Deliverable 3.2

Schemes for sharing systems services and RES integration

EC DEVCO - GRANT CONTRACT: ENPI/2014/347-006

“Mediterranean Project”

Task 3 “International Electricity Exchanges ”

Med-TSO is supported by the European Union.

This publication was produced with the financial support of the European Union. Its contents are the sole responsibility of Med-TSO and do not necessarily reflect the views of the European Union.

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List of acronyms

AC: Alternating Current
ADEME: Agence de l'Environnement et de la Maitrise de l'Energie
AGC: Automatic Generation Control
BALIT: Balancing Inter TSOs
BRP: Balance Responsible Party
BSP: Balance Services Provider
CAO GmbH: Central Allocation Office GmbH
CASC S.A: Capacity Allocation Service Company
CBA: Cost Benefit Analysis
CSP: Concentrated Solar Power
CESA: Continental Europe Synchronous Area
DC: Direct Current
ENTSO-E: European Network of Transmission System Operators for Electricity
ESS Working Group_MedTSO: Economic and Study Scenarios Working Group of MedTSO
EU: European Union
FCA: Forward Capacity Allocation
FCR: Frequency Containment Reserve
FRR: Frequency Restoration Reserve
HVDC: High Voltage Direct Current
IEM: Internal Electricity Market
IPP: Independent Power Plant
JAO: Joint Allocation Office
LEJS: Libya – Egypt – Jordan – Syria
MedReg: Mediterranean Energy Regulators
Med-TSO: Mediterranean Transmission System Operators
MIBEL: El Mercado Ibérico de la Electricidad
MO: Market Operator
NRA: National Regulatory Authority
NTC: Net Transfer Capacity
OME: Observatoire Méditerranéen de l'Energie
PST: Phase Shifting Transformer
PTR: Physical Transmission Right
RES: Renewable Energy Sources
RR: Replacement Reserve
SEE: South East Europe
SEE CAO: South East Europe Coordinated Auction Office
TC1: Technical Committee 1 of MedTSO
TC2: Technical Committee 2 of MedTSO
TC3: Technical Committee 3 of MedTSO
TSO: Transmission System Operator
TYNDP: Ten Years Network Development Plan
VSC: Voltage Sourced Converter
WG East: Working Group East of MedTSO
WG West: Working Group West of MedTSO

Definitions of technical terms

FCR (Frequency Containment Reserves): the spinning and non-spinning reserves activated to contain system frequency after the occurrence of an imbalance. Times of activation depending on level of frequency deviation (at the limit, to be activated up to 30 seconds for Continental Europe). Primary regulation was the former name of this category of reserve.

FRR (Frequency Restoration Reserve): the active power reserves activated to restore system frequency to the nominal frequency and for synchronous area consisting of more than one Load Frequency Control (LFC) area power balance to the scheduled value. This category is divided in two parts: Automatic Frequency Restoration Reserve (aFRR) and Manual Frequency Restoration Reserve (mFRR).

aFRR (Automatic Frequency Restoration Reserve): FRR with activation delay not greater than 30 seconds. Secondary regulation was the former name of this category.

mFRR (Manual Frequency Restoration Reserve): this resource would correspond to part of the tertiary reserve with activation time of less than 15 minutes.

RR (Replacement Reserve): the reserves used to restore/support the required level of FRR to be prepared for additional system imbalances. This category includes operating reserves with activation time from time to restore frequency (TTRF) up to hours. Activation time of more than 15 minutes. This resource would correspond to the remaining tertiary reserve and other slower reserves.

Imbalance Settlement: settlement of the difference between the contracted quantities and the realized quantities of energy products in a market balance area.

1. Executive summary

The present report provides an outlook on the possibilities of sharing ancillary services between cross border balancing areas in the Mediterranean Region.

The report is based on the data collected and on the results of a questionnaire completed by Med-TSO members. The analysis of the questionnaire shows that the situation of the Mediterranean power systems is not homogeneous.

In the Northern part of the Mediterranean region, the European countries belong to an integrated area that is advancing towards a real internal energy market. For many North shore countries, well under way to a complete market integration, it would be possible to share ancillary services. However, most of these countries elected, for several reasons, to share some selected reserves only.

At present, in the Southern and Eastern shore of the Mediterranean region, interconnections are used mainly for security of supply between the networks and not for market purpose. A large part of transfer capacity is available for further market development and for sharing ancillary services. So given the complementarities of supply and demand (growth and profile), increasing exchanges even without using an integrated market would help to develop more technical coordination in terms of network operations and sharing ancillary services.

In this study, the assessment of present reserves sharing possibilities, jointly with the expected RES development programs, was explored for the Med-TSO countries, keeping in mind that some sensitive data are missing, making it possible to indicate only some quantitative results (actually beyond the scope of the report) mainly in the area of new generation and infrastructures. It should be noted that some of these data need to be updated or, being sensitive in nature, are missing altogether.

Nevertheless, a possible scheme for sharing reserves in presence of strong RES integration is suggested to achieve a better utilization of existing and planned interconnections capacity. Main targets are harmonizing ancillary services, pertinent legislation and regulatory frameworks. Specific recommendations for harmonization are:

- Harmonization of the institutional consensus between interconnected countries
- Harmonization of the regulatory set ups between interconnected countries
- Harmonization of rules and statutory codes (focusing on reserves sharing) between interconnected TSOs
- Harmonization and strict coordination of technical parameters between interconnected TSOs
- Development Plans coordination between the two interconnected systems

The suggested scheme envisages balancing areas coordination to achieve larger areas reserves sharing. Further goals are coordinated scheduling among areas and, eventually, consolidated common operation of a larger geographical area.

This coordination will involve, as an immediate target, reserve sharing through:

- Defining type of services and technical parameters to be shared. This is the scope of this report
- Estimating total reserve requirements across balancing areas
- Allocating reserve requirements to each balancing area
- Estimating actual power flows that can occur at balancing area interface under various reserve sharing events

Longer-term *coordination target*, to be planned through additional accurate studies, will involve coordinated scheduling and facilitating bilateral exchanges. This will entail continuous information exchanges, a monitoring system and some financial compensation mechanisms. Consolidated operation, under a single operating authority, would be the next logical step but difficult to envisage at this stage. Please see the “Conclusions “section.

If coordinated balancing and consolidated operations appear to be achievable for some Northern shore countries, they seem to be only a long-term target for the Southern shore countries.

RES development plans are quite ambitious in a number of countries, mostly on the Southern shore, since Med-TSO European countries are slowing down their RES development plans due to several reasons, among them, the new limitations or the repeal of the RES incentives programs and because a significant amount of RES is already installed in several countries.

Basically, most of the reserves to be applied for accommodating such RES developments should be supplied by conventional generation of appropriate typologies, but reserves sharing between interconnected areas will help in reducing conventional reserves necessary. At all times, power systems hold reserves to maintain reliability in the event of a plant failure or other unpredicted changes in supply and demand. ***Sharing reserves between balancing areas*** means that each balancing area can maintain less reserve capacity. However, sharing services and lowering reserve requirements for neighboring TSOs, therefore mitigating the needs of conventional generation support in each country, is limited by interconnections capacity (NTC).

In spite of the existence of several interconnections, electricity trade among the Southern shore countries has remained modest with the average level of use around one third of the total capacity. However, despite such modest utilization of the interconnectors in the Southern shore countries, a strong program of new interconnectors is envisaged for the 2030 horizon. If this plan is actually implemented, it will pave the way not only to an enhanced international trade of capacity and energy but to a possible stronger flexibility in sharing ancillary services.

2. Recall of the Mediterranean Project

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

Based on a multilateral cooperation as a strategically 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 February 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 to support infrastructural projects and to progressively harmonize and strengthen the electricity markets in the Mediterranean region, following a bottom-up approach and direct involvement of Med-TSO members, through the following activity lines:

- **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.
- **Infrastructure.** Preparing and sharing guidelines for network planning and implementing a Euro-Mediterranean electricity reference grid for studies and coordinated development of interconnections.
- **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 countries complementarities and the optimized use of generation and transmission infrastructures.
- **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.
- **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 this 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 (Planning)
- TC2 (Regulation and Institutions)
- TC3 (International Electricity Exchanges)
- ESS Working Group (Economic Studies and Scenarios)
- WG East (Working Group East)
- WG West (Working Group West)

The objective of the activity of committee TC3 is to promote the development of the electricity exchanges, within a common vision of change in the Mediterranean region. This objective is aimed 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 deviation 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 will focus 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 Auxiliary applications and Services of regulations and RES integration
- Application and analysis of CBA methodology, defined by ad hoc Group, and complete the 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 defined by ESS Working Group

The overall activity (Task 3) is performed by the committee TC3 in coordination with ESS Working Group 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 is being finalized and is the subject of this report while the realisation of the Sub-Task 3.3 will follow.

4. Terms of Reference of the sub task 3.2 of TC03 committee and involvement of an external Expert

The activity 3.2 is the second deliverable to be performed within Task 3 of the Mediterranean Project, with the final objective to identify current situation and develop a proposal of methodologies and procedures for sharing system services and RES integration.

This activity focuses 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. The main focus of the activity is the identification and proposal of schemes of sharing system services, ancillary applications and services of regulation in presence of international exchanges with RES integration.

The analysis aims to provide a proposal of schemes and procedures of sharing system services, information exchanges, but also to identify adequate measures and incentives to cover the risks (risks assessment and allocation) in presence of RES.

The activities related to the deliverable 3.2 are:

- Schemes of sharing system services and RES integration
- Measures and incentives to cover the risks (risks assessment and allocation)
- Schemes of auxiliary applications and services of regulations and RES integration

TC3 has performed a preparatory work necessary for defining the Terms of Reference for subtask 3.2 and other issues to be included in the questionnaires and TC3 members decided to select an External Expert for assistance in performing Sub-Task 3.2 with the support of a Task Force formed by some members of TC3.

The specifications of the profile of the External Expert and the technical part of the call for tender have been prepared by TC3. Moreover, in the frame of the activities of this sub-task, the committee has drafted a preliminary questionnaire on ancillary services and RES integration

The selected Expert was in charge of building and analysing a set of questionnaires about schemes of sharing system services with RES integration. More precisely, the Expert was in charge of preparing a questionnaire and analysing the answers received from Med-TSO members (answers collected by TC3 committee from Med-TSO members). The activities of the Expert also included the preparation of a final report. This report was submitted by the Expert in the middle of March 2017.

