Deliverable 3.3

Results of complete CBA Methodology and assessment for interconnections case studies

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“Mediterranean Project”

Task 2 “Planning and development of the Euro-Mediterranean Electricity Reference Grid ”

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List of acronyms

AC	Alternating Current
ACER	Agency for the Cooperation of Energy Regulators
AIS	Air Insulated Switchgear
CBA	Cost – Benefit Analysis
BTC	Bilateral Transfer Capacity
CAPEX	Capital Expenditure
CESA	Continental Europe Synchronous Area
CO_2	Carbon dioxide
DC	Direct Current
EENS	Expected Energy Not Supplied
EETC	Egyptian Electricity Transmission Company (Egyptian TSO)
ELTAM	Egypt – Libya – Tunisia – Algeria – Morocco
ENTSO-E	European Network of Transmission System Operators for Electricity
ESO	Electricity System Operator (Bulgarian TSO)
ESS WG	Economic Studies and Scenarios Working Group of Med-TSO
ETS	Emission Trading Scheme
EU	European Union
GDP	Gross Domestic Product
GECOL	General Electricity Company of Libya (Libyan TSO)
GIS	Gas Insulated Switchgear
GTC	Gross Transfer Capacity
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IEC	Israel Electric Corporation (Israeli TSO)
IPTO	Independent Power Transmission Operator (Greek TSO)
IRR	Internal Rate of Return
LCC	Line Commutated Converter
MedReg	Mediterranean Regulators for Energy
Med-TSO	Mediterranean Transmission System Operators
MP	Mediterranean Project
MP I	Mediterranean Project I
NEPCO	National Electric Power Company (Jordanian TSO)
NPV	Net Present Value
NTC	Net Transfer Capacity
OHL	Overhead Line
ONEE	Office National de l'Electricité et de l'Eau Potable (Moroccan TSO)
O&M	Operation and Maintenance
OPEX	Operational Expenditure
PCI	Projects of Common Interest
PiT	Point in Time
PV	Present Value
REE	Red Eléctrica de España (Spanish TSO)
REN	Redes Energéticas Nacionais (Portuguese TSO)
RES	Renewable Energy Sources
RWG East	Regional Working Group East
RWG West	Regional Working Group West

SEW	Socio-economic Welfare
SoS	Security of Supply
Sonelgaz	Société Algérienne de l'Electricité et du Gaz (Algerian TSO)
STEG	Société Tunisienne de l'Electricité et du Gaz (Tunisian TSO)
TC1	Technical Committee 1 of Med-TSO (Planning)
TC2	Technical Committee 2 of Med-TSO (Regulations and Institutions)
TC3	Technical Committee 3 of Med-TSO (International Electricity Exchanges)
TEIAS	Türkiye Elektrik İletim A.Ş. (Turkish TSO)
Terna	Rete Elettrica Nazionale (Italian TSO)
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan
VSC	Voltage Source Converter

1. Executive Summary

The Market and Network Studies have identified and assessed 14 interconnection projects (9 of them in HVDC technology), according to the different energy scenarios elaborated at the year horizon 2030. Seven of these interconnection projects constitute the first link between these countries and, in particular, one of them is the end of the isolation of Cyprus.

Such interconnection projects are called Clusters, since they usually comprise a set of investments – new lines, new substations, other equipment for active and/or reactive power control, generally comprising both cross-border interconnections and network country reinforcements - necessary to realize a firm increase of energy exchange in both direction, measured through Gross Transmission Capacity (GTC) or, as an alternative, Net Transfer Capacity (NTC) across two particular countries/grid portions.

The Clusters are identified and selected through market studies as mentioned, to evaluate the reference interconnection capacities and network studies, to assess the fulfilment of the security of operation. The 14 Clusters are assessed through network studies, with the typical instruments of grid planning, i.e. evaluating which new lines/interconnections are beneficial to the system, under which scenario conditions, and evaluating their additional capacity considering boundary conditions, system constraints and credible contingencies.

After establishing a set of four realistic reference energy scenarios, specific market models and grid models have been developed for the evaluation of the impact of reference scenarios against current and future Euro-Mediterranean electricity systems (considering the new possible interconnections). This work relies on methodologies and criteria already developed by ENTSO-E for the TYNDP[1], adapted to the specificity of the Mediterranean region.

This document reports in particular on the application to each Cluster of a Cost-Benefit Analysis (CBA), adopting the widely accepted methodology also in use at European level by ENTSO-E; the main objective of the CBA is to provide a common and uniform basis for the assessment of the 14 Clusters.

Costs of Clusters (with their relevant grid reinforcements needed to guarantee harmonized security) are evaluated following the technical feasibility analysis, which determines the possible and most suitable technology to be used and the relevant costs (investment and energy losses).

Benefits of Clusters stem from the market studies, evaluated with perfect day-ahead market principles, i.e. unit commitment based on the generation merit order to satisfy load supply and reserve needs, optimization of overall generation cost including fuel cost, O&M and CO_2 emissions.

The applied CBA characterizes the impact of transmission Clusters, both in terms of added value for society (increase of capacity for exchanges of energy and balancing services between market areas, RES integration, increased security of supply) as well as in terms of social welfare (maximize the utilization of least cost generation). Some of the indicators are monetized, while others are quantified in their typical physical units (such as tons of CO_2 or GWh). Variation of losses due to a given grid development is one of the parameters of the CBA; losses are first evaluate in power terms (at a set of specific grid/market snapshots along the year), then translated into energy terms considering the load profiling of the transmission lines, and finally estimated in monetary terms assigning a value to the lost energy (value is country-specific, and sometimes also time-specific).

This multi-criteria approach highlights all the characteristics of a Cluster and gives sufficient information to the decision makers to further proceed in the investment initiatives.

[1] Ten-Year Network Development Plan

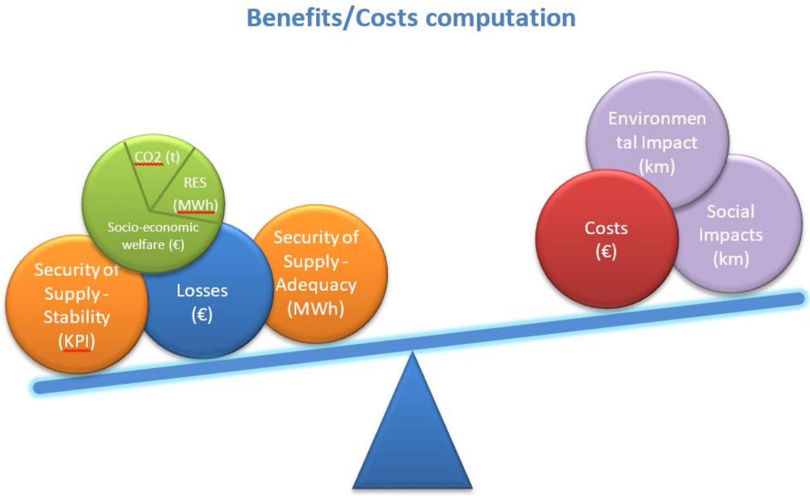


Figure 1 Main categories of the CBA computation (based on ENTSO-E documents)

Assumptions, details, calculation criteria, as well as concrete application to all 14 Clusters constitute the main body of this document.

The results show that, at this preliminary stage, all Clusters present positive economics in almost all scenarios and sensitivity cases, which means that they are all good candidates to be followed-up with further feasibility analysis.

Costs and benefits can also be put in relation together, through an economic analysis, but this requires further assumptions on the type of investment, funding and financial conditions, which will be suitable for further stages of the initiatives.

2. Recall of the Mediterranean Project

The possibility to develop an integrated regional electricity market within the Mediterranean area is a key factor for security and socio – economic development in this area. Indeed, electricity infrastructures are essential for achieving this objective, especially for what concerns the development of a reliable, secure and sustainable transmission network, capable to reinforce the interconnection between the countries and allow electricity exchange and integration of new generation sources, in particular from RES.

Based on a multilateral cooperation as a strategic approach to regional development for facilitating the integration of the Mediterranean power systems, Med-TSO has received from the EU Commission a three-year lasting grant (February 2015 to April 2018) to carry out what is called the "Mediterranean Project", defined by Med-TSO at the end of 2013 (Grant Agreement signed on December 30, 2014).

The Project aims at the progressive harmonization and strengthening of the electricity markets in the Mediterranean region, following a bottom-up approach and with a direct involvement of Med-TSO Members, through the following activity lines:

a) Rules

Developing and sharing a common set of basic rules, in cooperation with the association of the Mediterranean Regulators for energy (MedReg), for the interoperability of the Mediterranean power systems, facilitating electricity exchanges, development of infrastructures and institutional cooperation.

b) Infrastructure

Preparing and sharing guidelines for Network Planning and implementing a Euro-Mediterranean Electricity Reference Grid for studies and coordinated development of interconnections.

c) International Electricity Exchanges

Promoting the development of a Mediterranean Electricity System, focusing on methodologies, procedures and mechanisms for sharing resources through cross border exchanges, based on power systems complementarities and the optimized use of generation and transmission infrastructures.

d) Knowledge Sharing

Establishing a forum among the relevant professionals working in the fields related to the scope of the project (a sort of "Med-TSO Academy"), supporting also Med-TSO members and other relevant organizations through the organization of specific and oriented knowledge activities.

e) Med-TSO Database

Creation of a Mediterranean database for managing all the information shared in the frame of the project, dealing with network characteristics, energy scenarios and market data.

3. Scope of the present report within the Mediterranean Project

To carry out the activities defined in the framework of the Mediterranean Project, the operational bodies of Med-TSO were structured in three technical committees and three Working Groups:

- TC1 for planning and network studies
- TC2 for Regulation and Institutions
- TC3 for international electricity exchanges
- ESS Working Group for economic studies and scenarios
- WG East - Eastern Mediterranean Working Group
- WG West - Western Mediterranean Working Group

The objective of TC3 activity is to promote the development of the electricity exchanges, within a common vision of change in the Mediterranean region, to be reached by performing the following:

- Definition of operational schemes and methodologies for operation of interconnected systems in the presence of international exchanges and management of deviations and compensation of mutual exchanges;
- Schemes of sharing systems services with RES integration;
- Cross Border coordination, optimization of allocation and reserve margins management.

The activity assigned to TC3 is focused on methodologies, procedures and mechanisms for sharing resources through cross border exchanges, based on inter-grid complementarities and efficient use of generation infrastructures, allowed by the interconnection of the grids. This activity is detailed through the following:

- Assessment of regional cross border exchanges potential development: cross borders exchanges regulation, procedures and rules for coordinated dispatching and operation in presence of international exchanges;
- Schemes of sharing Ancillary Services of regulations with RES integration;

- Analysis and application of CBA methodology, criteria and assessment for interconnections cases studies.

This activity is organized in the three following sub-tasks:

- Sub-Task 3.1: Assessment of regional cross border exchanges
- Sub-Task 3.2: Schemes for sharing system services with RES integration
- Sub-Task 3.3: Application of the CBA methodology for the Clusters identified by network studies and market studies.

The overall activity (Task 3) is performed by the committee TC3 in coordination with ESS WG and TC1 for the definition of the CBA (Cost-Benefit Analysis) methodology and cost evaluation.

Sub-Task 3.1 was finalized in February 2016 and TC3 delivered a report on "*Assessment of regional cross border exchanges potential development in Mediterranean region*". The report was formally approved by Med-TSO General Assembly in April 2016 and submitted to the European Commission.

Sub-Task 3.2 was finalized in June 2017 and TC3 delivered a report on "*Schemes of sharing system services with RES integration*". The report was formally approved by Med-TSO General Assembly in July 2017 and submitted to the European Commission.

Sub-Task 3.3 "*Analysis and application of CBA methodology - criteria and assessment for interconnections cases studies*" is the subject of the present report.

The objective of sub task 3.3 is to apply the CBA (Cost Benefit Analysis) methodology used in the frame of ENTSO-E, adapted to the specific situations of the involved countries, to the interconnection projects identified in the Med-TSO 2030 regional market study conducted by ESS Working Group and analyzed/evaluated in the Network Study conducted by TC1 (Planning).

The approach consists in coupling the costs of both interconnection and internal reinforcements assessed by network studies and the benefits assessed within the market studies, thus providing a quantitative CBA and assessment of the interconnections case studies in the Mediterranean Region.

4. Assessment of Clusters

The CBA is carried out for the Clusters identified through network studies and analysed in market studies.

A Cluster is defined as the set of investments - new lines, new stations, other equipment for active and/or reactive power control, cross border interconnections or domestic reinforcements - necessary to realise a firm increase of energy exchange, measured through Gross Transmission Capacity (GTC) or in alternative Net Transfer Capacity (NTC) across two particular countries/grid portions.

The Clusters are identified through network studies, with the typical instruments of grid planning, i.e. evaluating which new lines are beneficial to the system, under which scenario conditions, and evaluating their additional capacity considering boundary conditions, system constraints and credible contingencies.

The technical feasibility analysis selects the possible and most suitable technology to be used and the relevant costs (investment and losses).

The market studies evaluate the benefits of such Cluster with perfect day-ahead market principles, i.e. unit commitment based on the generation merit order to satisfy load supply and reserve needs, optimization of overall generation cost including fuel cost, O&M and CO_2 emissions.

A summary of conclusions of such studies is reported below, as a useful framework information, while relevant details can be found in the specific deliverable documents of the Mediterranean Project.

4.1. Outcome of market studies - benefits

Med-TSO Reference Scenarios explore possible future situations of load and generation, interacting with the Euro-Mediterranean Power system. These scenarios are the baseline on which the interconnection projects of the Mediterranean Master Plan are assessed.

There are four scenarios selected with focus on the year 2030. The Northern bank is engaged in ambitious decarbonisation targets and market integration, however within a general stagnation of the electricity demand in the most of the countries. On the other hand, the Southern bank is characterized by large potential of renewable generation and by a fairly high rate of growth of the demand, supported by concrete examples of plans and deployment of RES. On the contrary, the market is still in slow evolution in this Southern region.

Therefore, the Med-TSO scenarios are defined with reference to six sets of drivers: economy and population, renewable energy development, technology development, new load, market integration, and thermal carbon free technologies. With these six drivers, four scenarios have been developed in the Market Studies:

- Scenario 1 – Business as usual
- Scenario 2 – Green Future
- Scenario 3 – High interconnection development
- Scenario 4 – Green Future & Market Integration

Based on the scenarios definition, a set of four market models has been set up. These models do not take into account the details of the transmission grids. They represent load and generation concentrated in a single node per each market area (usually one per country) and by specifying power plants characteristics (thermal, wind, photovoltaic, other -RES and non-RES undispatchable generation, run of river).

Every country border has a defined Bilateral Transfer Capacity (BTC) with interconnected neighbouring countries that contribute to guarantee the security of the electricity supply power system and allows economic exchanges of electricity. Med-TSO BTCs for the year 2030 have been directly addressed by Non-European TSOs in the Southern shore of Mediterranean, while TYNDP 2016 public data have been used for ENTSO-E countries. For the new interconnection projects between the two shores of the Mediterranean Sea, the Transfer Capacity (BTC) has been directly addressed by the TSOs involved in each project.

A Monte Carlo simulation model on a Mediterranean/European-wide basis is applied to carry out the market studies. The tool undertakes an optimal coordinated hydrothermal scheduling of the modelled electric system generation set, over a period of one year on an hourly basis. The simulation tool performs a day-ahead energy market, characterized by a system marginal cost and by a congestion management based on a zonal market splitting.

For each interconnection project (cluster) and each scenario, the market model calculates several annual indicators, as of:

- B1 indicator - the variation of Social Economic Welfare (SEW);
- B2 indicator - the RES curtailment;
- B3 indicator - the CO_2 emissions;

- and others.

All indicators are required to perform the CBA assessment.

The following tables present for each of the 14 interconnection projects, the range of assessment of those three indicators, considering the market results for the 4 scenarios referred above.

Interconnection Projects	B1 – SEW (M€ by year)	B2 – RES integration (GWh by year)	CO2 variation (kT by year)
Morocco - Portugal	66 / 140	70 / 520	-950 / 950
Morocco - Spain	63 / 140	70 / 460	-950 / 950
Algeria - Spain	120 / 200	90 / 1100	-1300 / 2400

Table 1 Benefit table for the interconnection projects of the Western corridor

Interconnection Projects	B1 – SEW (M€ by year)	B2 – RES integration (GWh by year)	CO2 variation (kT by year)
Algeria – Italy	130 / 250	340 / 2000	-700 / 2200
Tunisia – Italy I	67 / 150	240 / 1300	-500 / 900
Tunisia – Italy II	46 / 130	200 / 1170	-350 / 1000
Tunisia – Algeria	12 / 26	0 / 40	550 / 1200
Tunisia – Libya – Egypt	270 / 340	0	-1600 / -1000

Table 2 Benefit table for the interconnection projects of the Central corridor

Interconnection Projects	B1 – SEW (M€ by year)	B2 – RES integration (GWh by year)	CO2 variation (kT by year)
Greece – Turkey -Bulgaria	17 / 160	0 / 300	-1600 / 2800
Turkey – Syria - Jordan	210 / 330	0	-900 / 400
Jordan - Egypt	25 / 47	0	-450 / -150
Greece – Cyprus - Israel	480 / 710	190 / 1000	-3600 / 2100
Turkey - Israel	240 / 630	0	-1400 / 3200
Turkey - Egypt	370 / 880	0	-1800 / 4900

Table 3 Benefit table for the interconnection projects of the Eastern corridor

4.2. Outcome of network studies – investment costs

Market studies have shown the benefits in terms of both economics and adequacy of 14 interconnection projects/clusters. The network analysis, carried out by the TC1 (Planning) of Med-TSO, aims at assessing the attributes of each interconnection project/cluster when the transmission network and its physical laws are taken into account. Considering a new interconnection calls for verifying that the modification of the load flows will not hamper the security of operation and, in case, for highlighting the necessary reinforcements to the existing network that have to be designed.

At the end of the network analysis, security standards are fulfilled and the costs of the interconnection and the related reinforcements are known, together with the changes in losses that affect the efficiency introduced by the project. These further parameters are passed to the CBA for a final assessment of the viability of each project.

Therefore, the main goal of the Network studies was to assess the feasibility of the 14 interconnection projects (Clusters) proposed as outcome on the Market studies as shown in the Figure 2 , and to assess the overall cost of the Clusters to be included in the CBA. This cost includes two main components:

- cost of assets
- cost of active losses

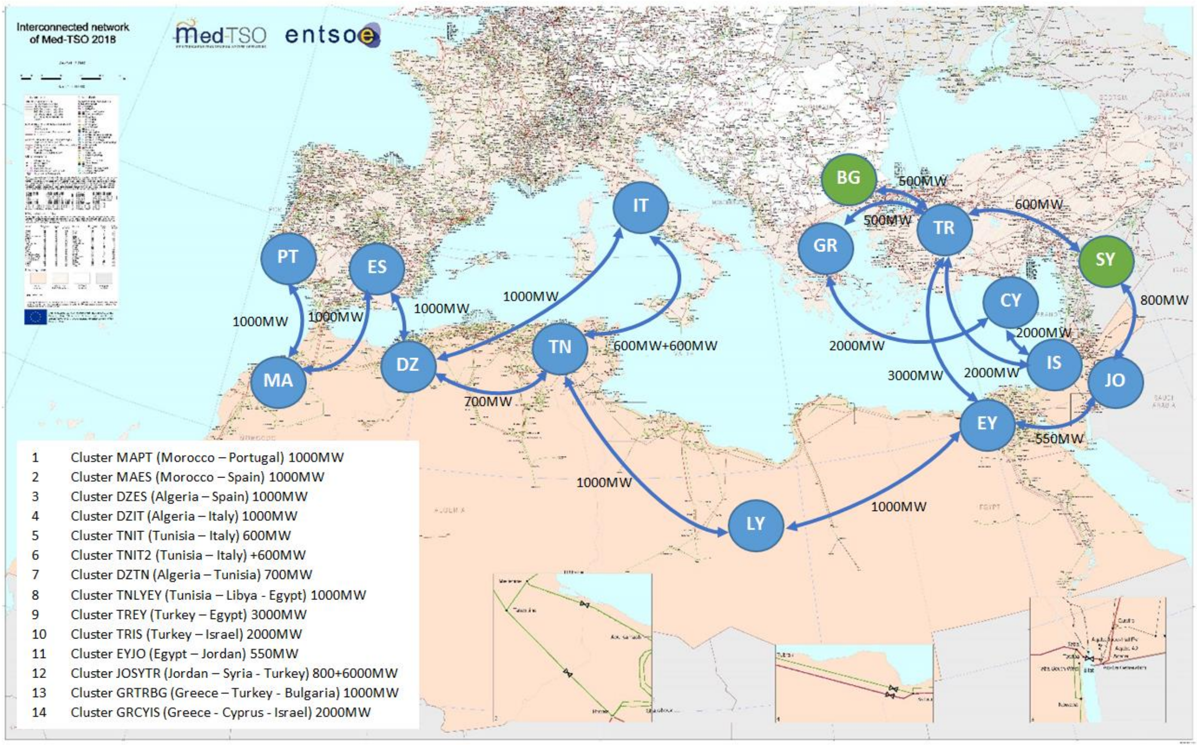


Figure 2 The 14 Mediterranean interconnection Projects/Clusters

For the assessment of the cost of assets, the Network studies should identify for each Cluster all internal electricity grid reinforcements required to guarantee the reliability of the interconnections and consequently the security of electricity supply in the Mediterranean Region. The following methodological steps were implemented:

1. The Mediterranean Region was divided in three main corridors:
   - Western (Blue): Algeria, France, Morocco, Portugal, Spain
   - Central (Brown): Algeria, Egypt, Greece, Italy, Libya, Montenegro, Slovenia and Tunisia);
   - Eastern (Red): Albania Cyprus, Egypt, Greece, Israel, Jordan, Lebanon, Palestine, Syria and Turkey.

