PAVING THE WAY FOR THE MEDITERRANEAN SOLAR PLAN

Addendum 2 to the Service Contract Nº ENPI 2010/248-486 signed on 30/08/2010

Master Plan of the

Mediterranean Interconnections

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Summary

1. INTRODUCTION

The activity here summarized, concerns the work undertaken by Med-TSO under the Addendum 2 to the Service Contract Nº ENPI 2010/248-486 signed on 30/08/2010.

The Addendum has been committed by the European Commission to introduce and encompasses two main objectives:

 Sub-Task C1: Sharing criteria among the Mediterranean TSOs, consistent with ENTSO-E experience, of a coordinated rolling planning of transmission infrastructures;
 Sub-Task C2: Analyzing projects of interconnections and related reinforcements of internal grids planned at short-term, whose feasibility studies are available and, where applicable, eligible for European PCI (Project of Common Interest) and ENTSO-E coordinated planning procedures.

Med-TSO was charged to carry on Task C and, during its activities from January to July 2013, two seminars were organized and four main documents (deliverables) were produced:

• D-C.1 National Development Plans 2012 – 2020

• D-C.2 Master Plan of the Mediterranean Interconnections

• D-C.3 Mediterranean Reference Grid at short term (on rolling base)

• D-C.4 Guidelines for coordinated planning:

The present document provides a summary of the main results, which are described in details in the above 4 documents.

2. **Methodology** (from deliverable D-C4)

The integration of the power systems of the Mediterranean basin, through their electrical interconnections, requires common rules for their planning and operation.

As a first step towards this goal, a document (deliverable D-C.4) describing the "Methodology for the Long term Network development Plan" was prepared, discussed and shared. The described procedure is inspired to the ENTSO-E methodology and foresees the following main actions (fig 2 of D-C.4):

1. definition of regional scenarios
2. creating reference power system models at regional level, performing market studies
3. analyzing the network behavior (load flow calculations)
4. defining the required new investments and their priorities

A detailed description of each of the above steps is given in D-C.4, including as well recommendation for the creation of a **common data base** of the interconnected power systems (section 4), **criteria for ensuring the system adequacy and security** (section 5), technical **and economic indicators to assess the impact of projects** (section 6), **procedure for market studies** (section 7) and for the **final ranking of the proposed new projects** (section 8).

Finally a simplified procedure was defined (section 9) to start a first application of the above methodology – which needs to be implemented in successive steps – to the planning of the Mediterranean interconnected system at a future horizon year (2022).

3. **National and Regional Development Plans** (from deliverable D-C1)

The official NDPs of the Med-TSO countries were summarized by each TSO and these summaries were collected in Annex II A (of D-C1) for the Western European Med-TSO countries (France, Spain, Portugal, Italy) and for the South East Area (Morocco, Algeria, Tunisia, Libya and Italy), and in Annex IIB for the Eastern countries (Albania, Greece, Bulgaria, Turkey, Syria*, Jordan, Lebanon*, Palestine*, Israel*, Egypt)[1]

[1] For countries marked with * use was made of the information collected in the previous activity of Task A and B of the paving the Way Project

From the above documents regional expansion plans for the decade 2013-2022 were elaborated concerning the evolution of the load demand, of the generation mix, of the electrical network. Among the mail achievements reported in D-C1 we may mention:

GROWTH OF THE DEMAND

In the West European Area (Italy, Spain, Portugal, France) the forecasted growth of the load demand is much lower (1-2% per year) and uncertain than in the Mediterranean areas at South West (from Morocco to Libya) and at south East (from Egypt to Turkey)) where a growth of 7 to 8% per year is foreseen (fig 1)