5. Methodology and scope of the work

The scope of this document is to present and analyse the methodology adopted, the results obtained, the different analyses carried out and the proposed conclusions of the work performed within the Sub-Task 3.2 which consists in building a set of questions relevant to schemes of sharing system services with RES integration, one of the activities assigned to TC3 committee in the framework of the Mediterranean Project, and analysing the answers of the interested TSOs, considering not only the current situation but also the expected development of the exchanges in the future.

Sub-Task 3.2 started in March 2016 just after submitting the deliverable 3.1 on “Assessment of regional cross border exchanges potential development in Mediterranean region”. The first actions performed in the framework of this activity were to perform a preparatory work necessary for defining the Terms of Reference and other issues to be included in the questionnaires.

The activity has been conducted by a Task Force formed by members of TC3 with the assistance of an External Expert which followed a cooperative approach involving all the members of the committee in answering to the questionnaires and enriching the reports.

Also, TC3 committee organized nine meetings and one teleconference in the framework of this activity, five TC3 meetings, four meetings gathering the Expert and the Task Force of TC3 committee and one teleconference between the External Expert and the Task Force members:

- 5th TC3 meeting in Rome on the October 9, 2016
- 6th TC3 meeting in Casablanca on the July20, 2016
- 1st Expert – Task Force meeting in Rome on October 5, 2016
- 7thTC3 meeting in Algiers on October 11, 2016
- 2nd Expert – Task Force meeting in Rome on November 30, 2016
- 8th TC3 meeting in Rome on February 1, 2017 (with the attendance of the Expert)
- 3rd Expert – Task Force meeting in Rome on February 1, 2017 (following the TC3 meeting)
- 4thExpert – Task Force meeting in Rome on February 28, 2017
- 9thTC3 meeting in Lisbon on March 29, 2017

In defining the methodology of this Sub-Task for formulating the required scheme, The Expert, in coordination with the TC3 Committee of Med-TSO, followed a logical path. The starting point considers a situation of scarcely coordinated neighbouring electrical systems evolving in to higher levels of coordination in sharing reserves and services. Beyond this specific goal, it is possible to reach a longer-term target of coordinated scheduling and, eventually, the maximum achievable goal of consolidated operation between balancing areas.

Concentrating on improving cooperation between balancing areas through sharing services, the first step of this "*GENERAL METHODOLOGY*" is to define the type, including FCR, FRR, RR, imbalance settlements and voltage support, and the technical parameters to be shared, synchronization requirement, time to begin response, time to reach full output, accuracy of response, and maximum duration of response.

This step covered by the report, should be followed by: (i) an estimate of the total reserve requirements, (ii) the allocation of reserve requirements to each balancing area and (iii) the estimate of actual power flows that can occur at balancing area interface under various reserve sharing events.

The "*SPECIFIC METHODOLOGY*" used has been a cooperative approach between all TSOs, the Task Force of TC3 committee and The Expert, with several meetings and a shared questionnaire in order to begin the analysis of the Expert and verify its evolution over time.

Specifically, five meetings and one teleconference were held:

- 1st meeting in Rome on October 5, 2016 (with the Task Force of TC3 committee)
- 2nd meeting in Rome on November 30, 2016 (with the Task Force of TC3 committee)
- 3rd meeting in Rome on February 1, 2017 (with TC3 committee)
- 4th meeting in Rome on February 1, 2017 (with the Task Force of TC3 committee following the meeting with TC3 committee)
- 5th meeting in Rome on February 28, 2017 (with the Task Force of TC3 committee)

The starting point of this study has been the reference documents:

- Activity Task 3.1: International Electricity Exchanges: Deliverable 1: Assessment of Regional Cross border Exchanges and Potential Development in Mediterranean Region (21/02/2016)
- ENTSO-E WGAS: Survey on Ancillary services procurement, Balancing market design 2015 (May 2016)
- Ancillary services, definitions and current situation (drafted by TC3)

On the basis of these documents, the first activity was to collect all the information regarding the exchange of the services around the Mediterranean region. For this purpose, a questionnaire (MS Excel file) was elaborated to collect information about:

A. Regulating Reserves
B. Imbalance Settlement
C. Load Participation
D. Voltage Control
E. Renewable Energy Sources
F. Regulatory Issues

The questionnaire was elaborated in cooperation with the Task Force of TC3 Committee. Such questionnaire was then sent to the TSOs and 14 answers were received. The Expert merged the answers in a Master Excel file (Annex #2) which was later analysed.

As it will be described in chapter 6 (Questionnaire analysis), a reduced version of the full questionnaire covering the most "relevant" questions was created and integrated in a map graphically depicting in different colours the groups of countries with the same answer in order to form an educated opinion on the possibilities of sharing reserves in the presence of RES integration. This Reduced MS Word file is reported in Annex #1.

The aggregation of the answers and a preliminary analysis, focusing on the implications relevant and consistent with the scope of the work, is reported in the MS Word document "Analysis of TSOs' Questionnaire" (Annex #3). This document is a statistical aggregation of the answers received and represents the basis of the analytical review of this work, developed in some degree of detail in the tables reported under Annex #4, "Interconnections Analysis".

In the following paragraphs under chapter 7, an analysis on each interconnection between two Mediterranean Countries (including countries that did not participate in this study), was carried out. In the tables of Annex #4, the main aspects of the interconnections are examined following in part the classification utilized for the Questionnaire. Load participation and Regulatory issues are not addressed in the tables but only later in this text.

A. Interconnections (General) between each country
B. Regulating Reserves (for each interconnection)
C. Imbalance Settlement (for each interconnection)
D. Voltage Control (for each interconnection)
E. Renewable Energy Sources (for each country)

These tables and, most relevant, the related considerations constitute the significant part of this study and could be the basis of possible future developments.

6. Questionnaire analysis

Table 1 shows the presence of an electricity market operator in all Med-TSO countries.

Country	Market Operator Presence	Notes
Libya	NO	TSO is the only player
Tunisia	NO	TSO is the only player
Algeria		M O set but not operating yet
Morocco		No answer or similar
Portugal	YES	
Spain	YES	
France	YES	
Italy	YES	
Slovenia	YES	
Albania		No answer or similar
Montenegro		No answer or similar
Greece	YES	
Turkey	YES	
Cyprus	YES	TSO Cyprus acts as a Market Operator
Jordan		TSO is the only player
Israel		No answer or similar
Egypt		No answer or similar

7. Table 1-Presence of an electricity market operator in Med-TSO countries

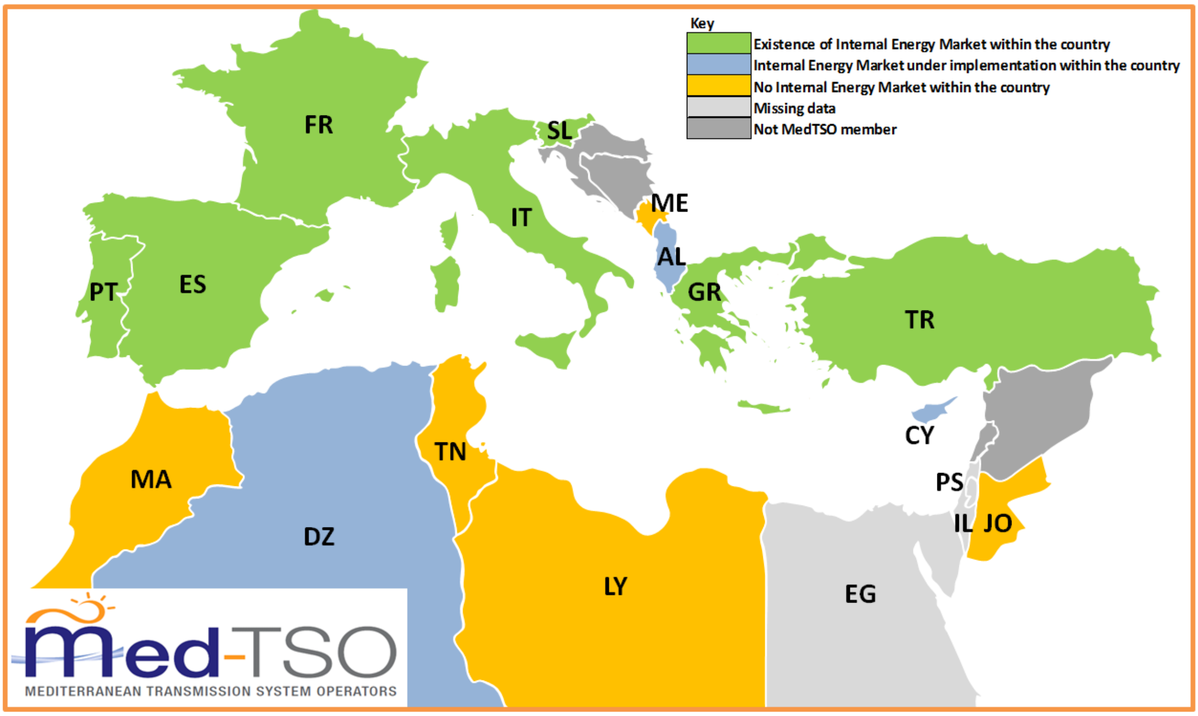


Fig. 3–Presence of an electricity market in Med-TSO countries

In the above Figure 3, distinction is highlighted between countries with an internal energy market is highlighted in green color, for those under implementation in blue and those with no internal energy market in orange. The dark gray shade indicates Mediterranean countries that are not Med-TSO members.

Annex #2 shows all consolidated answers to the Questionnaires (MS Excel file) filled in by the participant TSOs.

The initial composition of the questionnaire was assessed by TC3 Task Force, which suggested a reduction of the number of questions to a selection of the most relevant ones, by cutting out a significant part of the questions.

Southern countries appear to have the better potential for integrating into their systems a sizeable RES contribution at a relatively substantial pace. Therefore, it was deemed necessary to classify the questions as “relevant” (highlighted in red on the questionnaire MS Excel tabs) or “less relevant” for sharing ancillary services in view of RES integration.

For each question, the different answers were analysed and aggregated, considering all countries interested (annex #3, *“Analysis of TSOs Questionnaire”*: Word statistical analysis).

Each table refers to a block of questions in which the study was structured.