The following tables summarise the investment Clusters considered in the Network studies, as well as their maturity and the main drivers for their selection.

In the Western corridor, three Clusters have been studied connecting Iberian Peninsula and Maghreb:

Countries	Capacity (MW)	Maturity	Comment
Morocco - Portugal	1000 MW (HVDC)	Under consideration	Studies promoted by the TSOs under the umbrella of Med-TSO studies within MP I. Has been analysed in several studies promoted by the TSOs and/or governments.
Morocco - Spain	1000 MW (HVAC)	Under consideration	Additional to the existing interconnection Studies promoted by the TSOs under the umbrella of Med-TSO studies within MP I
Algeria - Spain	1000 MW (HVDC)	Under consideration	Studies promoted by the TSOs under the umbrella of Med-TSO studies within MP I

Table 4 Investment clusters studied in Western corridor

In the Central corridor, some of the Clusters are connecting south Italy and Maghreb While others are to reinforce the South Bank back bone from Algeria to Egypt.

Countries	Capacity (MW)	Maturity	Comment
Algeria – Italy	1000 MW	Under consideration	Studies promoted by the TSOs (2004 and 2014)
Tunisia – Italy I	600 MW	Project included in the PCI list and commissioning is expected by 2025 (feasibility study stage)	Project included in the Reference scenario
Tunisia – Italy II	600 MW	Under consideration	
Tunisia – Algeria	+700 MW		Additional to the existing interconnections (increasing NTC from 300 MW to 1000 MW)
Tunisia – Libya – Egypt	1000 MW	Under consideration	Was considered in ELTAM study

Table 5 Investment clusters studied in Central corridor

In the Eastern corridor, some Clusters are on-land while others consider submarine solutions.

Countries	Capacity (MW)	Maturity	Comment
Greece – Turkey -Bulgaria	500 + 500 MW	Under consideration	Main driver of the project to increase the transfer capacity in the CESA to Turkey transmission corridor
Turkey – Syria - Jordan	600 + 800 MW	Syria-Turkey - Project under consideration	Main driver of the project to double the transfer capacity in the Turkey – Syria – Jordan transmission corridor

Countries	Capacity (MW)	Maturity	Comment
Jordan - Egypt	550 MW		Main driver of the project to double the transfer capacity between Egypt-Jordan
Greece – Cyprus - Israel	2000 + 2000 MW	Planned (PCI TYNDP ENTSO-E)	Main driver of the project to create the electricity highway Israel-Cyprus-Greece and to end the Energy Isolation of Cyprus.
Turkey - Israel	2000 MW	Under consideration	Main driver of the project to develop a new corridor in the eastern Mediterranean
Turkey - Egypt	3000 MW	Under consideration	Main driver of the project to develop a new corridor in the eastern Mediterranean

Table 6 Investment clusters studied in Eastern corridor

2. This approach is driven by the geographical characteristics, but it also allows simplifications in performing the analysis. In Figure 3 the block diagram of the interconnections is presented, as well as how this approach allows to implement different levels of details concerning system representation in 3 different corridors.

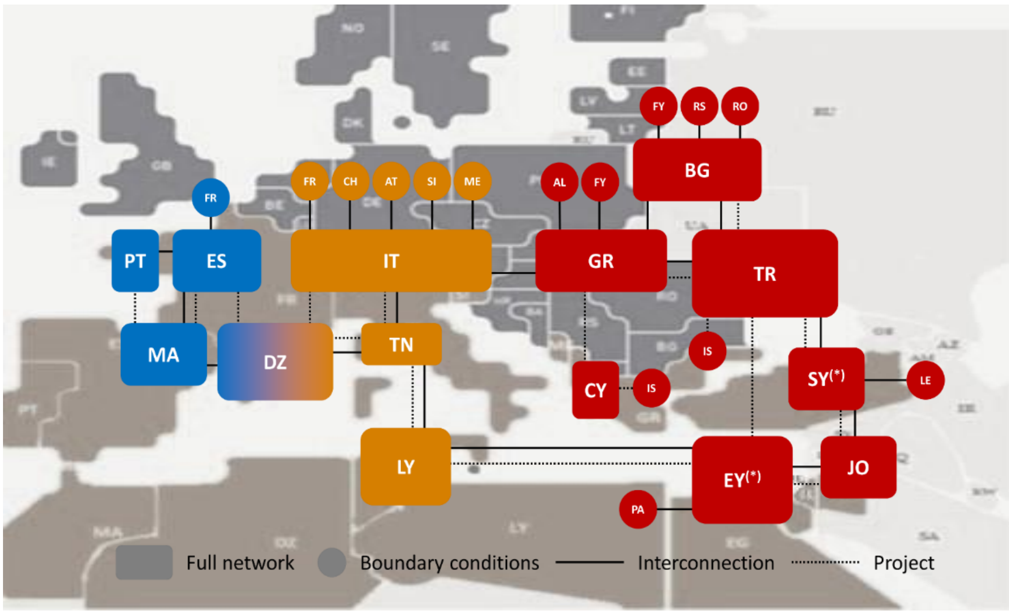


Figure 3 Division of the Mediterranean systems in 3 Corridors (Western, Central and Eastern)

3. For each Cluster, based on the hourly simulations available from the Market studies, adequate Points in Time (PiT) were selected, considered as representative of each one of the four scenarios to define the physical environment where the project will be in operation.

4. The individual models, compatible with the National Development Plans, were collected by the members, merged per region and adequately adjusted in terms of load and generation for each PiT to determine the snapshots to be used for network calculations. Concerning system representation included in the merged models, in some cases full neighbouring systems were considered, while in others it was sufficient (or necessary in lack of data) to include only a simplified

representation of some connected neighbours (equivalent model or representation as boundary condition).

5. Steady state and security analysis was performed (N-1 and partial N-2) for all Clusters taking into account the internal limits of voltage and currents adopted by each TSO member. Simulations were performed using DC approximation, which allowed the implementation of an increased number of simulations. AC simulations were also applied in a limited number of Clusters for which voltage issues were identified. These AC simulations are applied in some specific PiTs and not in all PiT selected. The process resulted in a list of internal reinforcements relevant to each Cluster.
6. The cost of the interconnection and the relevant internal reinforcements constitute the overall investment cost of each Cluster assessed by TC1. For the monetisation of the overall investment cost it was agreed to consider standard costs proposed by each Member for internal reinforcements and for the cost of the interconnection project to use standard costs proposed by a third party (External Expert) for the technology implemented for each project.
7. Moreover, using the same PiTs for each Cluster, the Network studies assessed the differential internal active losses in each system and the losses on the interconnection with and without the project, the cost of which also represents part of the overall costs (see in detail in section 5.2).

Based on the above, the main outcomes of the Network studies for the Clusters of each corridor are summarised below and presented in detail in chapter 6.

4.2.1. Western Corridor

The main conclusions of the Network studies for the investment Clusters of the Western Corridor are summarized to the following.

Morocco – Portugal (MA-PT)

The Cluster consists in a new interconnection between Portugal and Morocco in HVDC technology.

The HVDC interconnection will have a capacity of 1000 MW and a total length of around 265 km, of which approximately 220 km will be in submarine cable. The maximum depth for the installation of the undersea cable will be around 500m.

The HVDC link consider the configuration of 2 circuits (bipolar converter) of 500 MW each, between TAVIRA substation of 400 kV (PT) and BENI HARCHAN substation of 400 kV (MA).

This interconnection is promoted by REN and ONEE under the umbrella of Med-TSO studies within the MP I.

The security analysis performed with the merged full models of the systems of Portugal, Morocco, Algeria and Spain identified the internal reinforcements in the Portuguese, Moroccan and Spanish systems.

The overall investment cost ranges between 650 and 720 M€, 23% - 26% of which represents investment for internal reinforcements in Morocco, Portugal and Spain related to the project.

Morocco – Spain (MA-ES)

The Cluster consists in a new HVAC interconnection between Morocco and Spain that will increase the NTC between both countries in 1000 MW (additional to the 2 existing links).

The interconnection will have a capacity of 1000 MW and a total length of around 70 km corresponding 30 km to the length of the undersea cable. The maximum depth for the installation of the undersea cable will be around 500m.

The HVAC link consider a configuration of one circuit, between TARIFA2 substation of 400 kV (ES) and BENI HARCHAN substation of 400 kV (MA).

The interconnection is promoted by REE and ONEE in the field of Med-TSO studies.

The overall investment cost ranges between 400 and 420 M€, of which 62% - 64% represents investment for internal reinforcements in Morocco and Spain related to the project.

Algeria – Spain (DZ-ES)

The Cluster consists in a new interconnection between Algeria and Spain to be realized through an HVDC submarine cable.

The HVDC interconnection will have a capacity of 1000 MW and a total length of around 240 km. The maximum depth for the installation of the undersea cable will be around 2000m.

The HVDC link consider a configuration of 2 circuits (bipolar converter) of 500 MW each, between CARRIL2 substation of 400 kV (ES) and AIN FATAH substation of 400 kV (DZ). The connection of both AC/DC substations to the 400 kV grids will be performed through 120 km of 400 kV OHL (2x50 km in Algeria and 2x10 km in Spain).

This interconnection is promoted by REE and Sonelgaz in the field of Med-TSO studies.

The overall investment cost ranges between 900 and 930 M€, of which 25% - 27% represents investment for internal reinforcement in Algeria and Spain related to the project.

As a common remark, the internal reinforcements associated with these 3 Clusters in the Western Corridor (between Iberian Peninsula and Maghreb) are in general close to the border where the interconnections are located. They represent a small amount but not negligible for the interconnection projects MA-PT and DZ-ES (in general varying from 23% to 27% of the total investment cost) and more than 60% of the total investment cost for the MA-ES interconnection cluster.

Concerning losses, in general all interconnection Clusters of the Western corridor result in an increase of the overall losses in the global system, which is even more significant in the cases of the HVDC interconnections. The values of the losses (in the interconnections and in the transmission grids) as well as the estimate costs are presented in chapter 6 too.

4.2.2. Central Corridor

The main conclusions of the Network studies for the investment Clusters of the Central Corridor are summarized to the following.

Algeria – Italy (DZ-IT)

The Cluster consists of a new interconnection with a carrying capacity of 1000 MW between Algeria and Italy (Sardinia) in HVDC submarine cable. The HVDC interconnection has a total length of around 350 km. The maximum depth for the installation of the undersea cable will be over than 2000m.

The HVDC link will be between south of Sardinia (IT) and North – East of Algeria (Cheffia region), and the connection of AC/DC substation in the Algeria grid will be performed through 2x50 km of 400 kV OHL.

The study project has been proposed by Sonelgaz and Terna.

For the interconnection project between Algeria and Italy, no severe overloads have been detected due to the new interconnection for neither the Italian nor the Tunisian systems. Therefore, no reinforcements were defined for neither of them.

In the case of the Algerian system, some overloads are detected in the North – East region. To solve this situation, a single reinforcement has been defined in Algeria.

The overall investment cost is estimated at 850 M€, 2.5% of which represents investment for internal reinforcements in Algeria related to the project.

Tunisia – Italy (TN-IT)

The Cluster is analysed in two steps: the first interconnection TN-IT 1 (600 MW) and the second interconnection TN-IT 2 reinforcing the first one with 600 MW additional interconnection capacity.

Tunisia – Italy (TN-IT) 1

The Cluster consists in a new interconnection between Tunisia and Sicily in HVDC submarine cable. The realization of the Cluster is supported by the Italian and Tunisian Governments to increase the interconnection capacity of the Euro-Mediterranean system.

The Cluster will contribute to reducing present and future limitations to the power exchanges on the Northern Italian border under specific conditions, and therefore it will allow increasing significantly the transmission capacity and its exploitation by at least 500 MW on that boundary.

The new interconnection will be installed between Partanna (IT - Sicily) and Mornaguia (TN – Cape Bon).

The overall investment cost is estimated at 650 M€, 20% of which represents investment for internal reinforcements in Tunisia related to the project.

Tunisia – Italy (TN-IT) 2

The Cluster envisages the reinforcement of the first interconnection with additional 600 MW between Tunisia and Sicily, to be realized through an HVDC submarine cable. The Cluster may contribute to reduce present and future limitations to the power exchanges on the northern Italian border under specific conditions, and therefore it may allow increasing significantly the transmission capacity and its exploitation by on that boundary.

The overall investment cost is estimated at 580 M€, 10% of which represents investment for internal reinforcements in Tunisia related to the project.

Algeria – Tunisia (DZ-TN)

The Cluster consists in a new AC interconnection between Algeria and Tunisia, with increasing the NTC from 300 MW to 1000 MW (+700 MW).

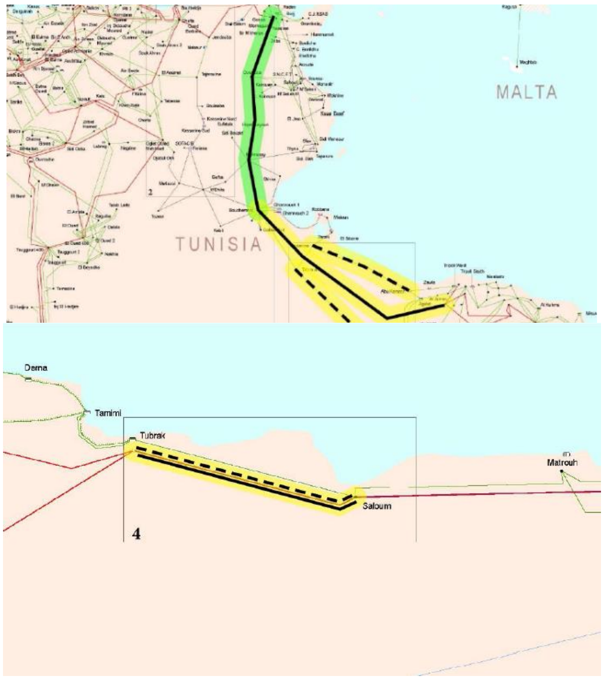
It is due to the significant number of hours of saturation that were detected in the preliminary market simulations that this cluster was added in the network studies.

Physically, it consists of a second 400 kV OHL from the substation Jendouba in Tunisia to the substation Cheffia in Algeria. No remarkable overloads associated to the new interconnection were identified in the Algerian system, thus no internal reinforcements were defined for Algeria. However, reinforcements are needed in Tunisia system in order to evacuate energy from the Jendouba Substation. A couple of alternatives are possible, both requiring a new 400 kV line. Between the alternatives proposed, the most effective involve the construction of a new 140km 400 kV circuit Oueslatia - Mornaguia and a new 150km 400kV circuit between Jendouba and Oueslatia.

The overall investment cost is estimated at 150 M€, 80% of which represents investment for internal reinforcements in Tunisia related to the project.

Tunisia – Libya – Egypt (TN-LY-EG)

The Cluster consists of a new interconnection between Tunisia, Libya and Egypt corresponding to 1000 MW of capacity.



The study project has been proposed by STEG and GECOL.

For the interconnection project between Tunisia, Libya and Egypt was detected reinforcements in Tunisia and Libya systems.

Tunisia: the energy interchange with Libya through the projected 400 kV interconnection comes down to the 220 kV network at the Bou Chema substation. This fact may un-dergo some overloads at the 220 kV net-work. To overcome this, a reinforcements are plannded to include new 400 kV circuits between Bou Chema and Oueslatia (250km) and Oueslatia and Mornaguia (150km), as well as 3 new 400 MVA, 220/400 kV transformers at both Oueslatia and Bou Chema substations.

Libya: relevant overloads detected at the 220 kV network. To overcome this, reinforcement of the 84 km OHL from Tubroc to Saloum is considered.

The overall investment cost is estimated at 540 M€, 40% of which represents investment for internal reinforcements in Tunisia and Libya related to the project.

4.2.3. Eastern Corridor

The main conclusions of the Network studies for the investment Clusters of the Eastern Corridor are summarized to the following:

Turkey – Egypt (TR-EG)

The Cluster is located in eastern Mediterranean and consists of a HVDC submarine cable between Turkey and Egypt.

The Cluster is planned as an alternative to existing north-south corridor passing through Turkey, Syria, Jordan and Egypt.

The main driver of the investment project is to develop a new corridor in the eastern Mediterranean region and to increase renewable energy integration in the region. Estimated capacity is about 3000 MW.

The security analysis performed with the full models of the system of Turkey identified in the Turkish system several reinforcements related to the Cluster. To reinforce the Turkish grid in the vicinity of TR-EG Cluster's connection point, connection of planned 400 kV Kozan – Sanko OHL should be modified by connecting this OHL to Misis OSB substation. After modification process, Kozan – Sanko OHL would be operated as 400kV Kozan – Misis OSB OHL and 400 kV Misis OSB – Sanko OHL. Additionally, replacement of existing 400 kV 2-bundle Adana – Bastug, Toscelik – Bastug, Erzin – Toscelik, and Erzin – Toscelik OHLs with 3-bundle conductors are required to reinforce the region.

On the Egypt side, the connection point and the reinforcements have to be indicated.

The overall investment cost is estimated at 2900 M€, less than 1% of which represents investment for internal reinforcements in the Turkish system related to the project, while the Egyptian system has not been evaluated.

Turkey - Israel (TR-IL)

The Cluster consists of a HVDC submarine cable between Turkey and Israel.

The main driver of the Cluster is to develop a corridor between Turkey and Israel to create trade possibilities and to increase renewable energy integration in the region. Estimated capacity is about 2000 MW.

To reinforce Turkish grid 400 kV Mersin – Adana OHL is required. Also replacement of existing 400 kV 2-bundle Toscelik – Bastug OHL with 3-bundle conductors is needed to reinforce the region. The Egypt system is still under evaluation.

The overall investment cost is about 1700 M€, less than 1% of which represents investment for internal reinforcements in the Turkish System related to the project, while the system of Israel has not been evaluated.

Egypt – Jordan (EG-JO)

The Cluster is relating to add a new interconnection between Jordan and Egypt, which will lead to double the current capacity (+550MW) between Egypt-Jordan to be 1100 MW.

Jordan and Egypt are electrically interconnected since 1998 via a 13 km, 400 kV submarine cable across the Gulf of Aqaba to Taba, with an exchange capacity of 550 MW. Egypt and Jordan are part of the Eight Countries interconnection, including also Syria, Lebanon, Turkey, Iraq, Palestine, and Libya.

The main driver of the interconnection project is to further increase the interconnection capacity between Egypt and Jordan to reach 1100 MW. This will improve the integration of RES generation and increase grid stabilization, helping both countries to meet their load demand, with the positive effect of postponing investments in both generation and transmission.

The security analysis identified:

- A new reinforcement in the Jordanian system consisting in doubling the existing 400 kV double circuit between Maan and Aqaba.
- A new reinforcement in the Egyptian system consisting in doubling the 500 kV circuit between O-Mousa and Taba and the 500/400 kV transformer at Taba substation.

The overall investment cost is estimated at 200 M€, 70% of which represents investment for internal reinforcements in the systems of Jordan and Egypt related to the project.

Jordan - Syria – Turkey (JO-SY-TR)

The Cluster consists of two new interconnections: one between Jordan and Syria and other between Syria and Turkey, to be realized through AC overhead lines and an HVDC Back-to-Back station in Turkey. The Cluster is expected to double the current to become 1600 MW between Jordan and Syria and 1200MW between Turkey and Syria.

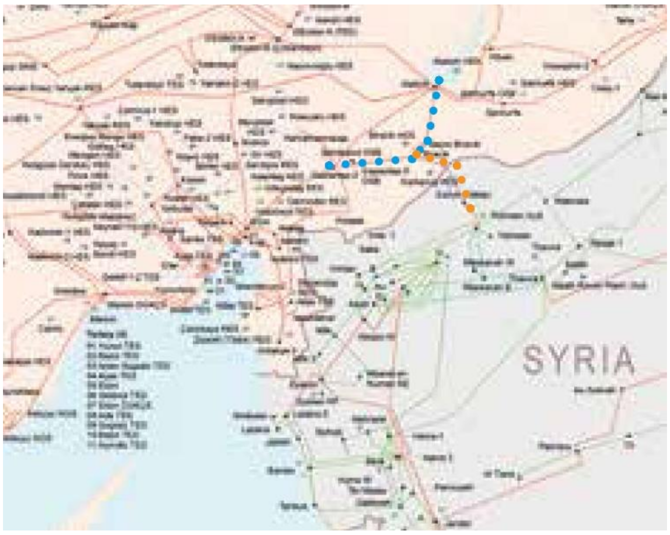
The Cluster is promoted by NEPCO and TEIAS (under the umbrella of the studies carried out by Med-TSO).