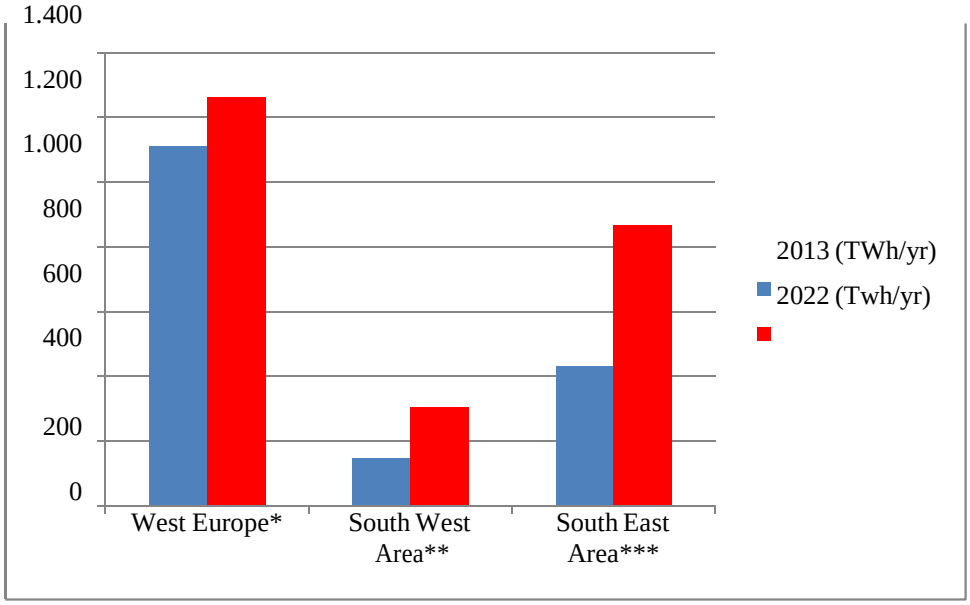

Fig 1. Forecast of load demand (TWh/yr) at 2013 and at 2022 (* France+Italy+Portugal; ** Morocco+Algeria+Tunisia+Lybia; *** Egypt+Jordan+Syria+Turkey)

NEW GENERATION TO BE INSTALLED

In the decade 2013-2022, the evolution of the generation (fig2) shows great differences between Europe and the South and East Mediterranean countries.

- Due to the modest rate of growth of the demand the considered European countries –and the rest of Europe as well - will increase of a small percentage their conventional generating capacity, the exploitation of RES being favoured.
- On the contrary, the southern countries from Morocco to Turkey plan to install new generating units for an amount of 150 GW close to 60% of their 2012 installed capacity, a large part of which of the traditional Thermal or Combined Cycle type, fueled by Natural gas.

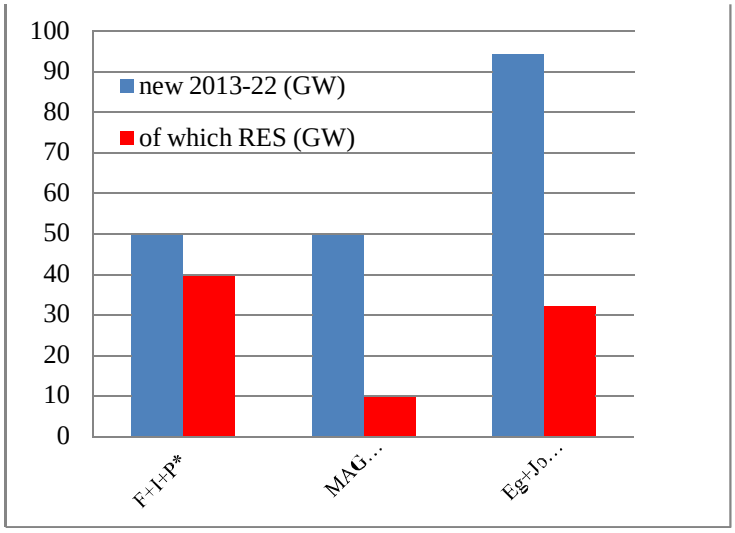

Fig 2: New generating capacity (MW) to be added in the 2013-2022 decade (* France+Italy+Portugal; ** Morocco+Algeria+Tunisia+Lybia; *** Egypt+Jordan+Syria+Turkey)