Furthermore, the TC3 Task Force and the Expert, after a joint examination of the questionnaire, decided to add a few questions that are highlighted in yellow on the questionnaire MS Excel tabs. These additional questions have been included among the “relevant” questions.

A review of the questionnaire results is reported in the following paragraphs.

6.1. Regulating reserves

All types of reserves are used internally in each Country.

For many **North Shore Countries**, well under way to a complete market integration, it would be possible to share ancillary services. However, most of these countries, for several reasons, opted to share some selected reserves only.

Among **Southern Shore Countries**, only FRR is presently shared, in theory, among Tunisia, Algeria and Morocco. For the significant RES developments expected in the future and for the eventual creation of common balancing areas capable of sharing services, there are several actions that can be envisaged starting from the harmonization of the regulatory frameworks and from the creation of common rules to be applied by facing TSOs. Please refer to the Chapter 7and Annex #4 for more details.

Basically, most of the reserves to be applied for accommodating the envisaged RES developments should be supplied by conventional generation of appropriate typologies, but it should be noted that a small contribution to reserves sharing can be obtained by wind turbines and PV plants of modern design. This contribution and sharing reserves by the TSOs will reduce the total amount of conventional generation reserves and it will be strongly recommended by ENTSO-E for the European countries.

6.2. Imbalance settlement

Balancing services, mainly provided by Balance Services Providers (BSPs), are necessary to compensate imbalances and to solve congestions problems that normally occur in the grids. Imbalances settlement is a typical market instrument mostly used for internal balancing adjustments by the **Northern Shore countries**. Settlement is used by Balancing Responsible Parties (BRPs) when the need arises. Settlement normally requires provisions for financial compensations or imposition of penalties and, in some cases, produces legal obligations. Most qualified generating units and some prequalified and selected loads participate in the imbalance settlements but RES and "must run" plants are normally exempted.

For the **Southern Shore countries**, with no market mechanism available, balancing is still needed and settlement is handled by the TSOs acting as BRPs for their systems. This is particularly true for Jordan that depends entirely on interconnections for balancing its system. Balancing the systems and sharing reserves between interconnected countries will probably eventually require appropriate management and allocation of responsibilities for the balancing interconnected areas.

6.3. Load participation

Load participation can be useful and in certain cases mandatory for reserve support. Balance Service Providers (BSPs) can use loads as well as generation to address unbalances. Therefore, in balancing, the results of load participation are very similar to the deployments of generators.

Northern Shore countries provided diversified answers. Load participation applied to facing TSOs is normally possible but not always applied. Its development should be verified in view of TSOs convenience and will to apply it.

Southern Shore countries do not use load participation as reported in their answers. Not considering possible long term contracts between TSOs and BSPs, most of the other mechanisms applied, such as auctions and pricing, are typical market instruments. To develop and apply load participation, facing TSOs should assess its applicability on their systems eventually verifying their convenience and will towards projected costs and procedures to be applied.

6.4. Voltage control

Voltage control does not appear to be a problem for all the TSOs. Voltage is regulated by using internal capacities in order to avoid or reduce as much as possible reactive power flow through interconnections. Voltage ranges are basically complying with prescribed limits that are set by each TSO for normal situations, in case of emergency or in case of potential problems, always respecting the N-1 conditions. These limits are generally applied both for internal networks and interconnections but there may be minor differences for some TSOs.

The measures applied for reactive management are mainly common for all TSOs. These measures include the use of reactive resources such as reactors, capacitors and generation units, the opening of some selected lines and the change of the topology, acting on the excitation systems of the generation units and acting on the tap changer transformers.

6.5. Renewable Energy Sources

The RES table in Annex #4, organized by Country, covers their present situation and expected growth, strong in the Southern shore, less strong but still significant on the Northern shore. In each country RES issues were listed, on the basis of the answers received by the TSOs, according to the following aspects:

- Current and future assessment of RES situation
- Deployment of forecasting programs assessing RES variability
- RES Real Time monitoring
- Regulating reserves sharing in presence of RES
- Publication of information on RES

In the ENTSO-E countries RES integration does not appear to be a significant problem for both the European Mediterranean countries (following the termination of national incentives) and for the European Continental countries that can count on large amounts of conventional generation and very strong meshed grids.

It should be noted that the most responding TSOs were unable to provide details on the RES related questions included in the questionnaire, specifically on RES and reserves percentages compared with conventional generation. Therefore, only some quantitative considerations were provided in this study.

Concentrating on the four countries on the Western area of the Southern shore, present RES capacity:

- Is not available for Libya
- Is about 0.3 GW in Tunisia(245 MW Wind,25 MW PV and 62 MW Hydro)
- Is about 353MW in Algeria
- Is about 2.3 GW in Morocco, including hydro

Outlook of RES capacity indicates a strong drive by the four countries to deploy a significant amount of PV and wind[1]:

- Libya indicates its targets in 1.1 GW for 2020 and 3.3 GW for 2030
- Tunisia indicates its targets at 1 GW by 2020 (350 MW Wind and 650 MW PV),an addition of 1.25 GW by 2025 and a total of 3 GW of installed capacity by 2030 (30% of installed capacity)
- Algeria indicates its targets in 0.5 GW for 2020 and a grand total, in the internal interconnected system, of 16 GW by 2030
- Morocco indicates its targets in 42% of installed capacity by 2020 and in 52% of installed capacity by 2030. These percentages could mean additional RES capacity estimated between 3.5 and 4 GW

It should be noted that some countries indicated that the additional RES deployment include hydro, biomass and CSP. These RES are not necessarily intermittent[2].Addressing present conventional generation, the following data are useful for orientation purposes only. There is no indication on the typology of power plants and, in the following figures, RES capacities are included. However, the usefulness of present data lays on the comparison with interconnection capacities as well as on the gross proportion of intermittent RES to total generation. Total generation available data are:

- Libya 10 GW (2016)
- Tunisia, 5.5 GW (2016)
- Algeria, 13.3 GW (2016)
- Morocco, 8.8 GW (2016)

[1] Future RES capacity values for Tunisia and Morocco are based on literature evaluations (OME and others) and on averages extrapolations that could be only useful for a first gross preliminary assessment. Future estimations need to be updated based on appropriate real values.

[2]Hydro “run of the river” is a “must run” case, an intermediate situation where there is dispatching priority and variability but not really intermittency. CSP is normally associated with some kind of storage, therefore dispatchable. Biomass can be considered dispatchable too.

Similarly, there are only some scant indications on the new capacity planned in these countries for the 2025-2030 horizon. More accurate estimations as well as typology will be required for a useful comparison to the projected RES growth in the same timeframe and to the projected interconnection capacities.

6.6. Regulatory issues

Based on the answers received by the responding TSOs, electric systems are generally regulated by the National Regulatory Authorities (NRAs).

Theses NRAs issue licenses for services exchanges in almost all countries except for Algeria, Jordan and Turkey (please see details at the end of this paragraph). Licenses for other activities like generation, transmission, distribution and retail, are normally handled by the NRAs. The NRAs also monitor compliance with licenses. A single document (often the Grid Code) reporting the references of the legislation and the complete regulatory guidance on electric system issues exists in a few countries.

NRAs have a role regarding:

- Issuance of rules on interconnection management and allocations in all countries
- Issuance of rules on system services management and allocations in all countries except on AGC (Automatic Generation Control) for France
- Market rules, grid codes, technical rules and metering rules in all countries
- Congestions management in all countries except Libya and Algeria
- Quality of service in all countries except France, Tunisia and Turkey
- Monitoring the duration of procedures for connection of new operators and for lines maintenance in all countries except Algeria, Turkey and Libya

All sorts of disputes are generally handled by the NRA. Decisions may be overruled by the courts arbitration or by the regulators themselves. Finally, in the Northern shore countries and in Algeria and Jordan, Authorities participate in the long-term supply demand balance assessments and in the guaranty of system service. In most countries (except Turkey and Libya) Authorities participate in the implementation of demand side management incentives and other measures for covering peak demand.

Among the four South West countries mentioned, NRA operates in Algeria, while the Ministry is responsible for regulations in Tunisia, Morocco and Libya. With the exceptions noted above, all regulators cover the extensive roles listed and are an active part not only in controlling and monitoring systems set ups and operations but also, through the licensing process, the planning and implementation of future developments including RES integration and services exchanges.

7. Interconnections analysis

7.1. General considerations

After the above considerations based on the statistical analysis, in this paragraph each interconnection is analysed since it was deemed more useful in order to assess the reserves sharing possibilities of facing TSOs.

As anticipated earlier, the suggested scheme for facilitating RES integration consists, at the first approach, in harmonizing ancillary services, pertinent legislation and regulatory frameworks across two interconnected areas in order to share balancing services.

At all times, power systems hold reserves to maintain reliability in the event of a plant failure or other unpredicted changes in supply and demand. ***Sharing reserves between balancing areas*** means that each balancing area can maintain less reserve capacity. Reserve sharing is one of the simplest methods to decrease total reserve requirement and minimize the economic impact of power system uncertainty, which increases with increasing variable RES generation. Therefore, sharing services is desirable since it will result in lowering the reserves requirements of each neighbouring country.

However, sharing services and lowering reserve requirements for neighbouring TSOs and therefore mitigating the needs of conventional generation support in each country, is limited by interconnections NTC.

As mentioned earlier, most ***ENTSO-E countries*** are under way to a fully integrated market. Market mechanisms are normally available and used for international exchanges (capacity and energy), balancing and other services. It should be noted that ENTSO-E countries can provide, on the whole (including non-Med-TSO countries) at present, up to 3.8 GW of RR in emergencies or black start up conditions.

In addition:

- Interconnections are sizeable and utilized, with significant expansion plans under way but often limited and delayed by authorization procedures
- Strong meshed grids are available in many countries
- Significant conventional generation is available providing good margin of reserves to accommodate contingencies and compensation for variable RES integration
- The recent ENTSO-E 2016 *"Ten Years Development Plan"* is in place providing an important guidance for participating European countries for increased interconnection capacity and even better market integration
- In these countries RES development seems to grow at different speeds.