Jordan, Syria, and Turkey are electrically connected by a 400 kV grid, with existing capacity of 600 MW (Turkey-Syria) and 800 MW (Jordan-Syria). These countries are part of the Eight countries interconnection, including also Egypt, Lebanon, Iraq, Palestine, and Libya.

Therefore, the main driver of this Cluster is to further increase the interconnection capacity between Syria, Turkey, and Jordan by another 800 MW between Jordan and Syria and 600 MW between Turkey and Syria. This will allow mainly meeting the Syrian demand and to integrate more renewable resources and base load units in the region.

The security analysis performed with the full models of the systems of Jordan and Turkey and equivalent models of the system of Syria did not identify any reinforcements in the system of Jordan. However, some reinforcements are detected in Syrian and Turkish systems, namely:

- A new reinforcement was identified in the Syrian network, consisting in doubling the existing 400 kV double circuit between Adra 2 and Dir-Ali (four circuits between Adraz and Dir-Ali).
- Two main relevant reinforcements were identified in the Turkish network, consisting in the replacement of the 2bundle OHLs with 3-bundle conductors to reinforce the region (replacement of 400 kV 2-bundle Ataturk – Birecik HL with double circuit 3bundle conductors and replacement of 400k V 2-bundle Birecik HES – Birecik).



The overall investment cost is estimated at 250 M€, 10% of which represents investment for internal reinforcements in Turkey and Syria related to the project.

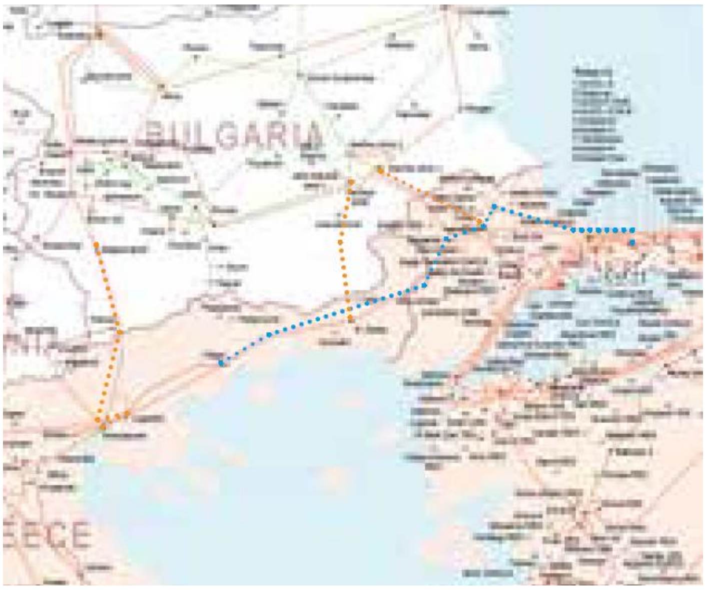
Greece - Turkey - Bulgaria (GR-TR-BG)

The Cluster consists in two new interconnections: one between Greece and Turkey and other between Bulgaria and Turkey to be realized through AC overhead lines. The project is promoted by IPTO, TEIAS and ESO. The main driver for the realization of the Cluster is to further increase the interconnection capacity between Turkey and the CESA (Continental Europe Synchronous Area) of about 1000 MW.

Two internal reinforcements in the Greek system close to the connection point of the Cluster, consisting in the construction of two double 400 kV OHL of a total length of 165km have been considered needed to guarantee security of operation. Also for Turkish system reinforcements are located close to the boarder and consist in the replacement of conductors of the existing 400 kV OHL of a total length of 25 km and the use of the spare circuit of Verbena (Hamitabat) – Habibler 400 kV OHL to reinforce the region.

In the analysis performed, NTC values considered exceed significantly the increase in the NTC foreseen by the new Cluster. This is due to the fact that the three systems represent an interconnected triangle, situation, which presents some difficulty in controlling the power flows in the interconnections to meet the values defined in the network scenarios. Thus, as a general remark it should be stressed that the internal reinforcements identified are required only in case the NTCs increase exceeds the foreseen values.

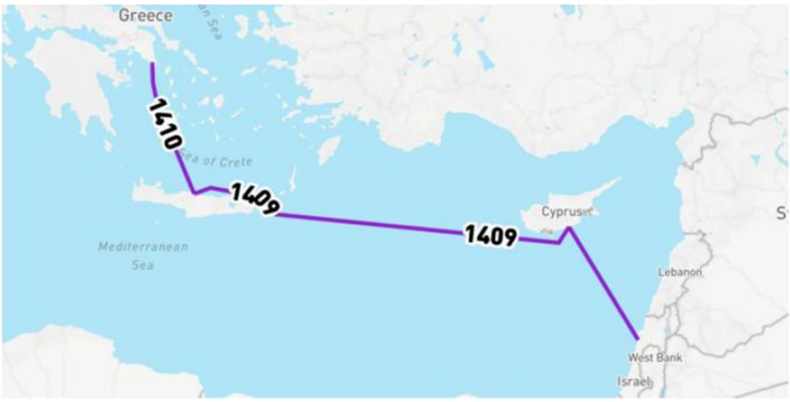
The overall cost is about 200 M€, 30% of which are needed in Greece and Turkey for additional reinforcements.



Greece - Cyprus - Israel (GR-CY-IL)

The Cluster refers to the Euro-Asia Interconnector, consisting of a HVDC VSC 500 kV submarine cable for the interconnection of the systems of Greece, Cyprus and Israel. The link has a capacity of 2000 MW and a total length of around 832 nautical miles/around 1541 km (approx. 314 km between Cyprus and Israel, 894 km between Cyprus and Crete and 333 km between Crete and Athens) and allow for reverse transmission of electricity.

This Cluster was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. It is expected to end the Energy Isolation of Cyprus, the last member of the European Union, which remains fully isolated without any electricity or gas interconnections.



Furthermore, it will promote the substantial development of the RES with the resulting reduction of the CO2 emissions and offer significant economic and geopolitical benefits to the involved countries.

It will also create the electricity highway from Israel-Cyprus-Crete-Greece (Europe) through which the European Union can securely be supplied with electricity produced by the gas reserves in Cyprus and Israel as well as from the available Renewable Energy Sources, contributing at the same time to the completion of the interconnections.

The security analysis performed with the merged full models of the systems of Greece and Cyprus did not identify any reinforcement in the two systems involved in the Cluster.

The overall investment cost is about 5900 M€, without internal reinforcements required in the countries involved.

As a general remark internal reinforcements associated with the six Clusters of the Eastern Corridor are rather shallow (close to the border where the interconnection is located), representing a small yet not negligible (in general varying from zero to less than 30%) part of the investment cost.

Concerning losses, in general all projects of the Eastern corridor result in an increase of the overall losses, which is even more significant in the cases of the HVDC interconnections, with the exception of the GRTRBG project which results in a significant reduction of the internal losses mainly in Turkey and secondary in Bulgaria (in Greece there is a small increase) and a consequently decrease of the overall losses for the project.

5. Methodologies for Cluster assessment

In the assessment of the different 14 clusters/interconnections, it was considered a Cost Benefit Analysis (CBA) methodology as global system approach, like used in ENTSO-E level.

5.1. CBA Methodology

The applied CBA methodology derives from the ENTSO-E proposal submitted to ACER on July 2016 and based on Regulation (EU) 347/2013 on guidelines for trans-European energy infrastructure; it sets out the Med-TSO criteria for the assessment of costs and benefits of a transmission project, all of which stem from ENTSO-E practice based on European policies on market integration, security of supply and sustainability.

The goal of project assessment is to characterize the impact of transmission projects, both in terms of added value for society (increase of capacity for exchanges of energy and ancillary services between market areas, RES integration, increased security of supply) as well as in terms of costs. In order to ensure a full assessment of all transmission benefits, some of the indicators are monetized, while others are quantified in their typical physical units (such as tons or GWh). A general overview of the indicators is included in the figure below.

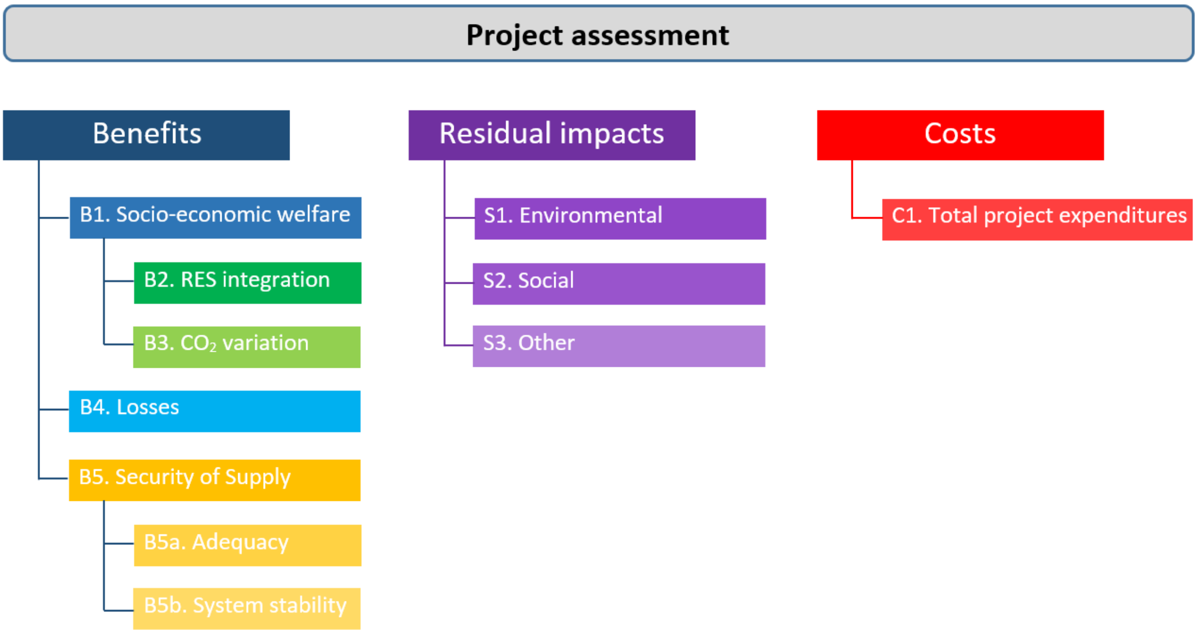


Figure 4 Main categories of the CBA methodology (based on ENTSO-E documents)

This set of common indicators forms a complete and solid basis for project assessment across the Mediterranean area within the scope of the Mediterranean Project. The multi-criteria approach highlights the characteristics of a project and gives sufficient information to the decision makers.

5.1.1. Benefits

Benefits are classified and measured as follows:

- **B1. Socio-economic welfare (SEW)** or market integration is characterized by the ability of a project to reduce congestion and thus provide an adequate GTC that ensures increasing NTC so that electricity markets can trade power in an economically efficient manner. SEW is defined as the economic surpluses of electricity consumers, producers, and transmission owners (congestion rent). The most common economic indicator for measuring benefits of transmission investments in planning scenarios is the reduction in total variable generation costs. The Market studies, performed by WG ESS within Med-TSO Mediterranean Project has produced for each interconnection project studied a SEW gain, expressed in M€ per year, which corresponds to the gains generated in proportional production costs throughout the simulated system.

  Changes in SEW must be reported for each project and for a given scenario. In addition to the overall socio-economic welfare changes, the SEW changes that are the result of integrating RES and that are the result of variation in CO_2-emissions must be reported separately:

  - Fuel savings due to integration of RES;
  - Avoided CO_2 emission costs.

- **B2. RES integration**: Support to RES integration is defined as the ability of the system to allow the connection of new RES plants and unlock existing and future “green” generation, while minimizing curtailments. Although this indicator is economically accounted for in the calculation of SEW (a variation of the RES integration will result in a variation of the energy from conventional sources and thus affect the system costs) the RES integration is one key target and is therefore displayed separately so the volume of integrated RES (in MW or MWh) must be reported in any case.

- **B3. Variation in CO_2 emissions** is the characterization of the evolution of CO_2 emissions in the power system due to the project. It is a consequence of B1 and B2 (the unlocking of generation with lower carbon content). Although this indicator is economically accounted for in the calculation of SEW (a variation of the CO_2 emission and the resulting change in emission costs will affect the system costs), the CO_2 indicator is one key targets and is therefore displayed separately (in tons).

- **B4. Variation in losses** in the transmission grid is the characterization of the evolution of energy losses in the power system due to the project. It is an indicator of energy efficiency. In order to calculate the difference in losses (in MWh) attributable to each project, and the related monetization, the losses have to be computed in two different simulations with the help of network studies, one with and one without the project. In this variation losses are included the internal losses of each relevant country grid (differential losses methodology) and the losses of the interconnection lines/cables. The methodology used for the losses calculation as well as for the losses monetization is explained in the section 5.2.

- **B5a & B5b. Security of supply**

  Adequacy to meet demand characterizes the project's impact on the ability of a power system to provide an adequate supply of electricity to meet the demand, taking into account the variability of climatic effects on demand and on forecasts of renewable energy sources production. The calculation is done first in expectation of avoided annual energy not supplied. The unit is MWh per year. The tool used for this evaluation operates with an internal failure valuation parameter, which is calculated for each country as the GDP divided by the electricity consumption. Thus, a "cost" of failure in k€ per MWh is obtained for each country. However, in many countries, there is an official value of the EENS used in planning studies, which of course differs from the standardized value used in the market study. This is why it is preferable to consider the project profit for EENS in MWh per year.

  System stability characterizes the project's impact on the ability of a power system to keep a stable and reliable supply of electricity taking into account the possible occurrences of system disturbances and faults. The assessment of system stability typically requires significant additional modelling and simulations to be undertaken for which the supporting models would be required. The studies are by their nature complex and time consuming and challenging to include within the Euro-Mediterranean region at this stage. Anyway, it could be practical to include a qualitative assessment based on the technology being employed in different factors: transient stability, voltage stability and frequency stability

5.1.2. Costs

Costs are classified and measured as follows:

- **C1. Total project expenditures** are based on prices used by each TSO and rough estimates on project consistency (e.g. km of lines). For each mature project, the cost (and corresponding uncertainty range) has to be reported, including all items. Costs for losses are not part of the total project expenditure, as the losses are reported separately by the indicator B4. The level of information about expected project costs depends on the status of the project. Therefore, reporting of costs shall be done using the best information available, whilst ensuring consistency of assumptions and thus comparable cost figures. For each cluster, the total costs are included the investments costs of the interconnections and the costs of internal reinforcements in the country grids affected.

5.1.3. External impacts

As far as environmental and social mitigation costs are concerned, the costs of measures taken to mitigate the impacts of a project should be included in the project cost (indicator C1). Some impacts may remain after these mitigation measures are implemented. These external impacts are accounted for by and included in indicators S1, S2, and S3. This split ensures that all measurable costs are taken into account, and that there is no double accounting between these indicators.

- **S1. Environmental impact** characterizes the project impact as assessed through preliminary studies, and aims at giving a measure of the environmental sensitivity associated with the project. S1 has been mostly used in the analysis include in the present report as a qualitative indicator, but in case it is quantified it can be expressed in terms of the number of kilometers that the routing of an overhead line or underground/submarine cable may run through environmentally 'sensitive' areas. This indicator only takes into account the residual impact of a project, i.e. the portion of impact that is not fully accounted for under C1.

- **S2. Social impact** characterizes the project impact on the local population that is affected by the project, as assessed through preliminary studies, and aims at giving a measure of the social sensitivity associated with the project. S2 has been mostly used in the analysis include in the present report as a qualitative indicator, but in case it is quantified it can be expressed in terms of the number of kilometers that the routing of an overhead line or underground/submarine cable may run through socially sensitive areas, such as areas of high touristic interest. This indicator only takes into account the residual impact of a project, i.e. the portion of impact that is not fully accounted for under C1.

- **S3. Other impacts**; this indicator lists the impact(s) of a project that are not covered by indicators S1 and S2, after potential mitigation measures defined when the project definition becomes more precise. These impacts may be positive or negative and will be included as a list in the assessment results. Impacts that are accounted for by indicators S1 or S2 shall not be included.

5.2. Methodology for losses estimation and monetization

Variation of losses due to a given project and related reinforcements is one of the parameters of the CBA. In line with ENTSO-E definitions, the following methodology has been adopted for the calculation of the variation of energy losses (in MWh) attributable to each Cluster and their monetization.

Energy losses attributable to each project represent the algebraic difference in annual losses with and without the specific project (losses with the project minus losses without the project). Therefore, with the help of network studies the losses have to be computed for a representative amount of hours in the two situations. An acceptable approximation of the amount of calculated losses is obtained, if at least the following requirements are met:

1. Losses are representative for the relevant geographical area;
2. Losses are representative for the relevant period of time;
3. Market results (generation dispatch pattern) used for each simulation are used to monetize losses in all the countries involved.

Total losses should include both the internal losses in each grid (each country) due to the new project and also the losses in the new interconnection line/cable.

The assessment of annual losses is performed in two different ways:

a) for the interconnection: considering the 8760 h flows from the Market Studies;
b) for internal national grids: considering the network studies based on the PiTs selected for the Market Studies.

5.2.1. Losses in the interconnection lines (HVDC only)

Market studies provide hourly time series of exchange among countries for each Med-TSO 2030 scenario and for each new interconnection project, and also for the reference case, which doesn't consider the new interconnection.

In case the interconnection project is AC, it should be considered as internal network of each country up to the border point (actual physical border point or conventional border if in the sea). In this case, losses in the interconnection are taken into account in the calculation of the internal losses (see paragraph 0 below).

5.2.1.1. Power and energy aspects

Since the Mediterranean Power System is weakly meshed, it can be assumed that physical flows on the interconnections are similar, or even absolutely equal, to commercial exchanges for most of the projects to be assessed (loop flows are negligible).

In case of an increase of an already existing exchange capacity, losses strictly due to the new project are assessed as the difference of exchange before and after the addition of the new capacity, for each hour of the year. Thus, expected result is the variation of losses due to the new interconnection project and the associated additional capacity.

Market studies have provided hourly time series of exchange among countries for the 14 Clusters in each of the four scenarios. Those time-series shall be used directly for the borders where there is no existing interconnection: (e.g.: MA-PT, DZ-ES, TR-EG, etc.), whereas for borders where interconnections exist (MA-ES), flows in the existing interconnection need to be deducted to obtain the additional flow in the new interconnection.

After selecting the exchanges hourly time series, the second stage is to convert flows into losses. This task has been performed in the frame of Network Studies, using a different formula for each HVDC technology to be implemented (A, B, etc.). As an example, the formula used for bipolar VSC technology, which is a suitable technology in most projects, is presented below:

$$P_{loss}(h) = P_{cable}(h) + P_{converters}(h) \qquad (1)$$

$$p_{cable}(h) = r_l d \left(\frac{P(h)}{V_{nom}}\right)^2 \qquad (2)$$

$$p_{converter}(h) = A\frac{P(h)}{V_{nom}} + B \qquad (3)$$

Where

r_l corresponds to the combined linear resistance of the cables and/or OHL that constitutes the new interconnection

d the length of the cables, V_{nom} the nominal voltage level

$P(h)$ the hourly-active power exchanged in the projected interconnection in MW

A and B loss coefficients of the converters.

Base on the formula appropriate for each technology, hourly time-series of additional losses were computed in MW, then summed-up to obtain annual additional losses in energy (MWh). Therefore, 4 different annual losses, one for each scenario, were provided for each technology considered for the new HVDC interconnections.

	Annual Losses in the new DC interconnection projects (MWh)			
	(Scenario 1)	(Scenario 2)	(Scenario 3)	(Scenario 4)
Cluster 1 – technology LCC				
Cluster 1 – technology VSC				

Table 7 Annual Losses in the new DC interconnection projects

5.2.1.2. Cost aspect

For the monetization of the additional losses, the cost of electricity to be considered is the Market Marginal Cost, representing the cost of the cheapest generation available to supply the additional electricity needed for the losses. The assessment of annual losses cost can be performed in two different approaches:

a) Since this Marginal Cost is different for each hour, it could be relevant that the annual cost of additional losses would be computed by considering both hourly additional losses and hourly Marginal Cost;
b) One simplified method is to consider only annual additional losses (in energy) and average annual Marginal Cost.

Implementation of the above approached with several examples did not show significant difference in the results, therefore the simplified method has been adopted.

The national Marginal Costs provided by Market studies for each Cluster and each Scenario, were used for the monetization of losses. Marginal costs are in general different in the two bordering countries, especially when the improvement of exchange capacity provides significant benefit. Nevertheless, since rules for providing the losses shall be agreed by the involved TSO (or investors) in a later stage, it can be assumed for this current assessment that losses on the interconnection can be monetized by considering the average value of the two bordering Marginal Costs. This can be assimilated to a scheme where each TSO provide 50% percent of the total losses from his own national market.

