22nd International Conference on Renewable Energies and Power Quality (ICREPQ'24)
Bilbao (Spain), 26th to 28th June 2024
*Renewable Energy and Power Quality Journal* (RE&PQJ)
ISSN 2172-038 X, Volume No.22, September 2024

# Power Interconnectivity for the Caribbean Area

F. Nuñez[1], L. Pacheco[2], G. Magallanes[1], N. Luo[2] and J. Vilà[2]

[1] Department of Electrical Engineering
Universidad Federico Henríquez y Carvajal UFHEC

Campus Santo Domingo Oeste, Rep. Dominicana
Phone/Fax number: 809-924-2826
[2] Polytechnic School, University of Girona, Campus Montilivi, 17003 Girona
(Spain)

**Abstract.** Caribbean area is considered a renewable energy hub when sustainable energy sources are considered. Renewable energy sources include solar, wind, hydropower, bioenergy, and geothermal energy. The PWRLINKCAR (Power Link Caribbean) project proposes the union of the electrical markets of Greater and Lesser Antilles for promoting the use of renewable energies. In this way, the integration of the electricity markets reduces energy stocks and electricity prices. Energy link geographical analysis is performed regarding the present infrastructures and the depth of the trajectory where submarine cable will be placed. Therefore, the cost of the power link is directly related to the depth of the ocean considering submarine cable performance and the installing process. The benefits of the interconnectivity are social, political, economic, and technical.

**Key words.** Caribbean area, Renewable energies, Interconnectivity of electricity markets.

## 1. Introduction

The present situation at Caribbean area includes thermo-electrical centrals based on fossil fuels as well as renewable sources of energy. Caribbean countries are considered as potentially net exporters of energy when renewables sources are considered. The electricity prices have a strong dependence on fossil fuel [1]. Moreover, many countries are stressed with high debt levels and limited economic space [2]. In this way, energy prices have a high impact to the society because families may reduce their income. However, Caribbean area has a great potential when renewable energy (RE) sources are considered [3]. RE sources (solar, wind, hydro, biomass, geothermal, and tidal energy) are frequent, and have a great potential at the area. Regarding the promotion of RE at Caribbean area, electrical market interconnectivity is considered as an important factor when economies of scale, and more efficient operation of electrical systems, are considered [4]. Greater exploitation, with integrity, security, and stability of the renewable resources of each one of the countries that participate in the interconnection of their markets is expected. Moreover, reduction of reserves in terms of auxiliary or peak stations and emergency stations can be achieved. It can be summarized as a more optimal use of the natural resources of each country or region, as well as the strengthening of relations between the countries which participate in regional electricity markets.

In this paper, the main results, concerning the PWRLINKCAR (Power Link Caribbean) project, are outlined. The PWRLINKCAR project began at 2021 and will end at 2024 [5]. It is led by researchers of Dominican Republic and includes researchers of America and Europe. The project is focused on the fact that interconnectivity will add security and stability to the electricity system because access to energy will be possible even under a lack of generation. The union of Greater Antilles with US, South of Florida, is planned at the north. While interconnection between Venezuela and Lesser Antilles is projected at the south. The link connects the following countries of Greater Antilles: Cuba, Jamaica, Haiti, Dominican Republic, and Puerto Rico. While cable link at Lesser Antilles includes the following countries: Virgin Islands (US), Virgin Islands (UK), Anguilla (UK), Saint Kitts, Antigua, Montserrat (UK), Guadeloupe (France), Dominique, Martinique (France), Saint Lucie, Saint Vicent, Grenade, Barbados, and Trinidad and Tobago.

By joining the generation centrals to the projected link, straightening of the power link will be achieved. Moreover, embedding optical cable within the power link is proposed, in order to share the power link with a link for telecommunications that can offer new possibilities because voice and data can be transmitted, and commercial capabilities are increased.

The following goals are expected:

- Investment attraction according to the market possibilities.
- To study the energy demand of the covered area, and to increase their potential by increasing the use of RE sources.
- To evaluate the technological possibilities, AC (alternating current) or DC (direct current), concerning the energy to be transmitted, distances between points, and the necessary infrastructure.
- As result of the bathymetry studies of Caribbean Sea, an analysis and a study of the different submarine

cable possibilities, according to the topology of each region and the market technology, is done.