In all cases:

- ✓ Sharing of ancillary services is already possible
- ✓ RES integration does not appear to be of any immediate concern
- ✓ There is no pressing need on the issue of sharing services

In spite of the existence of several interconnections, electricity trade among the ***Southern shore countries*** has remained modest as reported in the deliverable 3.1 of TC3. The average level of use is not more than one third of the total capacity. This can be mainly attributed to the institutional and economic barriers at national and regional levels. In several cases, technical issues also add to the problem. Integrated resource planning is therefore essential at the national as well as at the regional level to review, understand, and provide input to the planning decisions of the interconnection projects.

Despite the present modest utilization of the interconnectors in the ***Southern shore countries***, a strong program of new interconnectors is envisaged for the 2030 horizon. If this program is actually implemented, it will pave the way not only to an enhanced international trade of capacity and energy but to a stronger flexibility in sharing ancillary services.

The majority of the new interconnections planned in the Mediterranean region are HVDC links. Depending on the technology to be used for the HVDC links, these interconnections may have some limitations for reserve sharing.

Summing this up, in the medium to longer-term horizon, there are four "technical components" to consider for sharing reserves between balancing areas:

- *RES present situation and projected growth in terms of capacity and energy in the next 15 to 25 years*
- *Conventional generation present situation and expected capacity additions in the next 5 to 25 years considering their typology (hydro, coal, gas, etc.), their location on the grid, their flexibility and their projected ability to provide ancillary services*
- *The present availability of ancillary services in each TSO balancing area and their projected growth*
- *The present and future available NTCs at each interconnection between facing TSOs*

These "technical components" need to be considered jointly, but the first step is to assess the adequacy of the interconnectors.

Therefore, based on the preceding paragraph and on the Table in Annex #4, present Southern interconnectors are scarcely utilized; thus, in general, the existing infrastructure will presently grant ample access to concurrent additional power flows and reserves exchanges.

In the following paragraphs the results for each interconnection are briefly examined.

7.2. Current situation on the Mediterranean electricity systems and NTC expected in 2030

The Mediterranean power systems examined are composed by the networks of all Med-TSO countries: from Portugal to Turkey in the north, including Cyprus, and from Morocco to Jordan and Israel in the South and East.

In figure 1, the current situation regarding the Net Transfer Capacity (NTC) of interconnections within the Mediterranean Basin and with the neighbouring countries is shown.

The situation of the Mediterranean power systems is not homogeneous with a wide variety of advances regarding the integration of electric systems and electricity markets. In the Northern shore, the European countries belong to an integrated area that is currently advancing towards the actual implementation of an internal energy market.

The interconnection between Spain to Morocco is currently the only transmission corridor between Europe and Maghreb. The interconnection through Turkey to Bulgaria and Greece is currently the only transmission corridor in service in the South-eastern part of the Mediterranean. The asynchronous interconnection between Libya and Tunisia is currently not in operation due to stability constraints when Libya is synchronously connected to Egypt. The interconnection between Egypt and Libya is used sometimes to supply a portion of the Libyan network through a bilateral agreement. Turkey to Syria interconnection is out of service due to the current conflict in the region.

Mediterranean countries have defined plans for a series of reinforcements of their internal transmission networks, in coherence with the growth of the electricity energy demand in the south part and of the consequent planned new generation facilities. An update of the previous figure is reported in the figure 2, portraying the NTC additions due to the planned interconnection capacity increments larger than 500 MW.

Although several projects are actively investigated, the realization of new interconnection links in the southern region is still uncertain, probably due to the low amount of the present electricity exchanges, motivated more by the need to increase security of supply through interconnections rather than by economic advantages in the absence of a real functioning electricity market.

In terms of electricity energy demand in 2015, in the "*Mediterranean Energy Perspectives*" from OME (Observatoire Méditerranéen de l'Energie), it is mentioned that the *"Economic growth in the Mediterranean region"* is expected to sustain an average annual growth from 1990 to 2040 of 2.3%:

- 3.7% for the South East
- 3.4% for the South West
- 1.5% for the North

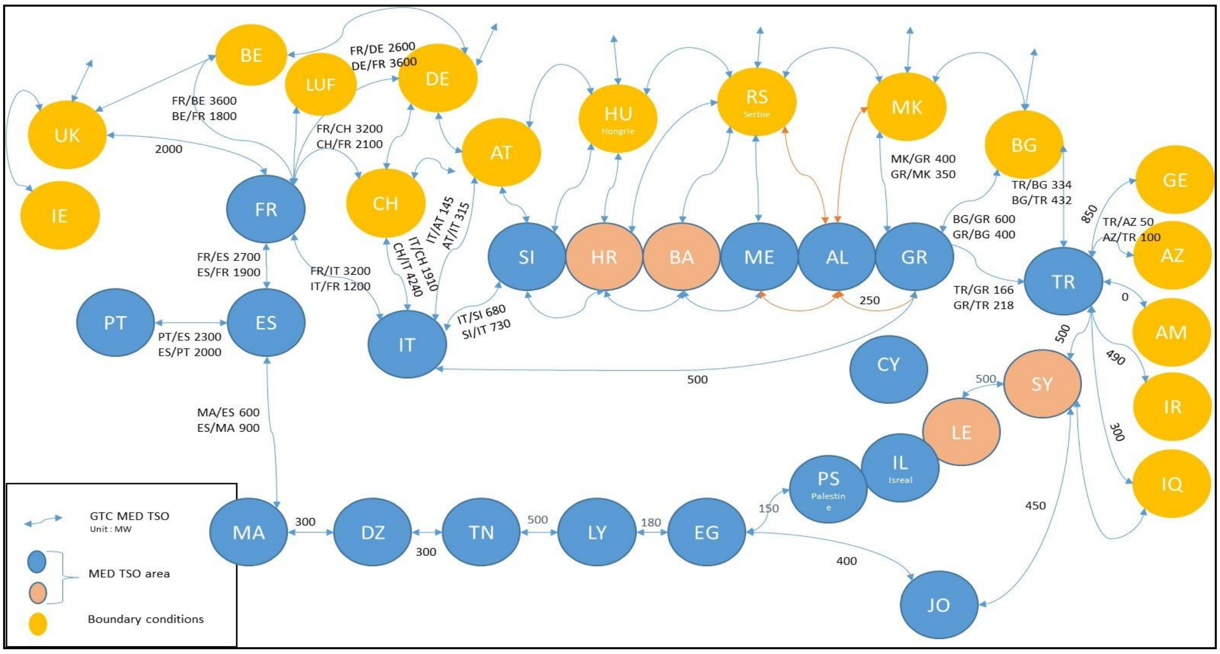


Fig. 1:NTC (MW) in terms of maximum capacity of existing interconnections in Mediterranean Basin (current situation in 2016)

Please note that the NTC of the Algeria – Morocco interconnection is 1000 MW. However, because of internal grid constraints, the NTC is limited to 400 MW from Algeria to Morocco and 300 MW from Morocco to Algeria. This situation will be improved within the short term.

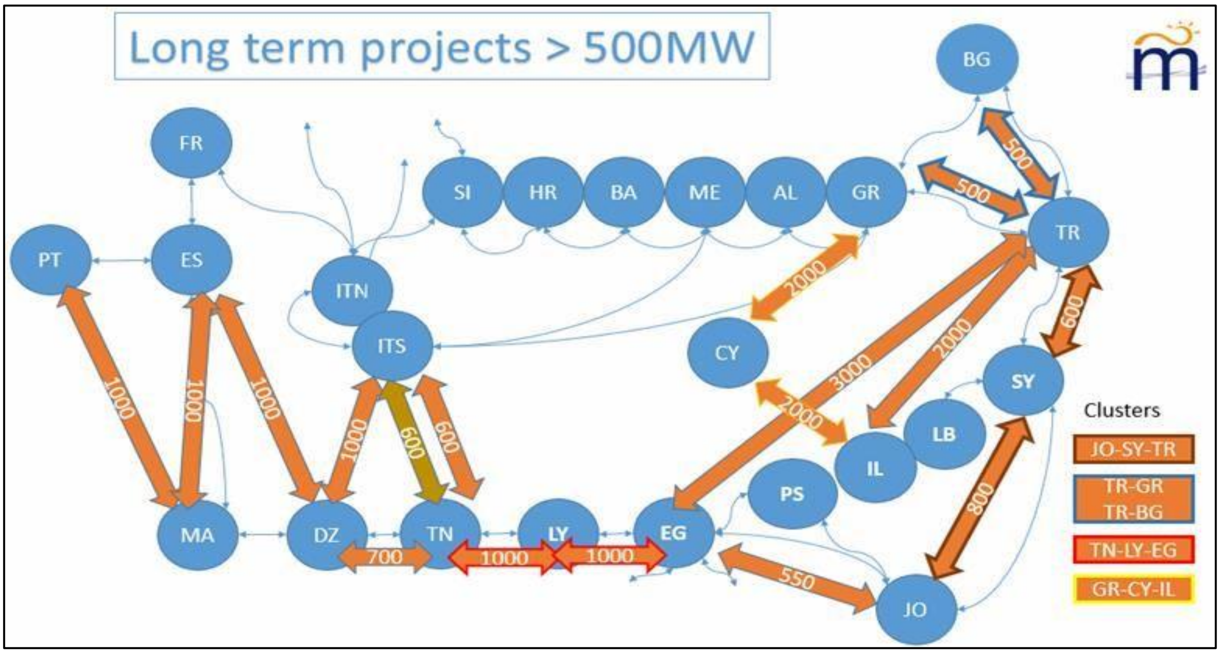


Fig. 2: Long term projects with NTC> 500 MW

More recently (July 2016) OME, ADEME and MedReg examined "the Mediterranean Energy Transition 2040 Scenario". It is based on a "Conservative (Business-As-Usual) scenario" and on an "Energy transition scenario" with the implementation of those measures that are currently the most technically, economically, and institutionally mature for large-scale rollout of ***energy efficiency and renewable energies***. This Scenario assumes no major technology breakthrough, but the deployment of existing technologies and sound energy efficiency policies and measures across all Mediterranean countries.

Compared to the OME Conservative Scenario (Business-As-Usual), by 2040, the Mediterranean Energy Transition Scenario would lead to significant beneficial changes in both energy demand and power generation.