Therefore, the monetization of the new HVDC interconnections shall be calculated according to the following equation and presented in the following table:

$$Losses\ Cost_{Interconnection_{\text{Scenario } i\ (1\ to\ 4)}}[€] = AE\ Losses_i \times \left(\frac{MC_{A,i} + MC_{B,i}}{2}\right)$$

Where:

AE Losses i *Annual Energy Losses (MWh) for the new interconnection for each Scenario i*

MCA,i Annual Average of the Marginal Cost (€) for the country A and the Scenario i (considering the interconnection)

MCB,i *Annual Average of the Marginal Cost (€) for the country B and the Scenario i (considering the interconnection)*

	Annual Losses Cost for the *DC interconnection projects* (M€)			
	(Scenario 1)	(Scenario 2)	(Scenario 3)	(Scenario 4)
Cluster 1 – technology LCC				
Cluster 1 – technology VSC				

Table 8 Annual Losses Cost for the DC interconnection projects

5.2.2. Internal losses in each country (including losses on AC interconnections)

For the internal grid, the assessment of the variation of losses shall be performed by considering the results of Network studies where the countries involved were represented by their systems, while Market studies considered only one node per country. In case the interconnection project is AC, losses in the interconnection are taken into account in the internal losses, considering the interconnection up to the border as internal network of each country.

5.2.2.1. Power aspect

In the Network studies, all PiTs were simulated for each Cluster and the losses (in MW) were calculated in two different situations:

A) one with the project and the relevant internal reinforcements (results in MW for each PiT);
B) Another without the project and the relevant internal reinforcements (results in MW for each PiT); in order to perform these simulations, it has been necessary to adjust the generation dispatch by country when the interconnection is disconnected.

When the situation B) without the project does not allow maintaining international exchanges due to a lower exchange capacity, exchanges have to be reduced to match with the existing capacity. In this case, the way to compensate the load-generation balance is of first importance since its localization is expected to impact the losses. In order to compensate in a relevant way taking into account the global merit order, the best way is to use the results of the Market studies for the Reference Case, i.e. the generation/load situation for the same hours/scenarios, but without the new interconnection project and relevant internal reinforcements (PiTs-without). The following example is provided the project between Iberia Peninsula and Maghreb:

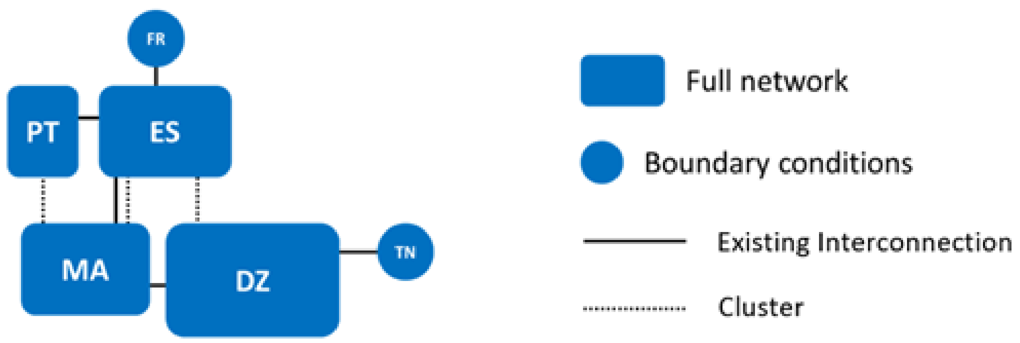


Figure 5 Example of regional perimeter to be considered in the internal grid losses calculation in western corridor

In this case, the variation of internal losses is assessed in all the 'Full network' countries, i.e., Portugal, Spain, Morocco and Algeria. This means that, even if a part of the compensation takes place in France or in Tunisia, it is assumed that this variation is not considered for the losses assessment. For each PiT, Network Studies shall provide the losses in case A) and in case B) mentioned above. The variation of losses shall be given with split by each country. Finally, the **variation in losses (MW)** will be calculated by the difference in the situations **A)** and **B)** for each PiT.

5.2.2.2. Energy aspect

After calculation of losses with/without the project and the related internal reinforcements for each PiT, the second stage is to convert power losses (MW) for each PiT into annual energy losses (MWh) for each Scenario, performed in the frame of Network Studies.

Since each PiT can be considered as an example, or a sample, of all the situations, the main issue is the weight to be associated to each PiT to convert from power to energy. Additionally, the number of PiTs being low (maximum 9) and mixing case in all of the four Scenarios, it is not viable to calculate a variation of losses for each scenario and it is assumed that all the PiTs are considered when computing the variation of losses (one common value for all four scenarios). The following two methods have been adopted:

1. If available, the time percentile (hours of the year) that each PiT represents is specified and multiplied with the delta losses calculated for each country for this PiT, to compute the losses in MWh (time percentile could also be zero if a PiT should be completely excluded from the calculation of losses);
2. If not available, all the PiTs analyzed shall be considered with equal weight and the median value of delta losses calculated country by country for all Pits shall be considered.

For both methods, it is important to note for the conversion from power to annual energy, that a new interconnection project does not provide any additional losses when exchanges are possible without this new project. The following figure shows as an example, the duration curve of exchange between Spain and Morocco with the existing interconnection.

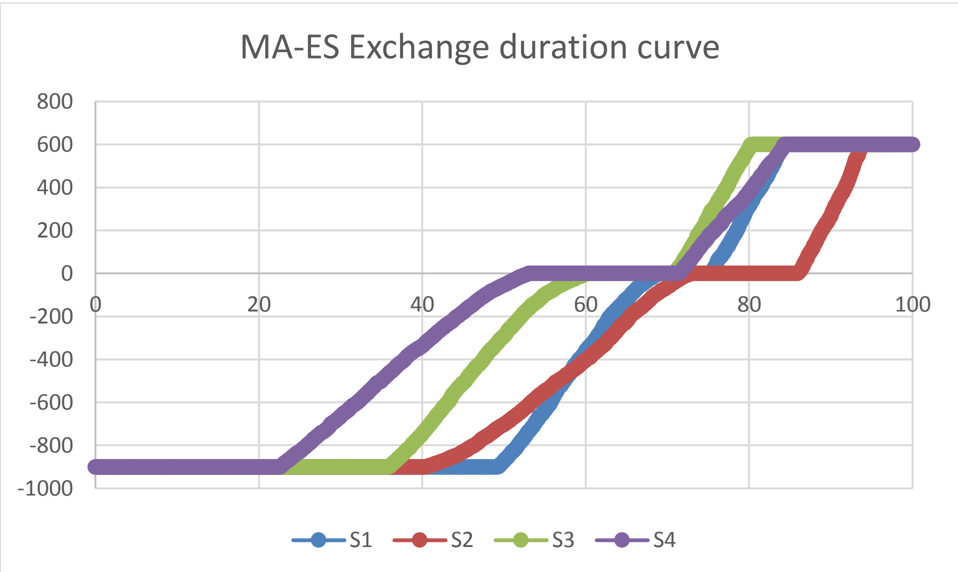


Figure 6 MA-ES exchange duration curve (as an example)

In this example, the interconnection is saturated around 40% of the time. This means that any new interconnection cannot provide internal variation of losses more than 40% of the year.

In the case of the method 2, Market Studies provide the number of saturation hours of the interconnection for each Scenario, to be considered for assessing the annual energy. In the case of the method 1, the cumulative number of hours shall not exceed what is to be considered in the method 2.

The following figure shows as an example the saturation hours for the Portugal – Morocco Cluster in the Scenario 1:

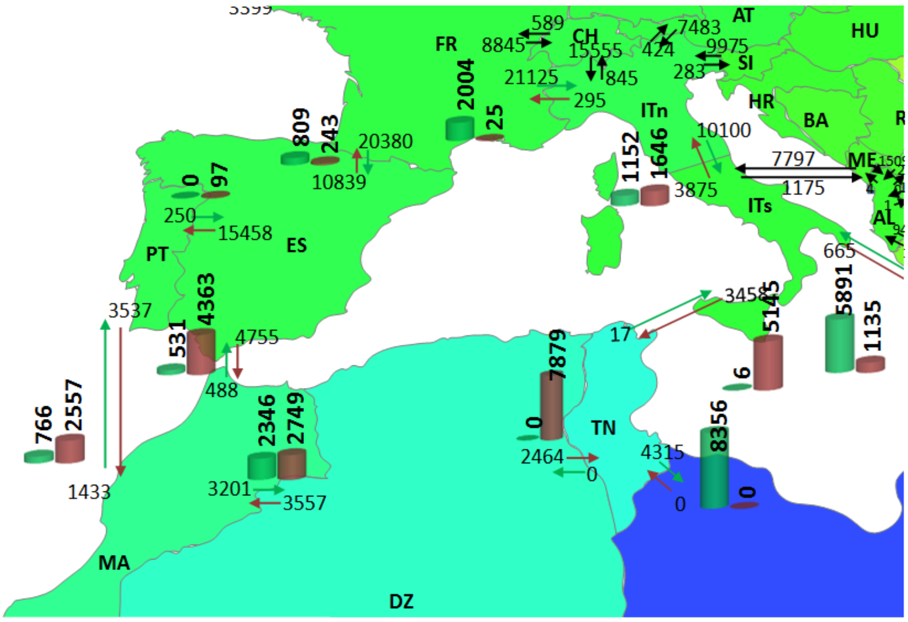


Figure 7 Saturation hours MA-PT Scenario 1 (as an example)

In this case, saturated hours are 2557 from Portugal to Morocco and 756 from Morocco to Portugal. Consequently, annual energy of the internal losses for this Cluster in the Scenario 1 shall be, when using the method 2, the average value of delta losses calculated for all nine PiTs multiplied by 3313 hours.

At this stage, it is important to keep the annual splitting by country since it is useful for the monetization. Therefore, the Variation in Losses (MW) for all PiTs calculated by Network Studies shall be converted to annual variation in losses (MWh) in each grid according to one of the methodologies referred above and presented in the following table.

	Annual variation of internal losses (MWh)			
	Country A	Country B	Country C	Country D
Cluster 1				

Table 9 Annual variation of internal losses

5.2.2.3. Cost aspect

For the monetization of annual variation of losses in each country**,** it is used the annual average value of Marginal Cost for each of the four Scenarios, as provided by the Market Studies. Starting from the previous annual result in energy (only one value for all four Scenarios), split by countries, and those energies shall be multiplied by the relevant Marginal Cost, to obtain the cost of variation of internal losses; this is performed according the following equation and presented in the following table:

$$Annual\ Losses\ Cost_{country\ A}[€]_{Scenario(1\ to\ 4)} = AVLosses_{countryA} \times MC_{A\_Scenario(1\ to\ 4)}$$

Where:

AVLossescountryA *Annual variation of losses (MWh) in country A (applicable for the other countries);*

MCA_Scenario (1 to 4) Annual average Marginal Cost (€) for country A (considering the interconnection) for each one of the four Scenarios (applicable for the other countries and Scenarios);

	Annual variation Losses Cost - internal grid (M€)											
	country A				country B				country n			
	Scenarios											
	1	2	3	4	1	2	3	4	1	2	3	4
Cluster 1												

Table 10 Annual variation cost for internal losses

6. Analysis and results by Clusters - CBA

As a result of the abovementioned indicators, the following assessment tables are used to present the results of the cost benefit analysis for each Cluster:

Assessment results for the Cluster														
non scenario	GTC increase direction 1 (MW)													
	GTC increase direction 2 (MW)													
scenario specific			MedTSO scenario											
			1			**2**			**3**			**4**		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		TR												
		IS												
Interconnection Rate (%)*		TR												
		IS												
Benefit Indicators	B1-SEW	(M€/y)												
	B2-RES	(GWh/y)												
	B3-CO_2	(kT/y)												
	B4 - Losses	(M€/y)												
		(GWh/y)												
	B5a-SoS Adequacy	(MWh/y)												
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs	(M€)												

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

Rules for sign of Benefit Indicators

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-CO_2 [kt/Year] = Negative when a project reduces the whole quantity of CO_2 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 [MWh/Year] = Positive when a project reduces the risk of lack of supply

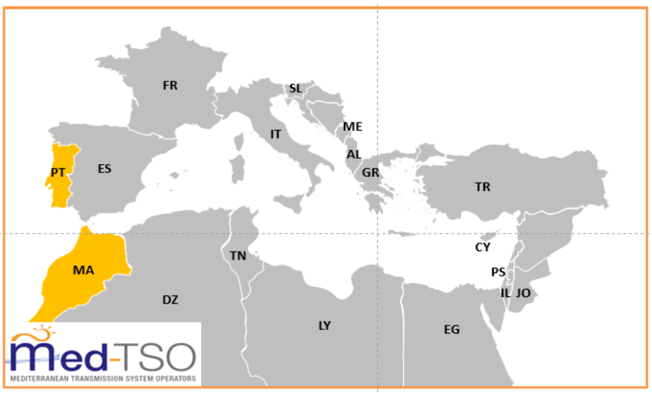
Assessment	**Color code**
negative impact	
neutral impact	
positive impact	
Not Available/Not Available	
monetized	

Table 11 Table assessment considered for the cost benefit analysis to the 14 interconnection projects under assessment

6.1. Cluster MA-PT (Morocco - Portugal)

Description

The Cluster consists in a new interconnection between Portugal and Morocco to be realized through an HVDC submarine cable. This interconnection project is supported by the two governments, which launched several studies about this possible interconnection, some of them in elaboration at the present time.



The HVDC interconnection has a capacity of 1000 MW and a total length of around 265km, of which approximately 220km will be in submarine cable. The HVDC interconnection consider the configuration of two circuits (bipolar converter) of 500 MW each, between TAVIRA substation of 400kV (PT) and BENI HARCHAN substation of 400kV (MA).

Additional Information

The project is promoted by REN and ONEE under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I.

The main driver of the project is to further increase the interconnection capacity between Mediterranean Countries, namely between Portugal and Morocco (without any interconnection between these two countries until now), in order to exploit the complementary characteristics of both countries. Estimated increase is of about 1000 MW.

Generally, the complementary characteristics in the power systems and economic conditions in the Mediterranean Countries can provide additional benefits over the time for the countries of southern and northern Mediterranean, and even northern Europe. Having this in mind, this interconnection was studied at Med-TSO.

Two possible configurations were considered:

1. HVDC link of two circuits (LCC bipolar converter) of 500 MW each between Tavira, PT 400kV substation, and Beni Harchan, MA 400kV substation.
2. HVDC link of two circuits (VSC bipolar converter) of 500 MW each between Tavira, PT 400kV substation, and Beni Harchan, MA 400kV substation.

Investment needs

Network studies performed by Med-TSO evaluated the internal grid reinforcements needed to accommodate 1000 MW of exchange in both directions between Morocco and Portugal and specified the best technologies to be used in this interconnection.

The security analysis performed with the merged full models of the systems of Portugal, Morocco, Algeria and Spain for eight PiTs selected identified the reinforcements in Portugal, Morocco and Spain, while no reinforcement was detected in Algeria. The reinforcements detected in the Portuguese, Moroccan and Spanish grids are:

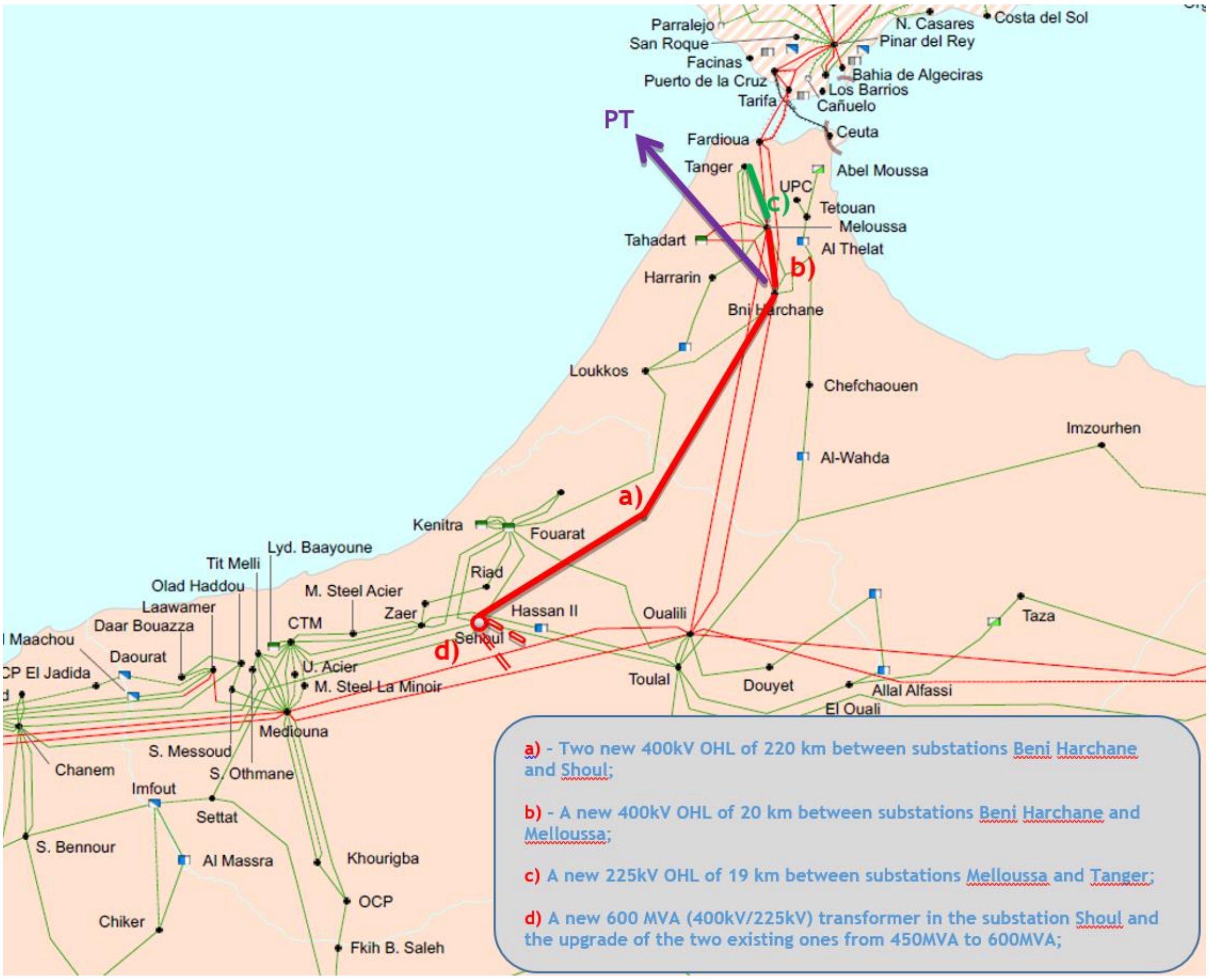
Portugal

- Upgrading for double circuit of OHL F.Alentejo – Tavira (400kV+150kV): currently, this corridor just contains only a 150 kV OHL. So, the reinforcements involve upgrading this actual corridor to a 400kV+150kV double circuit line;
- 2nd circuit of double OHL Tavira (PT) – Puebla de Guzman (ES): this double circuit OHL currently comprises only one circuit and needs to be upgraded to a full double circuit line (installation of the 2nd circuit in this interconnection). This reinforcement was identified by both TSOs (REN and REE) according the results of this Med-TSO study.

Internal reinforcements in Portugal which were considered in order to accommodate the 1000 MW flow between Portugal and Morocco

Morocco

- Two new 400 kV OHL of 220 km between substations D.CHAO40 and SHOUL_400
- A new 400 kV OHL of 20 km between substations D.CHAO40 and MLOUS400
- A new 225 kV OHL of 19 km between substations MLOUS225 and TANG225
- A new 600 MVA transformer between substations SHOUL_400 and ESSHOU22 and the upgrade of the two existing ones from 450MVA to 600MVA



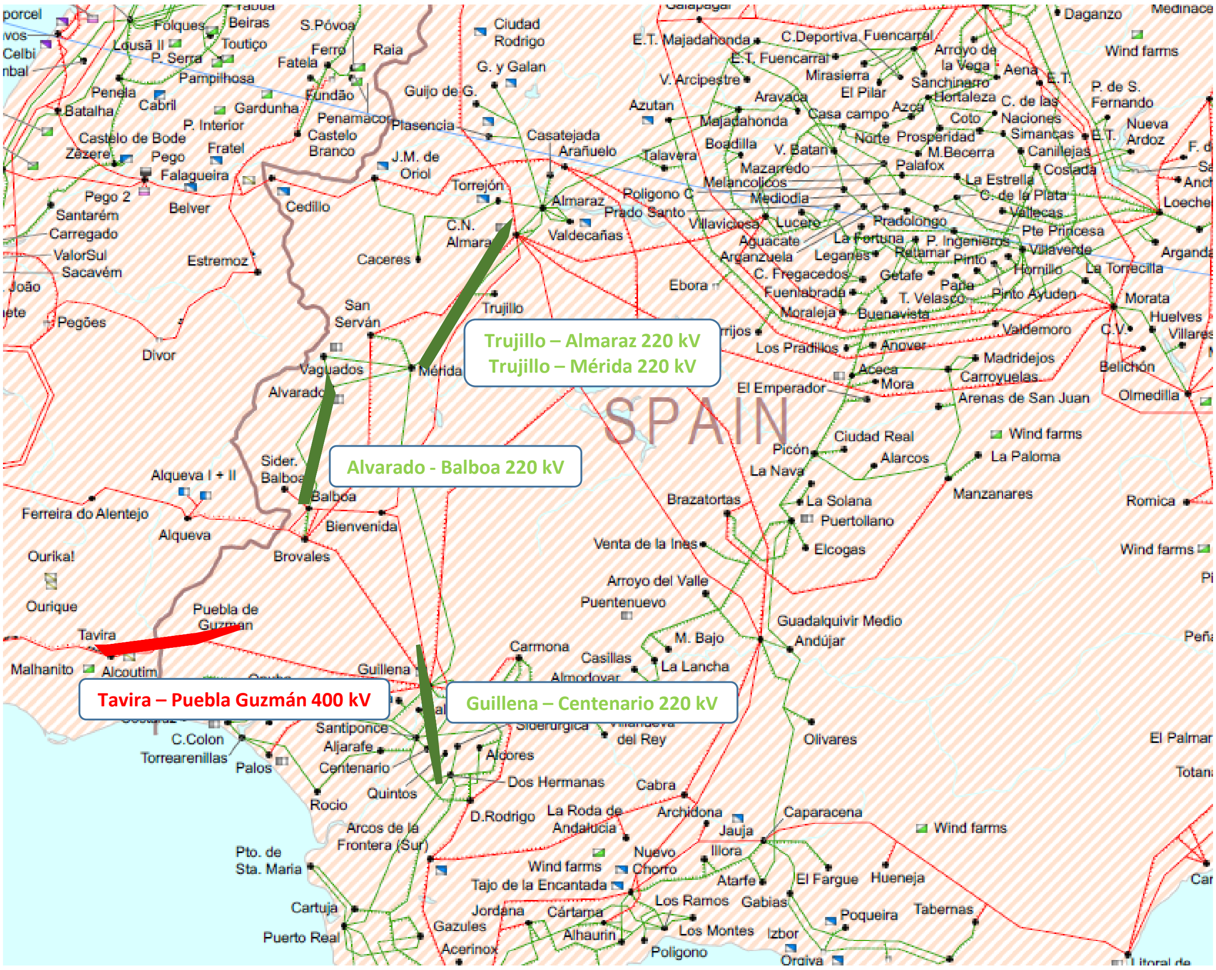
Internal reinforcements in Morocco which were considered in order to accommodate the 1000 MW flow between Portugal and Morocco

Spain

- Substitution of conductors to increase the ampacity in the following OHL:
    - TRUJILLO - MERIDA 220kV
    - TRUJILLO - ALMARAZ 220kV
    - ALVARADO – BALBOA 220kV
    - GUILLENA_B - CENTENARIO_NPB 220kV

- Installation the 2nd circuit of double OHL Tavira (PT) – Puebla de Guzman (ES): this double circuit OHL currently comprises only one circuit and needs to be upgraded to a full double circuit line (installation of the 2nd circuit in this interconnection).

