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Power Interconnectivity for the Caribbean Area

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Introduction

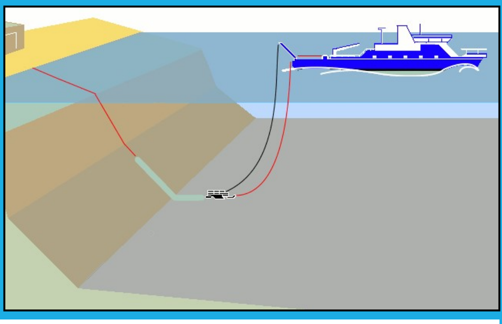
The PWRLINKCAR project is focused on the fact that interconnectivity will add security and stability to the electricity system because access to energy will be possible even under a lack of generation [1]. The union of Greater Antilles with US, South of Florida, is planned at the north. While interconnection 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.

The PWRLINKCAR project

The power link is presented under a technological perspective where power dimensioned, and complementary infrastructures are depicted [2]. Moreover, the cost of the link is formulated. Bathymetry studies are developed using data source provided by GEBCO (General Bathymetric Chart of the Oceans) [3]. Due to the fact that land-coast-shape cannot by inferred using GEBCO data, google earth is used. 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.

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. As result, a material more robust when heated is obtained. 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



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

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

Electrical Power Interconnectivity at South America

Interconnection System of Central American Countries (SIEPAC) is considered a successful example. Inter-American Development Bank (IDB), avoids intergovernmental conflicts and sudden changes in heads of state's preferences.

Necessary Infrastructure and Interconnections

Florida Coast US
VSC CP with Cuba: 230Kv HVAC/ 230Kv HVDC
Inland HVAC Voltage (230Kv), length (0.6 km)

Cuba
VSC at CP with US: 230Kv HVDC/ 169Kv HVAC
VSC at CP with Haiti: 169Kv HVAC/230Kv HVDC
VSC at CP with Jamaica: 169Kv HVAC/230Kv HVDC
Inland HVAC Voltage (230kV), length (700 km)

Jamaica
VSC at CP with Cuba:230Kv HVDC/138Kv HVAC
Inland HVAC Voltage (138Kv), length (2.5 km)

Haiti
VSC at CP with Cuba: 230Kv HVDC/115Kv HVAC
Inland HVAC Voltage (345kV), length (250 km)
Transformer (115Kv/345Kv)

Dominican Republic
Inland HVAC double line from CP with Haiti (Voltage (345Kv and 138Kv), length (176 km)
Inland buried link HVAC (345Kv), length (5 Km) with CP of Puerto Rico

Puerto Rico
VSC at CP with Dominican Republic: 230KVDC/230KVAC
Inland HVAC Voltage (230kV), length (176 km)

Puerto Rico
VSC at CP with V. Islands: 230 Kv HVAC/230Kv HVDC
Inland HVAC Voltage (230kV), length (176 km)

Virgin Islands (US)
(Submarine HVAC link with Puerto Rico)
same CP for Puerto Rico and Virgin Island (UK)
Transformer (230Kv/69Kv)

Virgin Islands (UK)
VSC at CP Virgin Islands and Anguilla: 230Kv HVAC/230KV HVD
Inland HVAC Voltage (69kV), length (1 km)
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)
Transformer (230Kv/11Kv)

Antigua
VSC at CP with Saint Kitts and Montserrat: 230Kv HVDC/60Kv HVAC
No Inland HVAC line
Transformer (230kV/60kV)

Montserrat (UK)
No need of VSC (Submarine HVAC link with Antigua)
VSC at CP with Guadeloupe: 230Kv HVAC/230Kv HVDC
Inland HVAC Voltage (11kV), length (0.12 km)
Transformer (230kV/11kV)

Guadeloupe (France)
VSC at CP with Montserrat and Dominique: 230Kv HVDC/63Kv HVAC,
Inland HVAC Voltage (63kV), length (3.2 km)

Dominique
VSC at CP with Guadeloupe and Martinique: 230KvVDC/11KvHVAC,
Inland HVAC Voltage (11kV), length (0.24 km), Transformer (11kV/230kV)

Martinique (France)
VSC at CP with Dominique and Saint Lucie: 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: 230KvVDC/66KvVAC
Inland HVAC Voltage (66kV), length (0.4 km)
Transformer (230kV/66kV)

Barbados CP with Saint Vincent
VSC at CP with Saint Vicent: 230KvHVAC/66KvHVAC
Inland HVAC Voltage (66kV), length (2 km)
Transformer (230kV/66kV)

Trinidad and Tobago
VSC at CP with Grenade and Venezuela: 230KvVDC/220KvHVAC
Inland HVAC Voltage (220Kv), length (2 km)
Transformer (230kV/220kV)

Venezuela
VSC at CP with Trinidad:230KVDC/230KVAC
Inland HVAC Voltage (230Kv) and length (20 km)

Cost of the Power Link:

The cost can be obtained using the following equation:

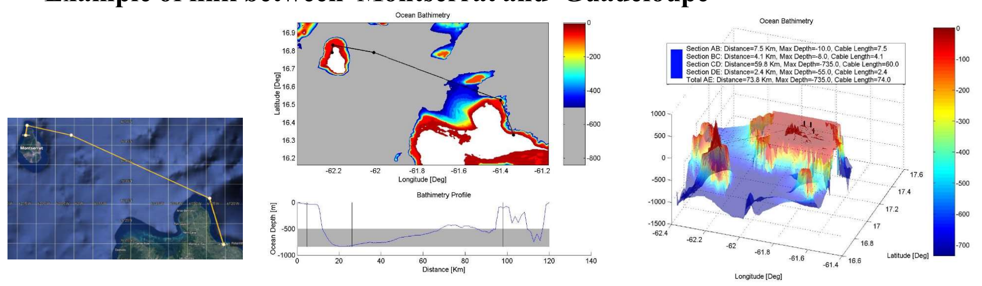
$$C = \sum_{i=1}^{NSEC} (L_i + I_i)$$

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:

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

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.

Example of link between Montserrat and Guadeloupe



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Conclusion

Expansion of RE is expected, from the geographical point of view. In a market interconnection scenario, higher projections would be achieved due to the advantages that such interconnection entails.

References

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[3] GEBCO. Accessed on January 24th of 2024: https://download.gebco.net/