MEDITERRANEAN TRANSMISSION SYSTEM OPERATORS

Deliverable 2.1.1

Guidelines for Coordinated Planning:

a) Grid Planning Methodology

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"Mediterranean Project"

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

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Basic Principles

The worldwide Energy transition and the evolution of the Energy Sectors involve the northern and southern banks of the Mediterranean basin in the same direction but with different peculiarities.

The Northern bank is engaged in ambitious decarbonisation targets and market integration within a general stagnation of the electricity demand.

The southern bank is characterized by large potentiality of renewable generation and by a fairly high rate of growth of the demand, supported by concrete examples of plans and deployment of RES. While the market is still in evolution.

These circumstances appear to be sufficient to sense synergies between the two banks. Moreover, the spring towards cooperation is reinforced by the political willingness to use the electricity as a vehicle of progress and welfare.

To make it happen, harmonization in methodologies, practices and sound infrastructures are necessary. Planning in a rigorous, transparent and consensus based process is the first step towards a stronger integration. Hence planning does not only mean designing interconnectors but it implies to reinforce entire areas for future operation based on the same best standards of reliability, resiliency and quality of supply.

The Euro-Mediterranean Region share the European necessity to enhance the coordination of the development plans and the electric grids operation in order to achieve the benefits resulting from the sharing of resources, costs and risks of investments in infrastructure.

This means that the transmission systems of the future need to be designed looking beyond the traditional TSO boundaries, towards regional and more and more global solutions, like a big coordinated Mediterranean grid which potentiate taking advantage of renewable resources. So, close co-operation of Companies' responsible members in the Med-TSO it is required to achieve a coherent and coordinated planning in order to launch a future development of the Mediterranean transmission system.

Then, the main objective of transmission system planning in the Med-TSO region is to ensure, in the mid and long term horizons and based on multilateral cooperation among countries, the development of an adequate transmission system to improve the integration of the Mediterranean Electricity Systems which:

- Provides a high level of security of supply at the Mediterranean area.
- Ensures safe system operation at the whole region.
- Contributes to a sustainable development.

- Contributes to economic efficiency of the entire Mediterranean system.
- Promotes the exploitation of more competitive generation within the region.
- Promotes and potentiates the integration of RES in Mediterranean region.
- Contributes to internal market integration and harmonization rules at all system.
- Facilitates grid access to all market participants/users.

In this way, the Med-TSO Association aims the integration of a regional electricity market in the long term, by coordinating the development plans and the operation of the grids in Med-TSO countries, encouraging the integration of their electricity systems and the implementation of common criteria and harmonized, transparent and non-discriminatory rules of access to and usage of grids.

Each TSO member of Med-TSO has to comply with the transmission planning criteria which are generally established in transmission planning documents for their countries, as mentioned in the appendix 2. These criteria have been generally developed for application by individual TSO's, taking into account the main energy drivers of each country, the above aspects and particular conditions to the network to which they relate.

In general terms, the planning standards from each TSO are technically rather similar as summarized in the appendix 2, but some simple, precisely and common assessment criteria for reinforcements at regional level are required.

The planning process should tend to gradually smooth the residual differences existing at TSO level in terms of grid performance (e.g. voltage range limits). This can be achieved by pursuing a policy to set common and progressive targets to be met in the medium- long term. A similar approach can be pursued in reference to environmental targets.

Bearing in mind the abovementioned factors, the planning process has the objective to create proposals to meet the general scope of interconnecting the two banks of the Mediterranean, taking as a basis and input the National Development Plans. The goal of harmonization in planning is that, once the process has been stabilized, the National Development Plans will gradually acquire the more general objective and proposals of the Mediterranean Master Plan (MMP) for the benefit of the whole Mediterranean basin system.

1 Planning Methodology

For the purposes of this section the Methodology is meant to be a set of agreed rules for carrying out the planning activity in the Med-TSO area whose final delivery is the Mediterranean Master Plan (MMP). The described methodology aims at the best modeling of the system, at the adoption of the state of the art techniques and at the closest interpretation of the objectives of harmonization of the Med-TSO Members.

Moreover, the Methodology aims at quantitative evaluations of the benefit indicators of the MMP. A specific section is dedicated to the proof of feasibility of such methodology, and its compatibility with the present practices and the procedures adopted among the Med-TSO Members.

The Methodology is split in two basic categories of assessments:

- The Adequacy and Cost Benefit Analysis
- The technical Analysis

1.1 Adequacy and Cost Benefit Analysis

1.1.1 Scope of Adequacy and Cost Benefit Analysis

The objectives of security of supply, sustainable development of the energy system with renewable energy source (RES) integration and affordable energy can be achieved in an interconnected system only adopting a common grid development project among neighboring countries.

