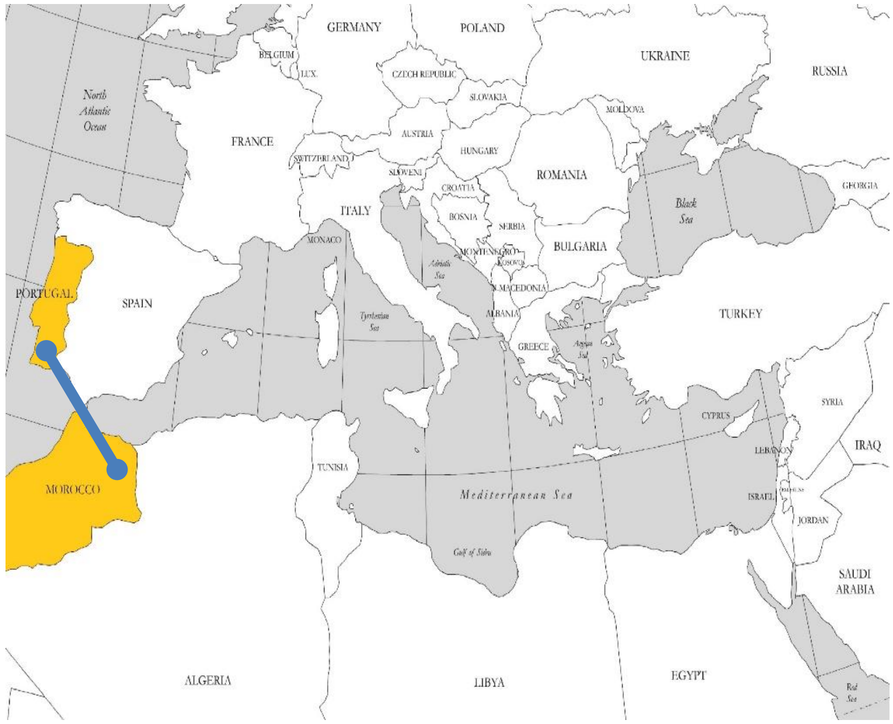
Project #1 – MOROCCO – PORTUGAL

Description

There are currently no interconnections between Morocco and Portugal. The Morocco grid is currently interconnected with the grids of Spain and Algeria, whereas the Portuguese grid is currently interconnected with the Spanish grid.



The existing interconnection between Morocco and Spain comprises two submarine links, enabling Net Transfer Capacities of 900 MW from Spain to Morocco and 600 MW from Morocco to Spain. A new link between Morocco and Spain is presently under study (Project #2 of Med-TSO), foreseeing an additional 600-650 MW NTC in both directions before 2030.

Concerning the interconnection between Morocco and Algeria, there are currently two 400 kV transmission lines and two 220 kV transmission lines, theoretically enabling an estimated Net Transfer Capacity of 1000 MW. However, until now, the transit has been limited to 300 MW from Morocco to Algeria and 600 MW from Algeria to Morocco, with the two 220 kV lines being disconnected in order to avoid a looping effect. The expected NTC between these two countries in the 2030 horizon is 1000 MW.

Portugal is a member of ENTSO-E and part of the Continental Europe Synchronous Area. Presently, Portugal is interconnected with Spain, through six 400 kV transmission lines and three 220 kV transmission lines. This interconnection infrastructure leads to estimated Net Transfer Capacities[1] of c.3300 MW and c.2600 MW, considering power flows from Portugal to Spain and from Spain to Portugal respectively. Considering the grid developments foreseen in the coming years, the NTC values between Portugal and Spain are projected to reach 3500 MW (flow from Portugal to Spain) and 4200 MW (flow from Spain to Portugal) before 2030.

This project consists of a new interconnection between Morocco and Portugal based on an HVDC link, with an envisaged capacity of 1000 MW and a total length of c.265 Km, of which approximately 220 Km consist of a submarine cable. This new link is expected to be based on a configuration of two circuits (bipolar converter) of 500 MW each. This project is promoted by the governments of both countries, who have jointly launched the elaboration of a Feasibility Study, presently under development.

Project Description Table

Description	*Substation (from)*	*Substation (to)*	*GTC contribution (MW)*	*Total Route length (km)*	*Present status*	*Expected commissioning date*	*Evolution*
New interconnection between Morocco and Portugal	Béni Harchane - Morocco	Tavira - Portugal	1000	265	Long-term project	TBD (feasibility study presently under development)	

[1] The indicated figures for NTC are calculated using the average annual values for the commercial available capacity, based on 2019 data.