- Other generic reinforcements are considered in Spanish grid, for those lines that, being already overloaded without the project (due to the Spanish generation mix) become significantly more overloaded (at least 5%) in the case with the MAPT project.



Internal reinforcements in Spain which were considered in order to accommodate the 1000 MW flow between Portugal and Morocco

Cost Benefit Analysis

In the following table, the assessment results for the Cluster are presented:

Assessment results for the Cluster P1 - MAPT														
non scenario	GTC increase direction 1 (MW)		1000											
	GTC increase direction 2 (MW)		1000											
scenario specific			MedTSO scenario											
			1			2			3			4		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		MA	1900	2900	1000	1900	2900	1000	1900	2900	1000	1900	2900	1000
		PT	4200	5200	1000	4200	5200	1000	4200	5200	1000	4200	5200	1000
Interconnection Rate (%)*		MA	9,0%	13,7%	4,7%	9,0%	13,7%	4,7%	7,8%	11,9%	4,1%	8,2%	12,5%	4,3%
		PT	20,9%	25,9%	5,0%	20,1%	24,9%	4,8%	18,1%	22,5%	4,3%	15,2%	18,8%	3,6%
Benefit Indicators	B1-SEW	(M€/y)	80			140			66			130		
	B2-RES	(GWh/y)	70			420			140			520		
	B3-CO_2	(kT/y)	950			-950			550			-900		
	B4 - Losses**	(M€/y)	14,6			12,7			13,2			12,4		
		(GWh/y)	270			233			243			220		
	B5a-SoS Adequacy	(MWh/y)	120			180			100			40		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs***	(M€)	650-720											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

** Estimation of losses in the HVDC interconnection considered VSC technology (bipolar 400 kV)

*** Range for investment cost dependent on HVDC technology selected for the interconnection (LCC/VSC) and on the cost of internal reinforcements in the Spanish grid

Rules for sign of Benefit Indicators

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-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 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 [MWh/Year] =	Positive when a project reduces the risk of lack of supply

Assessment	Color code
negative impact	
neutral impact	
positive impact	
Not Available/Not Applicable	
monetized	

6.2. Cluster MA-ES (Morocco - Spain)

Description

The Cluster consists in a new interconnection between Morocco and Spain that will increase the NTC between both countries in 1000 MW (additional to the two existing links) and to be realized through a third AC link.

Additional Information

The HVAC interconnection between Morocco and Spain will have a capacity of 1000 MW and a total length of around 70 km corresponding 30 km to the length of the undersea cable. The maximum depth for the installation of the undersea cable will be around 500m.

The HVAC link consider a configuration of 1000 MW circuit, between TARIFA substation of 400 kV (ES) and BENI HARCHAN substation of 400 kV (MA).

The interconnection project favors the use of the most efficient capacity in the PAN European interconnected system. The project also increases the system operational flexibility. Such benefits are ensured according to different future scenarios.

The studies are promoted by ONEE and REE (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I).

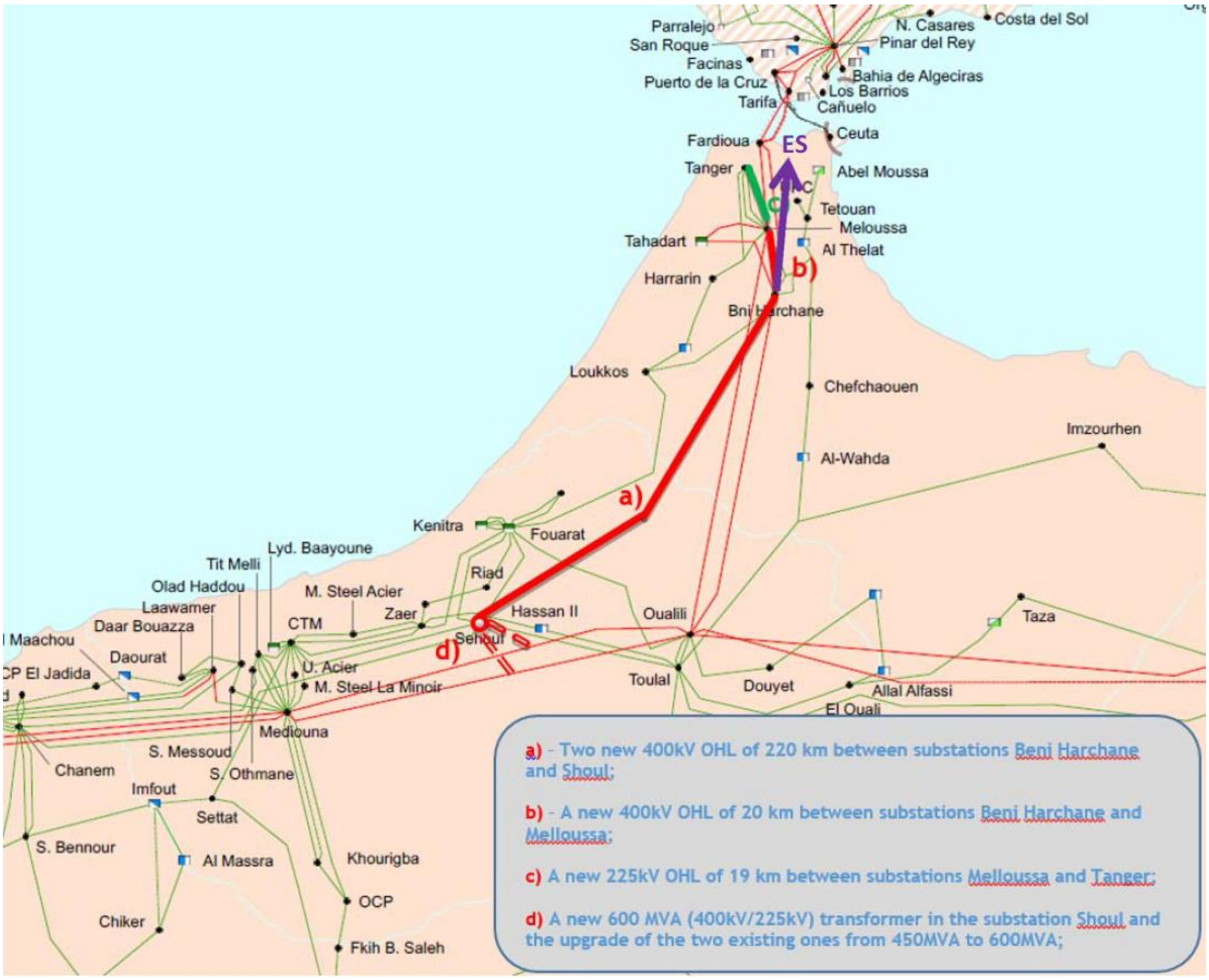
Investment needs

Network studies performed by Med-TSO evaluated the internal grid reinforcements in Morocco and Spain needed to accommodate 1000 MW of exchange in both directions, while no reinforcements were detected in Algeria and Portugal.

The reinforcements detected in the Moroccan and Spanish grids are:

Morocco

- Two new 400 kV OHL of 220 km between substations D.CHAO40 and SHOUL_400
- A new 400 kV OHL of 20 km between substations D.CHAO40 and MLOUS400
- A new 225 kV OHL of 19 km between substations MLOUS225 and TANG225
- A new 600 MVA transformer between substations SHOUL_400 and ESSHOU22 and the upgrade of the two existing ones from 450MVA to 600MVA

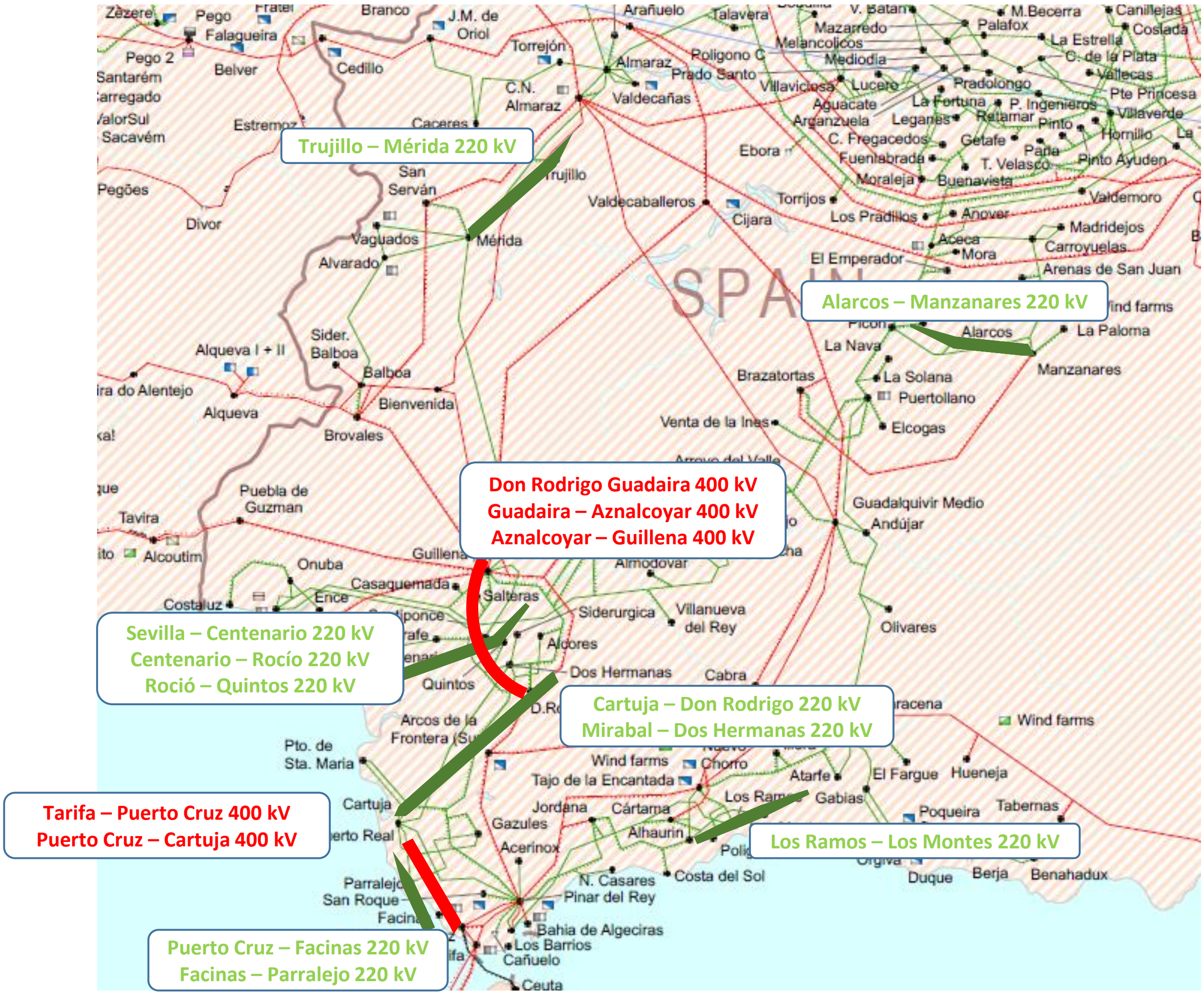


Internal reinforcements in Morocco which were considered in order to accommodate the 1000 MW flow between Spain and Morocco

Spain

- Two new substations 400 kV: GUADAIRA and AZNALCOYAR
- Two new 600MVA transformers 400/220kV in CARTUJA
- New double OHL 400 kV of 10 km between TARIFA and PTO. CRUZ
- New double OHL 400 kV of 90 km between CARTUJA and PTO. CRUZ
- New double OHL 400 kV of 20 km between D. RODRIGO and GUADAIRA
- New double OHL 220 kV of 33 km between FACINAS and PARRALEJO
- New single OHL 220 kV of 16 km between FACINAS and PTO. CRUZ
- New single OHL 400 kV of 45 km between GUADAIRA and AZNALCOYAR
- New single OHL 400 kV of 20 km between AZNALCOYAR and GUILLENA
- Substitution of conductors to increase the ampacity in the following OHL:
    - TRUJILLO - MERIDA 220kV
    - PSEVILLA - CENTENARIO_NPB 220kV
    - VIRGEN del ROCIO - CENTENARIO_NPB 220kV
    - QUINTOS – VIRGEN del ROCIO 220kV
    - ALARCOS – MANZANARES 220kV
    - Los RAMOS – Los MONTES 220kV
    - CARTUJA – D.RODRIGO 220kV
    - MIRABAL – Dos HERMANAS 220kV

- Other generic reinforcements are considered in Spanish grid for those lines that, being already overloaded without the project (due to the Spanish generation mix) become significantly more overloaded (at least 5%) in the case with the MAES project.



Internal reinforcements in Spain which were considered in order to accommodate the 1000 MW flow between Spain and Morocco

In the following table, the assessment results for the Cluster are presented:

Assessment results for the Cluster P2 - MAES														
non scenario	GTC increase direction 1 (MW)		1000											
	GTC increase direction 2 (MW)		1000											
scenario specific			MedTSO scenario											
			1			2			3			4		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		MA	1900	2900	1000	1900	2900	1000	1900	2900	1000	1900	2900	1000
		ES	12100	13100	1000	12100	13100	1000	12100	13100	1000	12100	13100	1000
Interconnection Rate (%)*		MA	9,0%	13,7%	4,7%	9,0%	13,7%	4,7%	7,8%	11,9%	4,1%	8,2%	12,5%	4,3%
		ES	9,5%	10,3%	0,8%	9,2%	9,9%	0,8%	8,2%	8,9%	0,7%	6,8%	7,4%	0,6%
Benefit Indicators	B1-SEW	(M€/y)	80			140			63			130		
	B2-RES	(GWh/y)	70			410			130			460		
	B3-CO_2	(kT/y)	950			-950			550			-900		
	B4 - Losses	(M€/y)	8,6			8,2			8,0			8,5		
		(GWh/y)	168			165			156			157		
	B5a-SoS Adequacy	(MWh/y)	120			180			100			60		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs**	(M€)	400-420											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

** Range for investment dependent on cost of internal reinforcements in the Spanish grid

Rules for sign of Benefit Indicators

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-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 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 [MWh/Year] =	Positive when a project reduces the risk of lack of supply

Assessment	Color code
negative impact	red
neutral impact	light pink
positive impact	green
Not Available/Not Available	grey
monetized	yellow

6.3. Cluster DZ-ES (Algeria - Spain)

Description

The Cluster consists in a new interconnection between Algeria and Spain to be realized through an HVDC submarine cable with 1000 MW of capacity.

Additional Information

The Cluster consists in a new interconnection of 240 km long, between Algeria and Spain to be realized through an HVDC submarine cable.

The HVDC interconnection will have a capacity of 1000 MW and a total length of around 240 km. The maximum depth for the installation of the undersea cable will be around 2000m.

The HVDC link consider the configuration of two circuits (bipolar converter) of 500 MW each, between CARRIL substation of 400 kV (ES) and AIN FATAH substation of 400 kV (DZ). The connection of both AC/DC substations to the 400 kV grids will be performed through 120 km of 400 kV OHL (2x50 km in Algeria and 2x10 km in Spain).

The studies are promoted by Sonelgaz and REE (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I).

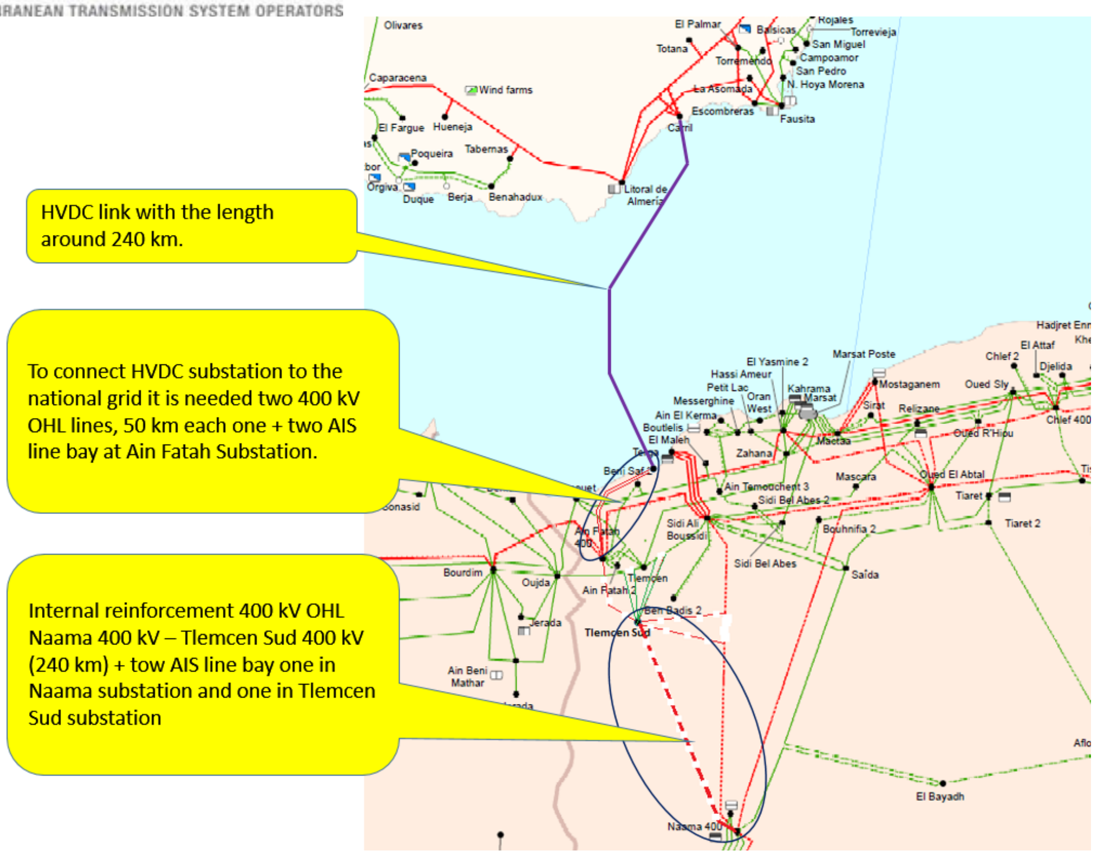
Investment needs

Network studies performed by Med-TSO evaluated the internal grid reinforcements in Algeria and Spain needed to accommodate 1000 MW of exchange in both directions, while no reinforcements were detected in Morocco and Portugal. For the purpose of Network studies

The reinforcements detected in the Algerian and Spanish grids are:

Algeria

- A new 400 kV OHL of 240km between substations NAAMA 400kV and TLEMCEN SUD 400kV