- The creation of a Caribbean Control Energy System for real-time control of the different operations concerning the interconnectivity of the link will be promoted.
- To study and to analyze the different legislations of the covered area. The objective is to adapt the laws to a new framework with a unique electrical market. Due to the major robustness of the system that will be achieved, new legislation that will increase the actual generation percentage of RE is expected.

Next section is focused in electrical power interconnectivity at America but also analyze Europe because actually is the place where the majority of the submarine links are placed [6]. Section 3 introduces some of the available technical solutions when submarine electric power is transmitted. Technological aspects such as cable installation and technology, and necessary infrastructure are also commented. Section 4 outlines the work carried out within the PWRLINKCAR project. It is depicted the geographical features of the link, and technological aspects as power dimensioned, and complementary infrastructures. The cost of the link is also formulated. Finally, section 5 presents the conclusion of this research.

## 2. Electrical Power Interconnectivity

Global warning, and climate change are important issues that affect the World wellness. A rapid global energy transition to electricity generation from renewables is proposed as a necessary target when climate change mitigation is pursued. Renewable electricity is currently used locally but trade across large world regions via HVDC (High Voltage Direct Current) interconnection can boost renewable electricity production [7]. Regarding Canada and US, an interconnected power system, which combine imports and exports of electricity, is still growing. Hence, greater integration and coordination of systems increase the reliability and flexibility of North America's electricity grid and help address challenges associated with integrating high levels of variable renewables [8-9]. However, turning to the South, US and Mexico trade in electricity depicts that US imports only a 0.6% of electricity consumption and Mexico less than 2% [10].

A deeper integration of electrical systems is proposed in order to promote the use of REs in both countries, while competiveness and reliability are achieved. In this way, South America faces several challenges in the development of the electricity sector: high fluctuations in hydro generation, high and volatile prices of fossil fuels, and environmental and social impacts associated to energy activities [11]. When the use of RE sources is studied, the need of an interconnected link is assumed [12]. Figure 1 depicts South and Central American sub-regions and HVDC transmission lines configuration, where dashed lines are projected links.


Fig. 1. Actual and future transmission line configurations for South and Central America. Courtesy of Barbosa et al.

Despite the lack of success of power energy lines interconnection in South America, the Electrical Interconnection System of Central American Countries (SIEPAC) is considered a successful example of cooperation between countries. According to [13], one important fact concerning the attainment of SIEPAC is the creation of supranational institutions as the Inter-American Development Bank (IDB), who works as an indirect governance institution that avoids intergovernmental conflicts and sudden changes in heads of state's preferences.

The analysis of the submarine power cables shows that most of the submarine energy links use HVDC technology, with voltage values around 500 KV. Different distances, from teens of km to hundreds of km, are suitable. According to [14], most submarine power cables are placed in Europe, see Figure 2.

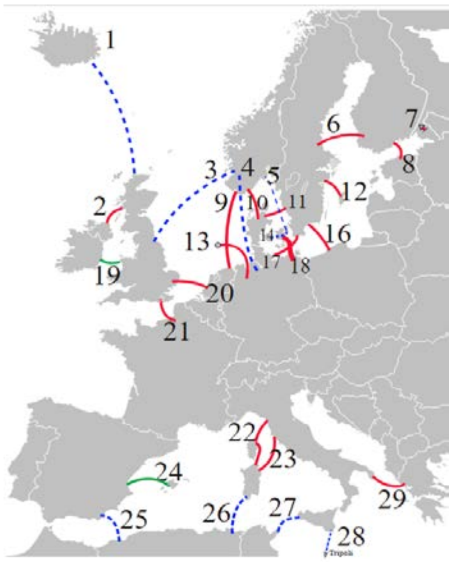


Fig. 2. Submarine HVDC links in Europe J. J. Messerly.