Limiting our attention to power generation and RES contribution, the OME report states that:

- Mediterranean countries' power generation would increase in 2040 by 77% in the conservative context but only by 22% (or 240 GW) in the Transition Scenario thus avoiding an additional 200 GW of fossil-fuel based production infrastructure
- The share of renewable energy will increase from the present 11% to 27% of the energy mix in the region
- In the Transition Scenario, the 2040 increase in the share of renewables capacity in the Northern shore will reach about 125 GW of solar PV and 113 GW of wind
- In the Transition Scenario, non-hydro renewable energy sources would expand to provide 66% of total installed capacity in the South by 2040, reaching 179 GW (59% from solar PV)
- These considerations, addressing a very beneficial transition scenario based on efficiencies and renewables, support the usefulness of the present study.

7.3. Description of Med-TSO interconnections

7.3.1. Interconnection Libya – Tunisia

NTC is presently 500 MW with planned long term additions of about 1000 MW. However, because of internal grid constraints, the NTC is now limited to 140 MW.

In the previous paragraphs, it is reported that RES planned development is estimated at around 3.3 GW of PV and wind in Libya and at about 3 GW equivalent to 30% of total 2030 capacity in Tunisia. The total capacity in Tunisia of about 5.5 GW in 2016 should grow to about 9.2 GW in 2030. This translates in to about 2.3 GW of additional

RES capacity. Not all of the additional capacity will be intermittent since some hydro, CSP, and biomass are included in the development program. This will lead to an intermittent RES capacity in Tunisia higher than that of Libya.

Even if a quantitative analysis is beyond the scope of this report, not enough data were provided by Libya on the estimation neither of reserve requirements needed by the system in the presence of RES nor of the reserves needed to be shared with the neighbouring country. Tunisia is using real time monitoring and forecasting programs. In addition, it gave an indication on the additional reserve capacity (6.5%) needed by the system if the RES capacity reaches 5% of the generation. But no other data were provided on the various estimations. A protocol is in place governing the exchange of power between the two countries. It enables TSOs joint operational practices.

While the present 500 MW interconnection appears to be adequate for next few years, the additional planned 1.000 MW may be necessary for a meaningful trading and for sharing reserves between the two countries. Financing the development programs, including the interconnectors, must be examined in the different institutional and socio-economic scenarios of the two countries.

However, it appears to be a stability problem in case of synchronizing the entire Mediterranean ring by synchronously connecting the LEJS (Libya – Egypt – Jordan – Syria), Tunisia – Algeria – Morocco and ENTSO-E systems, as reported by Sub task 3.1. The last experiment to connect the Libyan power system (without interconnection Libya – Egypt) to Tunisia – Algeria – Morocco – ENTSO-E interconnected power system was carried out successfully in 2010. However, instability was observed when synchronously connecting the LEJS with the interconnected Tunisia– Algeria – Morocco – ENTSO-E– power system. This instability will require appropriate measures and time to be solved which will enable a complete system interconnection between the Med-TSO countries.

Assuming that the stability problem is solved by grid reinforcements, the above issues depend mostly on the type of trade and cooperation between the TSOs of Libya and Tunisia. There are technical, commercial and practical issues to be addressed by the two TSOs that must be willing, in the long term, to accept a joint responsibility for running together the ancillary services sharing program. Appropriate protocols should lead to the total harmonization of the technical procedures and rules necessary for sharing reserves. Agreeing on protocols and to their implementation will take some time but must be concurrent with both the RES and the interconnectors development programs.

In Annex #4 this interconnection is analysed in some details for the present situation and future developments outlook.

It should be considered that, in addition with its interconnections “on shore”, Tunisia is planning a new submarine cable (600 MW which can be extended to 1200 MW) for future interconnection with Italy.

7.3.2. Interconnection Tunisia – Algeria

NTC is presently 300 MW in ‘N-1’ conditions, despite the existence of a 220 kV line and a 400 kV line. The doubling of the 400 kV line will increase the NTC to 1000 MW.

Tunisia, with the above reported assumptions, should achieve RES 2030 capacity additions of about 3 GW while Algeria planning indicates RES additions of about 0.5 GW (400 MW of PV and 100 MW of wind) by 2020. By 2030 Algeria plans a total of 16 GW (9 GW on PV, 5 GW on wind and 2 GW on CSP).

Algeria does not use real time monitoring but gave answers to some of the other questions related to the estimation of reserve requirements with RES. However, no specific data were provided. As mentioned earlier, Tunisia is using real time monitoring and forecasting programs. In addition, it gave an indication on the additional reserve capacity (6.5%) needed by the system if the RES capacity reaches 5% of the generation. But no other data were provided on the various estimations.

While the present 300 MW interconnection appears to be adequate for the immediate future (with only 0.5 TWh exchanged each way in 2014) the existing and the planned 400 kV line (1.000 MW) may be necessary to increase exchanges and a meaningful trading and for sharing reserves between the two countries. It should be noted that the difference between conventional generation in the two countries (Algeria capacity is about 3 times larger than

Tunisia) and the much larger difference in projected RES capacities (about 6 to 7 times) could limit the amount of shared reserves.

In addition to mutual voltage support through the interconnectors, there is presently a protocol between the two countries for exchanging FRR reserves including AGC. The protocol is designed to compensate, through FRR sharing, the failure and sudden loss of the largest generation unit in the systems of Tunisia, Algeria and Morocco. Reserves should be provided by Algeria (50%), Tunisia (20%) and Morocco (30%) with a delay of 15 minutes. On this basis, similar protocols could be entered for sharing RR and FCR if there is need, convenience and will for both Countries to do so. Harmonization will be essential for FCR and RR technical parameters. Joint planning will be needed for important additions of interconnections capacity where NTCs should be carefully evaluated in view of possible future contracted capacity and energy exchanges and possible reserves sharing at the same time.

It should be considered that Algeria is considering two additional “offshore” interconnections with the Northern shore, one with Italy (1000 MW) and one with Spain (1000 MW).

7.3.3. Interconnection Algeria – Morocco

NTC between the two countries is 1.000 MW. Because of internal grid constraints, in both countries, the NTC is presently limited to 400 MW from Algeria to Morocco and 300 MW from Morocco to Algeria, but these values are likely to evolve as the grid constraints will be eliminated in a short time.

As for Tunisia, in the assumption that Morocco’s demand will grow at the estimated average pace of 3.7% per year, its total capacity of about 8.8 GW in 2016 should grow to about 14 GW. Morocco is already operating with over 2.85 GW (1.77 GW of hydro) of RES with ongoing projects under construction that will raise this share to 47% in 2020. Morocco plans to reach a share of 52% RES capacity by 2030. This corresponds to about 3.7 to 4 GW of additional RES capacity. Not all of the additional RES capacity will be intermittent since some hydro and CSP are included in the development program.

The Moroccan 2020 RES target of 42% will be exceeded and the 2030 target of 52% is very realistic. Morocco already identified resources sites and RES generation has been opened to private companies.

The present interconnections (with 0.13 TWh imported by Algeria and 0.37 TWh exported to Morocco in 2016) may be adequate for the immediate future but, without additional interconnectors capacity, it will not allow future meaningful trading and sharing reserves between the two countries.

As noted above for the Tunisia – Algeria interconnections, in addition to mutual voltage support through the interconnectors, there is presently a protocol between the two countries for exchanging FRR reserves including AGC. The protocol is designed to compensate, through FRR sharing, the failure and sudden loss of the largest generation unit in the Tunisia, Algeria and Morocco systems. Reserve participation is 50% for Algeria, 20% for Tunisia and 30% for Morocco. On this basis, similar protocols could be entered for sharing RR and FCR if there is need, convenience and will for both countries to do so. Harmonization will be essential for FCR and RR technical procedures and rules.

7.3.4. Interconnection Morocco – Spain

The interconnection between Spain and Morocco constitutes one of the most important policy of cooperation between Europe and the Maghrebian countries. This interconnection represents an effective step forward for the development of Morocco's electricity infrastructure and contributes significantly to the frequency and voltage stability of the Maghreb interconnected power system. It also makes it possible to improve the technical and economical operation of energy production and transmission systems in the two countries.

Morocco and Spain built in 1997 a submarine cable, the first Europe to Maghreb interconnection and, about ten years later, a second cable was added on the same route. This 400 kV AC cable allows 900 MW capacity transfer from Spain to Morocco and 600 MW in the opposite direction. Presently this interconnection is used for energy and capacity trading on a contracted basis. Imports from Spain ranged from about 4 TWh in 2010 to about 5.9 TWh in 2014 (a less level of exchange of about 5 TWh in 2016 is due to an incident on the interconnection).

ONEE participated in the Iberian Electricity market since 1998. This gives it the possibility to carry out economic exchanges of energy (import or export) directly addressing the Spanish market and take advantage of weekly opportunities to purchase or sell electricity.

In addition to the possibility of taking advantage of opportunities to exchange energy at competitive prices in relation to Moroccan generation cost, the participation of ONEE in the Iberian electricity market also allows:

- Making electricity generation infrastructure more profitable and saving fuel
- Improving security and continuity of electric power supply
- Enabling other Maghreb countries to access Maghreb markets via the Moroccan network
- Paving the way for South-North cooperation in energy trade
- Importing electric power at competitive prices in either normal or emergency conditions

It should be noted that the interconnection between Morocco and Spain allowed Algeria too to participate in the Iberian Electricity Market.