At European level this task is performed by ENTSOE via the Ten-Year Network Development Plan (TYNDP[1]) that, with a biennial frequency, provides the central reference point for European electricity grid development. MMP shall be synchronized with TYNDP, if only to the fact that the Northern Bank network is a large part of the whole Med-TSO area.

The evaluation of the benefits associated with projects of pan-European significance is made applying a Cost Benefit Analysis (CBA[2]), designed by ENTSO-E and assessed through a consultation process. At least one member state should be interested from the project in order to include it in PCIs[3] list. Additionally, to become PCI, projects proposed by promoters shall participate in an appraisal phase starting by the TYNDP process coordinated by ENTSOE. In this sense, the development of a MMP in line with TYNDP methodologies is a valuable preparation for the candidature of future project proposals.

The aim of the Methodology is to develop market scenarios suitable for the evaluation of network investments to increase exchange capacity among countries.

The first target year is 2030 and the scenarios to be analyzed should be contrasting scenarios and provide a framework for a credible/probable future, ENTSO-E adopts the same approach for the TYNDP where four visions are developed to be used for the assessment of the benefits of the long term infrastructure proposals in the TYNDP preparation process.

Similarly the Methodology will aim at calculating the indicators reflecting the Security of supply, the Social Economic Welfare, the level of RES integration and the progresses in decarbonization.

[1] ENTSO-E, Ten-Year Network Development Plan 2014, 2014.
[2] ENTSO-E, Guideline for Cost Benefit Analysis of Grid Development Projects.
[3] PCI – Project of Common Interest evaluated by the European Commission.

The above mentioned indicators, in line with the ones defined in the ENTSO-E methodology the Benefit Categories are defined as follows:

- Improved security of supply (SoS) is the ability of a power system to provide an adequate and secure supply of electricity under ordinary conditions;
- Socio-economic welfare (SEW) or market integration is characterized by the ability of a power system to reduce congestion and thus provide an adequate GTC so that electricity markets can trade power in an economically efficient manner;
- 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;
- Variation in CO_2 emissions is the characterization of the evolution of CO_2 emissions in the power system.

1.1.2 Approach, Methodology and Assumptions

Basically the activity shall be organized in a two steps approach, in particular the first phase (Round A) will include the definition of the scenarios to be used, the data collection and the characterization of the market model to be used for the analyses.

The second phase (Round B) shall be dedicated to the refinement of the hypotheses on the basis of the results obtained in Round A.

The analysis shall quantize possible benefits related to investment projects, focusing on the Med-TSO member countries in order to improve transmission capacity and achieve benefits for the transmission system as a whole. It is to be mentioned that the methodology used to calculate the benefits and its share between systems will have to be based on:

- The assumptions that are adopted for future generation costs (CAPEX&OPEX, in particular fuel and CO2 emission prices)
- The assumptions that are adopted with respect to the regulatory model governing the electricity interchanges. Normally, a perfectly concurrent market is assumed.

The target shall be accomplished through the application of simulation models carrying out an optimal coordinated hydrothermal scheduling of the modeled electric system generation set, over a period of one year. The simulation tool shall implement an efficient energy market for the whole Med-TSO area, characterized by a zonal market and by a congestion management based on a zonal market-splitting and market coupling. In order to ease the calculations, market zones can be reduced to one per country.

An adequate tool to simulate competition in future market scenarios shall be adopted. It is recommended to explicitly model the power generation system considering thermal generation units, pumped-storage hydro power plants, and several equivalents for reservoir and for run-of-river hydro power plants, depending on data availability.

Considering both technical constraints for generation units and transmission constraints among market zones the method shall provide robust quantitative outputs on generation dispatching and market prices. Market simulation has to be able to perform the evaluation of the profitability of investments in grid by the dispatch assessment.

For all generation units total production, cost, number of in service hours and CO_2 emissions shall be provided by the market simulation tool.

Possible over generation problems due to RES integration are assumed to be managed by the minimal curtailments in production (once all storage and export possibilities have been used up). The amount should be shown in the results.

The method should allow to define an optimized maintenance schedule of thermal generating units starting from the week duration of maintenance.

A Monte Carlo approach applied to the availability of generating units and to interconnection capacity is considered suitable for the evaluation of the security of supply for the electric system under study and to provide information about limiting elements and main security of supply indicators.

1.1.2.1 Scenario study and task organization

Four scenarios, selected by TSOs in WG EES (or equivalent Team) with year 2030 as target date, shall be the base of the first step of the activity. The scenarios will be discussed and analyzed in order to be sure to cover all the relevant aspects for the aims of the planning process. Standard Scenarios are described in section 1.2

If it is agreed that the initial four scenarios are not sufficient to represent possible and relevant uncertainties in the future evolution of the system main figures, two additional scenarios will be analyzed. Uncertainties will preferably refer to:

- Load (demography, , energy efficiency, end-user equipments, …)
- Generation evolution (technology, capacity)
- Interconnection capacity
- Economy (fuel prices, CO2, GDP growth)
- Other (agreed by members)

The scenario definition will be applied only to Med-TSO member countries, while for all the other countries modeled will be considered a fixed scenario for year 2030.