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Project Merits

The major merits of the project relevant to the Mediterranean electricity system are listed below:

	PROJECT MERITS	ASSOCIATED SYSTEM NEEDS	PROJECT 1
Market	Reduce high price differentials between different market nodes and/or countries	Power studies with a 2030 time horizon can highlight significant differences in average marginal prices between countries, groups of countries or bidding zones. These differences are generally the consequence of structural differences in the composition of production fleets. The increase in the exchange capacity between these zones allows an economic optimization of the use of the generation plants and will be accompanied by electricity flow massively oriented in one direction, from the lower price country to the higher prices country, thus reducing the price differential	X
Dispatch, Adequacy and Security of Supply	Positively contribute to the integration of renewables	Infrastructure to mitigate RES curtailment and to improve accommodation of flows resulting from RES geographic spreading	X
	Contribute to solving issues related to adequacy and security of supply	Infrastructure that presents a benefit for the security of supply or system adequacy, in general by allowing additional importation at peak hours, in countries and areas presenting current of future risk of deficiencies	
Operation	Fully or partially contribute to resolving the isolation of countries in terms of power system connectivity or to meeting specific interconnection targets	Infrastructure to connect island systems, or to improve exchange capacity of countries showing low level of connectivity, or to contribute to meeting specific interconnection capacity targets	X
	Introduce additional System Restoration mechanisms	Infrastructure that could provide capability for Black Start & Islanding Operation thus decreasing the need for generation units with such capabilities	X
	Improve system flexibility and stability	Infrastructure to improve system flexibility and stability, by increasing sharing possibilities, namely in countries were expected changes in the generation fleet may raise concerns in those specific issues. Decreasing levels of dispatchable generation can be compensated by infrastructure and/or market design to provide balancing flexibility at cross-border level (international pooling/sharing of reserves, coordinated development of reserve capacity). The large increase in the penetration of asynchronous renewable generation is leading to Higher Rate of Change of Frequency (RoCoF) on the system, creating transient stability issues and causing voltage dips. This can be compensated through infrastructure designed to contain frequency during system events	
	Increase system voltage stability	Reactive power controllability of converters can be used to increase system voltage stability	X
	Enable cross-border flows to overcome internal grid congestions	Infrastructure to facilitate future scenarios and enable cross border flows, accommodating new power flow patterns, overcoming internal grid congestions	
	Mitigate loop flows in bordering systems	Infrastructure to mitigate the loop flows occurrence in the borders between Mediterranean countries, contributing to the improvement of exchange capacity	
	Contribute to the flexibility of the power systems through the control of power flows	Contribution to flexibility of power system operation by controlling power flows and optimizing usage of existing infrastructure	
Physical infrastructure	Refurbishment of obsolete infrastructure	Infrastructure to contribute to the refurbishment of obsolete part of grid initially designed in different context	