## 3. Submarine Energy Power Link Technology

XLPE (cross linked polyethylene) cables are proposed as a suitable submarine technology where the molecular structure of polyethylene is changed because of including additives [14]. As result, a material more robust when heated is obtained. Present research, study factors that include electric field stress, percentage of nanoparticles (most commonly $Al_2O_3$), distance from the high-voltage conductor, temperature, aging time, degassing time, frequency, and insulation thickness [15]. HVAC (High Voltage Alternating Current) and HVDC cables are suitable solutions when submarine cable interconnections are planned. HVAC cables increase the cost of manufacturing and laying, and also cause significant power loss. In comparison, VSC (Voltage Source Converters)-HVDC transmission technology has obvious advantages in terms of cost and reducing loss, although the investment on construction of converter equipment in the early investment is higher [16].

Efficient energy systems can be controlled as smart grids that can intelligently integrate the actions of all users connected to it. Connection to onshore AC power link can be done using VSC-HVDC (Voltage Sources Converter, High Voltage Direct Current). The design and implementation of a Multi-terminal VSC-HVDC has been tested on an experimental platform [17]. The research developed shows different operational points by considering intermittent power sources as offshore wind farms. The experimental platform has been tested under several conditions such as: normal operation, grid side converter disconnection and wind farm converter disconnection. Current Flow Controllers (CFCs) are proposed for managing line power flows and protection against DC faults. The integration of LCS (Load Commutation Switch) and Circuit Breakers for CFCs is proposed in [18].

When the installation of submarine cable is analyzed, the expected useful life and facility to repair are considered. Environment impact reduction and placement selection that take care of cable protection should be considered. Figure 3 shows the process of installing submarine cable. Exist different private companies that have equipment and technology to perform the installation of submarine cable. The depth of the sea plays and important role when installation of the cable is done on the trajectory selected.

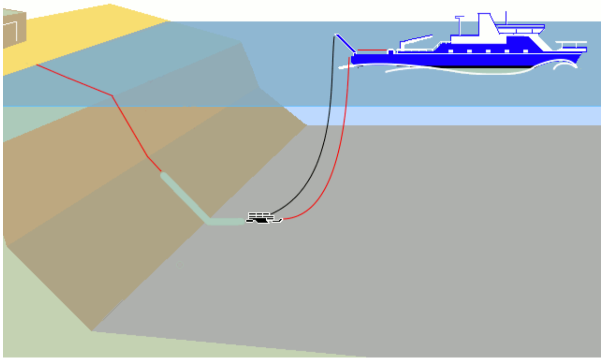

Figure 3: Undersea cable laying.
Attribution: Barbetorte, https://creativecommons.org/licenses/by-sa/3.0

For shallow water, divers can be employed, while for deep water, the use of VORs (Vehicle Operation Remote) are required. Cables are usually buried within the seafloor by different techniques. Normally, trenching, laying the cable and burying it, is done using the extracted sediment in a single operation. In the case of hard or deep bottoms, the cable can simply be laid on the seafloor and stabilized with suitable cover [19].

In this context, Greater and Lesser Antilles can be interconnected between them and with continental countries as US and Venezuela by using such technology.

## 4. The PWRLINKCAR project

In this section, firstly the interconnections of Greater and Lesser Antilles are depicted. The power link is presented under a technological perspective where power dimensioned, and complementary infrastructures are also depicted. Moreover, the cost of the link is formulated.

Bathymetry studies are developed using data source provided by GEBCO (General Bathymetric Chart of the Oceans) [20]. However, due to the fact that land-coast-shape cannot by inferred using GEBCO data, google earth is also used [21].

### *A. Connectivity Link in the Greater Antilles*

Greater Antilles interconnection, from US to Puerto Rico is proposed. Geographical coordinates, of the link at the Connection Points (CP), are presented in Table I. Estimated distances between CP, and estimated depth of the submarine link, between CP, are also depicted. Table I shows the link across the following countries: Cuba, Jamaica, Haiti, Dominican Republic, and Puerto Rico.

