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Research Article

Strategic Rationale for the Interconnection of the Dominican Republic and Puerto Rico Electricity Markets Through HVDC: Positioning the Dominican Republic as a Regional Generation Hub

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Abstract

Island power systems are inherently characterized by high fuel import dependency, limited generation diversity, constrained economies of scale, and elevated vulnerability to extreme weather events, resulting in higher system costs and reduced operational resilience. This paper presents a technical and strategic assessment of a proposed high-voltage direct current (HVDC) submarine interconnection between the Dominican Republic (DR) and Puerto Rico (PR) across the Mona Passage. The study evaluates comparative system characteristics including installed capacity, peak demand, renewable penetration, infrastructure constraints, and long-term demand projections. While Puerto Rico operates a mature but spatially constrained grid with limited demand growth and aging infrastructure, the Dominican Republic exhibits sustained load growth, greater siting flexibility, and expanding generation capacity with increasing renewable integration. The analysis demonstrates that the net economic and reliability benefits of the interconnection are maximized when incremental firm and renewable-supporting generation is developed in the Dominican Republic and transmitted to Puerto Rico via a controllable HVDC link. The HVDC configuration enables asynchronous grid coupling, bidirectional dispatchable power exchange, improved stability margins, reserve sharing, and enhanced system adequacy. Results indicate that coordinated generation–transmission planning under this architecture reduces total system costs, supports higher renewable penetration, and strengthens resilience under extreme-event contingencies. The proposed DR–PR HVDC interconnection constitutes a technically feasible and economically justified platform for regional power system optimization and Caribbean electricity market integration.

Keywords

HVDC Transmission, Submarine Power Cables, Island Power Systems, Electricity Market Integration, Renewable Energy Integration, Caribbean Energy Systems

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1. Introduction

Electric power systems in island environments are typically characterized by high generation costs, fuel import dependency, and limited system redundancy [1, 4, 5]. In the Caribbean, these challenges are compounded by exposure to extreme weather events and constrained land availability for infrastructure development.

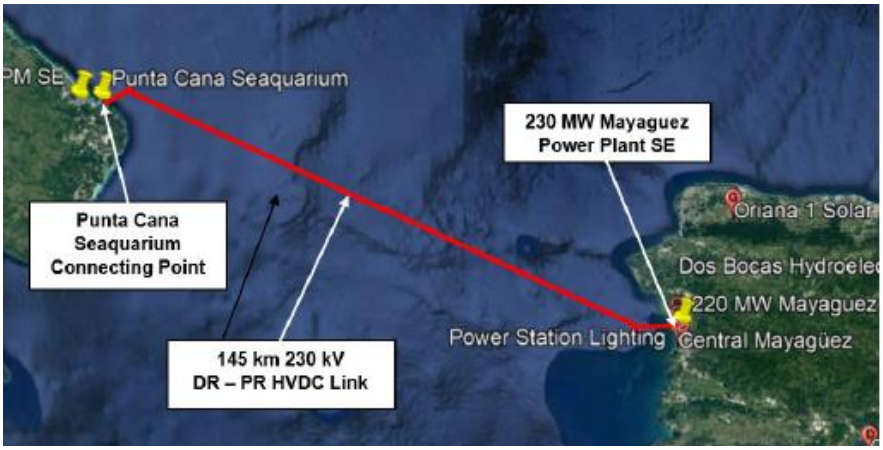
Historically, electricity planning in Caribbean island systems has been conducted independently at the national level [1, 5]. While this approach ensures sovereignty over energy policy, it often leads to suboptimal investment decisions, excess reserve margins, and higher electricity tariffs. Advances in HVDC submarine cable technology now enable the interconnection of island systems over long distances, creating opportunities for regional system optimization [4-6].

This paper evaluates the strategic case for an HVDC interconnection between the Dominican Republic and Puerto Rico, with particular emphasis on the optimal geographical allocation of new generation assets.