As a result of this development plan the Southern and Eastern Countries will present (see Fig 3) at 2022 a mix with a large share of Thermal units or CCGT, generally fueled by NG. If we exclude Turkey, having a large hydro capacity, the share of generation capacity from RES, will be of the order of 10% of the total installed capacity.[2], value much lower than that planned in Europe

[2] More in details:

- In the **Maghreb area, the** new conventional generation (about 40 GW added in the period 2012-2022) is largely based on Combined Cycle GT (26 GW) fueled by Natural Gas for base unit, and on GT (7, 8 GW) for peak duty. In addition a new capacity of about 9 GW from intermittent renewable energy sources (RES) is foreseen in 2022, mainly located in Morocco (4, 4 GW) and Algeria (3, 9 GW). The solar generation in the area accounts for 6 GW, while Hydro and Wind account for 2, 2 GW and 3 GW respectively.

- **In the Eastern area from Egypt to Turkey**, .the new capacity in the period 2013-2022 amounts at 94 GW and includes about 57 GW Thermal (50% of which are CCGT); 5 GW Nuclear (Egypt and Turkey);11 GW Wind ;3 GW solar; 18 GW hydro (in Turkey).
- **The western European Countries** examined (Portugal, Spain, France, and Italy) having a modest rate of growth of the demand do not need installation of traditional generating capacity, but plan for important amounts (about 40 GW) of generation from wind, solar, biomass. Similar trend is expected for the other two European countries (Greece and Albania) at north west of Turkey

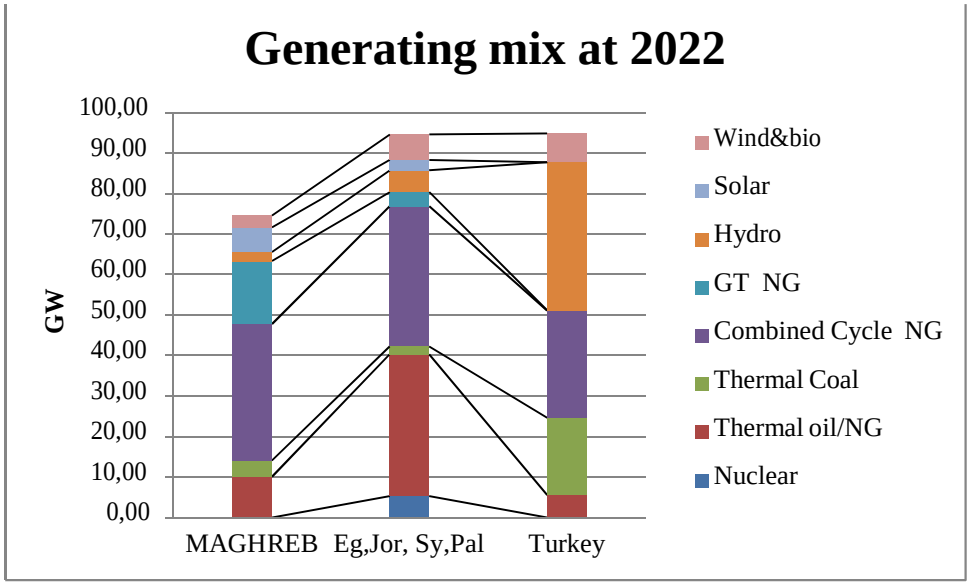

Fig 3: expected generating mix at year 2022

NETWORK DEVELOPMENT

INTERNAL NETWORKS:

All countries in the SEMC foresee a strong development of the internal networks for the purpose of connecting the new generation power plant, feeding the increasing load demand, integrating the production from RES. Most of the short term investments in transmission facilities are dedicated to the above tasks.