All information related to scenarios has to be stored in the MED data base (DBMED).

A template to be used for the data collection of Med-TSO members and DBMED upload is recommended.

1.1.2.2 Data Collection and Market Model (ROUND A)

DBMED shall be updated with a controlled data collection procedure to update the following:

- Load curves;
- Thermal generation (size, primary fuel, efficiency, maintenance, must run, reliability, flexibility degree...);
- Generation and CO_2 costs (the consultant strongly suggest to harmonize this information with fixed cost in relation to primary source and efficiency, according to the environmental policy assumptions of each scenario);
- Value of Loss Load associated to unsupplied energy;
- Hydro production (run of a river, natural inflow) and pump/storage capacity;
- Wind and solar potential production profiles (producible energy);
- Other renewable or not renewable profiles;
- Power reserves (shared or strategic reserve);
- Number of nodes needed for the market modeling by country;
- Exchanges capacities (both directions);
- Exchanges curves for neighboring countries outside from the perimeter or better (cost dependent) models if available;
- Other (specific use of energy water for the South countries, exchanges planned and long terms contracts between TSO's members of Med-TSO)

For European countries to be considered in the analyses, the data should be required from Med-TSO to ENTSO-E in the data format PEMMDB and PECD and transferred to DBMED. Each non European TSO shall upload its data on the DBMED.

After the collection and validation of the data of all involved TSOs a market model will be set up and tuned. A first run of the scenarios will be performed Monte Carlo extractions to verify the coherence of the data implemented with Med-TSO expectations (especially regarding EENS)[4].

The software tool should give an indication on the optimal maintenance schedule of thermal units considering thermal load all over the year and concentrating maintenance in period of low thermal load in order to minimize possible shortage problems.

The data preparation before the run of a whole year simulation includes also the hydro optimization for storage and pumping units, considering inflow time-series; the production of hydro units will be concentrated during period of high thermal load while pumping capacity is used to optimize system costs verifying the profit for the system to pump energy during low load hours to use it when costs are higher (including efficiency of pumping process).

[4] Probabilistic analysis is needed to check adequacy and correct using of hydro power plants

RES productions can be simulated starting from climatic database (PECD for European countries) selecting different production scenarios and maintaining the correlation between load and wind and solar productions.

In alternative, the tool shall start from typical or local producible curve for wind and photovoltaic and apply a probabilistic extraction to establish the level of production of intermittent generation..

A report describing the general results of market runs for each scenarios will be prepared including among the others:

- Energy exchanges among areas
- Generation production and costs for each type of unit
- Area and system cost
- Reliability indexes: EENS, LOLP, LOLE
- RES curtailment

1.1.2.3 Project assessment (ROUND A)

For the purposes of the planning methodology a "project" is defined as a cluster of investment items that have to be fully realized to achieve a desired effect. It follows that a project consists of one or a set of various investments. An investment should be included only if the project without this investment does not achieve the desired effect.

Clustering of a group of investments is recommended when:

- They are located in the same area or along the same transmission corridor;
- They achieve a common measurable goal;
- They belong to a general plan for that area or corridor.

The results of the first runs of the market model will provide information about the risk of energy not supplied in the system that can be due to lack of interconnection[5], power is available in a system area separated from the deficit one by saturated interconnections:

Marginal gain for EENS reduction associated to the increase in capability of single network elements will be provided purely as an indication for orienting analyses on possible investments.

[5] It is considered that the sizing of reserve is adequate to face possible fault of generating units and in a large interconnected system is improbable the lack of power in all the system

The analysis of the impact of each investment could be made considering alternatively the following methodologies. For certain clusters both methodologies may be considered:

- The TOOT (Take Out Once at Time) methodology consisting of excluding investment items (line, substation, PST or other transmission network device) or complete projects from the forecasted network structure on a one-by-one basis and to evaluate the load flows over the lines with and without the examined network reinforcement (a new line, a new substation, a new PST, ..).
- The PINT (put in once at the time) methodology considers each new network investment/project (line, substation, PST or other transmission network device) on the given network structure one-by-one and evaluates the load flows over the lines with and without the examined network reinforcement.

The considered benefit categories at this stage shall be: Security of supply, Social Economic Welfare, RES integration, CO_2 emission. In the following some more details are given.

Security of Supply

The aim of this task is to assess the reliability of the transmission/generation systems in the interconnected model to estimate the reduction of the **Expected Energy Not Supplied (EENS)** and the related monetization.