Table I. Link geographical features at Greater Antilles

| | |
|---|---|
| Florida (US) CP with Cuba: Nuclear Central of Turkey Point | |
| Latitude: N 25º 26'09'' | Longitude: W 80º 19'39" |
| Cable length to Cuba: 305 km | Maximum depth: 1,800 m |
| Cuba CP with US: Central of Antonio Guiteras | |
| Latitude: N 23º 06'27" | Longitude: W 81º31'51" |
| Cuba CP with Jamaica: Central of Antonio Maceo | |
| Latitude: N 19º 59' 39' | Longitude: W 75º 52' 16" |
| Length to Jamaica: 275 km | Maximum depth: 5,300 m |
| Jamaica CP with Cuba: Electrical Central JPS | |
| Latitude: N 18º 27' 47' | Longitude: W 77º 55' 44 |
| Cuba CP with Haiti: Central of Antonio Maceo | |
| Length to Haiti: 420 km | Maximum depth: 1,700 m |
| Haiti CP with Cuba: Carrefour Electricity Power Station | |
| Latitude: N 18º 32' 12' | Longitude: W 72º 23'03" |
| Dominican Republic CP with Puerto Rico: Central of Sea-aquarium at Punta Cana | |
| Latitude: N 18º 39' 36" | Longitude: W 68º23'08" |
| Length to Puerto Rico: 145 km | Maximum depth: 1,100m |
| Puerto Rico CP with Dominican Republic: Mayagüez Central | |
| Latitude: N 18º 13' 05" | Longitude: W 67º09'34" |

The links between Haiti and Dominican Republic (245 km), across Cuba (700 km), and across Puerto Rico (145 km) are terrestrial.

*B. Connectivity Link in the Lesser Antilles*

Lesser Antilles interconnection, from Puerto Rico to Venezuela, is proposed. Table II-A and Table II-B depict the latitude and longitude of the CP, and the estimated distances and depths of the submarine link. Bathymetry studies are developed using data source provided by GEBCO (General Bathymetric Chart of the Oceans) and Google earth [20-21].

Table II-A. – Link geographical features at Lesser Antilles

| | |
|---|---|
| Puerto Rico CP with Virgin Islands (US): Central of Isleta Marina | |
| Latitude N 18º19'59" | Longitude W 65º37'46" |
| Cable length to Virgin Islands (US): 73 km | Maximum depth: 36m |
| Virgin Islands (US) CP with Puerto Rico and Tortola: Randolph Hartley Power Station, Saint Thomas Island | |
| Latitude: N 18º19'57" | Longitude: W 64º57'43" |
| Length to Virgin Islands (UK): 50 km | Maximum depth: 45m |
| Virgin Islands (UK) CP with Virgin Islands (US) and Anguilla (UK): South Coast of Tortola Island | |
| Latitude: N 18º25'14" | Longitude: W 64º37'02" |
| Length to Anguilla: 175 Km | Maximum depth: 1,420 m |
| Anguilla (UK) CP with Virgin Islands (UK) and Saint Kitts: South Coast of Anguilla | |
| Latitude: N 18º11'52" | Longitude: W 63º02'50" |
| Length to S. Kitts: 110 km | Maximum depth: 600m |
| Saint Kitts Island CP with Anguilla (UK) and Antigua: Northeast coast of Saint Kitts | |
| Latitude: N 17º19'05" | Longitude: W 62º41'47" |
| Length to Antigua: 106 km | Maximum depth: 675m |
| Antigua CP with Saint Kitts and Montserrat: North Coast of Antigua | |
| Latitude: N 17º07'35" | Longitude: W 61º45'30" |
| Length to Montserrat: 75 km | Maximum depth: 735m |
| Montserrat Island (UK) CP with Antigua and Guadeloupe (France): North coast of Montserrat | |
| Latitude: N 16º47'29" | Longitude: W 62º12'48" |
| Length to Guadeloupe: 120 km | Maximum depth: 840m |
| Guadeloupe Island (France) CP with Montserrat and Dominique: Northeast coast of Guadeloupe | |
| Latitude: N 16º19'46" | Longitude: W 61º20'27" |
| Length to Dominique: 146 km | Maximum depth: 748m |
| Dominique Island CP (Guadeloupe and Martinique): Southwest coast of Dominique | |
| Latitude: N 15º18'52" | Longitude: W 61º23'19" |
| Length to Martinique: 80 km | Maximum depth: 1,500m |
| Martinique Island (France) CP with Dominique and Saint Lucie: West coast of Martinique | |
| Latitude: N 14º40'17" | Longitude: W 61º09'39" |
| Length to Saint Lucie: 82 km | Maximum depth: 1,100m |
| Saint Lucie Island CP with Martinique, Saint Vincent, and Barbados: North coast of Saint Lucie | |
| Latitude: N 14º00'58" | Longitude: W 60º59'35" |
| Length to S. Vicent: 120 km | Maximum depth: 950m |