According the data till now collected in D-C.3 for the Western area (the Eastern area has still to be completed) a total of 106 new 400 kV circuits and 41 new 220 kV circuits are at the moment in construction or result authorized while 32 projects at 400 kV are awaiting authorization.

The approximate total length of the listed projects reaches about 30.000 km (including internal reinforcements). In addition 3 HVDC links are foreseen, 2 internal to Spain at rated voltage 220 kV and 1 submarine in the South of France at 320 kV (European interconnections not directly involved in the potential North-South exchanges, have been disregarded).

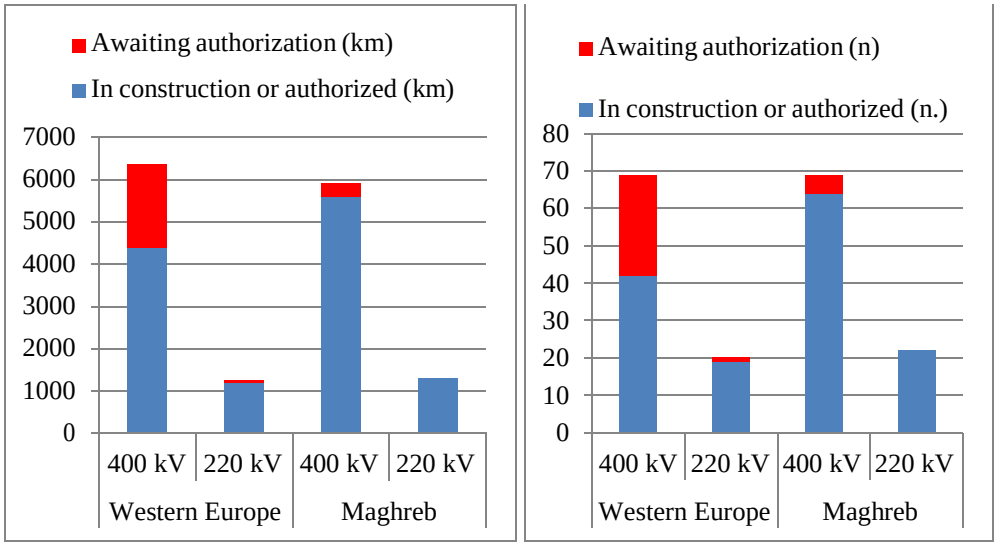

Fig 3: new internal lines in construction or authorized or awaiting authorization (for Western Europe: France, Italy, Spain, and Portugal)

INTERCONNECTIONS

The complete list of new interconnections having influence in the examined Mediterranean area is reported in D-C3 (see also next section) including a number of lines not yet decided but under consideration for future .Only those being in construction, authorized, waiting for authorization are indicated in the following Table 1

Table I- list of new interconnection under construction, authorized or waiting for authorization (decade 2013-2022)	
Spain -France	New HVDC interconnection between Sta.Llogaia (ES) and Baixas (FR) via DC underground cable
Italy-Slovenia	Italy-Slovenia interconnection (Salgareda- Divaca HVDC link)
Italy Switzerland	Italy –Switzerland interconnection (Airolo – Pallanzeno- Baggio HVAC/HVDC power line)
Italy -France	Savoie Piemont project : New Italy-France interconnection (Piossasco-Grand'Ile HVDC power line)
Italy-Momtenegro	New Italy-Montenegro interconnection (Villanova- Lastva HVDC power line)
Spain-Portugal	New double OHL Tavira (PT)–Puebla de Guzman (ES) (only one circuit installed)
Spain	Grid developments in Spain to support the new ES-PT interconnection c Guillena-Puebla de Guzmán
Spain-Portugal	New double OHL V. do Castelo (PT)–Covelo (ES) (only one circuit installed)
Morocco-Spain axis	Réalisation d'une ligne à deux ternes Ferdioua – Melloussa
Tunisia-Algeria	Exploitation de l'axe Jendouba – Mateur – Mornaguia en 400 kV (actuellement exploité en 225 kV)
Libya-Tunisia	d.c.OHL 220 kV Abukamash-Border
Libya-Tunisia	d.c.OHL 220 kV Rowis-Border
Libya-Tunisia	d.c.OHL 220 kV Mednine-Border
Libya-Tunisia	d.c.OHL 220 kVTataouine-Border
Turkey-Syria	HVDC B-to-B Station with 600 MW capacity between Turkey and Syria(400 kV)
(Turkey-Iraq)	(similar HVDC B-to-B Between Turkey and Irqaq)
Jordan-Palestine	d.c. OHL 400 KV between Jordan and West Bank with 1500 MVA thermal capacity
Egypt- Palestine	d.c. OHL 220 kV between Egypt and Gaza with 1000 MVA thermal capacity
Egypt-Libya	OHL 500 kV between Tobruq (Libya) - Saloum (Egypt)
	OHL= overhead line; d.c. double circuit ; HVDC High Voltag Direct Current