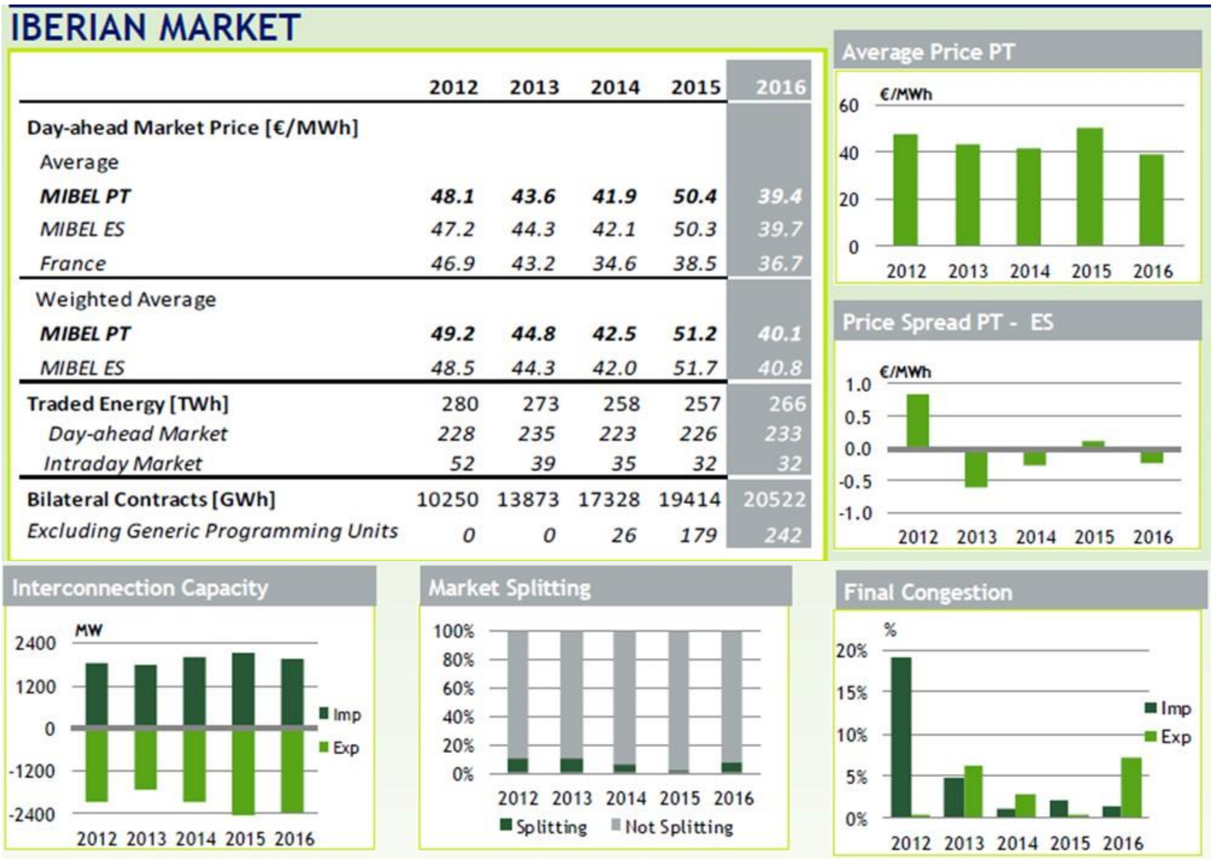
Planned interconnection developments

It should be noted that Med-TSO is considering a new link to Spain of about 1000 MW and another one with Portugal of about 1000 MW into the corridors to be analysed and studied.

7.3.5. Interconnection Spain – Portugal

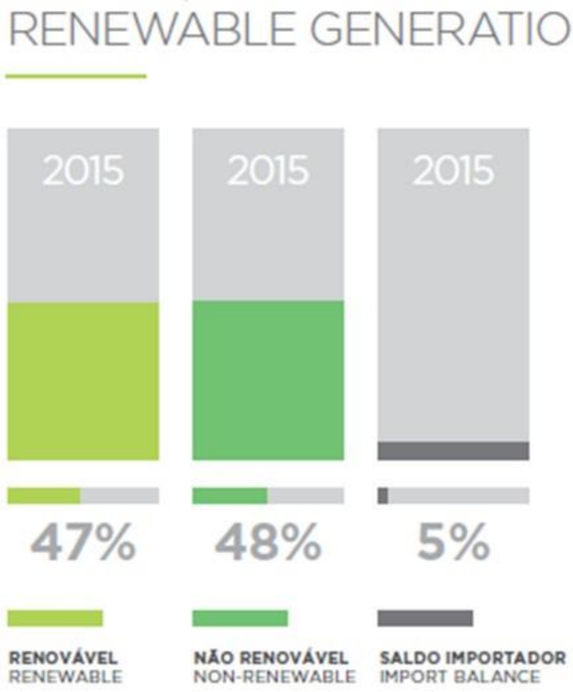
NTC is about 2000 MW in the direction from Spain to Portugal and 2500 MW in the opposite direction. Trade in 2016 was assessed at around 2 TWh in the direction from Spain to Portugal and around 7.1 TWh in the direction from Portugal to Spain.

Both Countries are proceeding according to the developments included in the ENTSO-E ten years development plan as shown in the following figures.



	2012	2013	2014	2015	2016
Day-ahead Market Price [€/MWh]					
Average					
MIBEL PT	48.1	43.6	41.9	50.4	39.4
MIBEL ES	47.2	44.3	42.1	50.3	39.7
France	46.9	43.2	34.6	38.5	36.7
Weighted Average					
MIBEL PT	49.2	44.8	42.5	51.2	40.1
MIBEL ES	48.5	44.3	42.0	51.7	40.8
Traded Energy [TWh]	280	273	258	257	266
Day-ahead Market	228	235	223	226	233
Intraday Market	52	39	35	32	32
Bilateral Contracts [GWh]	10250	13873	17328	19414	20522
Excluding Generic Programming Units	0	0	26	179	242

Both countries indicated in the questionnaire that their RES capacity and generation are presently over 30% of the total generation capacity. For Spain, the 2020 target on RES is 6 GW of solar PV, 2.3 GW of solar thermoelectric, 17.5 GW of hydro, 29.5 GW of wind and 1.3 GW of other renewable energy sources. All this will total about 56.6 GW for Spain. Portugal has in 2014 – 2015 the following RES generation figures.



Portugal plans for 2020 will be in compliance to the EU 20-20-20 targets. Therefore, Portuguese 2020 RES targets are 1.8 GW of PV, 5.5 GW of wind, 8 GW of hydro and 0.9 GW of other renewables. All of this will total about 16.2 GW of RES.

Sharing services is possible in both countries but it does not appear to be extensively applied. In the presence of RES, Portugal indicated that RR is important to share with neighbours and that it is able to estimate RR requirements across balancing areas while Spain indicated that FCR is important to share with neighbours. Both countries are able to estimate each other present reserve capacities in the presence of RES. There are agreements in place in both countries to share RR only while Spain indicated that sharing FCR, FRR and RR with neighbours is already possible at present.

Both countries participate in BALIT (Balancing Inter TSOs) platform which allows cross-border exchanges of balancing services among countries. Such platform entails the trading of unused balancing services in a control area. Services can be bid into neighbouring control areas. This will result in more reliability and efficiency **fostering competition** and mitigating balancing costs. In this platform, each TSO keeps its own reserves (MW) and its own procurement mechanism and may elect to bid its surplus of balancing energy into the other TSO's mechanism next to real time using the remaining interconnection capacity available at that moment.

Planned interconnection developments

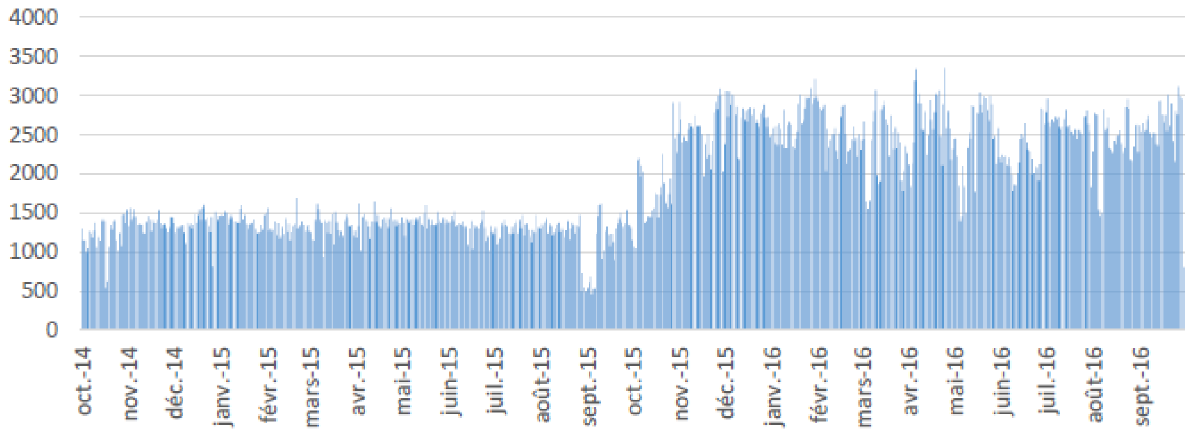
In order to strengthen the Internal Energy Market (IEM), the increase of the interconnection between Spain and Portugal is needed. A new 400kV overhead link between Fontefría (Spain) and Ponte de Lima (Portugal) is envisaged for 2018. Internal reinforcements complement this cross-border section both in Spain and Portugal. This will achieve the main objectives of the project: reinforcement of the interconnection maximum NTC between Portugal and Spain having in mind the MIBEL targets agreed by the Portuguese and Spanish governments (around 3 GW of NTC).

7.3.6. Interconnection Spain – France

Since October 5th 2015, RTE and REE carried out a double DC link 2x1000 MW interconnection between Baixas and Santa Llogaïa. With this new interconnection, NTC is about 2500 MW in the direction from Spain to France and 2700 MW in the opposite direction. Trade in 2016 was at around 5.5 TWh from Spain to France, and around 13.42 TWh from France to Spain.

Both countries are proceeding according to the developments included in the ENTSO-E Ten Years Network Development Plan (TYNDP); therefore, market mechanisms are available in both countries. All ancillary services are available and can be shared within each country.

Following figures show France – Spain cross border exchanges before and after the new Baixas – Santa Llogaïa interconnection has been carried out:



(Source: RTE)

In the presence of RES, France indicated that FRR is important to share with neighbouring power systems and that it is able to estimate present FCR and RR requirements across balancing areas while Spain indicated the same situation for FCR. Both countries are able to estimate each other present reserve capacities in the presence of RES. There are agreements with neighbours in place in France to share FCR only while Spain indicated that agreements on all reserves are in place at present and for 2030.

According to ENTSO-E, one of the main concerns in South Western Europe is the low NTC between France and Spain, too low to enable the Iberian Peninsula to fully participate in the IEM. In 2014, congestion in the France – Spain border was quite high (87% of saturated hours from October 2014 to October 2015). In October 2015, the new Eastern Interconnection was commissioned, reducing time of saturation to 70% from October 2015 to October 2016, while it is considered not enough, neither in the short nor long term.

Planned interconnection developments

Several projects are envisaged, some for the medium to longer term, to strengthen the NTC between the two countries. The first project is the installation of a phase shifting transformer (PST) to be installed at the Spanish end of the recently commissioned Arkale to Argia 220 kV cross border interconnector. This device is required to increase the France – Spain exchange capacity, especially from Spain to France, but it will also help to avoid the tripping of the Arkale – Argia tie line in case of contingencies, therefore improving the security of supply in the French Basque country. This project will have a remarkable impact on the exchange capacity with an expected NTC of 100 MW in the France to Spain direction and 500 MW in the opposite direction.