Table II-B. – Link geographical features at Lesser Antilles

| | |
|---|---|
| Saint Vincent Island CP with Saint Lucie and Grenade: South coast of Saint Vincent | |
| Latitude: N 13º08'13" | Longitude: W 61º12'21" |
| Length to Grenada: 143 km | Maximum depth: 1,157 m |
| Grenade Island CP with Saint Vicent and Trinidad: West coast of Grenade | |
| Latitude: N 12º03'52" | Longitude: W 61º45'16" |
| Length to Trinidad: 225 km | Maximum depth: 1,700 m |
| Barbados Island: Cane Hall central CP (with Saint Lucie): West coast of Barbados | |
| Latitude: N 13º07'30" | Longitude: W 59º37'56" |
| Length to Saint Lucie: 177 km | Maximum depth: 1,700 m |
| Trinidad and Tobago Islands CP (with Venezuela): Southwest coast of Trinidad | |
| Latitude: N 10º13'09" | Longitude: W61º37'54" |
| Length to Venezuela: 132 km | Maximum depth: 34 m |

Tables II-A and II-B shows the link across the following countries: Puerto Rico, Virgin Islands (US), Virgin Islands (UK), Anguilla (UK), and Saint Kitts, Antigua, Montserrat (UK), Guadeloupe (France), Dominique, Martinique (France), Saint Lucie, Saint Vincent, Grenade, Barbados, Trinidad and Tobago, and Venezuela. The link is connected to the Northwest coast of Venezuela (N 10º33'13", W 62º48'32").

*C. Necessary Infrastructure and Interconnections*

In this subsection, the different connections for each country are presented. The need of inland infrastructure is tackled. Table III and Table IV outline technical link features.

Table III. - Power energy link needs at Greater Antilles

| |
|---|
| Florida Coast US |
| VSC CP with Cuba: 230Kv HVAC/ 230Kv HVDC<br>Inland HVAC Voltage (230Kv), length (0.6 km) |
| Cuba |
| VSC at CP with US: 230Kv HVDC/ 169Kv HVAC<br>VSC at CP with Haiti: 169Kv HVAC/230Kv HVDC<br>VSC at CP with Jamaica: 169Kv HVAC/230Kv HVDC<br>Inland HVAC Voltage (230kV), length (700 km) |
| Jamaica |
| VSC at CP with Cuba:230Kv HVDC/138Kv HVAC<br>Inland HVAC Voltage (138Kv), length (2.5 km) |
| Haiti |
| VSC at CP with Cuba: 230Kv HVDC/115Kv HVAC<br>Inland HVAC Voltage (345kV), length (250 km)<br>Transformer (115Kv/345Kv) |
| Dominican Republic |
| Inland HVAC double line from CP with Haiti (Subestación Edeste) Voltage (345Kv and 138Kv), length (176 km)<br>Inland buried link HVAC (345Kv),<br>length (5 Km) with CP of Puerto Rico |
| Puerto Rico |
| VSC at CP with Dominican Republic: 230KVDC/230KVAC<br>Inland HVAC Voltage (230kV), length (176 km) |