To attain the above target, probabilistic simulations shall be carried out taking into account all uncertainty factors (e.g.: forced outage rate of generating units, interconnections, intermittency of RES generation, etc.). Furthermore, the analyses will not address specific operating conditions (e.g.: summer peak, winter peak, etc.), but shall cover as much as possible all expected conditions over a whole year and different scenarios. To this purpose, a probabilistic approach is adopted based on Monte Carlo technique.

It is important to highlight that in this phase the EENS and the other indexes are calculated without modeling the internal transmission network but only the generation system and the interconnections.

The quantitative assessment of the static reliability of the electric power system is evaluated by means of **EENS** index (**Expected Energy Not Supplied**) which expresses, in a probabilistic way, the matching between the load that must be supplied and the capacity of production and transmission systems. This index represents the average annual value of energy not supplied due to the unavailability of generation and transmission system considering the constraints represented by the active power limits of power plants and the exchange capacities of the new interconnector.

The economic benefit associated to EENS reduction can be calculated using the Value Of Lost Load (VOLL) multiplied for EENS figure. It is worth to notice that VOLL value may change from country to country due to intrinsic value of energy for the country. At least a common methodology for VOLL evaluation should be adopted from all the countries, as well explained from ENTSO-E in Annex 4 of CBA[6].

Together with the Expected Energy Not Supplied, also the following "risk indices" can be estimated:

- **Loss Of Load Expectation (LOLE)**: annual value of expected average number of hours with not supplied load;
- **Loss Of Load Probability (LOLP)**: probability of being unable to meet the weekly peak load due to lack of available capacity.

It is important to highlight that the EENS and the other indexes are calculated in static condition and so they do not consider the transient phenomena that appear when a fault occurs in the system, considering that exchange capacity calculation includes N and N-1 security rules (and stability constraint if relevant).

SEW variation

A project, that increases interconnection exchange capacity between market zones, allows generators in the lower-priced area to export power to the higher priced area, therefore a transmission project can increase socio-economic welfare (SEW) over the analyzed perimeter. According to ACER[7] recommendation the Market model shall identify the variation of SEW benefit for each country and, inside each country, for specific stakeholder groups: variation of producer surplus PS, variation of consumer surplus CS and variation of congestion revenues CR). The demand will be considered as inelastic, that is, fixed and independent from electricity costs.

RES integration

Integration of existing and planned RES generation is considered. This indicator measures the reduction of renewable generation curtailment (avoided spillage) due to the over generation respect to the load of the area. This indicator could be calculated in terms of energy curtailment or monetized considering the cost of substitution energy.

CO_2 variation

Reinforcements may enable low-carbon more economic generation to generate more electricity, replacing old power plants with higher cost and carbon emissions. Monetization of eventually avoided CO_2 emission is already included in SEW variation so this benefit is expressed in term of avoided quantity of emission.

[6] ENTSO-E, Guideline for Cost Benefit Analysis of Grid Development Projects.
[7] ACER - Agency for the Cooperation of Energy Regulators

1.1.2.4 Analysis of the results (ROUND A)

A final report will be drafted, integrating previous report and including the results obtained for each cluster and scenario and structured as follow:

- Executive summary
- Global view of the study
- Scenarios' presentation
- Data and hypothesis for each scenario
- Market model
- Projects assessment for each scenario
- Analysis of results and flow generated with the market
- Conclusion
- Annexes: detailed results of the analysis

1.1.3 Second iteration of Project assessment (ROUND B)

A second iteration for the project could be performed. This second iteration will be based on improvement from Med-TSO, and network development plan updates.

One or more scenarios could be modified and ESS WG will receive the updated data from Med-TSO TC1 in an agreed format.

The benefits of each clusters previously defined, or any new cluster resulting from the Round A analysis, will be calculated with the update of scenarios.

A new report will be issued containing the update of the results and highlighting the differences.

1.2 Scenario Definition

The evaluation of scenarios is the modern approach to System planning. It is the starting point to orient the development of the grid in a market environment. The Med-TSO methodology includes this activity in the planning process.

In addition, the scenario evaluation is the main element of harmonization of Med-TSO and ENTSOE Development plans.

The construction of multiple generation-demand scenarios for evaluating new transmission assets is an essential tool for dealing with uncertainties. The scenarios lay down technical and economic assumptions and identify possible solutions.

Scenarios analysis intends to deliver a set of multiple diversified and plausible future environments and TSO strategies for power systems. Scenario analysis gives decision makers an overview of future perspectives and facilitates decision making in complex and unpredictable situations.

The methodology developed by the European project e-Highway 2050 was applied to define Med-TSO scenarios (with the authorization of the project).

In this methodology scenarios are the combination of:

- Possible futures: which rely on a combination of uncertainties
- Possible TSO strategies: which options TSO can decide to deal with

In the following the definition of the scenarios is given. They are used to start the process of planning and supposed to be adopted also in the future unless TC1 will select some different ones.

1.2.1 Reference Energy Scenarios

Four scenarios, designed by Med-TSO with year 2030 as target date, are the base of the activity.