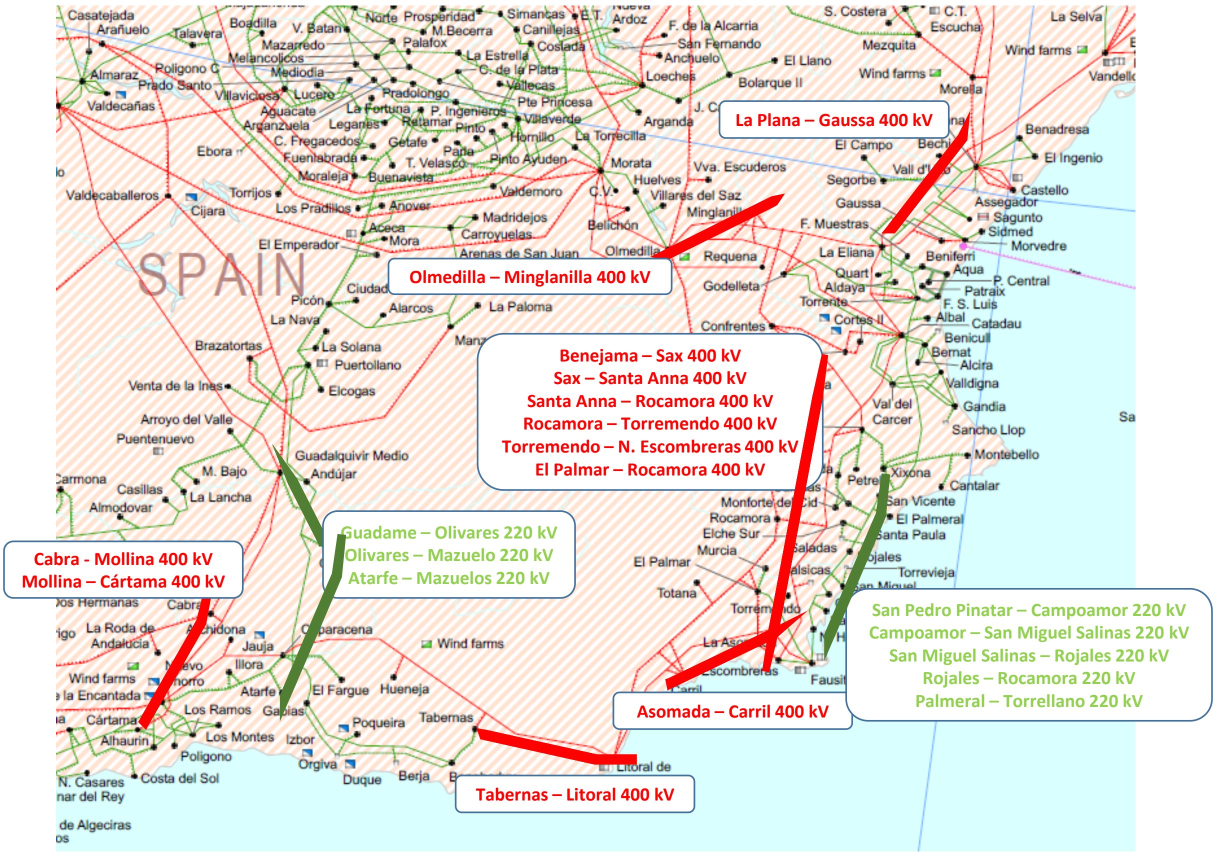
Internal reinforcements in Algeria which were considered in order to accommodate the 1000 MW flow between Spain and Algeria

Spain

- A rate upgrade of the 220 KV OHL of 99 km between ATARFE - MAZUELOS - OLIVARES to 360MVA
- A new 400 kV OHL of 38 km between TABERNAS - LITORAL de ALMERIA
- Upgrade from single to double the following OHL:
  - CAMPOAMO - DESF.SMS 220kV
  - ASOMADA – CARRIL 400kV
  - GUADAME – OLIVARES 220kV
- Substitution of conductors to increase the ampacity in the following OHL:
  - ELCHE2 - SALADAS 220kV
  - PALMAR – ROCAMORA 400kV
  - ROCAMORA – TREMENDO 400kV
  - ROCAMORA - STA ANNA 400kV
  - ROCAMORA – ROJALES 220kV
  - ROJALES – SMSALINN 220kV
  - NESCOMBR – TREMENDO 400kV
  - STA ANNA – SAX 400kV
  - BENEJAMA – SAX 400kV
  - PALMERAL – TORLLANO 220kV
  - CAMPOAMO - S.P.PINA 220kV

- MINGLANI – OLMEDILL 400kV
- CABRA – MOLLINA 400kV
- CARTAMA – MOLLINA 400kV
- LA PLANA – GAUSSA 400kV

▪ Other generic reinforcements are considered in Spanish grid for those lines that, being already overloaded without the project (due to the Spanish generation mix) become significantly more overloaded (at least 5%) in the case with the DZES project.



Internal reinforcements in Spain which were considered in order to accommodate the 1000 MW flow between Spain and Algeria

In the following table, the assessment results for the Cluster are presented:

Assessment results for the Cluster P3 - DZES														
non scenario	GTC increase direction 1 (MW)		1000											
	GTC increase direction 2 (MW)		1000											
scenario specific			MedTSO scenario											
			1			**2**			**3**			**4**		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		DZ	1300	2300	1000	1300	2300	1000	1300	2300	1000	1300	2300	1000
		ES	12100	13100	1000	12100	13100	1000	12100	13100	1000	12100	13100	1000
Interconnection Rate (%)*		DZ	2,6%	4,7%	2,0%	2,5%	4,3%	1,9%	1,9%	3,4%	1,5%	2,0%	3,6%	1,6%
		ES	9,5%	10,3%	0,8%	9,2%	9,9%	0,8%	8,2%	8,9%	0,7%	6,8%	7,4%	0,6%
Benefit Indicators	B1-SEW	(M€/y)	140			190			120			200		
	B2-RES	(GWh/y)	90			620			210			1100		
	B3-CO_2	(kT/y)	2400			-1000			1500			-1300		
	B4 - Losses**	(M€/y)	15,7			19,9			14,0			15,5		
		(GWh/y)	257			309			227			242		
	B5a-SoS Adequacy	(MWh/y)	0			0			40			20		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs***	(M€)	900-930											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

** Estimation of losses in the HVDC interconnection considered VSC technology (bipolar 400 kV)

*** Range for investment cost dependent on cost of internal reinforcements in the Spanish grid and selecting MI as cable technology

Rules for sign of Benefit Indicators

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-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 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 [MWh/Year] =	Positive when a project reduces the risk of lack of supply

Assessment	Color code
negative impact	red
neutral impact	light pink
positive impact	green
Not Available/Not Available	grey
monetized	yellow

6.4. Cluster DZ-IT (Algeria - Italy)

Description

The Cluster consists of a new interconnection with a carrying capacity of 1000 MW between Algeria and Italy (Sardinia) in HVDC submarine cable.

Additional Information

The project is promoted by Sonelgaz and TERNA (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I).

The HVDC interconnection will have a capacity of 1000 MW and a total length of around 350 km. The maximum depth for the installation of the undersea cable will be over than 2000m.

The HVDC link will be between south of Sardinia (IT) and North – Est of Algeria (Cheffia region), the connection of AC/DC substation to the national grid (Cheffia substations) will be performed through 2x50 km of 400 kV OHL.

Investment needs

Network studies performed by Med-TSO evaluated the internal grid reinforcements in Algeria needed to accommodate 1000 MW of exchange in both directions between Algeria and Italy.

No severe overloads have been detected due to the new interconnection for neither the Italian nor the Tunisian systems. Therefore, no reinforcements were defined for neither of them.

In the case of the Algerian system, some overloads are detected in the area between Ramdane Djamel and Berrahal substations. These overloads appear in the 220 kV network under the outage of 400 kV circuits Ramdane Djamel - Berrahal. To solve this situation, a single reinforcement has been defined to be analyzed. This reinforcement consists of doubling the 400 kV 60 km circuit between Berrahal and Ramdane Djamel substations.

The figure shows the maps of projected interconnection (yellow line), and corresponding reinforcements (green line).

The cost of these internal reinforcements is presented in the below, together with the investment cost of the new interconnection.

In the following table, the assessment results for the Cluster are presented:

Assessment results for the Cluster P4 - DZIT														
non scenario	GTC increase direction 1 (MW)		1000											
	GTC increase direction 2 (MW)		1000											
scenario specific			MedTSO scenario											
			1			**2**			**3**			**4**		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		DZ	1300	2300	1000	1300	2300	1000	1300	2300	1000	1300	2300	1000
		ITn ITs	10625	11625	1000	10625	11625	1000	10625	11625	1000	10625	11625	1000
Interconnection Rate (%)*		DZ	2,6%	4,7%	2,0%	2,5%	4,3%	1,9%	1,9%	3,4%	1,5%	2,0%	3,6%	1,6%
		ITn ITs	8,9%	9,7%	0,8%	9,0%	9,9%	0,8%	7,7%	8,4%	0,7%	7,5%	8,2%	0,7%
Benefit Indicators	B1-SEW	(M€/y)	160			130			250			140		
	B2-RES	(GWh/y)	340			630			2000			1300		
	B3-CO_2	(kT/y)	2200			-700			400			-350		
	B4 - Losses**	(M€/y)	13,9			26,2			7,9			25,8		
		(GWh/y)	214			391			82			385		
	B5a-SoS Adequacy	(MWh/y)	0			0			0			0		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs	(M€)	850											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

** Estimation of losses in the HVDC interconnection considered VSC technology (bipolar 400 kV)

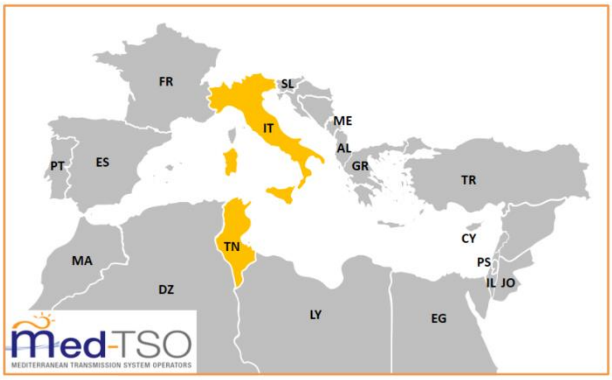
Rules for sign of Benefit Indicators

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-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 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 [MWh/Year] =	Positive when a project reduces the risk of lack of supply

Assessment	Color code
negative impact	
neutral impact	
positive impact	
Not Available/Not Available	
monetized	

6.5. Cluster TN-IT 1 (Tunisia – Italy 1)

Description



The Cluster consists in a new interconnection between Tunisia and Sicily to be realized through an HVDC submarine cable. The realization of the project is supported by both Italian and Tunisian Governments to increase the interconnection capacity of the Euro-Mediterranean system. Moreover, the project will contribute to reduce present and future limitations to the power exchanges on the Northern Italian border under specific conditions, and therefore it will allow increasing significantly the transmission capacity and its exploitation by at least 500 MW on that boundary.
The Italy – Tunisia project consists mainly of a 600 MW 400-500 kV HVDC submarine cable of about 200 km (sea depth around 750 m) between the Cap Bon peninsula (Tunisia) and Sicily (Italy).

Additional Information

The project is promoted by STEG and TERNA (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I).
Based on the recent pre-feasibility study, the connection nodes have been preliminary fixed at:

- On the Tunisian side: the new 400 kV substation in the area of Cap Bon; at the 400 kV existing electrical substation of Mornaguia. The converter station shall be located in the peninsula area of Cap Bon and n.2 new 400kV OHL will be necessary to link the new substation with the existing electrical 400 kV internal grid. The need of other synchronous compensator in the area of Cap Bon needs to be evaluated and is depending on the technology of the converter station.
- On the Italian side: at the 220 kV bus bar of the existing electrical substation of Partanna. The converter station shall be located in an area close to this substation.
- The new 380 kV double circuit line Chiaramonte Gulfi - Ciminna (currently under permitting), further local reinforcements of the existing high voltage grid and the installation of any synchronous compensator in Sicily (still under evaluation) should be the necessary internal reinforcements. The project is under feasibility study phase: (Network Study, Terrestrial and Marine Survey Study and Environmental and Social Impact Study).

Investment needs

The new HVDC link between Tunisia and Italy consists of 200 km of VSC bipolar undersea cable. Using 1.24 M€/km for the cost of the cables including installation, the estimate for the cable cost is 248 M€. The estimated cost for the two converters is 270 M€. Finally, the total investment cost in the new HVDC interconnection is 641 M€, including relevant internal reinforcements.

Network studies performed by Med-TSO identified the need of additional reinforcement in the Tunisian System, consisting in the reinforcement of 400kV OHL line Mornaguia – Hawaria. The figure shows the maps of projected interconnection (yellow line), and corresponding reinforcements (green line).

The cost of the reinforcements is presented below, together with the investment cost of the new interconnection.

Cost Benefit Analysis

In the following table, the assessment results for the Cluster are presented:

Assessment results for the Cluster P5 - TNIT

non scenario	GTC increase direction 1 (MW)		600											
	GTC increase direction 2 (MW)		600											
scenario specific			MedTSO scenario											
			1			2			3			4		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		TN	800	1400	600	800	1400	600	800	1400	600	800	1400	600
		ITn, ITs	10625	11225	600	10625	11225	600	10625	11225	600	10625	11225	600
Interconnection Rate (%)*		TN	8,8%	15,5%	6,6%	8,4%	14,6%	6,3%	7,7%	13,5%	5,8%	6,2%	10,9%	4,7%
		ITn, ITs	8,9%	9,4%	0,5%	9,0%	9,5%	0,5%	7,7%	8,2%	0,4%	7,5%	7,9%	0,4%
Benefit Indicators	B1-SEW	(M€/y)	82			67			150			78		
	B2-RES	(GWh/y)	240			360			1260			720		
	B3-CO_2	(kT/y)	900			-400			300			-500		
	B4 - Losses**	(M€/y)	-11,8			-0,2			-9,3			-1,7		
		(GWh/y)	-176			-9			-239			-33		
	B5a-SoS Adequacy	(MWh/y)	0			0			0			0		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs	(M€)	650											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

** Estimation of losses in the HVDC interconnection considered VSC technology (bipolar 400 kV)

Rules for sign of Benefit Indicators

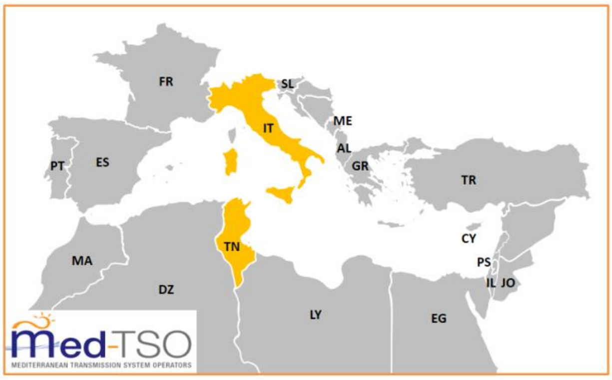
B1- Sew [M€/year] =	Positive when a project reduces the annual generation cost of the whole Power System
B2-RES integration [GWh/Year] =	Positive when a project reduces the amount of RES curtailment
B3-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 emitted in one year
B4-Losses - [M€/Year] and [GWh/Year] =	Negative when a project reduces the annual energy lost in the Transmission Network
B5a-SoS [MWh/Year] =	Positive when a project reduces the risk of lack of supply

Assessment	Color code
negative impact	
neutral impact	
positive impact	
Not Available/Not Available	
monetized	

6.6. Cluster TN-IT 2 (Tunisia – Italy 2)

Description

The Cluster involves the reinforcement of the first interconnection (600 MW) between Tunisia and Sicily to be realized through an HVDC submarine cable. The project may contribute to reduce present and future limitations to the power exchanges on the Northern Italian border under specific conditions, and therefore it may allow to increase significantly the transmission capacity and its exploitation by on that boundary.



Additional Information

The project is promoted by STEG and TERNA (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I).

Investment needs

The second step of the HVDC link between Tunisia and Italy consists of another link like TN-IT1 and assumed to have the same cost, and the internal reinforcements to cater for the total of 1200 MW interconnection are amount at 65 M€, bringing the total for TN-IT2 investment cost at 583 M€.

Network studies performed by Med-TSO identified the need of additional reinforcement only in the Tunisian System, consisting in a new 400 kV circuit between Mornaguia and Oueslatia (140 km) and corresponding 400/220 kV transformers at the Oueslatia substation. The figure shows the map of the projected interconnection (yellow line), and corresponding reinforcements (green line).

The cost of the reinforcements is presented below, together with the investment cost of the new interconnection.

Cost Benefit Analysis

In the following table, the assessment results for the Cluster are presented:

<table>
<tr><th colspan="16">Assessment results for the Cluster P6 - TNIT2</th></tr>
<tr><td rowspan="2">non scenario</td><td colspan="2">GTC increase direction 1 (MW)</td><td colspan="12">600</td></tr>
<tr><td colspan="2">GTC increase direction 2 (MW)</td><td colspan="12">600</td></tr>
<tr><td colspan="3" rowspan="3">scenario specific</td><td colspan="12">MedTSO scenario</td></tr>
<tr><td colspan="3">1</td><td colspan="3">2</td><td colspan="3">3</td><td colspan="3">4</td></tr>
<tr><td>Ref. Scenario</td><td>with new project</td><td>Delta</td><td>Ref. Scenario</td><td>with new project</td><td>Delta</td><td>Ref. Scenario</td><td>with new project</td><td>Delta</td><td>Ref. Scenario</td><td>with new project</td><td>Delta</td></tr>
<tr><td colspan="2" rowspan="3">GTC / NTC (import)</td><td>TN</td><td>1400</td><td>2000</td><td>600</td><td>1400</td><td>2000</td><td>600</td><td>1400</td><td>2000</td><td>600</td><td>1400</td><td>2000</td><td>600</td></tr>
<tr><td>ITn</td><td rowspan="2">11225</td><td rowspan="2">11825</td><td rowspan="2">600</td><td rowspan="2">11225</td><td rowspan="2">11825</td><td rowspan="2">600</td><td rowspan="2">11225</td><td rowspan="2">11825</td><td rowspan="2">600</td><td rowspan="2">11225</td><td rowspan="2">11825</td><td rowspan="2">600</td></tr>
<tr><td>ITs</td></tr>
<tr><td colspan="2" rowspan="3">Interconnection Rate (%)*</td><td>TN</td><td>15,5%</td><td>22,1%</td><td>6,6%</td><td>14,6%</td><td>20,9%</td><td>6,3%</td><td>13,5%</td><td>19,2%</td><td>5,8%</td><td>10,9%</td><td>15,5%</td><td>4,7%</td></tr>
<tr><td>ITn</td><td rowspan="2">9,4%</td><td rowspan="2">9,9%</td><td rowspan="2">0,5%</td><td rowspan="2">9,5%</td><td rowspan="2">10,0%</td><td rowspan="2">0,5%</td><td rowspan="2">8,2%</td><td rowspan="2">8,6%</td><td rowspan="2">0,4%</td><td rowspan="2">7,9%</td><td rowspan="2">8,3%</td><td rowspan="2">0,4%</td></tr>
<tr><td>ITs</td></tr>
<tr><td rowspan="7">Benefit Indicators</td><td>B1-SEW</td><td>(M€/y)</td><td colspan="3">69</td><td colspan="3">46</td><td colspan="3">130</td><td colspan="3">63</td></tr>
<tr><td>B2-RES</td><td>(GWh/y)</td><td colspan="3">200</td><td colspan="3">300</td><td colspan="3">1170</td><td colspan="3">640</td></tr>
<tr><td>B3-CO_2</td><td>(kT/y)</td><td colspan="3">1000</td><td colspan="3">-250</td><td colspan="3">400</td><td colspan="3">-350</td></tr>
<tr><td rowspan="2">B4 - Losses</td><td>(M€/y)</td><td colspan="3">-13,4</td><td colspan="3">-2,2</td><td colspan="3">-13,0</td><td colspan="3">-4,0</td></tr>
<tr><td>(GWh/y)</td><td colspan="3">-314</td><td colspan="3">-53</td><td colspan="3">-455</td><td colspan="3">-86</td></tr>
<tr><td>B5a-SoS Adequacy</td><td>(MWh/y)</td><td colspan="3">0</td><td colspan="3">0</td><td colspan="3">0</td><td colspan="3">0</td></tr>
<tr><td colspan="2">B5b-SoS System Stability</td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td rowspan="3">Residual Impact Indicators</td><td colspan="2">S1- Environmental Impact</td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td colspan="2">S2-Social Impact</td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td colspan="2">S3-Other Impact</td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td>Costs</td><td>C1-Estimated Costs</td><td>(M€)</td><td colspan="12">580</td></tr>
</table>

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

Rules for sign of Benefit Indicators

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-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 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 [MWh/Year] =	Positive when a project reduces the risk of lack of supply

Assessment	Color code
negative impact	
neutral impact	
positive impact	
Not Available/Not Available	
monetized	

6.7. Cluster DZ-TN (Algeria - Tunisia)

Description

The Cluster consists in a new interconnection between Algeria and Tunisia, with increasing the NTC from 300 MW to 1000 MW (+ 700 MW).

It is due to the important hours of saturation that were detected in the preliminary market simulations that this cluster was added. Physically, it consists on a second 400 kV OHL from the substation Jendouba in Tunisia to the substation Cheffia in Algeria.

