OMNIA
THE PLURAL OF ENERGY

APOLLO-LINK: Technical Description and Project Network Modelling Data

APOLLO-LINK
THE MEDITERRANEAN SOLAR BRIDGE

1. Technical description and location of the project

The newly introduced 2 GW DC interconnection standard is a significant development in the field of high-voltage direct current (HVDC) systems, specifically designed to cater to large-scale, efficient power transmission for offshore wind electricity generation facilities. This standard developed by various ENTSO-E TSOs aims at facilitating the integration of larger offshore wind farms into the grid and enhancing the overall system's reliability. The adoption of this 2 GW standard for a point-to-point interconnection project aims at setting another standard and represents a strategic move towards achieving ambitious renewable energy targets set in Europe through standardisation.

The envisaged HVDC interconnector project, which is scheduled for commissioning in 2032, will leverage this **2 GW** standard to establish a technologically advanced and robust system. This system will be based on a **Rigid Bipole (RBP)** configuration, a setup that enhances system reliability by allowing independent operation of each pole. The link will span approximately **700 km**, connecting the substations **Ramis (Spain)** and **La Spezia (Italy)**, using this RBP configuration for optimal power transmission.

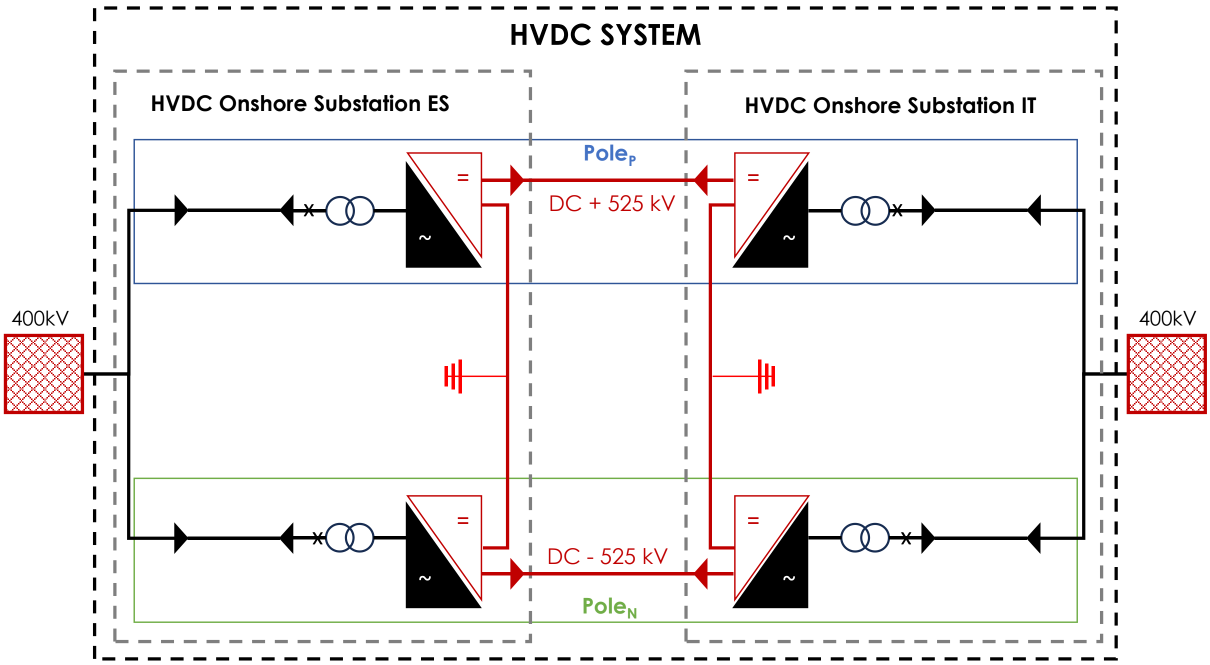

Figure 1: Single Line Diagram of 2 GW Interconnection System[1]

The system will employ a **525 kV** transmission cable, designed with two poles or strands. The cable uses **cross-linked polyethylene (XLPE) insulation**, renowned for its excellent dielectric strength, thermal characteristics, and resistance to environmental stressors. XLPE is ideally suited to this specific project, which involves high voltage and long-

[1] Based on Alefragkis, Kabul (2022): 'Next Generation Offshore Grid Connection Systems: TenneT's 2 GW Standard', available here: https://electra.cigre.org/321-april-2022/technology-e2e/next-generation-offshore-grid-connection-systems-tennets-2-gw-standard.html, as of 27 July 2023.

distance transmission in deep waters up to approx. 2,500m water depth. Currently, there are ongoing investigations on potential alternatives to XLPE conducted by some of the EU TSOs that created the 2 GW HVDC standard. Where these developments bring about new insights and findings into better, more economic, or more comprehensively available solutions, the project is inclined to adopt new standards. Furthermore, a fiber-optic cable will be integrated for real-time communication and system monitoring.