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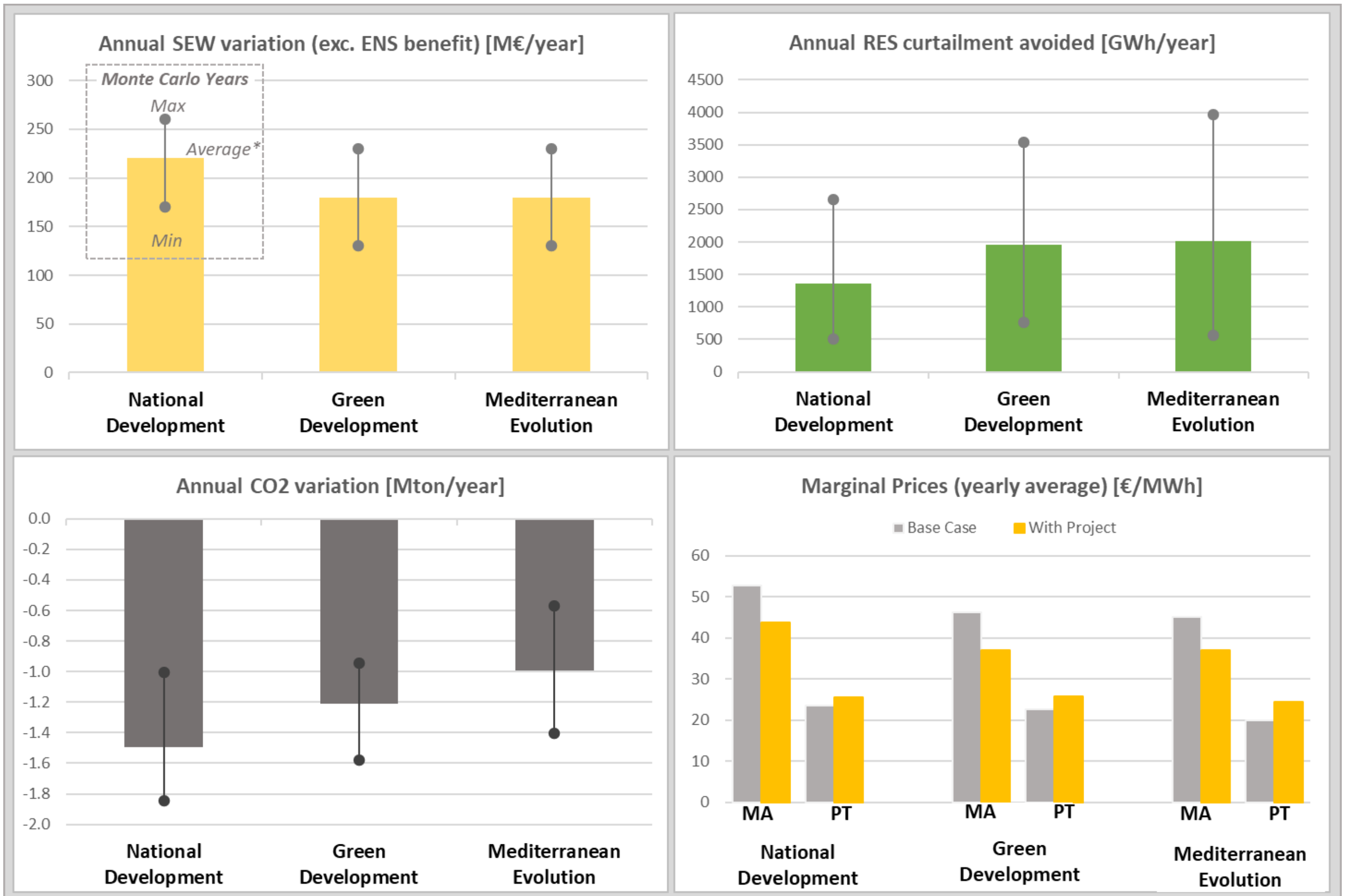
Project assessment analysis

CBA Indicators

Project 1 yields a positive impact in the expected values of all the analysed quantitative CBA indicators, except for the expected Energy Not Supplied, on which the impact is null since the expected ENS is already null in the base case. Specifically, the project drives consistent increases in the Social-Economic Welfare and RES Curtailment and a consistent decrease in the CO_2 emissions across the 3 simulated scenarios.