2. Objective of the DR–PR Interconnection

The primary objectives of the proposed HVDC interconnection are to:

1) Enable secure and controllable power exchange between DR and PR
2) Decouple generation sitting from electricity consumption
3) Reduce total system costs through coordinated planning
4) Improve reliability and reduce reserve requirements
5) Facilitate higher penetration of renewable energy
6) Enhance resilience to extreme weather events



Source: Power Market Interconnection in the Caribbean [6]

Figure 1. *The Dominican Republic – Puerto Rico HVDC Interconnection.*

Figure 1 shows the schematic representation of the interconnection between the Dominican Republic and Puerto Rico through a HVDC subsea cable:

3. Overview of the Dominican Republic Electricity System

The Dominican Republic is one of the largest electricity markets in the Caribbean, with a population exceeding 10 million inhabitants and sustained long-term demand growth. Installed generation capacity is approximately 6,423 MW, with a maximum demand of about 3,252 MW [2, 7].

Renewable energy represents approximately 24.5% of installed capacity [8, 9], supported by a diversified mix of hydroelectric, wind, solar photovoltaic, and biomass resources. Major base-load additions and ongoing grid rehabilitation programs have significantly improved system adequacy and operational flexibility.

These characteristics position the Dominican Republic as a suitable host for large-scale generation projects serving both domestic demand and potential exports.

Table 1 provide the profile of the Dominican Republic's power system.

Table 1. *Profile of the Dominican Republic's Power Systems.*

Profile of the Dominican Republic's Power System					
Year	**Total Installed Capacity (MW)**	**Peak Demand (MW)**	**Renewable Capacity (MW)**	**Renewable Share (%)**	**Notes / Source**
2019	4870	2506	1184	24,3	MEM / CNE / IRENA
2020	5000	2600	1200	24,0	MEM / IRENA
2021	5300	2800	1300	24,5	MEM
2022	5600	3000	1450	25,9	MEM / CNE
2023	5900	3200	1600	27,1	MEM
2024	6200	3640	1750	28,2	MEM Annual Report 2024
2025	6423	3252	1850	24,5	MEM Monthly Bulletin / CNE Jun-2025

MEM: Ministry of Energy and Mines; CNE: Energy National Commission; IRENA: International Renewable Energy Agency

Technical Comments:

1) Official sources from the Ministry of Energy and Mines (MEM) show a significant increase in installed capacity between 2024 and 2025 (monthly bulletins). The MEM also published the annual peak demand for 2024 (3,640 MW) and monthly peak demand figures for 2025.
2) The National Energy Commission (CNE) reported (June 13, 2025) that renewables account for approximately 24.5% of the total energy mix and have a very large project portfolio (>7,400 MW), confirming a robust pipeline for expansion [8].
3) IRENA offers a consolidated and useful statistical profile for international comparisons (renewable capacity data by technology).

4. Overview of the Puerto Rico Electricity System

Table 2. *Profile of Puerto Rico's Power Systems.*

Profile of the Puerto Rico's Power System					
Year	**Total Installed Capacity (MW)**	**Peak Demand (MW)**	**Renewable Capacity (MW)**	**Renewable Share (%)**	**Notes / Source**
2019	5839	2866	307	5,2	PREPA / EIA
2020	5800	2800	320	5,5	EIA
2021	5750	2700	550	9,6	EIA / Distributed PV
2022	5900	2600	800	13,6	EIA / LUMA
2023	6100	2550	1000	16,4	LUMA / PREB
2024	6300	2512	1150	18,3	LUMA Dec-2024 Report
2025	6300	2900	1230	19,5	LUMA / DOE /PREB Mid-2025

PREPA: Puerto Rico Electric Power Authority; EIA: Energy Information Administration; LUMA Energy: Private Company of Transmission and Distributions System in Puerto Rico; DOE: Department of Energy

Puerto Rico operates a mature electricity system with installed capacity of approximately 6,300 MW and a maximum demand of about 2,900 MW [3, 11, 12]. Despite apparent capacity margins, effective system performance is constrained by aging infrastructure, unit deratings, and vulnerability to hurricanes and other extreme events [11, 13, 14].