Among the several new interconnections in Europe, the new HVDC link between Spain and France (that will increase to 2, 8 GW the NTC between the two countries) is the most relevant for our study.

In the non European countries, the authorized projects often do not have a definite year of commissioning. At short term there are certainly the 600 MW back to back connection between Turkey and Syria (and Turkey-Iraq), expected in service before 2017, and the planned reinforcements of the 400 kV links Morocco, Algeria and Tunisia[3].

Several factors may be considered as causes of possible delay in the interconnection construction: i.e. long distances (the case of central Egypt towards Libya and Jordan) and consequent large investments; priority for feeding the domestic load; presence of vertically integrated utilities acting in a monopolistic situation (absence of incentives to growth); absence of an electricity market; the long structure of the regional power systems (e. g. from Tunis to the Nile area) with consequent problems of stability.

Nevertheless the situation is improving: the block Morocco Algeria Tunisia is interconnected enough and the transfer capacity will be soon further improved. The area at South East is going to be connected for the first time to Turkey in view of increasing the commercial exchanges (see section 4).The set up of an organization as Med-TSO is in itself a sign of the wish of more cooperation and interconnection.

Finally the increasing installation of generation from RES (solar and wind) is an important factor pushing for more powerful interconnections among areas (the European power system included) having different climatic conditions and different structure of the generating mix.

4. **Mediterranean Reference Grid at short term, updated on rolling base** (from deliverable D-C3)

One pre-requisite for studying new interconnection is the availability of updated and precise information on the power system to be connected

The ambitious goal of creating **a common and shared data base** of the Mediterranean interconnected power system requires a step-by step approach and important affords from the organizational and financial point of view (see the ENTSO-E experience).

On the other hand, it gives a strong support in improving the cooperation among the TSOs, in facilitating studies and decisions, in increasing transparency of information, in encouraging cross border trades and the coordinated system operation.

[3] *Projects declared under construction or authorized: 400 kV double circuit line Ferdioua – Melloussa from morocco towards the Spain connection; energization at 400 kV of the connection Jendouba-Mateur-Mornaguia between Algeria and Tunisia. Without commissioning year: connections 400 kv Jordan-West bank; 220kv Egypt –Gaza; 500 kV Egypt-Lybia; Four 220 kV from Lybia to Tunisia*

Med-TSO decided to start immediately a first concrete action in this direction, by collecting – during the first 6 months of its activity- the list of the network reinforcements (internal and interconnections) that are foreseen in the Mediterranean area in the next decade (2013-2022).

Deliverable 3 may be considered the initial stage of the Med-TSO data base for any regional study. Of course there is a long way to go (i.e. to decide how to manage this data base, the confidentiality rules, the software structure, the updating time) but the positive answer so far received promises that the work can be successfully done.