* Average of the outputs calculated for all the Monte Carlo Years

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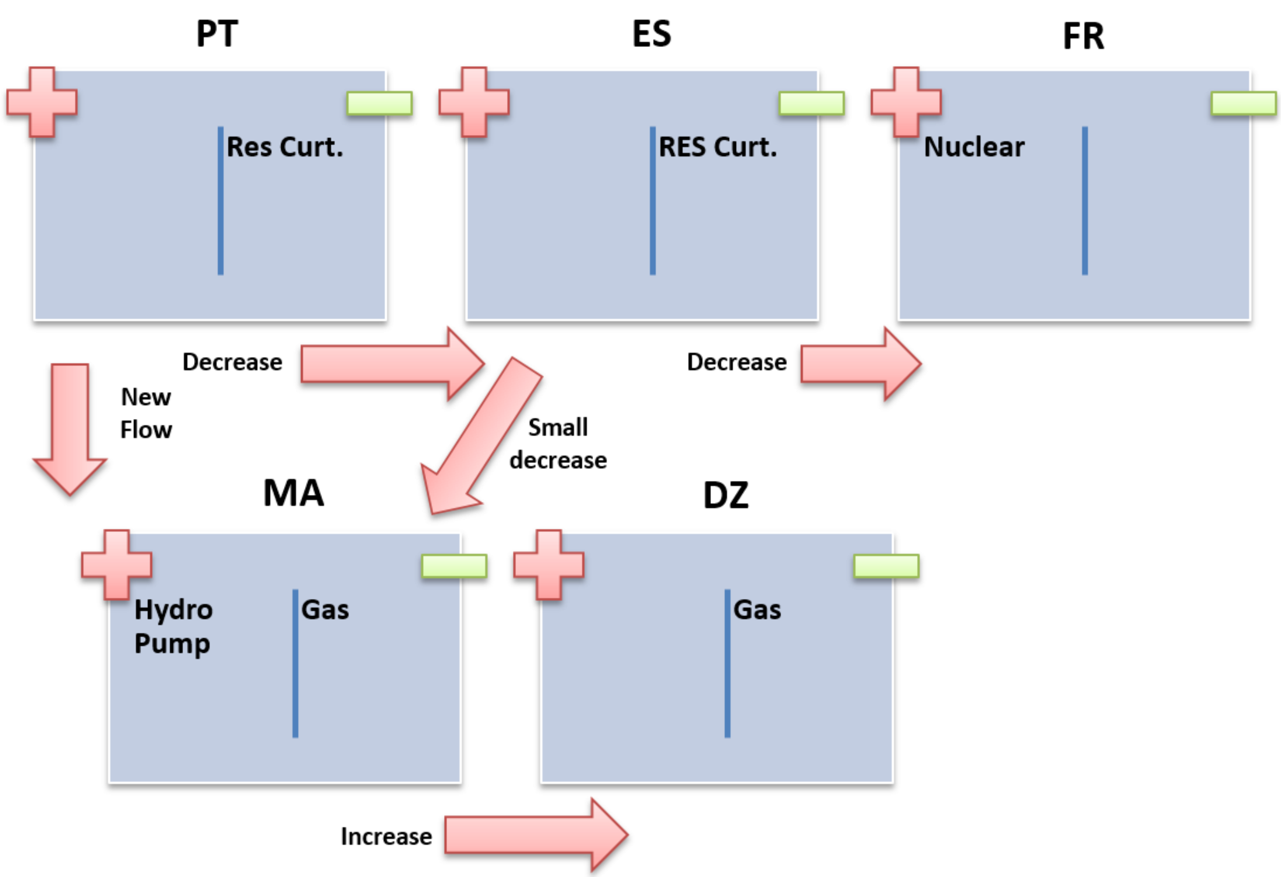
Project assessment analysis

Market Studies

Project 1 drives a reduction in gas generation, which is most noticeable in Algeria and in Morocco. This reduction in gas generation is mostly compensated by an increase in nuclear generation in France and an increase in RES generation, through the avoidance of curtailment in Portugal (but also in Spain). It is worth mentioning that this is not a direct compensation between French nuclear and Moroccan-Algerian gas generation. Instead, the effect of the new link is to change the direction of the flow of the Iberian RES surplus generation from France to Morocco/Algeria, where marginal prices are higher. Consequently, Morocco and Algeria see a decrease in their gas generation and France sees an increase in its nuclear generation to compensate the decrease in its imports from Spain. More specifically:

- **Generation mix:**
  - **MA:** reduction in gas generation (and slight increase in hydro pump generation in all scenarios)
  - **PT:** reduction in RES curtailment
  - **DZ:** reduction in gas generation
  - **FR:** increase in nuclear generation

Country balance and cross-country power flows: the flows observed in this new interconnection are mostly from Portugal to Morocco, with an expected significant number of hours of saturation of the flow in this direction. Furthermore, the project drives a decrease in the expected annual exports both from Portugal to Spain and from Spain to France. Additionally, there is an expected increase of annual exports from Morocco to Algeria, with both countries benefiting from the lower energy marginal prices observed in Portugal.



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Project assessment analysis

The project consists in a new HVDC interconnection between Portugal and Morocco with a carrying capacity of 1000 MW and a total length of 265km. The HVDC link consider the configuration of 2 circuits (bipolar converter) of 500 MW each. With a complete transmission network model have been represented the systems of Portugal, Morocco, Spain and Algeria, while France and Tunisia are represented as bus bar countries.
For the N and N-1 security analysys applied to the transmission network, 3 different scenarios have been distinguished and a total number of 9 Points in Time were examined.
The analysis identified the reinforcements for the system of Morocco and no reinforcements for the system of Portugal, given in the table below. For the third countries that are included in the project no internal reinforcements are suggested.

Scenario 1, 2, 3	
Description (Morocco)	**Description (Portugal)**
New 400kV double circuit between Bni Harchane and Shoul	
New 400kV OHL between Bni Harchane and Tetouan	
New 400kV/225kV transformer in Shoul	

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Project assessment analysis

The overall investment cost is expected to be between 645M€ and 745 M€, 11%-10% of which represent investment cost for internal reinforcements in Morocco. The more detailed breakdown of the cost is presented below.