Renewable energy penetration remains limited to approximately 19.5% of installed capacity, despite aggressive policy targets [11, 12]. Electricity prices in Puerto Rico are among the highest in the Caribbean, adversely affecting economic competitiveness and increasing sensitivity to fuel price volatility.

Land availability, permitting complexity, and grid fragility significantly constrain the deployment of large-scale new generation facilities on the island.

The profile of Puerto Rico's Power System is given in Table 2:

Technical Comments:

1) Puerto Rico has a gap between installed capacity and actual available capacity due to aging and deratings; peak demand is approximately 2.5–2.9 GW, but availability can be much lower, which is why supplemental and emergency resources (PREB orders, temporary contracts) have been requested.
2) The deployment of distributed solar has been massive in 2022–2025 (from approximately 228 MW in 2021 to approximately 1,230 MW in June 2025 (according to regulatory summaries), which substantially changes effective capacity and operational requirements (variability, storage needs).
3) PR100 (DOE/NLRE) provides technical pathways and recommended storage capacities to meet targets (e.g., 40% to 100%) and is the primary source for transition projections.

5. Power Demand Outlook

Demand projections indicate a structural divergence between both systems [7, 10, 13]. The Dominican Republic is expected to experience continued demand growth driven by economic expansion and electrification, while Puerto Rico's demand is expected to remain relatively flat [11, 12].

This divergence implies that incremental generation capacity in Puerto Rico offers limited long-term economic justification, whereas the Dominican Republic requires new capacity to support growth and system modernization.

6. Technical Suitability of HVDC Interconnection

HVDC technology is the preferred solution for the DR–PR interconnection [1, 4-6] due to:

1) The length of the submarine crossing
2) Electrical decoupling of asynchronous systems
3) Full controllability of power flows
4) Improved system stability and reliability
5) Bidirectional operation capability

HVDC enables coordinated operation without requiring harmonization of operating standards, making it particularly suitable for interconnecting heterogeneous island grids [4, 5].

7. Justification for Locating New Generation in the Dominican Republic

From a system optimization perspective, locating new generation capacity in the Dominican Republic offers several advantages [1, 7, 8]:

1) Lower levelized cost of electricity due to economies of scale
2) Greater land availability and fewer permitting constraints
3) Improved fuel logistics and diversification options
4) Higher grid hosting capacity and operational flexibility
5) By contrast, Puerto Rico faces structural limitations that increase the cost and complexity of large-scale generation expansion. Installing new generation in the Dominican Republic and exporting power to Puerto Rico via HVDC reduces total system costs [1, 6, 11], lowers reserve requirements, and improves reliability for both systems

8. Implications for Renewable Energy Integration

The Dominican Republic has nearly achieved its renewable energy target of 25% by 2025 [8, 9], demonstrating an operationally mature framework for renewable integration. Puerto Rico's renewable targets—40% by 2024, 60% by 2040, and 100% by 2050 [13, 14]—require substantial additional capacity and backup resources.

Regional integration via HVDC allows renewable and firm low-cost generation developed in the Dominican Republic to contribute to Puerto Rico's decarbonization objectives while mitigating the need for excessive local infrastructure expansion.

A significant advance in the development of the interconnection of electricity markets consists of the introduction of the concept of smart grids, a topic that we will analyze in a future research project in the Caribbean region [15].

9. Methodology

This study adopts a structured analytical and comparative methodology to evaluate the technical, economic, and strate-

gic feasibility of an HVDC interconnection between the Dominican Republic (DR) and Puerto Rico (PR). The research approach integrates secondary data analysis, power system characterization, and system-level optimization reasoning within a regional planning framework.