Table IV. - Power energy link needs at Lesser Antilles

| |
|---|
| Puerto Rico |
| VSC at CP with V. Islands: 230 Kv HVAC/230Kv HVDC<br>Inland HVAC Voltage (230kV), length (176 km) |
| Virgin Islands (US) |
| (Submarine HVAC link with Puerto Rico)<br>same CP for Puerto Rico and Virgin Island (UK)<br>Transformer (230Kv/69Kv) |
| Virgin Islands (UK) |
| VSC at CP Virgin Islands and Anguilla: 230Kv HVAC/230KV HVD Inland HVAC Voltage (69kV), length (1 km)<br>Transformer (230Kv/69Kv) |
| Anguilla (UK) |
| VSC at CP with Virgin Islands (US) and Saint Kitts: 230KVDC/230KVAC Inland HVAC Voltage (13.8kV), length (0.75 km) Transformer (230Kv/13.8Kv) |
| Saint Kitts |
| VSC at CP with Anguilla and Antigua: 230KVv HVDC/11Kv HVAC Inland HVAC Voltage (11kV), length (5 km)<br>Transformer (230Kv/11Kv) |
| Antigua |
| VSC at CP with Saint Kitts and Montserrat: 230Kv<br>HVDC/60Kv HVAC No Inland HVAC line<br>Transformer (230kV/60kV) |
| Montserrat (UK) |
| No need of VSC (Submarine HVAC link with Antigua)<br>VSC at CP with Guadeloupe: 230Kv HVAC/230Kv HVDC<br>Inland HVAC Voltage (11kV), length (0.12 km)<br>Transformer (230kV/11kV) |
| Guadeloupe (France) |
| VSC at CP with Montserrat and Dominique: 230Kv<br>HVDC/63Kv HVAC,<br>Inland HVAC Voltage (63kV), length (3.2 km) |
| Dominique |
| VSC at CP with Guadeloupe and Martinique:<br>230KvVDC/11KvHVAC, Inland HVAC Voltage (11kV), length (0.24 km), Transformer (11kV/230kV) |
| Martinique (France) |
| VSC at CP with Dominique and Saint Lucie:<br>230KvVAC/63KvVAC Inland HVAC Voltage (63kV), length (1 km), Transformer (230kV/63kV) |
| Saint Lucie |
| VSC at CP with Martinique and Saint Vicent:230KvVAC/230KvVDC, Inland HVAC Voltage (66kV), length (0.2 km), Transformer (230kV/63kV) |
| Saint Vincent |
| VSC at CP Grenade, Barbados, and Saint Lucie: 230Kv HVDC/66Kv HVAC, Inland HVAC Voltage (66kV), length (2 km), Transformer (230kV/66kV) |
| Grenade |
| VSC at CP with Trinidad and Saint Vicent:<br>230KvVDC/66KvVAC<br>Inland HVAC Voltage (66kV), length (0.4 km)<br>Transformer (230kV/66kV) |
| Barbados CP with Saint Vincent |
| VSC at CP with Saint Vicent: 230KvHVAC/66KvHVAC<br>Inland HVAC Voltage (66kV), length (2 km)<br>Transformer (230kV/66kV) |
| Trinidad and Tobago |
| VSC at CP with Grenade and Venezuela:<br>230KvVDC/220KvHVAC<br>Inland HVAC Voltage (220Kv), length (2 km)<br>Transformer (230kV/220kV) |
| Venezuela |
| VSC at CP with Trinidad:230KVDC/230KVAC<br>Inland HVAC Voltage (230Kv) and length (20 km) |

The link has 500 MVA of power but the union of Cuba with Haiti has only 400 MVA. For submarine distances, of more than 100 km, 230 KVDC link is proposed but when distances are less than 100 km, HVAC link of 230 kV is analysed. VSCs are used to adapt the different HVDC of the submarine link with the inland values of the HVAC required. A transformer may be needed when HVAC adaptation is required. HVAC frequencies are 60 Hz but Martinique, Saint Lucie, Saint Vincent, Barbados and Grenada use 50Hz.

### *D. Summary and Cost of the Power Link*

The total length of the submarine power link has near 3,200 km. Link depths have different maximum values, from 34m to near 2,000m, with the exception of the interconnection with Jamaica where the planned link can have more than 4,000m of depth. That means, that the union of US with South America through Caribbean Area is feasible with the actual technology. The power link cost has a strong dependence with the depth and consequently with the planned trajectory. The cost can be obtained using the following equation [5]:

$$C = \sum_{i=1}^{NSEC} (L_i + I_i) \quad (1)$$

Where C denotes the total submarine cost of the power link. The link cost ($L_i$: cable and placement) and the necessary infrastructure ($I_i$) is computed for each sector, using (2):

$$L_i\left(GC_i, GC_F\right) = \int_{GCI}^{GCF} (L_{inst}(d) + L_C(d))\Delta d_{GCN\ GCW} \quad (2)$$

