Project #2 – SPAIN - MOROCCO

Description

The Maghreb region has been synchronized with the European electrical system since 1997, when the first interconnection between Spain and Morocco entered in operation. This first interconnection between these two countries consisted of an HVAC line of 700 MW with a total length of around 60km, with 30 Km corresponding to a subsea cable and the remaining 30km to an overhead line. In June 2006, the interconnection capacity doubled, through the development of a second HVAC connection of the same capacity, ultimately resulting in a total capacity of 1400 MW. The current NTC is 900 MW from Spain to Morocco and 600 MW from Morocco to Spain.

This project consists of a new interconnection between Morocco and Spain. In addition to the two existing links, the project consists of a third link, based on HVAC technology, which will increase the NTC between both countries by 600 MW or 650 MW (Morocco – Spain and Spain – Morocco respectively). The total length of the interconnection line is estimated at around 60km, corresponding to a 30km subsea cable and a 30km overhead line.

This project is promoted by ONEE and REE.

Project Description Table

Description	*Substation (from)*	*Substation (to)*	*GTC contribution (MW)*	*Total Route length (km)*	*Present status*	*Expected commissioning date*	*Evolution*
New interconnection between Spain and Morocco	Béni Harchane - Morocco	Puerto de la Cruz - Spain	700	60	Long-term project	2026	

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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 2
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	
	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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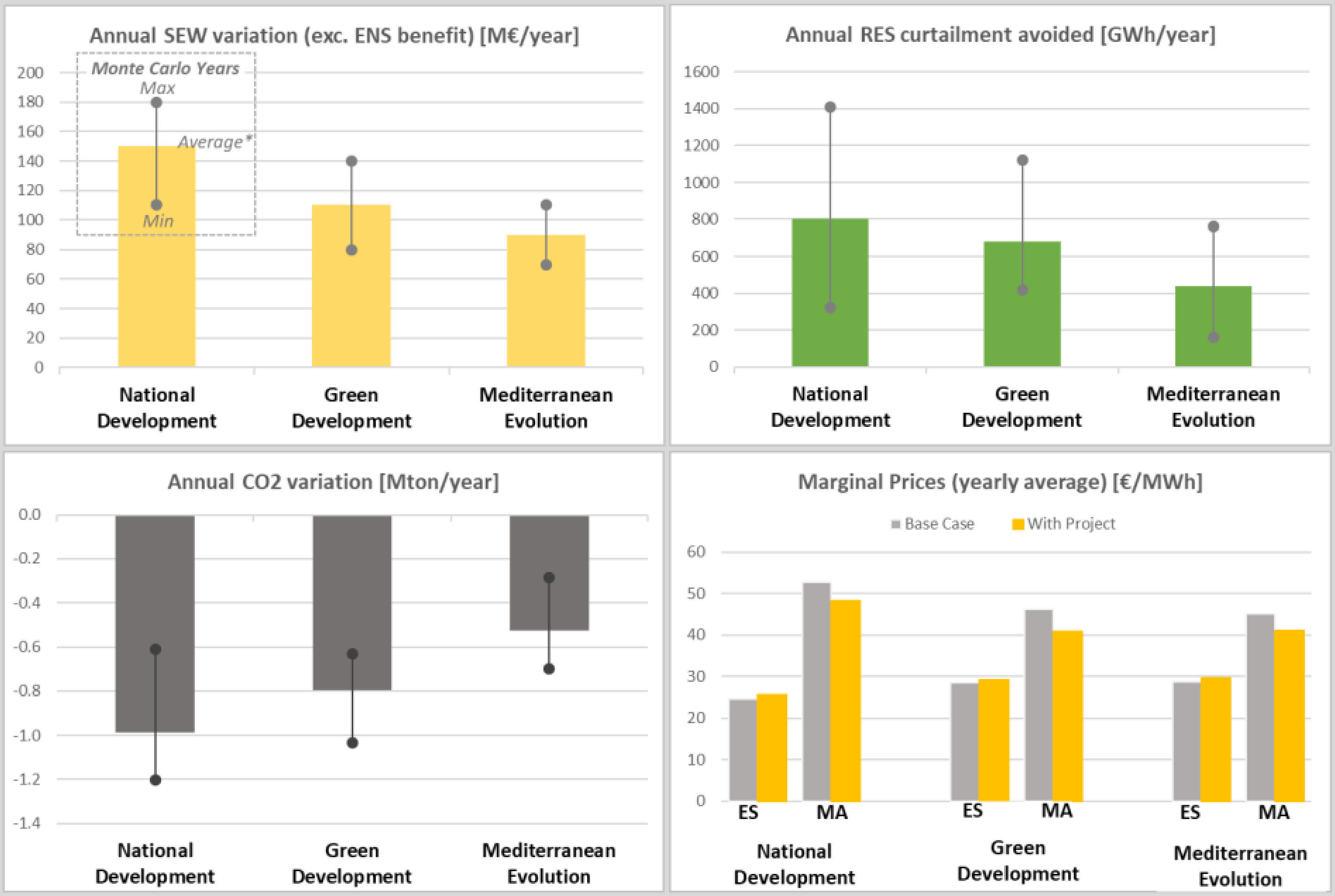
Project assessment analysis