The four scenarios are based on distinctively different assumptions, thus the actual future evolution of parameters is expected to lie in-between:

1. Business as usual and security of supply improvement;
2. Green future based on gas utilization and on local integration of renewable energies (and management of the complexities of this kind of grids);
3. High economic growth which supports high interconnection development and free carbon thermal plants development in the South of the Mediterranean area;
4. Green future and market integration at an international level.

Two extra scenarios have been described, but not implemented:

5. Green future and mutual approach;
6. Low progress and security of supply improvement.

To define these scenarios, six sets of parameters are defined:

- Economy (GDP growth, population growth, demand forecast, primary resources prices);
- Renewable energy development;
- Technology development (storage, load management, smart grid);
- New load (water desalination, electric cars, public transportation, energy efficiency);
- Market integration (internal market, regional market, or global market);
- Thermal carbon free technologies (i.e. nuclear development in the South of the Mediterranean area).

Each scenario is presented in the next chapter.

To have a coherent approach between Med-TSO and ENTSO-E, the economic model for each Med-TSO scenario is based on ENTSO-E visions for European countries (TYNDP 2014 for the Round A assessment). Assumptions for price values are the ones adopted for TYNDP 2014 based on IEA scenarios.

The following table compares the scenarios adopted by the abovementioned 3 Associations.

Med-TSO "Scenarios"	1 - Business as usual	2 – Green future	3 – High economic growth	4 – Green future and market integration
ENTSO-E "Visions"	Vision 1	Vision 3	Vision 2	Vision 4
IEA "Reference scenarios"	Current Policies	450 Scenario coal from New Policies	New Policies low gas price (DECC low)	450 Scenario CO2 price higher

Scenarios and price values shall be agreed among Med-TSO members before quantitative analysis is performed.

1.2.1.1 Business as usual and security of supply improvement

This scenario is a conservative/medium scenario.

The load consumption increase with the same trend in each Med-TSO countries.

The hypothesis on the economic environment is one of the partial cash-up phase of global demand in the North. The development in South and East of Mediterranean is between 4 and 6%.

Energy policy is marked by the continuation of the current trend in each countries. The policy of supporting renewable energies is pursued but their growth remains well short of the level seen in other countries like Spain and Italy.

Interconnection and internal grid in the South is based on the improvement of the security of supply.

1.2.1.2 Green future based on gas use and on local integration of renewable energy

This scenario is a green scenario based on a bottom-up approach. Each country has decided a common policy tool to integrate RES and minimize climatic changes.

The CO2 price is high in European countries. South countries policy is based on an attentive use of primary resources and the development of renewable energy funds from primary resources incomes.

Gas power plants are built in the South for the guaranty of supply and to minimize CO2 emissions. These gas power plants will have also to be flexible to deal with a new energy mix based on renewable energy.

The load consumption increases higher than the same medium trend in each MED TSO countries because of the development of new electricity uses like public transportation.

The hypothesis on the economic environment is one of the partial cash-up phase of global demand in the North. The development in the South and East of Mediterranean is between 4 and 6%.

Interconnection development in the South is based on the improvement of the security of supply and exportation of RES.

1.2.1.3 High economic growth which supports high interconnection development

This scenario assumes that following new primary resources discovered the economy of the Mediterranean area goes up especially in the South. A 7% GDP growth could be expected in the South and 2% for the European countries.

Southern countries decide to develop free carbon thermal power plants (e.g. if this is more feasible than investing in thermal units powered by local resources) to support the electricity demand without using their primary resources.

New interconnections are built to share the low cost electricity of this kind of power plants and to share production margins (diversity of primary energy generation resources should be taken into due account) or reserve margins.

1.2.1.4 Green future and market integration at an international level

This scenario is based on a top-down approach with two issues:

- The CO_2 reduction for electricity production but also for transportation (new electricity uses);
- High technology development for load and generation management especially in the North bank;
- The RES and Nuclear investment in the South to support electricity demand, to limit the consumption of primary resources and to export the surplus of electricity.

This scenario is based on high multinational interconnections to support a global electricity market all around the Mediterranean area.

1.2.2 Extra scenarios

1.2.2.1 Green future and mutual approach

This scenario is an in-between scenario regarding a local green approach and an international green approach.

Maghreb area will develop cooperation to optimize their electrical systems.

European countries go on their green policy on their own.

Few Eastern countries sign an agreement for cooperation in renewable integration and for storage facilities.

1.2.2.2 Low progress and security of supply improvement

This scenario is the worst scenario for the Mediterranean area.

Because of low progress of the economy, each country decides to run their own electrical grid by itself in the South. Grid reinforcements are focused on the security of supply.

1.2.3 Weight of parameters vs. scenarios

So far the simulation will be performed adopting the following weights for each scenario (in scale from 0 to 3).

