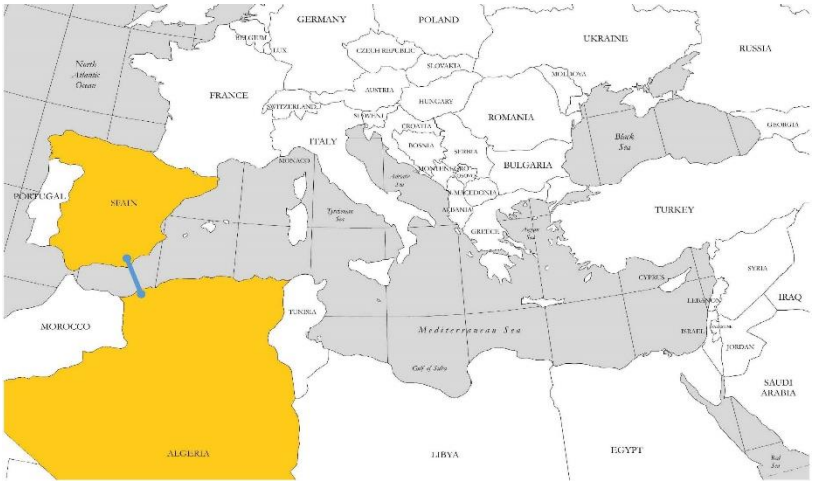
## Project #3 – ALGERIA - SPAIN

## Description

There are presently no existing interconnections between Spain and Algeria. The Algeria grid is currently interconnected with Morocco and Tunisia, whereas the Spanish grid is currently interconnected with Morocco, Portugal and France.

The interconnection between Spain and Portugal comprises six 400kV transmission lines and three 220kV transmission lines, leading 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 expected to reach 3500 MW (flow from Portugal to Spain) and 4200 MW (flow from Spain to Portugal) in 2022.

Presently Spain is interconnected with France through the HVDC link between Santa Llogaia (Girona) and Baixàs (Rousillon). This project increased the NTC from 1400 MW to 2800 MW in both directions. New grid developments are foreseen for the coming years, such as the Biscay Gulf Project that it is expected to increase the NTC by 2200 MW and later on the Trans-Pyrenees Projects that will increase the NTC value by an additional 3000 MW.




Regarding the interconnection between Spain and Morocco, it 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), which can add an additional 600-650 MW NTC 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.

As for the interconnection between Algeria and Tunisia, there are currently: one 400 kV transmission line; one 220 kV transmission line; one 150 kV transmission line; and two 90 kV transmission lines (150kV and 90 kV lines to be decommissioned in a middle-term horizon). This infrastructure enables an estimated total Net Transfer Capacity of 250 MW.

This project consists of a new interconnection between Algeria (Ain Fatah) and Spain (El Carril) to be realized through an HVDC submarine cable. The HVDC interconnection will have a capacity of 1000MW and a total length of around 240km. The maximum depth for the installation of the undersea cable will be around 2000m. In addition, in the Algerian side, the connection of the HVDC converter station to the national grid will require a 2x50 km 400 kV AC overhead line.

***Project Description Table***

| *Description* | *Substation (from)* | *Substation (to)* | *GTC contribution (MW)* | *Total Route length (km)* | *Present status* | *Expected commissioning date* | *Evolution* |
|---|---|---|---|---|---|---|---|
| *New interconnection between Algeria and Spain* | Ain Fatah - Algeria | Carril - Spain | 1000 | 240 | Long-term project | TBD | |