Investment cost-Interconnection		
Line	***Cost [M€]****	
	LCC bip	***VSC***
Voltage level [kV]	**500kV**	**500 kV**
DC cable	280	280
OHTL DC line Portugal	10	10
OHTL DC line Morocco	20	20
AC/DC converter station Morocco	130	180
AC/DC converter station Portugal	130	180
TOTAL	**570**	**670**

Investment cost –internal reinforcements	
Lines (Morocco)	***Cost [M€]****
400kV OHL Bni Harchane-Shoul	**75**
225kV OHL Bni Harchane-Tetouan	
Transformers (Morocco)	
400kV/225kV Shoul	
Total	

*Rounded values

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Project cost benefit analysis results

Assessment results for the Project #1: Morocco - Portugal										
GTC increase direction 1 (MW)			1000							
GTC increase direction 2 (MW)			1000							
Scenario Specific			MedTSO Scenario							
			1 - National Development (ND)			2 - Green Development (GD)			3 - Mediterranean Evolution (ME)	
			Reference Scenario	With new project	Delta	Reference Scenario	With new project	Delta	Reference Scenario	With new project	Delta
GTC/NTC - Import		MA	1900	2900	1000	1900	2900	1000	1900	2900	1000
		PT	4200	5200	1000	4200	5200	1000	4200	5200	1000
GTC/NTC - Export		MA	1600	2600	1000	1600	2600	1000	1600	2600	1000
		PT	3500	4500	1000	3500	4500	1000	3500	4500	1000
Interconnection Rate - Import/Export (%) [1]		MA	11.8% / 9.9%	18.0% / 16.2%	6.2%	9.8% / 8.2%	14.9% / 13.4%	5.1%	7.7% / 6.4%	11.7% / 10.5%	4.0%
		PT	13.1% / 10.9%	16.2% / 14.0%	3.1%	11.8% / 9.9%	14.6% / 12.7%	2.8%	12.9% / 10.7%	15.9% / 13.8%	3.1%

Scenario Specific			MedTSO Scenario								
			1 - National Development (ND)			2 - Green Development (GD)			3 - Mediterranean Evolution (ME)		
Based on Monte Carlo Years			Average	Min	Max	Average	Min	Max	Average	Min	Max
Benefit Indicators	B1 - SEW[2]	(M€/y)	220	170	260	180	130	230	180	130	230
	B2 - RES Integration[3]	(GWh/y)	1360	510	2650	1960	760	3540	2010	560	3960
	B3 - CO2	(Mton/y)	-1.5	-1.8	-1.0	-1.2	-1.6	-0.9	-1.0	-1.4	-0.6
	B4 - Losses[2]	(M€/y)	20			20			20		
		(GWh/y)	220			360			350		
	B5a - SoS Adequacy[4]	(GWh/y)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		(M€/y)	0	0	0	0	0	0	0	0	0
	B5b - SoS System Stability										
Residual Impact Indicators	S1 - Environmental Impact										
	S2 - Social Impact										
	S3 - Other Impact										
Costs	C1 - Estimated Cost[5]	(M€)	700								

[1] considering the GTC/NTC for 2030 and the Installed generation for 2030

[2] considering adequate rounding of values (to the tens)

[3] ignoring low values and negative values of RES integration (average values below 50GWh lead to setting average, min and max equal to zero) and considering adequate rounding of values (to the tens)

[4] ignoring low values (average values below 0.1 GWh/y lead to setting average, min and max equal to zero)

[5] based on the average value of the different technology options considered in the analysis (if applicable)

B1- Sew [M€/year] =	Positive when a project reduces the annual generation cost of the whole Power System
B2-RES integration [GWh/Year] =	Positive when a project reduces the amount of RES curtailment
B3-CO2 [Mton/Year] =	Negative when a project reduces the whole quantity of CO2 emitted in one year
B4-Losses - [M€/Year] and [GWh/Year] =	Negative when a project reduces the annual energy lost in the Transmission Network
B5a-SoS [GWh/Year] and [M€/y]=	Positive when a project reduces the risk of lack of supply

negative impact	(red)
neutral impact	(light pink)
positive impact	(green)
Not Available/Not Applicable	(grey)
monetized	(yellow)

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Additional Information

- Communication from the Portuguese Government concerning contract award for the project's feasibility study and the strategic interest of the project https://www.portugal.gov.pt/download-ficheiros/ficheiro.aspx?v=01983994-40aa-4450-bcea-684b8788793e