Where $L_i$ *($GC_i$, $GC_F$)* denotes the initial and final *GC* (Geographical Coordinates) of each interconnection sector. *Linst(d)* depicts the link cost of installing the cable, it is function of the depth *(d)*, while *Lc(d)* denotes the cost of the cable which is also function of the depth. The depth is related to global coordinate north (*GCN*), and global coordinate west (*GCW*) of the different CPs, and the trajectories selected. Figures 4 and 5 show respectively the earth shape of the islands and the depth profile of the link. It consists of a set of points that join the different CP of the islands. The cost of the necessary infrastructure, $I_i$, includes VSCs, transformers, frequency converters, and necessary inland new links. Regarding the flexibility, the power link is reversible. Furthermore, it can be initiated at any point by interconnecting any country.

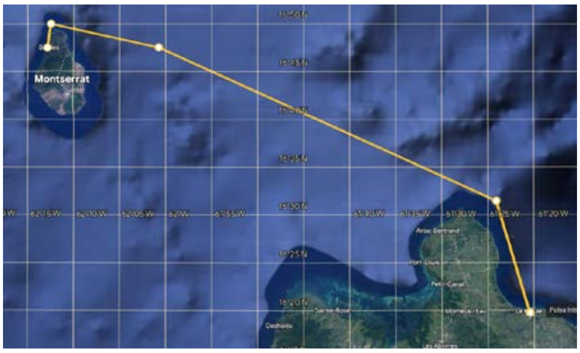


Fig. 4. Example of link between Montserrat and Guadeloupe.

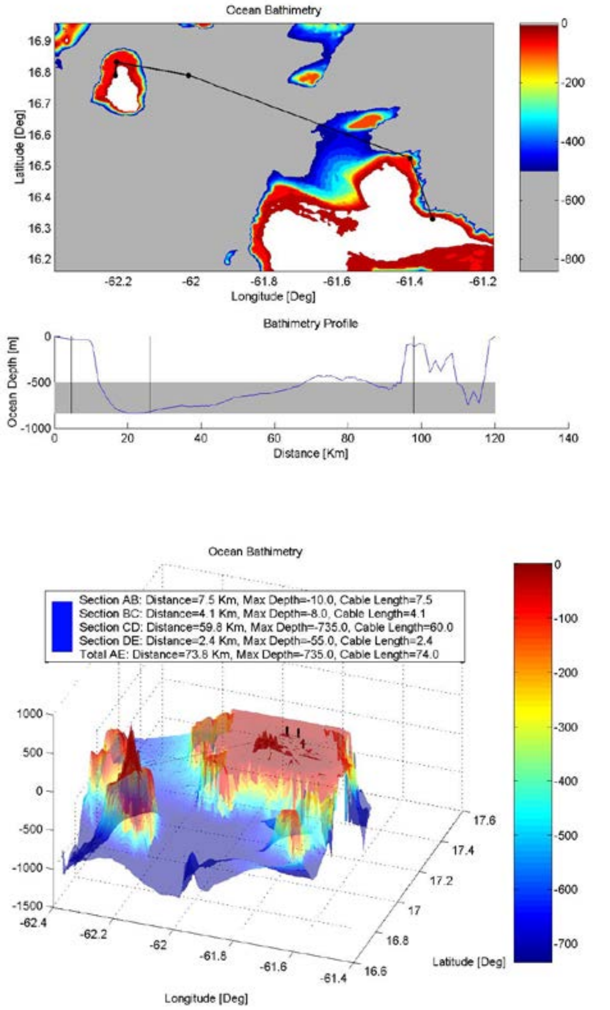


Fig. 5. Depth and distances for each section (Union between Montserrat and Guadeloupe).