Scenarios / Parameters	Business as usual & security of supply	Green future on gas & RES integration	High economic growth & high interconnection	Green future & market integration	Green Future & Mutual approach	Low progress & security of supply
Scenario #	1	2	3	4	5+	6+
Economy (GDP growth, population growth, demand forecast, primary resources price);	2	2	3	2,5	2	1
Renewable energy development;	2	2	2	3	2	1
Technology development (storage, load management, smart grid);	2	3	2,5	3	2	1
New load (water desalination, electric cars, public transportation, energy efficiency);	1	3	2	3	2	1
Market integration (internal market, regional market,	1	1	3	3	2	1

or global market);						
Thermal carbon free technologies (i.e. nuclear development in the South of the Mediterranean area).	1	1	3	3	1	1

1.3 Methodology for Technical Analysis in Planning

Among the outcomes of the market studies there are the confirmation of projects or the indications about the opportunity of opening new corridors (new initiatives). The technical analysis follows the adequacy and market analysis. At this stage of the process, the main characteristics of the investments are assumed as defined. On the basis of such definition further steps are needed to :a) define the main physical characteristics of the features of an investment, b) the impact on the existing infrastructure and the steps for its integration; c) the reinforcements of the existing grid . All these evaluations contribute to the feasibility of an investment both from the physical and costs point of view. All these elements are part of the decision making process.

By technical Analysis is meant all the necessary technical evaluations needed before the decision about whether to include a project in the MMP or not can be taken, with which timing and ranking final benefits.

The technical analysis can affect the feasibility of a project or its rank in profitability. Therefore, it has to be run in full transparency of technical rules and figures. In particular, the results can be affected by the operating permissible limits, the contingency lists and the potential remedial actions that could be taken in operation time (in accordance with each TSO operation practices, which are supposed to be in full respect of national laws). Differences in national practices should be gradually harmonized.

1.3.1 Methodology for the Network Analysis

The technical analysis is performed by snapshots, i.e. by a series of Point in Time situations that is, a series of forecasted instantaneous operation situations which are considered representative of critical but credible grid operating conditions. Snapshots are the single cases to be studied where topology and control variables for network studies are defined.

The accurate and transparent selection of the cases to be studied is of highest importance for an adequate analysis of investments effects on the planned network. A selection of credible cases to be studied shall start from realistic network operational snapshots (load/generation balance, presence and production of renewable generation power plants) agreed by TSOs considering among the other factors, like:

- clusters under investigation/assessment,
- TSOs historical knowledge of grid critical conditions,
- amount of renewable generation production (High RES or Low RES cases) and
- Interaction with other projects.
- International power exchanges;
- Seasonal schemes;

The general methodology implies the following common criteria for developing network analysis.

1.3.2 Snapshots and planning scenarios

Snapshots have to be consistent with the more general system conditions transferred in the scenarios in order to make the extrapolation of technical and economic robust conclusions on profitability and security possible.

The following issues are the most important to be taken into account when building detailed case studies for planning exercise/activities in different time horizons:

- Demand and generation fluctuates through a day and through the year (e.g. Peak/Off-Peak and e. g. Winter/Summer);
- Power exchange forecasts (trading energy contracts and/or estimated main power exchanges with external systems);
- Specific sets of network facilities (taking into account the forecasted commissioning and decommissioning dates);
- Weather is a factor that not only influences demand and, increasingly, generation, but also the technical capabilities of the transmission network (e.g. wind, temperature, sun, etc.).

At the end, the snapshots for network studies should be chosen from energy flows, load and generation set provided by market studies. Each selected network case is assessed by analyzing the cases that characterize and represent the points indicated above and considering their representativeness. These cases are defined by the TSOs involved in each study, taking into account regional and national particularities.

Regarding the time horizons for network analysis, will be considered the same time horizons that were applied in the market studies, i.e., long-term horizon (e.g. 2030).

1.3.3 Technical criteria for Network analysis in Med-TSO (Common general criteria for planning)

In order to identify future problems and determine the required development of the transmission network, it was defined some general technical criteria to be used when TSOs assessing the planning scenarios (technical studies).

The general procedure implies the following common technical criteria for planning, like used in ENTSO-E members:

Network analysis

- Investigation of base case topology (all network elements available);
- Different types of events or contingencies (failures of network elements, loss of generation, loss of relevant loads, etc.) are considered depending on their probability of occurrence and/or depending the particular region/system or country.

Evaluation of results

The evaluation of consequences needs to be performed by checking at the whole network the main technical indicators like as:

- Cascade tripping;
- Thermal limits (normal and overload ratings);
- Voltages;
- Loss of demand;
- Loss of generation;
- Short circuit levels;
- Stability conditions
- Angular differences.

As a main general rule and in the context of the main factors mentioned above, it will not be acceptable that the limits set by TSOs or country legislations, can be exceeded. However, the precise definition of acceptable consequences may depend on the probability of occurrence of the specific event.