The new connections are characterized by their technical main features (voltage, length, type of conductor, etc) and subdivided into 3 groups: *Major works in construction or authorized; Major works awaiting authorization; Major works under consideration*. While the first two categories have an acceptable confidence, the third category (link under consideration) suffers of many uncertainties and will be better examined in Deliverable 2 (Master Plan of interconnection).

Most of the info recorded for each project are the same as for ENTSO-E (see fig 4), with the exception of the parameters linked to operating limits and social & environmental items It will be a Med-TSO decision to establish type and number of the additional information to be collected in the future.

OF THE ENTSO-E Scheme, only the items in red were -for the time being - c ollected by Med-TSO

Project number	Investment number	Substation 1	Substation 2	Brief technical description	Present status	Expected commissioning date	Grid transfer capability increase	Social and economic welfare	RES integration	Improved security of supply	Losses variation	CO^2 emissions mitigation	Technical resilience	Flexibility	Social and environmental impact	Project costs	Investment comment	Project comment
1																		
2																		

Fig 4. Parameters collected by ENTSO-E on the new transmission projects

The “archive” includes as well a table of “reference unitary costs”, to be used for an approximate and preliminary estimate of the investments that are foreseen in the decade 2013-2022.

5. Master plan of Mediterranean interconnections (from deliverable D-C2)

The list of new lines provided in Deliverable III includes lines “*under construction or authorized, awaiting authorization, under consideration”* in the decade 2012-2022 for all the Med-TSOs countries. They are mentioned in the National development Plans, but their

coherence and the possibility of their correct operation- particularly in the case of interconnection projects foreseen far in the future - have to be assessed and verified when inserted in a unique interconnected network surrounding the Mediterranean basin .

Med-TSO wishes to overcome this gap, by defining a coherent network (*Master Plan of Interconnections*) at one future horizon year. The resulting "*Mediterranean future network*" shall be used as a reference for regional studies, in similar way as it is done by ENTSO-E for Europe.

Several difficulties (e.g. Libya and Syria not yet active in Med-TSO; the Eastern countries now focused on short term studies; uncertainties on the future of the electricity market, etc.) prevented Med-TSO from arriving immediately at a final results but the work has started and two regional networks are now available: at year 2022 for the Western countries and at year 2015-16 for the Eastern countries[4].

REFERENCE REGIONAL NETWORK FOR THE EASTERN AREA

The regional reference network at 2016 includes the relevant elements of the power systems of Turkey, Syria, Lebanon, Jordan, Palestine, Egypt and Libya. Being Israel not yet connected to the rest of the system, its grid has not been, up to now, included in the 2016 network simulations.

As shown in Fig.5 and in previous Table I, the Turkish power system (that operates synchronously with the European system) will be soon connected (in asynchronous way) with its Southern neighbors by two 600 MW back-to-back devices (one between Turkey and Syria and one between Turkey and Iraq). Interconnections among the remaining countries are basically those existing today (with the exception of possible feeders from Egypt and Jordan to Palestine, and the 500 kV line Egypt Libya, which are however foreseen at later dates)

With this structure, shown in fig 5, the possibility to transfer in normal conditions about 600 MW from Turkey to Egypt in summer and from Egypt to Turkey in winter has been verified; power exchanges obviously interests all the connected countries.

This transfer capability has to be reduced to fulfill N-1 security constraints: the main critical sections were detected between Egypt and Jordan (the long 500 kV Egyptian lines O-MOUSA– TABA and the following Taba – Aqaba submarine cable) and projects for reinforcing in the future this axis are being studied. Connection Egypt -Libya is another link for which reinforcements are studied (a new line at 500 kV is being considered).

[4] The discrepancy between the two time horizons concerns however the calculations only, while the expected developments (demand, generation, new lines) after 2016 are reported in deliverable 1 and 3 and the TSOs of the Eastern Group assure that the basis exists for the calculations for following years.