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

## Project #3 – ALGERIA - SPAIN

## Project Merits

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

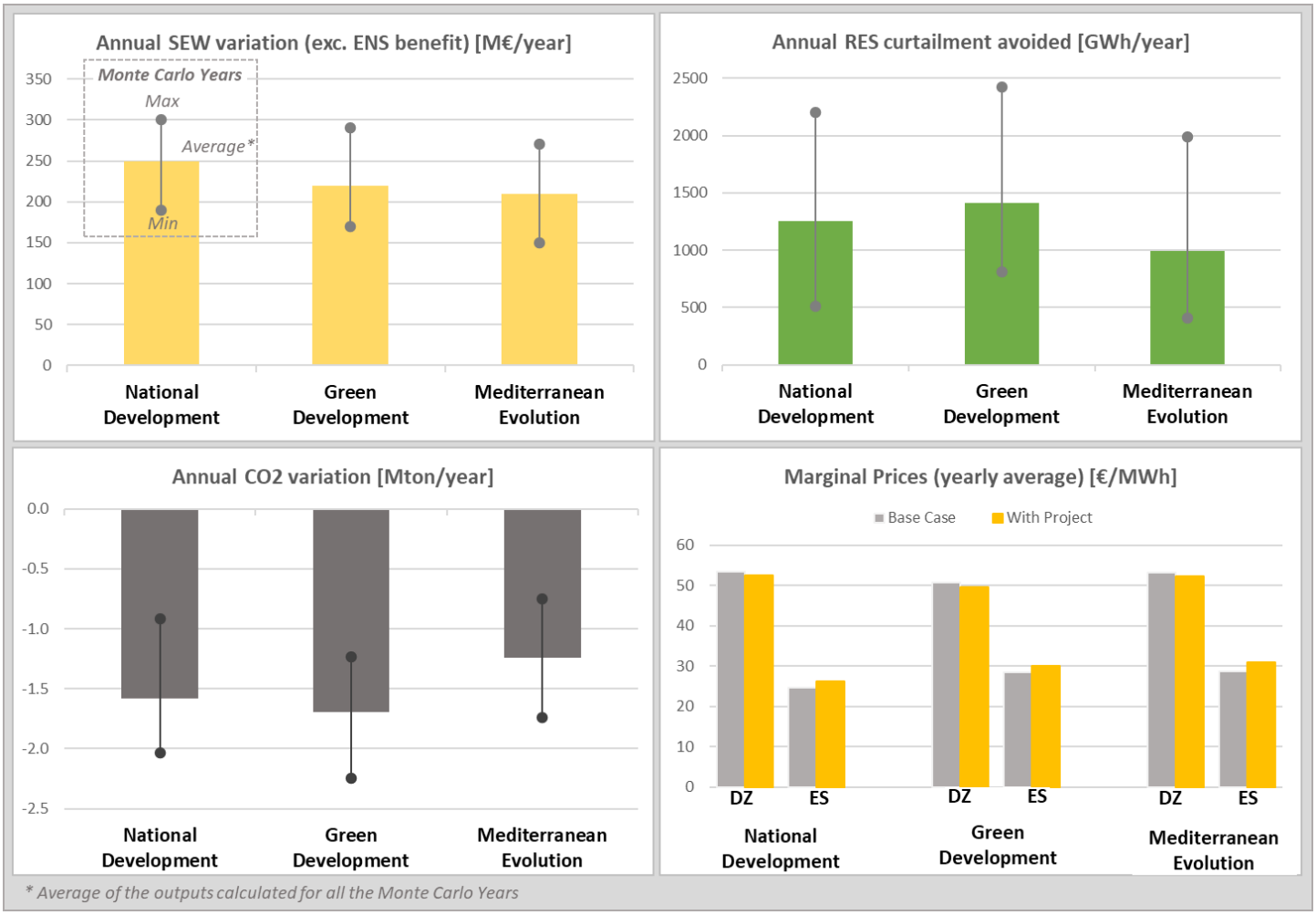
| | PROJECT MERITS | ASSOCIATED SYSTEM NEEDS | PROJECT 3 |
|---|---|---|---|
| **Market** | Reduce high price differentials between different market nodes and/or countries | Power studies with a 2030 time horizon can highlight significant differences in average marginal prices between countries, groups 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.<br>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).<br>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 | |

## Project #3 – ALGERIA - SPAIN

## Project assessment analysis

### CBA Indicators

Project 3 yields a positive impact in the expected values of all the analysed quantitative CBA indicators. Specifically, the project drives consistent increases in the Social-Economic Welfare and RES Curtailment and a consistent decrease in the CO2 emissions across the 3 simulated scenarios. As for the Energy not Supplied indicator, the impact of the project is negligible, considering the value of this indicator is also negligible in the base case (i.e. without the project) in the involved countries.