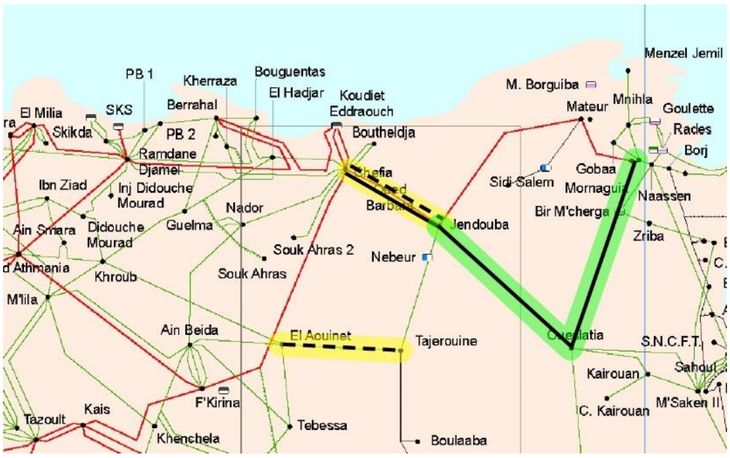
Additional Information

The project is promoted by Sonelgaz and STEG (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I).

Investment needs

The new AC link between Algeria and Tunisia consists of 82 km of AC OHL (40 km in Algerian side and 42 km in Tunisian side). The estimate for the total investment is around 27.3 M€ (13.3 M€ for Algeria and 14 M€ for Tunisia). The total cost includes the cost of the link and the end substations (AIS bay in the Algerian substation and GIS bay in the Tunisian substation).

Network studies performed by Med-TSO identified the need of additional reinforcement only in the Tunisian System. The figure shows the maps of interconnections, both existing (dashed-yellow line) and projected (yellow line), and corresponding reinforcements (green line).



The energy interchange with Algeria through the existing and projected interconnection undergoes some overloads in the 220 kV network. To overcome this, the 220 kV interconnection between Algeria and Tunisia is opened, thus the energy tends to flow through the 400 kV sub network. To reinforce it, next new devices are considered:

- New 400 kV circuit Oueslatia - Mornaguia (140 km)
- New 220/400 kV transformer at Oueslatia substation

In addition, a reinforcement is needed to evacuate the power at Jendouba substation. Two different alternatives have been considered, 1) a new 400 kV circuit between Jendouba and Oueslatia substations, or 2) a new 400 kV circuit between Jendouba and Mornaguia substations. Both alternatives provide a new 400 kV corridor for the energy of the interconnection, and results obtained in the security analysis are quite similar, solving most of the overloads due to the new interconnection. Comparing them, first alternative (400 kV Jendouba - Oueslatia) seems to be a bit more effective, since the second alternative (400 kV Jendouba - Mornagui) is not capable of solving some of the problems in the N-1 situations, such as 220 kV Jendouba – Kef (PiT 4), or 200 kV B.MCherga – Mornagui, Mnihla – Chotrana and Naassen - Mornagui (PiT 5).

The cost of the reinforcements is presented below, together with the investment cost of the new interconnection.

Cost Benefit Analysis

In the following table, the assessment results for the Cluster are presented:

Assessment results for the Cluster P7 - DZTN														
non scenario	GTC increase direction 1 (MW)		700											
	GTC increase direction 2 (MW)		700											
scenario specific			MedTSO scenario											
			1			**2**			**3**			**4**		
			Ref, Scenario	with new project	Delta	Ref, Scenario	with new project	Delta	Ref, Scenario	with new project	Delta	Ref, Scenario	with new project	Delta
GTC / NTC (import)		DZ	1300	2000	700	1300	2000	700	1300	2000	700	1300	2000	700
		TN	800	1500	700	800	1500	700	800	1500	700	800	1500	700
Interconnection Rate (%)*		DZ	2,6%	4,1%	1,4%	2,5%	3,8%	1,3%	1,9%	2,9%	1,0%	2,0%	3,1%	1,1%
		TN	8,8%	16,6%	7,7%	8,4%	15,7%	7,3%	7,7%	14,4%	6,7%	6,2%	11,6%	5,4%
Benefit Indicators	B1-SEW	(M€/y)	19			26			12			22		
	B2-RES	(GWh/y)	0			0			0			40		
	B3-CO_2	(kT/y)	1200			550			800			900		
	B4 - Losses	(M€/y)	15,5			16,6			5,0			-9,6		
		(GWh/y)	233			232			70			-125		
	B5a-SoS Adequacy	(MWh/y)	0			0			20			20		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs	(M€)	150											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

Rules for sign of Benefit Indicators

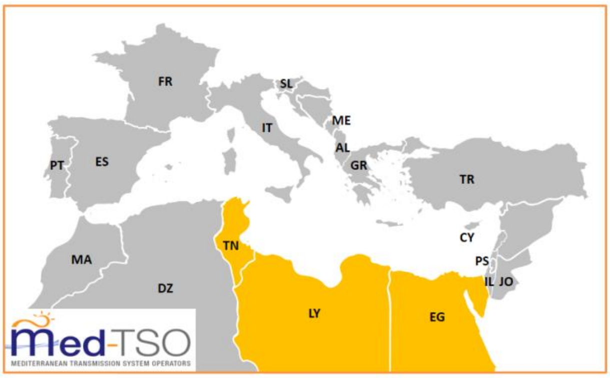
B1- Sew [M€/year] =	Positive when a project reduces the annual generation cost of the whole Power System
B2-RES integration [GWh/Year] =	Positive when a project reduces the amount of RES curtailment
B3-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 emitted in one year
B4-Losses - [M€/Year] and [GWh/Year] =	Negative when a project reduces the annual energy lost in the Transmission Network
B5a-SoS [MWh/Year] =	Positive when a project reduces the risk of lack of supply

Assessment	**Color code**
negative impact	
neutral impact	
positive impact	
Not Available/Not Available	
monetized	

6.8. Cluster TN-LY-EG (Tunisia - Libya - Egypt)

Description

The Cluster consists in a new interconnection across Tunisia, Libya and Egypt.



Tunisia has been connected to Libya's network in HVAC since 2002 with three 220 kV HVAC lines. However, these connections remain out of service due to stability problems and high power oscillations caused by the Mediterranean eastern power system (Libya and Egypt). Egypt and Libya are interconnected by one 220 kV HVAC line and it 'is in service since 1998.

Additional Information

The project is promoted by STEG, GECOL and TERNA (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I).

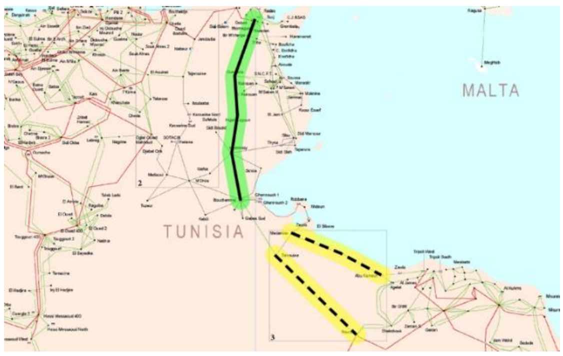
Investment needs

The new AC link between Tunisia and Libya consists of 300 km of AC OHL. Using 0.5 M€/km for the cost of the AC cables including installation, the estimate for the cable cost is 150 M€. The cost of the end substations is estimated to be 1.5 M€, each one including one AIS bay. Finally, the total investment cost in the new AC interconnection is 153 M€.

The new AC link between Libya and Egypt consists of 350 km of AC OHL. Using 0.5 M€/km for the cost of the AC cables including installation, the estimate for the cable cost is 175 M€. The cost of the end substations is estimated to be 1.5 M€, each one including one AIS bay. Finally, the total investment cost in the new AC interconnection is 178 M€.

Network studies performed by Med-TSO identified the need of additional reinforcement in the Tunisian and Libyan Systems. The figure shows the maps of interconnections, both existing (dashed-yellow line) and projected (yellow line), and corresponding reinforcements (green line). The main outcomes of the contingency analysis for each system involved in the project could be summarized to the following:

Tunisia:



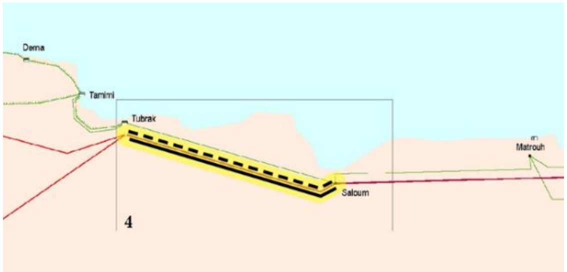
The energy interchange with Libya through the projected 400 kV interconnection comes down to the 220 kV network at the Bouchemma substation. This fact may undergo some overloads at the 220 kV network. To overcome this, it is planned to include new 400 kV circuits that takes most of the energy interchanged between the north and the south. Reinforcements considered are:

- New 400 kV circuit between Bouchemma and Oueslatia.

- New 400 kV circuit between Oueslatia and Mornaguia.
- New 220/400 kV transformer at Oueslatia substation.
- New 220/400 kV transformer at Bouchemma substation.

Libya:

Relevant overloads detected at the 220 kV network are due to the fact that those cables have not enough ampacity. To overcome this, all overloaded 220 kV are planned to be replaced with better lines conductor specification (superconductor lines) as shown in the table below which already operating in Libya transmission network.



The cost of the reinforcements is presented below, together with the investment cost of the new interconnection.

Cost Benefit Analysis

In the following table, the assessment results for the Cluster are presented:

Assessment results for the Cluster P8 - TNLYEG														
non scenario	GTC increase direction 1 (MW)		1000 (TN-LI) - 1000 (LI-EG)											
	GTC increase direction 2 (MW)		1000 (LI-TN) - 1000 (EG-LI)											
scenario specific			MedTSO scenario											
			1			2			3			4		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		TN	800	1800	1000	800	1800	1000	800	1800	1000	800	1800	1000
		LY	1050	3050	2000	1050	3050	2000	1050	3050	2000	1050	3050	2000
		EG	1250	2250	1000	1250	2250	1000	1250	2250	1000	1250	2250	1000
Interconnection Rate (%)*		TN	8,8%	19,9%	11,0%	8,4%	18,8%	10,5%	7,7%	17,3%	9,6%	6,2%	14,0%	7,8%
		LY	4,5%	13,0%	8,5%	4,5%	13,0%	8,5%	4,5%	13,0%	8,5%	4,5%	13,0%	8,5%
		EG	1,4%	2,6%	1,1%	1,4%	2,6%	1,1%	1,3%	2,4%	1,1%	1,4%	2,5%	1,1%
Benefit Indicators	B1-SEW	(M€/y)	270			290			290			340		
	B2-RES	(GWh/y)	0			0			0			0		
	B3-CO_2	(kT/y)	-1600			-1000			-1600			-1500		
	B4 - Losses	(M€/y)	47,1			140,5			130,8			144,7		
		(GWh/y)	580			1466			1477			1625		
	B5a-SoS Adequacy	(MWh/y)	0			60			60			40		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs	(M€)	540											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

Rules for sign of Benefit Indicators

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-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 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 [MWh/Year] =	Positive when a project reduces the risk of lack of supply

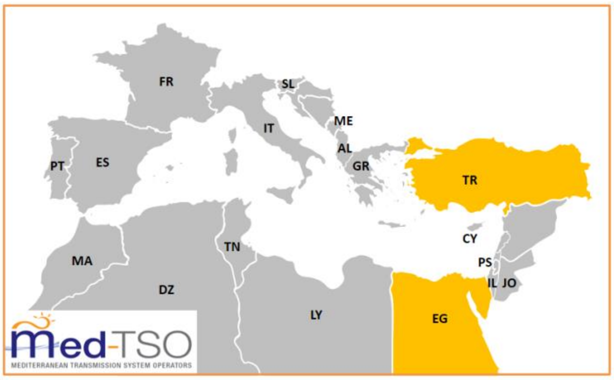
Assessment	Color code
negative impact	
neutral impact	
positive impact	
Not Available/Not Available	
monetized	

Note that few countries (Egypt, Israel, Libya, Palestine, Syria and Lebanon) are modelled starting from available data to obtain an average scenario since no data were directly provided to Med-TSO by the TSOs of those countries. The benefit of the project has been assessed using this average scenario.

6.9. Cluster TR-EG (Turkey - Egypt)

Description

The Cluster is located in eastern Mediterranean and consists of a HVDC submarine cable between Turkey and Egypt. It is planned as an alternative to existing north-south corridor passing through Turkey, Syria, Jordan and Egypt.



The new HVDC link between Turkey and Egypt is expected to be implemented using VSC technology, which presents several advantages over the LCC technology.

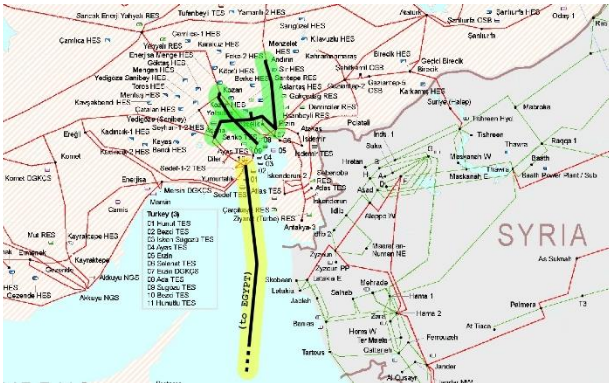
Additional Information

The project is promoted by TEIAS and EETC (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I).

The main driver of the project is to develop a new corridor in the eastern Mediterranean region and to increase renewable energy integration in the region. Estimated capacity is about 3000MW.

Investment needs

Network studies performed by Med-TSO identified the need of additional reinforcement in the Turkish System while the Egyptian System was not analyzed. The figure shows the maps of the projected interconnection (yellow line) and corresponding reinforcements (green line). The main outcomes of the contingency analysis performed could be summarized to the following:



Several reinforcements related to the project were identified in the Turkish system. To reinforce Turkish grid in the vicinity of TREG project’s connection point, connection of planned 400kV Kozan – Sanko OHL should be modified by connecting this OHL to Misis OSB substation. After modification process, Kozan – Sanko OHL would be operated as 400kV Kozan – Misis OSB OHL and 400kV Misis OSB – Sanko OHL. Additionally, replacement of existing 400 kV 2-bundle Adana – Bastug, Toscelik – Bastug, Erzin – Toscelik, and Erzin – Toscelik OHLs with 3-bundle conductors are required to reinforce the region.

The cost of the reinforcements is presented below, together with the investment cost of the new interconnection.

Cost Benefit Analysis

In the following table, the assessment results for the Cluster are presented:

Assessment results for the Cluster P9 - TREG														
non scenario	GTC increase direction 1 (MW)		3000											
	GTC increase direction 2 (MW)		3000											
scenario specific			MedTSO scenario											
			1			2			3			4		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		TR	6200	9200	3000	6200	9200	3000	6200	9200	3000	6200	9200	3000
		EG	1250	4250	3000	1250	4250	3000	1250	4250	3000	1250	4250	3000
Interconnection Rate (%)*		TR	4,9%	7,3%	2,4%	4,9%	7,2%	2,4%	4,4%	6,5%	2,1%	4,1%	6,0%	2,0%
		EG	1,4%	4,9%	3,4%	1,4%	4,9%	3,4%	1,3%	4,5%	3,2%	1,4%	4,7%	3,3%
Benefit Indicators	B1-SEW	(M€/y)	880			440			470			370		
	B2-RES	(GWh/y)	0			0			0			0		
	B3-CO_2	(kT/y)	4900			-850			-1800			-1100		
	B4 - Losses	(M€/y)	84,1			75,5			51,5			72,6		
		(GWh/y)	1323			935			725			870		
	B5a-SoS Adequacy	(MWh/y)	0			0			500			20		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs	(M€)	2900											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

Rules for sign of Benefit Indicators

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-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 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 [MWh/Year] =	Positive when a project reduces the risk of lack of supply

Assessment	Color code
negative impact	
neutral impact	
positive impact	
Not Available/Not Available	
monetized	

Note that few countries (Egypt, Israel, Libya, Palestine, Syria and Lebanon) are modelled starting from available data to obtain an average scenario since no data were directly provided to Med-TSO by the TSOs of those countries. The benefit of the project has been assessed using this average scenario.

6.10. Cluster TR-IL (Turkey - Israel)

Description

The Cluster is located in eastern Mediterranean and consists of a HVDC submarine cable between Turkey and Israel.

The new HVDC link between Turkey and Israel is expected to be implemented using VSC technology, which presents several advantages over the LCC technology.

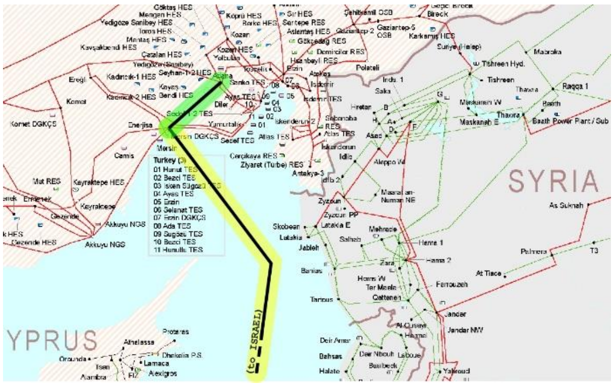
Additional Information

The project is promoted by TEIAS and IEC (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I).

The main driver of the project is to develop a corridor between Turkey and Israel to create trade possibilities and to increase renewable energy integration in the region. Estimated capacity is about 2000MW.

Investment needs

Network studies performed by Med-TSO identified the need of additional reinforcement in the Turkish System while the System of Israel was not analyzed. The figure shows the maps of the projected interconnection (yellow line) and corresponding reinforcements (green line). The main outcomes of the contingency analysis for the Turkish system could be summarized to the following:



To reinforce Turkish grid in the vicinity of TRIL project's connection point, reinforcement of 400 kV Mersin – Adana OHL is required. Also, replacement of existing 400kV 2bundle Toscelik – Bastug OHL with 3-bundle conductors is needed to reinforce the region.

The cost of the reinforcements is presented below, together with the investment cost of the new interconnection.

Cost Benefit Analysis

In the following table, the assessment results for the Cluster are presented:

Assessment results for the Cluster P10 - TRIL														
non scenario	GTC increase direction 1 (MW)		2000											
	GTC increase direction 2 (MW)		2000											
scenario specific			MedTSO scenario											
			1			2			3			4		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		TR	6200	8200	2000	6200	8200	2000	6200	8200	2000	6200	8200	2000
		IL	0	2000	2000	0	2000	2000	0	2000	2000	0	2000	2000
Interconnection Rate (%)*		TR	4,9%	6,5%	1,6%	4,9%	6,4%	1,6%	4,4%	5,8%	1,4%	4,1%	5,4%	1,3%
		IL	0,0%	10,9%	10,9%	0,0%	10,9%	10,9%	0,0%	10,9%	10,9%	0,0%	10,9%	10,9%
Benefit Indicators	B1-SEW	(M€/y)	630			270			360			240		
	B2-RES	(GWh/y)	0			0			0			0		
	B3-CO_2	(kT/y)	3200			1600			-1400			2000		
	B4 - Losses	(M€/y)	44,2			55,7			41,7			55,3		
		(GWh/y)	704			657			565			619		
	B5a-SoS Adequacy	(MWh/y)	0			0			500			20		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs	(M€)	1700											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

Rules for sign of Benefit Indicators

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-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 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 [MWh/Year] =	Positive when a project reduces the risk of lack of supply

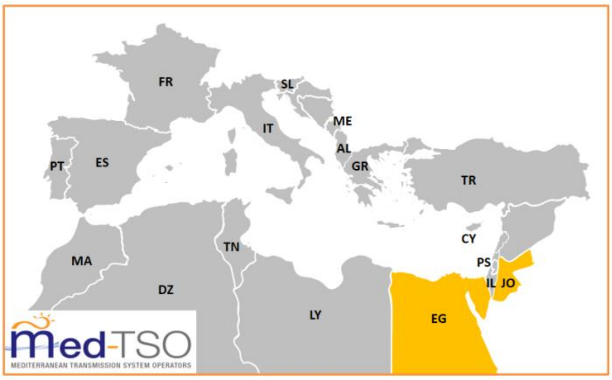
Assessment	Color code
negative impact	red
neutral impact	
positive impact	
Not Available/Not Available	
monetized	

Note that few countries (Egypt, Israel, Libya, Palestine, Syria and Lebanon) are modelled starting from available data to obtain an average scenario since no data were directly provided to Med-TSO by the TSOs of those countries. The benefit of the project has been assessed using this average scenario.

6.11. Cluster EG-JO (Egypt - Jordan)

Description

The Cluster is related to add between Jordan and Egypt a new interconnection, which will lead to double the current capacity between Egypt-Jordan to be 1100 MW.



Additional Information

The project is promoted by NEPCO and EETC (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I).

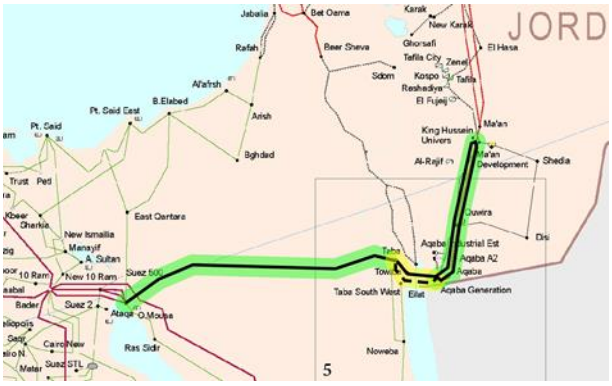
Jordan and Egypt are electrically interconnected since 1998 via a 13km, 400kV submarine cable across the Gulf of Aqaba to Taba, with an exchange capacity of 550MW. Egypt and Jordan are part of the Eight countries interconnection, including also Syria, Lebanon, Turkey, Iraq, Palestine, and Libya.