Fig 5: reference network at 2016 for the Eastern area (in red new lines to be added)

REFERENCE REGIONAL NETWORK FOR THE WESTERN AREA

For the Western countries one scenario at 2022 has preliminary been examined of exchanges among Morocco, Algeria, Tunisia, and between these countries and Europe. Libya was not yet included, in this scenario, waiting for more precise information on its system.

Scenario 1: 1000-1300 MW transfer capacity East-West (axis Morocco-Tunisia); 3000 MW South-North (1500 MW through Italy and 1500 MW through Spain)

- In a first scenario the following new interconnections have been introduced in addition to those listed in table I: a) uprating from 700 to 1500 MW the Morocco Spain (AC or DC) connection; one HVDC link Algeria –Sardinia (500 MW, 330 km); a similar one from Tunisia to Sicily (1000MW, 220 km); a new 400 kV ,250 km line between Algeria and Tunisia; internal reinforcements for the Spanish and Italian networks (not evaluated in details , but apparently of modest costs); the already planned HVDC link “Biscay Gulf” between Gatica (Spain) and Aquitaine (France).

The above additional investments result in:

- A net transfer capacity of 1000 MW between Algeria and Morocco and of 500 MW, with possible extension to 1000 MW, between Algeria and Tunisia; the three countries become in this way a solid interconnected block.
- Transits between Maghreb and central Europe reaching 1500 MW through Spain and 1500 MW through Italy (Connection of Libya to Tunisia was not considered). It may be worthwhile to underline that the transmission of 1500 MW to Italy can be reached –thanks to the modular characteristics of the DC links- by progressive steps (of 500 MW each), thus attenuating the impact of the financial requirements