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

## Project #3 – ALGERIA - SPAIN

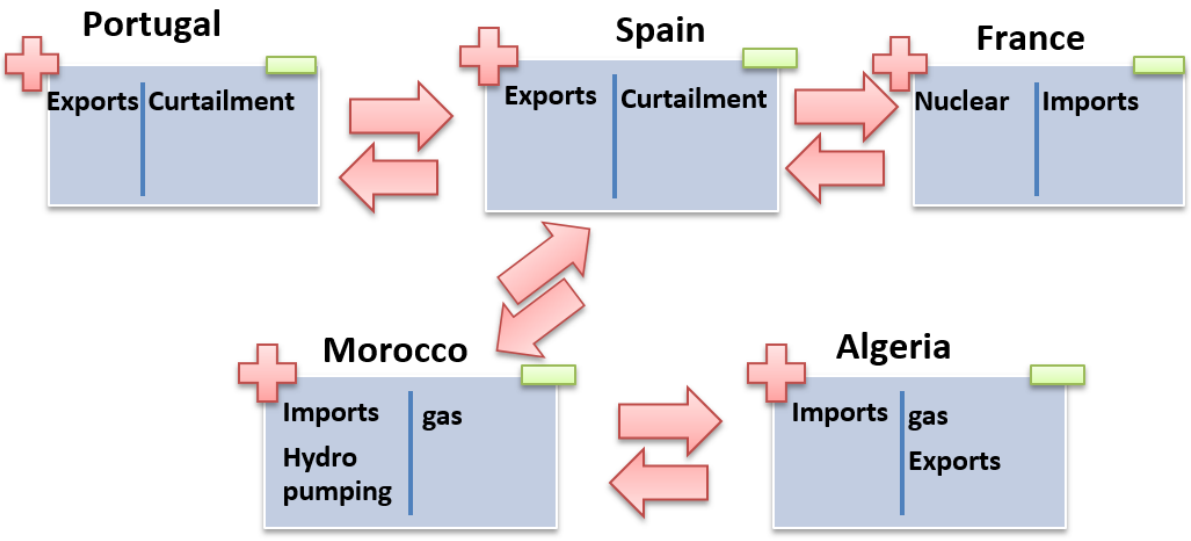
## Project assessment analysis

**Market Studies**

Project 3 drives a reduction in Gas generation, which is most noticeable in Algeria. This reduction in Gas generation is mostly compensated by an increase in Nuclear generation in France and in RES generation, through the avoidance of curtailment in Spain and in Portugal. More specifically:

- **Generation mix:**
  - **DZ:** reduction in Gas generation
  - **ES:** reduction in RES curtailment
  - **MA:** slight reduction in Gas generation and slight increase in Hydro Pump generation
  - **PT:** reduction in RES curtailment
  - **FR:** increase in Nuclear generation

**Country balance and cross-country power flows:** the flows observed in this new interconnection are mostly from Spain to Algeria, with an expected significant number of hours of saturation of the flow in this direction. Additionally, the project drives a positive impact on Algeria's balance with both Morocco (increase in exports to Morocco in Scenario ND and decrease in imports from Morocco in Scenarios GD and ME) and Tunisia (minor increase in exports to Tunisia in the 3 scenarios). Furthermore, the project results in a decrease in Spain's exports to France and an increase in Spain' imports from Portugal.



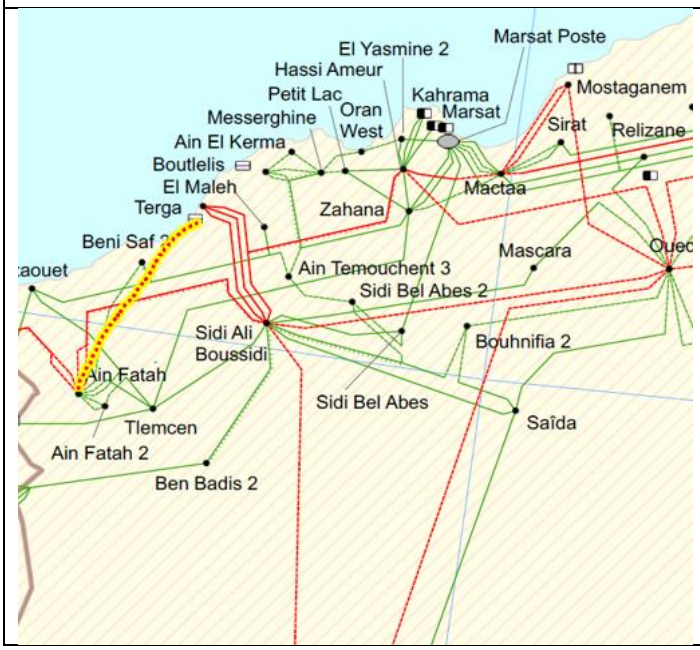
## Project #3 – ALGERIA - SPAIN

## Project assessment analysis


This project studies the interconnection between Spain and Algeria that will be realized through a 500kV HVDC submarine cable with a capacity of 1000MW and a total length of around 240km. In addition, in the Algerian side, the connection of the HVDC converter station to the national grid will require a 2x50 km 400 kV AC overhead line.

For the analysis a complete network model was adopted for the systems of Portugal, Spain, Morocco and Algeria. On the other hand, the system of France and Tunisia was represented as an external bus.