## 5. Conclusion

Interconnection of the markets adds best use of natural resources, and the possibility of future interconnection with existing interconnected markets, such as the Electrical Interconnection System of Central American Countries (SIEPAC) and integration into its Regional Electrical Market (MER). Regarding financial and economic aspects, investment is supported by multilateral financing banks, such as the World Bank and the Inter-American Development Bank. Financial support can add greater income of foreign currency for the countries of Caribbean area, by concept of the commercialization of the energy in the different electrical markets, and the creation of new companies that would participate in the new regional market. Finally, it is important to point out that projections for the expansion of RE in each country and territory have been made considering island electrical systems, from the geographical point of view, when green energy sources are studied. In a market interconnection scenario, higher projections would be achieved due to the advantages that such interconnection entails.

## Acknowledgement

This work has been cofounded by the Ministerio de Educación Superior and Tecnología (MESCYT) of Dominican Republic through their National Founds for Innovation and Scientific.

## References

[1] L. Burunciuc, "Clean energy in the Caribbean: A triple win." *World Bank Blogs*, 2022.
[2] H. Thomsom *et al.*, " Understanding, recognizing, and sharing energy poverty knowledge and gaps in Latin America and the Caribbean – because conocer es resolver," *Energy Research & Social Science*, vol. 87, p. 102475, 2022.
[3] A. Bárcena, " Latin America energy week, United Nations," 2021.
[4] ACER, " European Union Agency for the cooperation of energy regulation, ACER's final assessment of the EU wholesale electricity market design," 2022.
[5] F. Nuñez *et al.*, "The power link caribbean project," *RE&PQJ*, vol. 21, pp. 345-350, 2023.
[6] M. Ardelean and P. Minnebo, "HVDC submarine power cables in the world," *Joint Research Center*, 2015.
[7] F. Guo, B. J. Van Ruijven, and B. Zakeri, " Implications of intercontinental renewable electricity trade for energy systems and emissions," *Nat Energy* , vol. 7, p p . 1144-1156, 2022.
[8] P. Beiter, W. J. Cole, and D. C. Steinberg, "Modeling the value of integrated U.S. and Canadian power sector expansion," *The Electricity Journal*, vol. 30, no. 2, pp. 47-59, 2017.
[9] D. Vine, " Interconnected: Canadian and U.S. Electricity," *Center for Climate and Energy Solutions*, pp. 1-15, 2017.
[10] J. McNeece, V. Irastorza, and J. M. Martin, "A Call for a Deeper Integration between Electrical Systems of the United States and Mexico." iamericas.org. 2022.
[11] C. A. Agostini, A. M. Guzmán, S. Nasirov, and C. Silva, "A surplus based framework for cross-border electricity trade in South America," *Energy Policy*, vol. 12, pp. 673-684, 2019.
[12] L. Barbosa *et al.*, " Hydro, wind and solar power as a base for a 100% renewable energy supply for South and Central America, " *PloS One*, vol. 12, no. 3, p. e0173820, 2017.
[13] S. Palistine, " Orchestrating regionalism: The interamerican development bank and the central American electric system," *Review of Policy Research*, pp.329-346, 2024.
[14] M. Ardelean and P. Minnebo, " HVDC submarine power cables in the world," *Joint Research Center*, 2015.
[15] T. Worzyk, *Submarine Power Cables: Design, Installation, Repair, Environmental Aspects*. Springer-Verlag, 2009.
[16] Z. Nadolny, "Electric field distribution and dielectric losses in XLPE insulation and semiconductor screens of high-voltage cables, " Energies, vol. 15, p. 4692, 2022.
[17] J. Sau, E. Prieto, and O. Gomis, "Modelling and control of an interline current flow controller for meshed HVDC grids," *IEEE Transactions on Power Delivery*, vol. 32, pp.11-22, 2015.
[18] O. Cwikowski *et al.*, "Integrated HVDC circuit breakers with current flow control capability," *IEEE Transactions on Power Delivery*, vol. 33, no. 1, pp. 371-380, 2017.
[19] B. Taormina *et al.*, "A review of potential impacts of submarine power cable on the marine environment: Knowledge gaps, recommendations and future directions," *Renewable and Sustainable Energy Reviews*, pp.380-391, 2018.
[20] "GEBCO." gebco.net. https://download.gebco.net/ (accessed Jan. 24, 2024).
[21 "Google Earth." google. com. https://www.google.com/intl/es/earth/about/ (accessed Jan. 24, 2024).