The Biscay Gulf project would be the next in line to increase the exchange capacity at the France to Spain border. The project aims at improving the interconnection between Iberia and mainland Europe to around 5 GW in both directions, allowing for higher integration of RES in Spain and Portugal. The project entails 370 km HVDC – VSC link (2 dipoles of 1000 MW each) mainly sub-marine in the Biscay Gulf, between Gatica (Basque Country, Spain) and Cubnezais (Nouvelle Aquitaine, France).

The ENTSO-E Regional Investment Plan of 2015 established the future market interest of increasing the cross-border France to Spain capacity from 5 GW, reached with planned reinforcements, to 8 GW. So, after the Arkale and the Biscay Gulf projects, the next project on line would consist of a set of two new interconnections between France and Spain that could be located in the West and the Central part of the Pyrenees, each being a new 2x1000 MW HVDC link. Internal reinforcements in Spain and in France complementing the cross border section would be needed to reach 8 GW of NTC, including both substations and new 400 kV lines. Included in the Madrid Declaration, those projects would aim at improving the interconnection between the Iberian Peninsula and the rest of Continental

Europe, allowing for higher integration of RES, especially solar, and helping Spain to come closer to the 10% interconnection ratio objective.

7.3.7. Interconnection France – Italy

Both countries are proceeding to full market integration according to the *ENTSO-E TYNDP*; therefore, market mechanisms are available in both countries. All ancillary services are available and can be shared. However, such sharing appears to be somewhat limited since Italy elected to share RR only in emergency situations.

NTC is about 1160 MW in the direction from Italy to France and 3150 MW in the opposite direction. Planned interconnections for 2020 will total 2160 MW in the direction from Italy to France and 4350 MW in the opposite direction. Electricity energy trade in 2014 was assessed at around 2.9 TWh of Italy exports to France and exports from France to Italy at around 19.8 TWh.

Historically, the main driver for grid development on the Northern Italian borders is the integration of the Italian peninsula power system, with predominant gas generation, into the main European system where prices are usually lower. Therefore, since several years, the sizeable imports to Italy are based on economic convenience in comparison with domestic generation prices. Thus, it is necessary to increase the capacity of the Italian Northern border to improve access on the Italian peninsula to the European electricity market. In addition, such increase will enhance possible mutual support of both countries and favour RES integration.

Planned interconnection developments

A new HVDC interconnection between France and Italy is envisaged for commissioning in 2019. The new HVDC link will connect the substations of Piossasco and Grande Ile mainly along existing highways and the Fréjus tunnel. The project includes the removing of limitations on existing 380 kV internal Italian lines. The removing of limitation is necessary to take full advantage of the increase of interconnection maximum NTC provided by the cross-border line. Expected improvement of total NTC is about 1000 MW in the Italy to France direction and 1200 MW in the opposite direction.

As noted above, this border, the Italian Northern boundary, is mainly used in import direction towards Italy but during high peak hours in France the flows could be observed in the opposite directions. This phenomenon may become relevant in case of a very strong future RES contribution, triggered by the development of solar generation in Italy which benefits from one of the biggest potentials in Europe. Either way, the new interconnection will lead the system to a more efficient use of the generation in Europe, in low RES scenarios, and to a better integration of Italian renewable generation in the strong RES scenarios.

7.3.8. Interconnection Italy – Greece

NTC on a 400 kV HVDC submarine cable is about 500 MW in both directions, which corresponds to the maximum capacity of the interconnection. Trade in 2016 was assessed at around 2.2 TWh of Greece imports from Italy and exports from Greece to Italy at around 0.4 TWh. Voltage control is possible but not applied.

With the aim to facilitate market integration and harmonization of cross-border congestion management and in accordance to Commission Regulation[3], CASC S.A and CAO GmbH auction offices were merged on the 1st of September 2015 creating the Joint Allocation Office (JAO). As a result, the capacity allocation of the DC interconnector between Greece and Italy is now conducted by JAO by means of explicit auctions. ENTSO-E rules are applied on the exchanges.

7.3.9. Interconnection Italy – Montenegro

The Italy-Montenegro interconnection, now under construction, includes a new 1000 MW HVDC submarine cable between Villanova (Italy) and Lastva (Montenegro) and the DC converter stations. The HVDC link between Italy and Balkans is correlated with the Trans-Balkan Corridor that represents a strategic investment of regional and

[3] A Single Auction Office platform is a European requirement under the Commission Regulation (EU) 1719/26.9.2016 establishing a guideline on Forward Capacity Allocation (FCA).

pan-European significance. When completed, the Trans-Balkan Corridor will significantly strengthen the critical North East – South West, East – West regional and pan-European corridors which are some of the most congested transmission corridors in the South East Europe region. The project will enable power transits directed to new HVDC link towards Italy.

The project will allow to have a link between the Italian peninsula and the South East Europe in order to help the most efficient use of generation capacity located in Eastern countries. This link will enable possible mutual support of Italian and Balkan power systems and will contribute to the RES integration (as the solar generation in Italy) in the European interconnected system by improving cross border exchanges.

In Italy, the Day Ahead Electricity Market is split in 6 different bidding zones due to internal congestions on the South to North axis and between the main Islands and the Italian peninsula. The project contributes to overcome internal boundaries which affect power exchanges within price zones and market structure. Furthermore, the project favours the integration of RES generation installed in central part of Italy, especially wind and solar power plants.

7.3.10. Interconnection Italy – Slovenia

Interconnected Maximum NTC is about 730 MW (winter) in the direction from Slovenia to Italy and 660 MW (winter) in the opposite direction. Electricity energy trade in 2016 was assessed at around 5 TWh.

A future interconnection between the two countries is planned since 2011. The project will connect the Salgaredo (Italy) and Divaça (Slovenia) stations through an HVDC link. It will reduce congestions on Slovenia – Italy border and increase cross-border NTC by 1000 MW in the Slovenia to Italy direction and 800 MW in the opposite direction. A higher market integration is expected (also indicated by an increase of NTC values on Slovenia – Italy border) and even higher level of the existing market coupling could be achieved.

The biggest impact on neighbouring countries is an increased security operation, a higher market integration, the elimination of congestions and an increased operational security in case of outages throughout Slovenia and neighbouring countries.

7.3.11. Interconnection Greece – Albania

NTC between Greece and Albania is of 250 MW in both directions which is rather low compared to the total maximum capacity of around 1200 MVA of the two AC transmission lines connecting the two systems, namely Kardia – Zemblak (400 kV) and Mourtos – Bistrica (150 kV). This is mainly due to transmission constraints in the Albanian power system, as well as in other interconnections within the Balkan area.

Substation Bistrica has been upgraded with a new 80 MVA transformer, replacing the old 40 MVA one, consequently the 154 kV line Bistrica – Mourtos can be synchronously operated.

Greece imports from Albania around 0.82 TWh and exports around 0.49 TWh (2016). Systems are synchronously connected and market mechanisms are available in both countries. PTRs are auctioned on a daily, monthly and yearly basis at the South East Europe Coordinated Auction Office (SEE CAO). ENTSO-E rules are applied on the exchanges.

With the aim to facilitate market integration and harmonization of cross-border congestion management, a number of TSOs from South East Europe (SEE) founded at the end of 2014 the SEE Coordinated Auction Office (SEE CAO) aiming to conduct the capacity allocation in this region. SEE CAO inter alia performs auctions between Greece and Albania from the 1st of January 2016, by means of explicit auctions on a daily, monthly and yearly basis.

7.3.12. Interconnection Albania – Montenegro

Net Transfer Capacity between Montenegro and Albania is of 400 MW in both directions. The two systems are connected through the 400 kV overhead line Tirana 2 – Podgorica 2 and the 220 kV overhead line Koplik – Podgorica 1. Albania imports from Montenegro around 1.22 TWh and exports around 0.35 TWh (2016). Systems are synchronously connected and market mechanisms are available in both countries. PTRs are auctioned on a daily, monthly and yearly basis at the South East Europe Coordinated Auction Office (SEE CAO). ENTSO-E rules are applied on the exchanges.

7.3.13. Interconnection Greece – Turkey

Net Transfer Capacity (NTC) between Greece and Turkey is about 218 MW in the direction from Greece to Turkey and 166 MW in the opposite direction, which is rather low compared to the maximum capacity of around 1600 MVA of the AC interconnection N. Santa – Babaeski (400kV).

Greece – Turkey interconnector is part of the ENTSO-E to Turkey transmission corridor (the other part is represented by two interconnectors between Turkey and Bulgaria). Total NTC values are 650 MW in the Continental Europe Synchronous Area (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, hence the above capacity values of the Greece to Turkey connection.

Electricity energy trade in 2016 was assessed at around 0.2 TWh of Greece imports from Turkey and exports from Greece to Turkey at around 0.8 TWh.

Systems are synchronous and ENTSO-E market mechanisms are available in both countries. Physical Transmission Right (PTR) is auctioned on a daily, monthly and yearly basis. SEE CAO performs auctions between Greece and Turkey from the 1st of October 2015.

Some ancillary services can be exchanged: FCR for emergency in Greece.

Planned interconnection developments

The second planned Bulgaria to Greece tie-line (Maritsa 3 – N. Santa) and the related strengthening of the 400 KV South East Bulgarian network is under way. These reinforcements as well as the third Turkey – Bulgaria interconnector (under discussion) will help to increase future NTC on the Turkey to CESA direction of about 1250 MW and 1350 MW on the CESA to Turkey direction with the expected commissioning in 2021.

In this hypothesis, 2030 NTC values for the Turkey to ENTSO-E transmission corridor are expected to be around 2000 MW in the ENTSO-E to Turkey direction and 1750 MW in the opposite direction. Hence, one third of the above is allocated to Greece that will have an export capacity of 660 MW and an import capacity of 580 MW.