Permissible grid Limits

Permissible grid limits are the upper and lower limits of the voltages at the nodes of the System, the maximum currents that can flow through the network components in steady state or in temporary conditions and the maximum and minimum system frequencies. Such limits include all quality, safety and security constraints and cannot be violated. Any network analysis can be accepted if the resulting system variables are within such limits.

The permissible grid limits are: a) standard values needed for comparing results and for guaranteeing transparency; b) in planning cannot be higher than the same limits in operation

Permissible Voltage limits. As general voltage limits, it is assumed +5% -10% of rated voltage in N condition and -15% +10% under contingency situations, unless national legislation\regulation prescribes stricter limits. The TSOs will declare these limits.

Permissible Current limits: it is assumed the rated values declared by the TSOs corresponding to the max temperature compatible with the max sagging allowed by law. According to local laws on safety they can be variable according to the season, TSOs have to declare the values that can be sustained continuously for 20 min before reaching the max temperature and the initial values. In case of lack of such values is assumed 120% of rated value starting from an initial value equal to 80% of the rated value. However, the current limits included in the national legislation of each TSO will be considered if they are different. The TSOs will declare these limits.

Permissible Frequency limits: ±0,2% in normal conditions, and ±0,5% in upset conditions

In the next points are presented the most relevant technical criteria for network planning and development in Med-TSO region.

1.3.4 Load flow analysis to be performed

Evaluation of normal contingencies: The N-1 criterion is systematically assessed taking into account each single normal contingency of one of the elements mentioned below (loss of one of the following elements):

- Generation unit;
- Transmission circuit (overhead, underground or mixed);
- A single transmission transformer or two transformers connected to the same bay;
- Shunt device (i.e. capacitor banks, reactors, etc.);
- Single DC circuit;
- Network equipment for load flow control (phase shifter, FACTS, series reactors, etc.);
- A line with two or more circuits on the same towers if a TSO considers that this is adequate in its normal system planning. Some Countries/TSOs consider this situation if the line with two circuits on the same towers has more than a specified number of Km.

N-1 curative approach is applied. The remedial actions used by each country in normal practice shall be declared by the TSOs before simulations start.

Evaluation of rare contingencies: Unusual contingencies are analyzed in order to prevent serious interruption of supply within a large area. This kind of assessment is done only in some specific cases based on the probability of occurrence and/or based on the severity of the consequences. A rare contingency is the loss of one of the following elements:

- A line with two or more circuits on the same towers if a TSO considers this appropriate and does not include this contingency in its normal system planning;
- A single busbar;
- A common mode failure with the loss of more than one generating unit or plant;
- A common mode failure with the loss of more than one DC link;

Evaluation some of out-of-range contingencies: These type of contingencies are very rarely assessed. Their consequences are minimized through Defence Plans. The out-of-range contingency includes the very unusual loss of one of the following elements:

- Two lines independently and simultaneously (N-1-1) which could occur when contingencies occur simultaneously with maintenance;
- A total substation with more than one busbar;
- Loss of more than one generation unit independently;

In the planning network simulation, the N-1 security principle is satisfied if the network is within acceptable limits for expected transmission and supply situations as defined by the planning cases, following a temporary (or in some cases, permanent) outage of one of the elements of the normal contingency.

As mentioned above, different contingency can be simulated. The loss of one or several elements of the power transmission system is possible, considering some specific approach for each country. Therefore, the definitions of normal and rare contingencies can differ among Med-TSO members.

After that, these common criteria should not restrict the application of some alternatives contingencies which weren't described in this document, based on specific knowledge of TSO. Therefore, other contingencies may be considered, taking into account the probability and impact within a specific network.

For sake of transparency the rare and out range contingencies should be discussed when affecting significantly the benefits of an investment.

1.3.4.1 Short circuit analysis

This type of analyses assesses the evolution of the maximum and minimum symmetrical and single-phase short-circuit currents in each bus of the transmission network.

This type of analysis will not be performed at Med-TSO studies at this stage of the Mediterranean project, but can be assessed by each TSO, taking into account some specific new investment cluster considered in their network.

Cooperation among neighboring TSOs is required to arrange the best grid models for simulations.

1.3.4.2 Voltage collapse analysis

In order to evaluate the impact of some new development envisage in the network, a new scenario analysis with a further demand increase by a certain percentage above the peak demand value is carried out. The voltage profile, reactive power reserves, and transformer tap positions are calculated.

This type of analysis will not be performed at Med-TSO studies at this stage of the Mediterranean project. However, each TSO can perform this type of analysis, taking into account a specific new investment cluster considered in its system.

Cooperation among neighboring TSOs is required to arrange the best grid models for simulations.

1.3.4.3 Stability analysis

Based on TSOs knowledge, some transient simulations (and other detailed analysis oriented to identifying possible instability) shall be performed only in cases where stability problems can be expected.

