

2023 Integrated Resource Plan Proposal Summary

Introduction

The Electricity Act 2016 (**EA**), as amended, requires the Regulatory Authority (**RA**) of Bermuda to request an Integrated Resource Plan (**IRP**) proposal from Bermuda Electric Light Company Limited (**BELCO**) as the Transmission, Distribution, and Retail (**TD&R**) Licensee at least every five years. As such, the RA gave notice to the TD&R Licensee to prepare the 2023 IRP Proposal on 17 November 2022 (the **RA Notice**).¹ This document is a short summary of the full 2023 IRP Proposal for Bermuda (the **2023 IRP Proposal**) that provides further technical and economic details.

The TD&R Licensee prepared the 2023 IRP Proposal in line with the RA Notice, aiming to update the island's energy plan. The plan identifies a roadmap for Bermuda to meet future energy supply and demand requirements while aligning with legislative, regulatory, and policy goals and transitioning towards a more affordable, reliable, and sustainable energy future.

Bermuda has sufficient renewable energy resources, such as solar, wind and wave energy, to contribute to the energy mix. However, these technologies must be proven to work for Bermuda, and they must be invested in at the correct time to minimize the long-term costs to society. The 2023 IRP Proposal identifies the road map that best meets Bermuda's future energy needs.

Objectives of the 2023 IRP Proposal

In line with the RA Notice and EA, a key objective of the 2023 IRP Proposal is to determine the lowest cost portfolio, subject to trade-offs such as reliability and sustainability. The 2023 IRP Proposal assesses many portfolios that include various resource mixes while maintaining system reliability. The objectives within the 2023 IRP Proposal were developed specifically for Bermuda from the applicable legislative, policy and regulatory framework, and include customer affordability, rate stability, environmental stewardship, resource adequacy, resource diversity, minimization of curtailment, and land use.

Bermuda's Electricity System

BELCO serves approximately 36,000 customers and is the island's primary electricity provider. The island's grid relies on 135 miles of transmission and 665 miles of distribution network to deliver energy to the people of Bermuda. Currently, the majority of electricity is generated by fuel oil, making the supply reliable but also vulnerable to global fuel prices and carbon emissions.

Portfolio Options and Modelling

Bermuda requires a reliable supply of energy that meets demand but is generated from more sustainable sources. Renewable energy technology makes use of variable solar, wind, and wave resources to generate low-cost, low-carbon electricity. However, the variable nature of the weather requires energy storage and dispatchable generation to maintain the reliable supply of power. Often technologies are compared by the levelized cost of energy, a financial measure used to compare

¹ <https://www.ra.bm/legal-documents/integrated-resource-plan-proposal-request-2022>

the lifetime costs of generating electricity across various generation technologies, but such analysis does not consider the ability to meet demand when renewable sources are not available, nor the cost of the system required to provide a reliable supply of electricity. Therefore, different technologies must be considered holistically at a system level as it is not prudent to evaluate a single technology in isolation.

Solar energy is one of the most prominent renewable energy sources and has the lowest levelized cost of energy. Solar energy is susceptible to seasonal, daily, and momentary variations in sunshine. Seasonally, winter brings reduced daylight hours and a lower elevation of the sun, which reduces solar power output. Momentary cloud cover can lead to short periods of low output, followed by rapid ramps to return to full output. Such variability in generation requires other resources to smooth out the energy supply. To help in comparing the energy produced by different generators (including renewables), a capacity factor is used as a measure of actual energy output as a percentage of rated capacity output.

For bulk solar energy, the capacity factor is approximately 18%, or in other words, a 100MW solar farm outputs, on average, 18MW based on the available sunshine, ignoring any maintenance downtime. In comparison, a diesel plant could have a capacity factor of about 90%, including maintenance requirements.

The capacity factor of offshore wind energy is approximately 42%, as it is less variable than solar energy and is therefore more predictable. Wind energy is a smoother and delayed function of the sun's energy that heats and cools the earth causing wind to flow. However, there are consecutive days throughout the year when the wind speed is too low to contribute to our energy demand.

The wind flows across the oceans and generates waves that are more predictable and less variable than wind or solar energy. However, the oceans are harsh on the technology required to generate electricity, therefore the equipment cost is high when compared to solar and wind. Wave energy has been developed for almost half a century but requires further research funding and development protocols to ensure commercial and technical viability.

From this menu of renewable energy resources for Bermuda, the 2023 IRP Proposal sought to determine a low-cost, sustainable energy mix that meets the island's reliability needs. Energy, capacity, and grid stability are key considerations to adopting variable renewable energy on the grid.