7.3.14. Interconnection Israel – Cyprus – Greece (planned)

This planned interconnection, known as the Euro Asia Interconnector, consists of a 400 kV DC submarine electric cable and any essential equipment and/or installation for interconnecting the Cypriot, Israeli and the Greek transmission networks (submarine cable). According to the ENTSO-E report on planned interconnections, this link will have a capacity of 2000 MW and a total length of around 820 nautical miles/around 1518 km (approximately 329 km between Cyprus and Israel, 879 km between Cyprus and Crete and 310 km between Crete and Athens) and allows for reverse transmission of electricity. However, the Cyprus TSO reported that it is very difficult to define the energy flow of the planned Interconnection with the current available data. Furthermore, it was agreed to add a new cluster of studies for assessing power flows patterns on the future Greece – Cyprus – Israel interconnection within the Med-TSO 2030 regional market study being conducted by the ESS Working Group.

7.3.15. Interconnection Turkey – Syria

NTC value is about 500 MW with a new 400 kV HVDC link (600 MW) planned but no indication about the time horizon. The existing 400 kV interconnection transmission line is out of service since 2012 because of the current conflict in the region.

7.3.16. Interconnection Jordan – Syria

NTC is about 800 MW with the option to add a double circuit of 800 MW by 2030. The existing 400 kV interconnection transmission line is out of service since 2012 because of the current conflict in the region. The focus is primarily targeting bilateral coordination. Jordan is planning to apply in the future the rules and requirements issued from the 8 interconnected countries in the area. There is no electricity market at the moment.

7.3.17. Interconnection Jordan – Egypt

NTC is about 550 MW with an option to add a link of 550 MW in 2030. Usually, energy exchanges are basically in the Egypt to Jordan direction since 1999.

7.3.18. Interconnection Jordan – Palestine (West Bank)

NTC is about 20 MW on a 132 kV (operated at 33 KV) link with a future expansion to 100 MW planned (supply line). In the West Bank, there is no power generation and all the lines with the neighbours are supply lines (the called NTC is the capacity of the line).

7.3.19. Interconnection Israel – Palestine (West Bank)

NTC is about 200 MW on a 161 kV double circuit line.

In the West Bank, there is no power generation and all the lines with neighbours are supply lines (the called NTC is the capacity of that line).

7.3.20. Interconnection Egypt – Palestine (Gaza)

NTC is about 400MW on a 161 kV with a future expansion to 100 MW planned.

In Gaza too, there is no power generation and all the lines with the neighbours are supply lines (the called NTC is the capacity of the line).

7.3.21. Interconnection Egypt – Libya

NTC is about 180 MW with a future expansion to 1000 MW under consideration. This interconnection is currently operated synchronously and used for power exchange between the two countries (normally Libya imports electric power from Egypt).

8. Conclusions

8.1. Final considerations

In this study the assessment of present reserves sharing possibilities jointly with the expected RES development programs was explored for the selected countries making it possible to indicate some quantitative results, actually beyond the scope of the report, mainly in the area of new generation facilities and transmission infrastructures. It should be noted that some data need to be updated or, being sensitive in nature, are missing all together.

In addition to the sharing of ancillary services to facilitate RES integration, cross-border interconnections are necessary for achieving such sharing since interconnectors are intended for capacity and energy exchanges as well as for providing capacity reserve security support between facing TSOs. These three “ingredients” (RES, sharing and interconnectors) appear to be instrumental for supporting significant infrastructural, economic and social developments in both interconnected countries and this is even more relevant for the developing Southern shore countries.

More specifically, without sharing services, the maximum admissible level for RES deployment depends on the parallel growth of the fast response conventional generation facilities. In addition to the relatively small present contribution of RES themselves (**which should be considered in the total contribution, as recently recommended by ENTSO-E**), system’s FCR can be achieved by increasing generators statism and improving ramping capabilities. This will be possible with significant hardware retrofitting or, for future generators, at the design level, evaluating the cost of this option against the benefit of increasing RES deployment. FRR and RR, slower in response, appear to be a lesser problem but still require adequate attention for determining the size of the necessary reserves to accommodate RES growth.

In most of the ENTSO-E countries sharing services is possible but it does not appear to be widely deployed nowadays except for emergency support among countries. It seems that most of these countries have chosen to relay on their own reserves to compensate for grid disturbances. Nevertheless, it is expected that sharing services will considerably increase in the near future as a desirable feature that will include mitigating the impact of large RES development programs.

Some Southern shore countries have ambitious goals on RES growth but limited electricity markets and smaller conventional generation parks to support such growth. Most of the features mentioned earlier for Northern countries with ambitious goals on RES growth (such as Germany and Denmark) could represent a good example of future developments for the Southern shore countries as well. The only possible mitigating solution is therefore the sharing of ancillary services.

Sharing services can be enhanced by market mechanisms, where they exist, making BSPs (Balancing Services Providers) more effective because of economic convenience (lucrative prices). However, sharing services can be also achieved by specific TSOs agreements (protocols) **even where there is no market**. In this case, TSOs may assume the role of Balance Responsible Party and be instrumental in setting up Balance Service Providers organizations.

Flexibility is a prized characteristic in power systems with significant RES. How this flexibility is procured is strongly shaped by the ***regulatory context***. Vertically integrated utilities typically can use contractual or policy mechanisms to extract flexibility from generators. In contrast, in partially or wholly restructured power markets, like in some ENTSO-E countries, system operators use market designs —with clear definitions of performance requirements— to incentivize the provision of power system flexibility. Interconnected countries can pool flexible resource by coupling markets, if they exist, and cooperating on reserve/balancing, pooling response, ramping capabilities and system services.

The ***BALIT*** (Balancing Inter TSO's) platform, already mentioned in the Portugal to Spain interconnection on paragraph 7.3.5, is definitely a good example of a very beneficial practice that could be applied in other countries too. BALIT allows cross-border exchanges of balancing services among Countries. Such platform entails the trading of unused balancing services in a control area. In market oriented countries, services can be bid into neighbouring control areas and this will result in more reliability and efficiency **fostering competition** and mitigating balancing costs. In this platform, each TSO keeps its own reserves and its own procurement mechanisms and may elect to bid its surplus of balancing energy into the other TSO's mechanism next to real time using the remaining NTC available at that moment. The applicability of this concept to non-market oriented countries should be studied in order to replace the market related features of this platform with appropriate agreements among TSOs covering the technical requirements and the financial compensations necessary for a real application of this platform.

8.2. Sharing services: Possible schemes

As mentioned earlier, in ENTSO-E countries sharing services is possible and the trend appears to be in direction of coordinating balancing areas. Supporting each other balancing areas is already possible as applied in the BALIT platform.

For the Southern and Eastern shores, the only possible scheme considered for the immediate future is the scheme suggested under the following point 8.2.1. The ultimate target is achieving balancing areas coordination between facing TSOs entailing, among other things, a better utilization of existing and planned interconnections capacity.

Other schemes to share ancillary services without achieving balancing areas coordination may exist but this one appears to be more logical and effective. Within this proposed scheme, after achieving the 6 immediate targets listed below, there are several ways to reach the objective of sharing services. Choosing the most appropriate way depends on the technical set-ups of each TSO and on the accuracy, completeness and thoroughness of the agreements that are needed between facing TSOs.

The scheme will apply in different phases each with its appropriate timing. Its applicability depends on the TSOs' needs, will and convenience. Anyhow, a cost-benefit analysis (CBA) of the scheme appears to be necessary.

8.2.1. Recommendations to implement sharing of system services

Specific recommendations for the Southern shore countries are:

i. Harmonization of the institutional consensus between interconnected countries
ii. Interconnected systems stakeholders support including generators and IPPs, if present
iii. Harmonization of the regulatory set ups between interconnected countries
iv. Harmonization of rules and statutory grid codes (focusing on reserves sharing) between interconnected TSOs
v. Harmonization and strict coordination of technical parameters between interconnected TSOs
vi. Development plans coordination, for both conventional and RES generation, between the two interconnected systems

As mentioned, establishing a coordinated balancing area is the main target of this effort. A critical question in drafting the TSOs agreements covering the last three items of the list will be the effective sharing the responsibilities on the "coordinated" balancing area between the facing TSOs. Med-TSO could have an important advisory role in establishing and/or mediating agreements on the rules. Even on the issue of the institutional consensus, Med-TSO could suggest appropriate actions in both countries in order to foster and support coordinated policies implementation in the Southern countries regional balance.

Sharing services with neighbouring TSO will mitigate the level of each country reserves. Therefore, one of the first steps necessary for both TSOs is to coordinate each other planning to achieve the best results in terms of optimizing such mitigation.

8.2.2. Future challenges: Addressing balancing areas coordination

The following considerations were briefly anticipated in the "General Methodology" reported in Chapter 5 and applicable to all Med-TSO countries.

Having dealt with the harmonization issues listed under **8.2.1**, Balancing Areas coordination will involve, as the next target, the issues related to reserves sharing through defining type of services and technical parameters to be shared. **Type of services include FCR, FRR, RR and voltage support. Technical parameters include synchronization requirement, time to begin response, time to reach full output, accuracy of response, and maximum duration of response**.

The next steps will address:

- Estimating total reserve requirements across balancing areas
- Allocating reserve requirements to each balancing area
- Estimating actual power flows that can occur at balancing area interface under various reserve sharing events

The significant feature of reserve sharing is that it is relatively simple to implement and typically does not require market transactions.

8.2.3. Balancing area coordination: Longer term issues

Further goals in this logical path are ***coordinated scheduling*** among areas and common operation of a larger geographical area.

Longer term coordination target, to be planned through additional accurate studies, will involve coordinated scheduling facilitating bilateral exchanges either through a centralized bid market (Energy imbalance market) or, more likely, through a less complex electronic brokerage platform. In both cases the key steps to achieve coordination are:

- Establish a system for continuous information exchange of generators availability and costs,
- Create a monitoring system and a financial compensation mechanism for energy exchanges and transmission grid usage,
- Establish a means to calculate transmission capability on relevant time scales.

The final goal of coordination is to achieve ***a jointly coordinated operation*** for maximum economic benefit and least cost RES integration. Jointly coordinated operation consists in merging of two or more balancing areas run by a joint single operating organization. Similar results can be achieved by a virtual or partial jointly coordinated operation based on specific cooperative agreements creating a new operating entity responsible for running both balancing areas. In any case, this target may be quite difficult to achieve where national interests are predominant and conflicting.

If coordinated balancing and jointly coordinated operation appear to be achievable for some Northern shore countries, they seem to be only a long-term target for the Southern shore countries.

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