CBA Indicators

Project 2 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

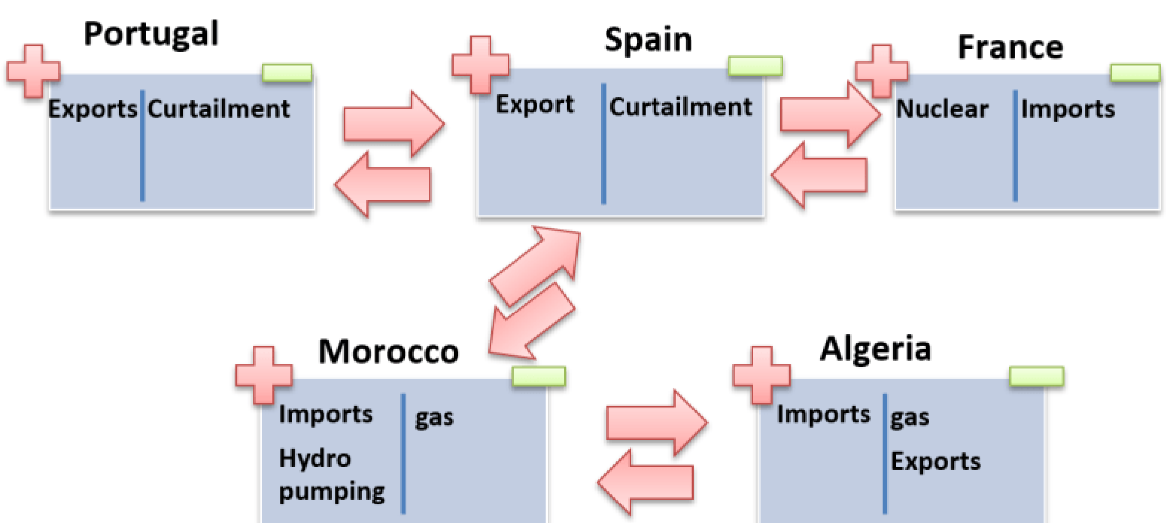
Market Studies

Project 2 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 Spain and in Portugal. More specifically:

- **Generation mix:**
  - **MA: r**eduction in Gas generation (and slight increase in Hydro Pump generation in all scenarios)
  - **ES:** reduction in RES curtailment
  - **PT:** reduction in RES curtailment
  - **DZ:** reduction in Gas generation
  - **FR:** increase in Nuclear generation

Country balance and cross-country power flows: the new interconnection significantly increases the annual flow from Spain to Morocco, contributing to an important reduction of the saturation hours of the interconnection between these two countries (Spain to Morocco direction). An important share of the energy imported by Morocco from Spain is exported to Algeria, with both Morocco and Algeria benefiting from the lower energy marginal prices observed in Spain.

