e.g., Project of common interest) • Active Network Management Unit • Demand turns up
	Regional excess renewable generation due to low system demand.			
Commitment patterns of conventional plant strongly affected by both system load and amount of renewable generation	Impacts security of supply by affecting state of readiness of plant providing black start services	• Increase the risk of unavailability for black state response • Increase black start services cost. Conventional plants are kept online or warm using real time and balancing markets to ensure service availability	• Storage with sufficient duration can provide black start services • Storage with shorter duration can provide the service when aggregated with other resources.	• Grid service market (e.g., Standalone Black Start, Distributed Restoration – Black Start from DER)