Voltage Source Converters (VSCs) will be deployed in both converter stations of this project. VSCs are known for their ability to independently control active and reactive power, offering a more advanced alternative to traditional Line Commutated Converters (LCCs). This technology aids in ensuring grid stability, providing reactive power support, and enabling black-start capability, which is crucial for quick system recovery following power outages.

The design of this system ensures identical transmission limits throughout the year, maintaining a **steady 2 GW** transmission possibility regardless of the season. This uniformity is achieved through efficient thermal management systems that cool both the converter stations and transmission cables, as well as in-built redundancy in the system design.

Pursuant to the technical description above, the application of the 2 GW standard, the specific details like the MVAr, losses, and unavailability due to planned maintenance will be determined based on the final design that will be put forward in the tender process. For the present document, relevant assumptions were made based on experience with existing HVDC system connecting EU Member States where needed. As example, we currently foresee a thermal capacity of the planned project of 2,091 MW, assuming a loss factor of 3.3%[2] and 94 hours of annual maintenance (scheduled outages). Additionally, no unscheduled outages due to the technological development regarding system resilience of future HVDC systems are expected.

In particular, equipment proposed by a/several to be selected suppliers will also affect these technical aspects. Given the early stage of the project ("under consideration"), these elements will be fine-tuned/determined in later and more advanced project stages to ensure maximum system efficiency and reliability.

2. Project network modelling data

In the following, the requested data from the TYNDP 2024 guidance for applicants (chapter 2.2, section p. Project network modelling data) for a proper modelling of the project in the network tool used by ENTSO-E in the assessment process is outlined:

[2] Calculated based on: ABB: 'HVDC Cable Transmission', available here: https://library.e.abb.com/public/d4863a9b0f77b74ec1257b0c00552758/HVDC%20Cable%20Transmission.pdf, as of 27 July 2023.

i. Electro-technical parameters for a direct current (DC) infrastructure

No.	Parameter	Value/description/justifications
1	Connection points (substations name)	ES: Ramis IT: La Spezia
1a	Alternative connection points	ES: Vandellòs IT: La Spezia
2	Type of conductor	RBP (Rigid Bipole)
3	Type of converters (VSC/LCC)	VSC (Voltage Source Converter)
4	Nominal voltage	525 kV
5	Capacity	2,000 MW
6	Km to each border if the infrastructure is a tie-line	n. a.
7	Winter and summer thermal limit (Imax)	Identical / no differentiation between summer and winter given it is a sub-sea cable Imax: Approx 2,000 A, depending on detailed specification (i.e. used material, cable diameter, assumed surrounding temperature, etc.)
8	Mvar capability range at terminals	To be specified with the connecting TSOs at a later stage, VCC converters have high flexibility in reactive power provision by technical design though (e. g. with a power factor of 0.95, reactive power of +/- 33% of the nominal capacity could be provided)
9	Bus-bar to bus-bar losses profile over MW range	Given the early stage of the project, the loss profile will be subject to later technical specification of the system with the selected supplier

10	Idle losses	Given the early stage of the project, the loss profile will be subject to later technical specification of the system with the selected supplier. However, based on technological best-practice of latest HVDC systems, these losses are usually neglectable compared to the nominal power.
11	Losses at Pnom	Assumption of a loss factor of 3.3%

ii. Expected yearly unavailability, differentiating between planned and forced outages, and the maximum single failure according to the design

12	Planned outages	94 hours a year for scheduled maintenance
13	Unplanned / forced outages	Currently not foreseen given the early stage of the project. To be specified in a later stage with selected supplier(s)
14	Maximum single failure according to the design	Currently not known yet given the early stage of the project. To be specified in a later stage with selected supplier(s)