From a stability perspective, the grid technology to mitigate these variable systems is still developing. From an energy capacity perspective, these systems all require storage technology to shift energy so that generation can match demand at the time needed. These storage systems require gradual growth in size to provide increased services in line with amount of renewable energy installed. The key is to combine these systems in a diverse energy mix that requires less storage and less cost, as sometimes the sun shines when the wind is low, and sometimes the wind blows after the sun has set.

The 2023 IRP Proposal evaluates 11 portfolios based on different fuel strategies and renewable energy targets, analysing pathways to a balanced energy mix. These portfolios explore technology such as onshore solar, floating solar, wave energy, wind energy, biomass, energy storage, and new fuel strategies for existing thermal plants. The modelling software analyses many iterations to identify the energy mix that most likely meets the island's future energy demand, subject to certain resource and

system constraints. The software considers external factors such as fuel costs, inflation, the social cost of carbon (a measure of the societal costs of emitting carbon dioxide), and other variables to determine a portfolio/plan that minimises cost and risk. Every plan is then tested against different future scenarios that determine how robust the plan is at meeting the needs of a changing landscape.

Third-Party Review

Professor Aristides E. Kiprakis, Senior Member of the Institute of Electrical and Electronics Engineers (**SMIEEE**), Member of the Institution of Engineering and Technology (**MIET**), and Chair of Agile Energy Systems at the Institute for Energy Systems within the University of Edinburgh, carried out a third-party review of the IRP Proposal for Bermuda. The review found that the 2023 IRP Proposal is reasonable and in line with international best practice. The review concluded that the analysis includes all the major system components and variables. The review found that the modelling process was appropriate and complete for a long-term development plan, considering the size and special characteristics of Bermuda's energy system. The selection of input data and assumptions were also determined to be reasonable. The review found that the simulations offered adequate granularity of results, in agreement with the international experience. The review also stated that the IRP Proposal is fit for purpose and that the selected portfolio is the best compromise between sustainability and affordability for Bermuda, considering all the societal and technoeconomic constraints while minimising risk.

Black & Veatch, a consulting firm with expertise in sustainable infrastructure, reviewed the supply-side resource cost and performance characteristics, generally finding them to appear to be reasonable, and in line with their in-house database of similar projects.

Stakeholders

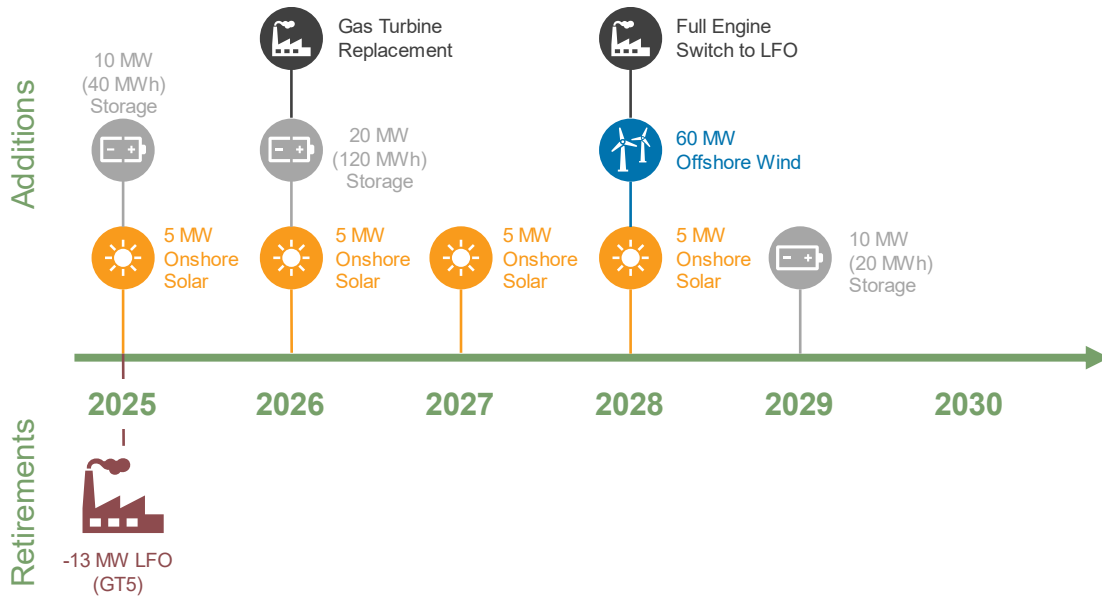
During the 2023 IRP Proposal process, BELCO engaged with several local stakeholders, including renewable energy advocates, and project developers. Through this process, BELCO received feedback on its draft input assumptions, which was then incorporated into the 2023 IRP Proposal.