10. Conclusions

1) The HVDC interconnection between the Dominican Republic and Puerto Rico represents a transition from isolated national planning toward regional electricity system optimization [1, 5, 13].
2) The analysis demonstrates that the benefits of the interconnection are maximized when new generation assets are located in the Dominican Republic and exported to Puerto Rico.
3) This configuration reduces total system costs, enhances reliability, supports renewable energy integration, and improves resilience to extreme events.
4) Beyond bilateral benefits, the project establishes a scalable platform for future Caribbean electricity market integration.

11. Final Recommendations

Based on the comparative technical, economic, and structural assessment of the electricity systems of the Dominican Republic and Puerto Rico, the following recommendations are proposed:

1. Adopt a Regional Optimization Approach to Power System Planning

Electricity planning in the Caribbean should evolve from isolated, country-specific strategies toward regional system optimization [1, 7, 13]. The Dominican Republic–Puerto Rico HVDC interconnection should be treated not as a bilateral trading mechanism, but as strategic regional infrastructure enabling optimal allocation of generation resources across districts.

2. Prioritize the Dominican Republic as the Primary Location for New Large-Scale Generation

New firm and renewable-supporting generation assets intended to supply the interconnected market should be preferentially located in the Dominican Republic. This recommendation is supported by:

1) Greater land availability and fewer sitting constraints,
2) Lower development and permitting risk,
3) Superior capability to host large-scale generation and balancing resources, and
4) Stronger alignment with long-term demand growth trends.

Puerto Rico, by contrast, should avoid over-reliance on local large-scale generation expansion given its spatial, environmental, and grid constraints.

3. Implement the DR–PR Interconnection Using HVDC as a Controllable System Asset

The interconnection should be developed using HVDC technology, not only for technical feasibility but as an operational control tool. HVDC enables:

1) Full decoupling of system dynamics,
2) Bidirectional and dispatchable power flows,
3) Reduction of reserve requirements in both systems, and
4) Improved system stability under high renewable penetration.

4. Use the Interconnection to Support Puerto Rico's Energy Transition Targets

Puerto Rico's ambitious renewable energy targets (40% by 2025, 60% by 2040, 100% by 2050) face significant implementation risks if pursued exclusively through local generation. The HVDC interconnection should be leveraged to:

1) Complement local renewable deployment with regional imports,
2) Reduce the need for excessive local backup and overbuilding, and
3) Improve reliability during the transition to high renewable penetration,

5. Integrate Generation Expansion and Transmission Planning

Generation development in the Dominican Republic and HVDC transmission planning should be co-optimized, rather than treated as separate projects. Joint planning will maximize economic benefits, avoid stranded assets, and ensure that generation additions are synchronized with transmission capacity and system needs.

6. Strengthen Institutional and Regulatory Coordination

Successful implementation requires early and sustained coordination between regulators, system operators, and policymakers in both districts. Key actions include:

1) Harmonizing technical standards relevant to HVDC operation,
2) Establishing clear commercial and tariff frameworks for power exchange, and
3) Defining transparent rules for capacity, energy, and ancillary service transactions.

7. Position of the Project as a First Step Toward Broader Caribbean Integration

The DR–PR HVDC interconnection should be designed with future scalability in mind. It can serve as a foundational element for a wider Caribbean electricity market, enabling future interconnections with other island systems that exhibit complementary resource profiles.

Abbreviations

CNE	Energy National Commission (of the Dominican Republic)
DOE	Department of Energy (of the United States of America)
DR	Dominican Republic
EIA	Energy Information Administration (of the

	United States of America)
GW	Giga Watts
HVDC	High Voltage Direct Current
IRENA	International Renewable Energy Agency
LUMA	Private Company of Transmission and Distribution (of Puerto Rico)
MEM	Ministry of Energy and Mines (of the Dominican Republic)
MW	Megawatts
NLRE	National Laboratory of Renewable Energy
PREPA	Puerto Rico Electric Power Agency
PR	Puerto Rico

Author Contributions

Francisco Núñez-Ramírez: Conceptualization, Methodology, Data curation, Investigation, Formal Analysis, Writing – original draft, Writing – review & editing

Conflicts of Interest

The author declares no conflicts of interest.

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