The main driver of the project is to further increase the interconnection capacity between Egypt, and Jordan to reach 1100 MW. This will enhance the integration of RES generation and increase grid stabilization, helping both countries to meet their load demand, with the positive effect of postponing investments in both generation and transmission.

Investment needs

Network studies performed by Med-TSO identified the need of significant additional reinforcement in both Systems. The figure shows the maps of interconnections, both existing (dashed-yellow line) and projected (yellow line), and corresponding reinforcements (green line). The main outcomes of the contingency analysis could be summarized to the following:

- A new reinforcement in the Jordanian system consisting in doubling the existing 400 kV double circuit between MAAMN and ATP400 (four circuits between MAAMN and ATP400.
- A new reinforcement in the Egyptian system consisting in doubling the 500 kV circuit between O-MOUSA and TABA400 and the 500/400 kV transformer at TABA substation.



The cost of the reinforcements is presented below, together with the investment cost of the new interconnection.

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Cost Benefit Analysis

In the following table, the assessment results for the Cluster are presented:

Assessment results for the Cluster P11 - EGJO														
non scenario	GTC increase direction 1 (MW)		550											
	GTC increase direction 2 (MW)		550											
scenario specific			MedTSO scenario											
			1			2			3			4		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		EG	1250	1800	550	1250	1800	550	1250	1800	550	1250	1800	550
		JO	1350	1900	550	1350	1900	550	1350	1900	550	1350	1900	550
Interconnection Rate (%)*		EG	1,4%	2,1%	0,6%	1,4%	2,1%	0,6%	1,3%	1,9%	0,6%	1,4%	2,0%	0,6%
		JO	12,6%	17,8%	5,1%	11,6%	16,3%	4,7%	12,4%	17,5%	5,1%	11,0%	15,5%	4,5%
Benefit Indicators	B1-SEW	(M€/y)	25			39			35			47		
	B2-RES	(GWh/y)	0			0			0			0		
	B3-CO_2	(kT/y)	-150			-300			-200			-450		
	B4 - Losses	(M€/y)	7,3			9,9			7,5			9,4		
		(GWh/y)	88			110			92			107		
	B5a-SoS Adequacy	(MWh/y)	0			0			60			20		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs	(M€)	200											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

Rules for sign of Benefit Indicators

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-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 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 [MWh/Year] =	Positive when a project reduces the risk of lack of supply

Assessment	**Color code**
negative impact	
neutral impact	
positive impact	
Not Available/Not Available	
monetized	

Note that few countries (Egypt, Israel, Libya, Palestine, Syria and Lebanon) are modelled starting from available data to obtain an average scenario since no data were directly provided to Med-TSO by the TSOs of those countries. The benefit of the project has been assessed using this average scenario.

6.12. Cluster JO-SY-TR (Jordan - Syria - Turkey)

Description

The Cluster is located in eastern Mediterranean and consists of two new interconnections: one between Jordan and Syria and one between Syria and Turkey, to be realized through AC overhead lines and an HVDC Back-to-Back station in Turkey. The project is expected to double the current to become 1600 MW between Jordan and Syria and 1200 between Turkey and Syria.

Additional Information

The project is promoted by NEPCO and TEIAS (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I).

Jordan, Syria and Turkey are electrically connected by a 400 kV grid, with existing capacity of 600 MW (Turkey-Syria) and 800 MW (Jordan-Syria). These countries are part of the Eight countries interconnection, including also Egypt, Lebanon, Iraq, Palestine, and Libya.

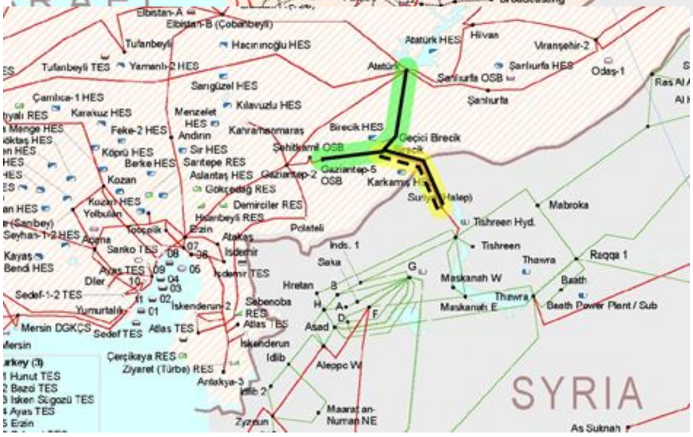
The main driver of the project is to further increase the interconnection capacity between Syria, Turkey and Jordan by another 800 MW between Jordan and Syria and 600 MW between Turkey and Syria. This will allow mainly meeting the Syrian demand and to integrate more renewable resources and base load units in the region.

Investment needs

Network studies performed by Med-TSO identified the need of additional reinforcement in the Systems of Turkey and Syria. The figure shows the maps of interconnections, both existing (dashed-yellow line) and projected (yellow line), and corresponding reinforcements (green line). The main outcomes of the contingency analysis could be summarized to the following:

- A new reinforcement was identified in the Syrian network, consisting in doubling the existing 400 kV double circuit between ADRA 2 and DIR-ALI (four circuits between ADRAZ and DIR-ALI).

- Two main relevant reinforcements were identified in the Turkish network, consisting in the replacement of the 2-bundle OHLs with 3-bundle conductors to reinforce the region (replacement of 400-kV 2-bundle Ataturk – Birecik OHL with double circuit 3-bundle conductors and replacement of 400-kV 2-bundle Birecik HES – Birecik).



The cost of these internal reinforcements is presented in the below, together with the investment cost of the new interconnection.

Cost Benefit Analysis

In the following table, the assessment results for the project are presented:

Assessment results for the Cluster P12 - JOSYTR														
non scenario	GTC increase direction 1 (MW)		800 (JO-SY) - 600 (TR-SY)											
	GTC increase direction 2 (MW)		800 (SY-JO) - 600 (SY-TR)											
scenario specific			MedTSO scenario											
			1			**2**			**3**			**4**		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		JO	1350	2150	800	1350	2150	800	1350	2150	800	1350	2150	800
		SY	2200	3600	1400	2200	3600	1400	2200	3600	1400	2200	3600	1400
		TR	6200	6800	600	6200	6800	600	6200	6800	600	6200	6800	600
Interconnection Rate (%)*		JO	12,6%	20,1%	7,5%	11,6%	18,4%	6,9%	12,4%	19,8%	7,3%	11,0%	17,5%	6,5%
		SY	8,3%	13,6%	5,3%	8,3%	13,6%	5,3%	8,3%	13,6%	5,3%	8,3%	13,6%	5,3%
		TR	4,9%	5,4%	0,5%	4,9%	5,3%	0,5%	4,4%	4,8%	0,4%	4,1%	4,4%	0,4%
Benefit Indicators	B1-SEW	(M€/y)	330			210			210			220		
	B2-RES	(GWh/y)	0			0			0			0		
	B3-CO_2	(kT/y)	400			300			-900			200		
	B4 - Losses	(M€/y)	20,6			26,5			24,0			29,4		
		(GWh/y)	335			314			308			331		
	B5a-SoS Adequacy	(MWh/y)	0			0			540			20		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs	(M€)	250											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

Rules for sign of Benefit Indicators

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-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 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 [MWh/Year] =	Positive when a project reduces the risk of lack of supply

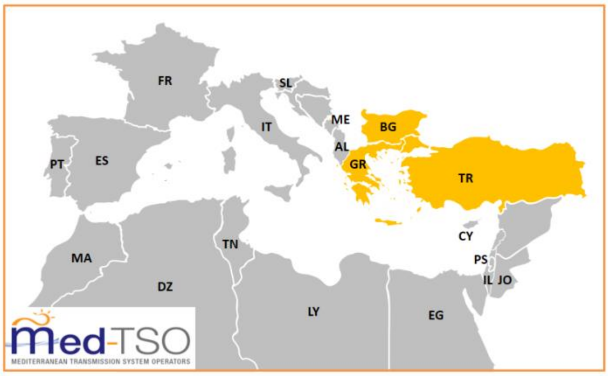
Assessment	**Color code**
negative impact	
neutral impact	
positive impact	
Not Available/Not Available	
monetized	

Note that few countries (Egypt, Israel, Libya, Palestine, Syria and Lebanon) are modelled starting from available data to obtain an average scenario since no data were directly provided to Med-TSO by the TSOs of those countries. The benefit of the project has been assessed using this average scenario.

6.13. Cluster GR-TR-BG – Greece-Turkey-Bulgaria

Description

The project GRTRBG consists in two new interconnections: one between Greece and Turkey and one between Bulgaria and Turkey to be realized through AC overhead lines, with the aim to increase the interconnection capacity between Turkey and the CESA (Continental Europe Synchronous Area) of about 1000MW.



Additional Information

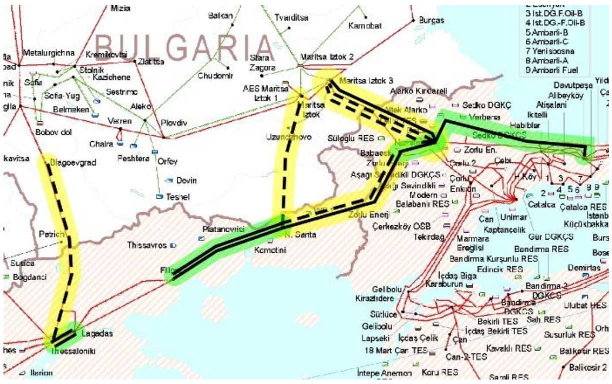
The project necessity stems from the need to increase the transfer capacity in the Continental Europe Synchronous Area (CESA) to Turkey transmission corridor. Greece and Bulgaria are part of CESA to Turkey transmission corridor. Currently there is one interconnection between Greece and Bulgaria, one between Greece and Turkey and two between Bulgaria and Turkey. Total NTC values are 650 MW CESA to Turkey direction and 500 MW in the opposite direction. Two thirds of this NTC are presently allocated to the Bulgaria to Turkey connection and one third is allocated to the Turkey to Greece connection.

The second Greece to Bulgaria and the related strengthening of the 400 KV south East Bulgaria network which is currently under way, will help to increase future NTC to 1350 MW on CESA to Turkey direction and to 1250 MW on the opposite direction. The realization of the project GRTRBG is aiming to further increase the interconnection capacity between Turkey and the CESA (Continental Europe Synchronous Area) of about 1000MW.

The project is promoted by IPTO, TEIAS and ESO (under the umbrella of the studies carried out by Med-TSO within the Mediterranean Project I).

Investment needs

Network studies performed by Med-TSO identified the need of additional reinforcement in the Systems of Turkey and Greece, while no reinforcements were identified in the Bulgarian System. The figure shows the maps of interconnections, both existing (dashed-yellow line) and projected (yellow line), and corresponding reinforcements (green line). The main outcomes of the contingency analysis could be summarized to the following:



- two internal reinforcements were identified in the Greek system close to the connection point of the project, consisting in the construction of two double 400 kV OHL of a total length of 165km.
- reinforcements identified in the Turkish system are also located close to the boarder and consist in the replacement of conductors of the existing 400kV OHL of a total length of 25 km and the use

of the spare circuit of Verbena (Hamitabat) – Habibler 400 kV OHL to reinforce the region. No reinforcements were identified in the Bulgarian system.

In the analysis performed, NTC values considered exceed significantly the increase in the NTC foreseen by the new project. This is due to the fact that the three systems represent an interconnected triangle, situation, which presents some difficulty in controlling the power flows in the interconnections to meet the values defined in the PiTs. Thus, as a general remark, it should be stressed that the internal reinforcements identified are required only in case the NTCs increase exceeds the foreseen values.

The cost of the reinforcements is presented below, together with the investment cost of the new interconnection.

Cost Benefit Analysis

In the following table, the assessment results for the Cluster are presented:

Assessment results for the Cluster P13 - GRBGTR														
non scenario	GTC increase direction 1 (MW)		500 (GR-TR) - 500 (BG-TR)											
	GTC increase direction 2 (MW)		500 (TR-GR) - 500 (TR-BG)											
scenario specific			MedTSO scenario											
			1			**2**			**3**			**4**		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		GR	3462	3962	500	3462	3962	500	3462	3962	500	3462	3962	500
		BG	2090	2590	500	2090	2590	500	2090	2590	500	2090	2590	500
		TR	6200	7200	1000	6200	7200	1000	6200	7200	1000	6200	7200	1000
Interconnection Rate (%)*		GR	14,4%	16,5%	2,1%	17,8%	20,4%	2,6%	13,0%	14,9%	1,9%	13,0%	14,9%	1,9%
		BG	15,3%	18,9%	3,7%	16,4%	20,3%	3,9%	14,0%	17,3%	3,3%	17,8%	22,1%	4,3%
		TR	4,9%	5,7%	0,8%	4,9%	5,7%	0,8%	4,4%	5,1%	0,7%	4,1%	4,7%	0,7%
Benefit Indicators	B1-SEW	(M€/y)	17			37			160			71		
	B2-RES	(GWh/y)	0			0			60			300		
	B3-CO_2	(kT/y)	300			-1600			2800			-1100		
	B4 - Losses	(M€/y)	-3,7			-5,4			-12,0			-13,8		
		(GWh/y)	-84			-70			-80			-121		
	B5a-SoS Adequacy	(MWh/y)	0			0			260			200		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact													
Costs	C1-Estimated Costs	(M€)	200											

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

Rules for sign of Benefit Indicators

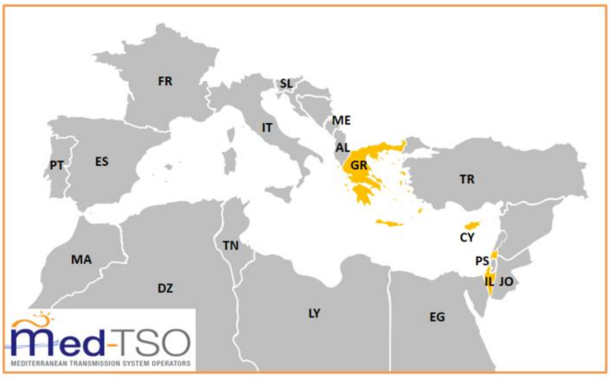
B1- Sew [M€/year] =	Positive when a project reduces the annual generation cost of the whole Power System
B2-RES integration [GWh/Year] =	Positive when a project reduces the amount of RES curtailment
B3-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 emitted in one year
B4-Losses - [M€/Year] and [GWh/Year] =	Negative when a project reduces the annual energy lost in the Transmission Network
B5a-SoS [MWh/Year] =	Positive when a project reduces the risk of lack of supply

Assessment	Color code
negative impact	
neutral impact	
positive impact	
Not Available/Not Available	
monetized	

6.14. Cluster GR-CY-IL – Greece - Cyprus - Israel

Description

The Cluster GRCYIL (Euro Asia Interconnector) consists of a HVDC VSC 500 kV submarine cable for the interconnection of the systems of Greece, Cyprus and Israel. The link will have a capacity of 2000 MW and a total length of around 832 nautical miles/around 1541 km (approx. 314 km between Cyprus and Israel, 894 km between Cyprus and Crete and 333 km between Crete and Athens) and allow for reverse transmission of electricity.



Additional Information

The project GRCYIL was promoted for TYNDP inclusion by a non-ENTSO-E member (promoter EuroAsia Interconnector), complying with the EC's draft guidelines for treatment of all promoters.

It has a significant contribution to the EU energy targets as presented below:

- Marks the end of the energy isolation of Cyprus, the last member of the EU remaining fully isolated without any electricity or gas interconnections.
- Creates the electricity highway from Israel-Cyprus-Crete-Greece (Europe) through which the European Union can be securely supplied with electricity produced by the gas reserves in Cyprus and Israel, as well as from the available RES, contributing at the same time to the completion of the European Internal market.
- Promotes the substantial development of RES and contributes to the reduction of the CO_2 emissions.
- Offers significant economic and geopolitical benefits to the involved countries.
- Contributes to the target of the European Union for 10 % of electricity interconnection between Member States.
- “Provides significant socio-economic benefits at the range of 10 billion euros.”

Project website:
https://docstore.entsoe.eu/Documents/TYNDP%20documents/TYNDP%202016/projects/P219.pdf

Investment needs

Network studies performed by Med-TSO did not identify the need of additional reinforcements in the Systems of Greece and Cyprus, while the System of Israel was not analyzed.

Cost Benefit Analysis

In the following table, the assessment results for the Cluster are presented:

Assessment results for the Cluster P14 - GRCYIL														
non scenario	GTC increase direction 1 (MW)		2000											
	GTC increase direction 2 (MW)		2000											
scenario specific			MedTSO scenario											
			1			**2**			**3**			**4**		
			Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta	Ref. Scenario	with new project	Delta
GTC / NTC (import)		GR	3462	5462	2000	3462	5462	2000	3462	5462	2000	3462	5462	2000
		CY	0	2000	2000	0	2000	2000	0	2000	2000	0	2000	2000
		IL	0	2000	2000	0	2000	2000	0	2000	2000	0	2000	2000
Interconnection Rate (%)*		GR	14,4%	22,7%	8,3%	17,8%	28,1%	10,3%	13,0%	20,5%	7,5%	10,6%	16,7%	6,1%
		CY	0,0%	86,2%	86,2%	0,0%	76,2%	76,2%	0,0%	88,9%	88,9%	0,0%	75,9%	75,9%
		IL	0,0%	10,9%	10,9%	0,0%	10,9%	10,9%	0,0%	10,9%	10,9%	0,0%	10,9%	10,9%
Benefit Indicators	B1-SEW	(M€/y)							710			480		
	B2-RES	(GWh/y)							190			1000		
	B3-CO_2	(kT/y)							-3600			2100		
	B4 - Losses	(M€/y)							93,4			114,7		
		(GWh/y)							1400			1380		
	B5a-SoS Adequacy	(MWh/y)							21000			32000		
	B5b-SoS System Stability													
Residual Impact Indicators	S1- Environmental Impact													
	S2-Social Impact													
	S3-Other Impact**													
Costs	C1-Estimated Costs	(M€)							5900					

* considering the GTC for 2030 , the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E)

** contribution to EU energy targets: the project marks the end of the energy isolation of Cyprus, last member of EU remaining fully isolated without any electricity or gas interconnections.

Rules for sign of Benefit Indicators

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-CO_2 [kt/Year] =	Negative when a project reduces the whole quantity of CO_2 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 [MWh/Year] =	Positive when a project reduces the risk of lack of supply

Assessment	Color code
negative impact	red
neutral impact	light beige
positive impact	green
Not Available/Not Available	grey
monetized	yellow

Note that few countries (Egypt, Israel, Libya, Palestine, Syria and Lebanon) are modelled starting from available data to obtain an average scenario since no data were directly provided to Med-TSO by the TSOs of those countries. The benefit of the project has been assessed using this average scenario.

7. Conclusions

Market Studies provides the annual expected benefits for the 14 interconnection projects under assessment, in terms of Socio-economic welfare (SEW), RES integration and Variation in CO2 emissions for the four scenarios evaluated.

The total benefits expected for the 14 interconnection projects can expressed in a range 2000 to 3000 M€ by year for the Socio-economic welfare (SEW) indicator, while the benefits related with the RES integration can be expressed in a range 1000 to 6000 GWh by year (reduction of RES curtailment). Regarding the expected evolution of CO_2 emissions in the power system due to the 14 interconnection projects is characterized in a range -5500 (reduction) to 16500 (increase) kT by year.

On the other hand, the network studies identified the necessary reinforcements in the countries to accommodate the flows from the new interconnections as well as the cost of these internal reinforcements. The costs of these new interconnections and the most appropriate technology were also identified.

With the information provided by the Market and Network studies, the Cost-Benefit Analysis was applied to the 14 interconnection projects. The interconnection rate (%) and the increase of this rate were calculated for the 14 interconnection projects considering the GTC for 2030, the Install generation for 2030 and the GTC for importation (the same criteria used in the ENTSO-E) for each scenario of Market studies. The increase of the interconnection rate with the new clusters can expressed in range of 0.5% - 89%.

The impact of the losses in the transmission grids were also analyzed, as well as some indicators of Security of supply (Adequacy to meet demand and System stability).

As a final summary, the studies identified and 14 new interconnection projects which add about 18 000 MW of the new interconnection capacity in the Mediterranean region. The Socio-economic welfare expected in a range 2000 to 3000 M€ per year, while the total investment for these interconnections is around 16 000 M€, where 10% of which are needed for internal reinforcements in the countries. The Cost-Benefit Analysis was applied for these 14 interconnection projects in order to characterized and demonstrate the several benefits of the new clusters in the Mediterranean region.

For the next steps will be need to continue the consolidation of these market and network studies, and of course the CBA application, in order to achieve a deeply characterization of the all CBA indicators for the new interconnection project.

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