Note: The fuel and Co2 price assumptions used for the market studies result in a gas before coal economic merit order. However, coal fired power plants in Morocco are under IPP contracts and have to respect take or pay constraints. In order to maintain coal power plants in Morocco functioning beyond take or pay constraints, an hourly must-run profile for each coal cluster has been prepared. This led to the simulation of an additional Scenario, based on Scenario 1 (National Development) but with a higher contribution of coal generation in Morocco. The results of this additional simulation may be found in the detailed project assessment (link).



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Project assessment analysis

The project consists in a new interconnection between Spain and Morocco. The new AC OHL will increase the interchange capacity between Spain and Morocco for an additional 700 MW. The total length of the link is estimated to be around 60km (30km OHL and 30km subsea cable).

For the N and N-1 static analysis full model representation is considered for the systems of Spain, Morocco, Algeria and Portugal, while France and Tunisia are represented as bus bar countries. For security analysys three different scenarios have been distinguished and 9 points in time have been defined. The analysis identified the reinforcements that should be done for the system of Morocco, while for Spain no internal reinforcements are identified. For the third countries that are included in the project no internal reinforcements are suggested.

Scenario 1, 2, 3	
Description (Morocco)	**Description (Spain)**
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 223M€, 33% of which represent investment for internal reinforcements in Morocco. The more detailed breakdown of the cost is presented below.

Investment cost-Interconnection	
Lines	***Cost [M€]****
AC cable Morocco	30
AC cable Spain	30
AC line Morocco	10
AC line Spain	0
AC cable Morocco	70
line bay Morocco	2
line bay Spain	2
line reactor Morocco	2
line reactor Spain	2
TOTAL	**148**

<table>
<tr><th colspan="2">Investment cost –internal reinforcements</th></tr>
<tr><th>Lines (Morocco)</th><th>Cost [M€]*</th></tr>
<tr><td>400kV OHL Bni Harchane-Shoul</td><td rowspan="5">75</td></tr>
<tr><td>225kV OHL Bni Harchane-Tetouan</td></tr>
<tr><td>Transformers (Morocco)</td></tr>
<tr><td>400kV/225kV Shoul</td></tr>
<tr><td>Total</td></tr>
</table>

*Rounded values

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Project cost benefit analysis results

Assessment results for the Project #2: Spain - Morocco											
GTC increase direction 1 (MW)			700								
GTC increase direction 2 (MW)			700								
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		ES	12100	12700	600	12100	12700	600	12100	12700	600
		MA	1900	2550	650	1900	2550	650	1900	2550	650
GTC/NTC - Export		ES	13100	13750	650	13100	13750	650	13100	13750	650
		MA	1600	2200	600	1600	2200	600	1600	2200	600
Interconnection Rate - Import/Export (%) [1]		ES	7.7% / 8.3%	8.0% / 8.7%	0.4% / 0.4%	7.5% / 8.1%	7.8% / 8.5%	0.4% / 0.4%	8.1% / 8.8%	8.5% / 9.2%	0.4% / 0.4%
		MA	11.8% / 9.9%	15.8% / 13.7%	4.0% / 3.7%	9.8% / 8.2%	13.1% / 11.3%	3.3% / 3.1%	7.7% / 6.4%	10.3% / 8.9%	2.6% / 2.4%
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)	150	110	180	110	80	140	90	70	110
	B2 - RES Integration[3]	(GWh/y)	800	320	1410	680	420	1120	440	160	760
	B3 - CO2	(Mton/y)	-1.0	-1.2	-0.6	-0.8	-1.0	-0.6	-0.5	-0.7	-0.3
	B4 - Losses[2]	(M€/y)	20			10			20		
		(GWh/y)	130			-30			180		
	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€)	220								

[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)