For this project three different scenarios have been distinguished and 3 points in time per scenarios were examined. The N and N-1 static analysis identified the internal reinforcements for the Algerian system and the system of Spain that are 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 (Algeria)** | **Description (Spain)** |
| New 400kV OHL between Terga and Ain Fateh | Repowering 400kV OHL between Benejama and Sax |
| | Repowering 400kV OHL between Catadau and Torrente |
| | Repowering 400kV OHL between Cofrente and La Muela1 |
| | Repowering 400kV OHL between Cofrente and La Muela2 |
| | Repowering 400kV OHL between Eliana and Godellet |
| | Repowering 400kV OHL between Eliana and Torrente |
| | Repowering 400kV OHL between Minglani and Olmedill |
| | Repowering 400kV OHL between Minglani and Requena |
| | Repowering 400kV OHL between Rocamora and Sax |
|  |  |

## Project #3 – ALGERIA - SPAIN

## Project assessment analysis

The overall investment cost is expected to be 720M€, 5.5% of which represent investment for internal reinforcements in Spain and Algeria. The more detailed breakdown of the cost is presented below.

| *Investment cost-Interconnection* | |
|---|---|
| ***Lines*** | ***Cost [M€]**** |
| DC cable | 350 |
| AC/DC converter station Algeria | 150 |
| AC/DC converter station Spain | 150 |
| AC line Algeria | 20 |
| AC line Spain | 0 |
| line bay Algeria | 10 |
| line bay Spain | 0 |
| **TOTAL** | **680** |

| *Investment cost –internal reinforcements* | |
|---|---|
| ***Lines (Spain)*** | ***Cost [M€]**** |
| Repowering 400kV OHL between Benejama and Sax | 10 |
| Repowering 400kV OHL between Catadau and Torrente | |
| Repowering 400kV OHL between Cofrente and La Muela1 | |
| Repowering 400kV OHL between Cofrente and La Muela2 | |
| Repowering 400kV OHL between Eliana and Godellet | |
| Repowering 400kV OHL between Eliana and Torrente | |
| Repowering 400kV OHL between Minglani and Olmedill | |
| Repowering 400kV OHL between Minglani and Requena | |
| Repowering 400kV OHL between Rocamora and Sax | |
| ***Lines (Algeria)*** | |
| 400kV OHL Ain Fateh-Terga | 30 |
| **TOTAL** | **40** |

*Rounded values

# Project #3 – ALGERIA - SPAIN

## Project cost benefit analysis results

| Assessment results for the Project #3: Algeria - Spain | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | | DZ | 1250 | 2250 | 1000 | 1250 | 2250 | 1000 | 1250 | 2250 | 1000 | |
| | | ES | 12100 | 13100 | 1000 | 12100 | 13100 | 1000 | 12100 | 13100 | 1000 | |
| GTC/NTC - Export | | DZ | 1250 | 2250 | 1000 | 1250 | 2250 | 1000 | 1250 | 2250 | 1000 | |
| | | ES | 13100 | 14100 | 1000 | 13100 | 14100 | 1000 | 13100 | 14100 | 1000 | |
| Interconnection Rate - Import/Export (%) [1] | | DZ | 3.5% / 3.5% | 6.3% / 6.3% | 2.8% | 3.4% / 3.4% | 6.1% / 6.1% | 2.7% | 2.9% / 2.9% | 5.2% / 5.2% | 2.3% | |
| | | ES | 7.7% / 8.3% | 8.3% / 8.9% | 0.6% | 7.5% / 8.1% | 8.1% / 8.7% | 0.6% | 8.1% / 8.8% | 8.8% / 9.5% | 0.7% | |
| 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) | 250 | 190 | 300 | 220 | 170 | 290 | 210 | 150 | 270 | |
| | B2 - RES Integration[3] | (GWh/y) | 1250 | 510 | 2200 | 1410 | 810 | 2420 | 990 | 410 | 1990 | |
| | B3 - CO2 | (Mton/y) | -1.6 | -2.0 | -0.9 | -1.7 | -2.2 | -1.2 | -1.2 | -1.7 | -0.7 | |
| | B4 - Losses[2] | (M€/y) | 40 | | | 40 | | | 60 | | | |
| | | (GWh/y) | 420 | | | 270 | | | 540 | | | |
| | B5a - SoS Adequacy[4] | (GWh/y) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 2.1 | |
| | | (M€/y) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | |
| | B5b - SoS System Stability | | | | | | | | | | | |
| Residual Impact Indicators | S1 - Environmental Impact | | | | | | | | | | | |
| | S2 - Social Impact | | | | | | | | | | | |
| | S3 - Other Impact | | | | | | | | | | | |
| Costs | C1 - Estimated Cost[5] | (M€) | 720 | | | | | | | | | |

[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 | |
| neutral impact | |
| positive impact | |
| Not Available/Not Applicable | |
| monetized | |