This type of analysis will not be performed at Med-TSO studies at this stage of the Mediterranean project. However, each TSO can perform this type of analysis, taking into account a specific new investment cluster considered in your system.

Cooperation among neighboring TSOs is required to arrange the best grid models for simulations.

1.3.4.4 Criteria for evaluating consequences in the network

As mentioned above, the main criteria for evaluating consequences in the network are:

- Cascade tripping: a single contingency should not result in any cascade tripping);
- Thermal limits (normal and overload ratings): at the base case and all single contingencies must not result in a permanent excess of the permissible rated limits of the network equipment;
- Voltages: base case and all single contingencies must not result in permanent violation of the permissible voltages limits on the busbars of all transmission system substations;
- Loss of demand: should not exceed the power available in primary regulation reserve for each synchronous region;
- Loss of generation: should not exceed the power available in primary regulation reserve for each synchronous region;
- Short circuit levels: the short-circuit current rating of the equipment should not be exceeded;
- Stability conditions: three phase short circuits with subsequent fault clearing (N-1 element) in any of the elements of the transmission system must not result in the loss of synchronization for any generating unit, unless the short circuit is located directly in the power plant;
- Angular difference: the angular difference limits should not be exceeded in order to ensure the ability of circuit breakers for reclosing, without imposing unacceptable step changes on local generation

Different approach is now considered for each MED-TSO member, but a common methodology can be reached in some of these issues in the future stages of the Mediterranean project. In fact, the possible market integration which is analysed in the Med-TSO, requires the development of these common methodologies/criteria.

In the Survey and Tools for Supporting the a harmonized Planning process document the state of the art of technical criteria for network analysis for each Med-TSO country is presented.

1.3.5 Solution proposal for network development

During the network analysis described above, if the security standards are not met, then reinforcement of the grid is planned by TSOs. These measures can include, but are not limited, to the following situations:

- Reinforcement of overhead circuits to increase their capacity (e.g. replacing circuits, increased distance to ground, etc.);
- Duplication of cables to increase rating;
- Replacing of network equipment or reinforcement of substations (e. g. based on short-circuit rating);
- Extension of substations and construction of new ones;
- Installation of reactive-power compensation equipment (e. g. capacitor banks, etc.);
- Addition of network equipment to control the active power flow (e. g. phase shifter, series compensation devices, FACTS, etc.);
- Additional transformer capacities;
- Construction of new circuits (overhead and cable).

The simulations shall be carried out in several conditions of load and generation, adjusting the power injection/consumption in each node of the grid, with regards to the Winter and Summer situations (or other representative scenarios).

Among the more extreme conditions, a couple of cases shall be selected for the high level of exchange within the Med-TSO Area, in order to check the capacity of the interconnections to transmit the power flow without limit violations. For instance, analysis with Low RES scenario and High RES scenario, and others need to be performed.

1.3.6 Some specific criteria for HVDC Interconnection assessment

Some specific criteria are possible to be considered in the assessment of the interconnections between the Mediterranean countries, namely related to the specific characteristics of the HVDC connections.

The studies that will be developed within the Med-TSO umbrella, should propose the adequate HVDC terminal station technology as well as the DC cable types and physical arrangement and lay-out are required. Technical rules should be aligned with the ENTSO-E proposed Network Code on High Voltage Direct Current Connections (HVDC Connection Code) and others proposed within the TC02 -Regulations and Institutions of Med-TSO Association.

In order to complete the assessment of new HVDC links in the Med-TSO region, some specific impacts on reliability should also be taken into account concerning:

- Used technology;
- losses in the HVDC link;
- water depth of the submarine cable;
- Defense Plans or Special protection schemes;

Different approach is now considered for each MED-TSO member (only a few TSOs have experience in this type of technology, and their experience is in many cases too small), but a common methodology can be reached in some of these issues in the future stages of the Mediterranean project.

1.3.7 Grid Model

Med-TSO considers necessary to perform analysis for areas larger than single country. To this purpose it is needed to merge individual grid models into a common grid model. The merger will require a shared methodology and in long run a dedicated tool.
Based on the experiences and practices adopted by ENTSOE these calculations can be limited to steady state simulations, leaving the responsibility for stability and short circuit studies to the Members at smaller area level.
Merged cases for the whole ENTSOE area or for ENTSOE regions will be obtained from ENTSOE. These merged cases will be merged with the Southern Bank area by Med-TSO.

Once the common grid model is available a network analysis tool is necessary. All the mentioned tools are able to accomplish the task and each Member will use its own tool. For the reasons explained later Med-TSO decided to use the SPIRA tool. This tool is not the official tool, but in a pragmatic approaches the one that will be used by Med-TSO for the next 4 – 5 years, in order to comply with the Mediterranean Project schedules.

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