Preferred Portfolio

The preferred plan identified in the 2023 IRP Proposal is the one that strikes the best balance between reliability, affordability, and sustainability while meeting renewable energy targets and is resilient to changes in the economic landscape of the future.

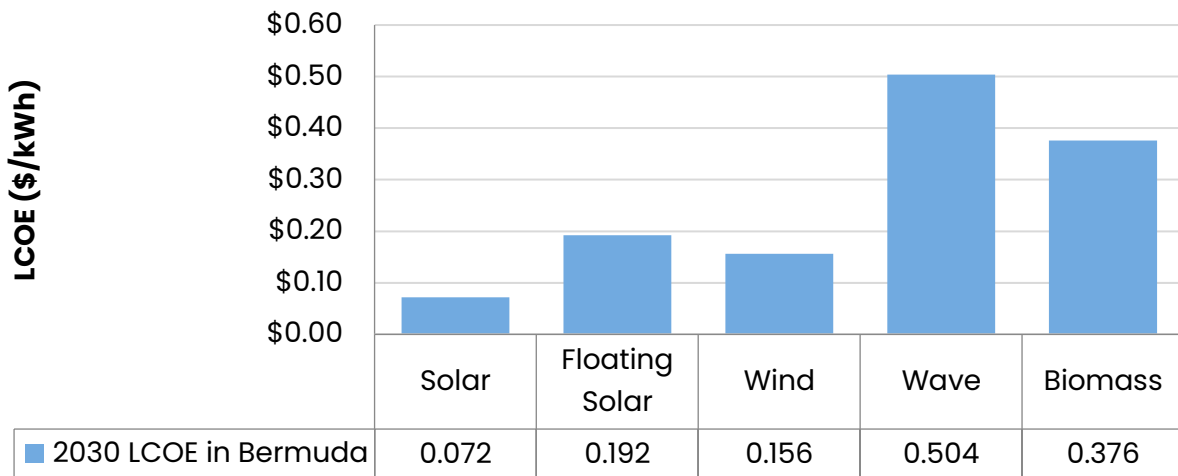
The preferred portfolio aims for an 82% reduction in carbon emissions by 2043, with immediate investments in solar, storage, and offshore wind. The preferred plan installs 20MW of onshore solar in the next four years, 40MW (180MWh) of battery energy storage, and calls for 60MW of offshore wind to be installed by 2028 or as soon as possible. A gas turbine replacement is required in 2026 for contingency reserves. The plan also proposes that fuel should switch to light fuel oil in 2028. Floating solar, wave energy technology and biomass are not required before 2030.

Figure 1: Preferred Portfolio Additions and Retirement Timeline Over Procurement Window



The levelised cost of energy (**LCOE**) shown in Figure 2 demonstrates the relative lifetime cost of different technologies. The LCOE varies with weather, time, engine dispatch, and renewable curtailment. The capacity expansion model considers LCOE when determining the final portfolio mix but within the context of other system requirements. As demonstrated below, the plan selects the lower cost technologies such as onshore solar and wind energy. The preferred portfolio predicts a rate growth of 4.7% per year over the 20-year forecast period. The plan also mitigates the deployment risks associated with a fuel switch to liquefied natural gas (**LNG**).

Figure 2: Levelised Cost of Energy for New Resources in Bermuda



Near Term Actions, Signposts, and Pivot Strategies

The 2023 IRP Proposal suggests that resource studies for wind and wave energy are initiated immediately.

Demand-side management programs and incentives to lower demand should be developed as soon as possible to shape the island's demand to better match its evolving energy patterns and reduce costly peak demands.

An offshore wind farm takes about four years to develop, so if a mix of solar and wind energy is needed by 2028, the island must start resource studies now.

If the 60 acres of land required for 20 MW of onshore solar are not available, then floating solar technologies should be considered sooner.

Conclusion

The preferred portfolio offers a transition to lighter fuel oil with renewable energy investments, reducing emissions and maintaining affordability. It provides flexibility for future technology advancements while ensuring a reliable and sustainable energy supply for Bermuda.

The 2023 IRP Proposal also outlines strategies to adapt to market changes, considering factors like offshore wind development, alternative fuel, solar technology advancements, and the maturation of emerging technologies.