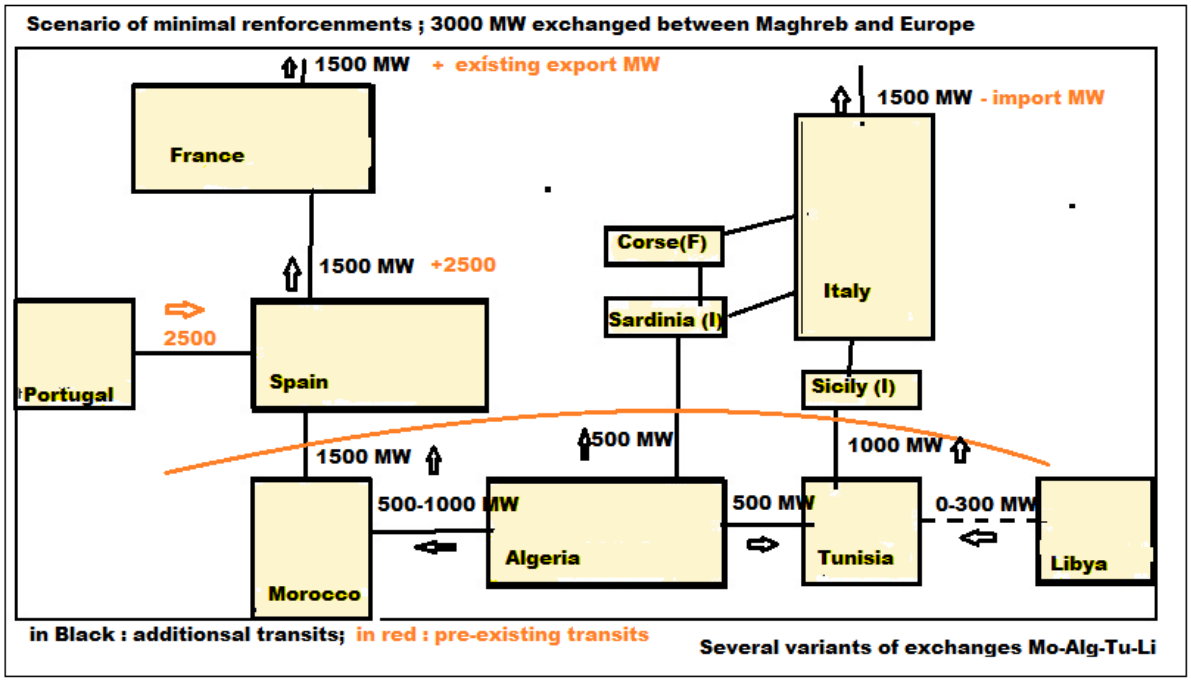

Fig 6. Reference network for the Eastern area at 2022; assumed transits

The additional investments shown in dotted line in fig 7

Scenario 2: Increase to 6000 MW the exchange capacity South-North

In addition to the above scenario, a second scenario with enhanced cross border transits was qualitatively examined for the western area. Transits between Maghreb and Europe of the order of 6000 MW seem to be feasible, including in this solution the Libyan network. Due to its complexity in terms of number of alternative solutions (see fig.7) the Group decided to postpone quantitative analysis after a detailed definition of Scenario 1.

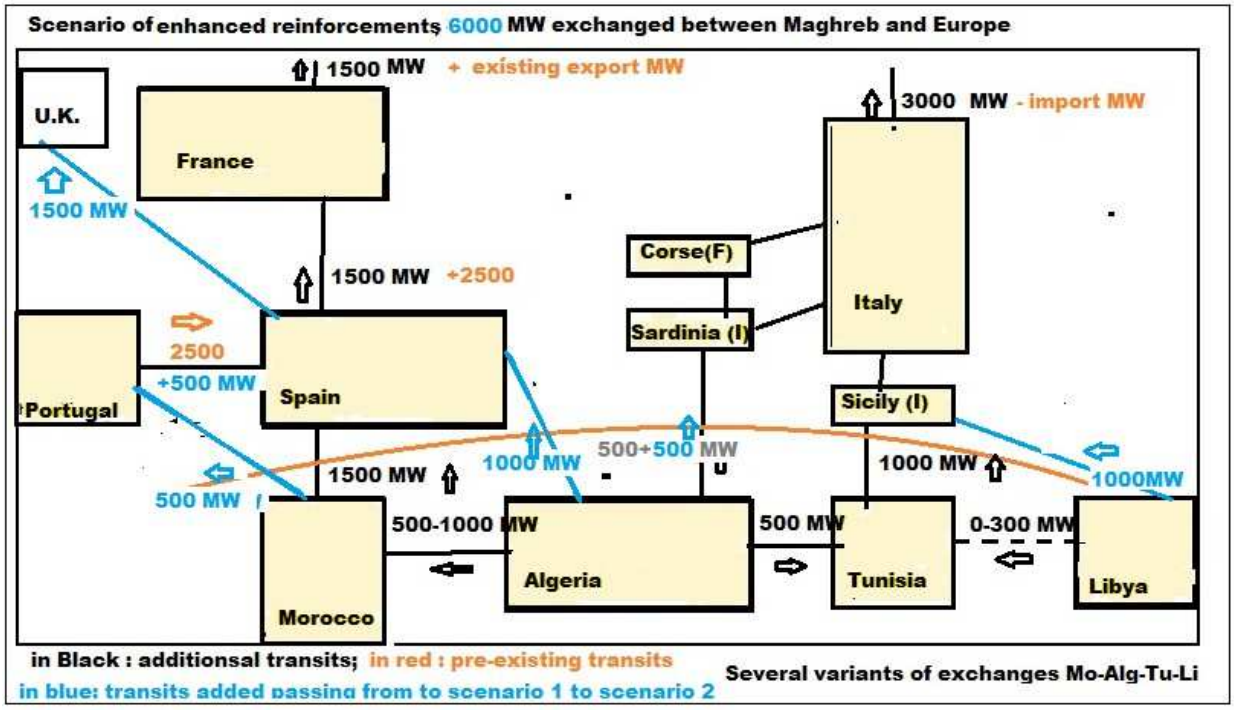

Fig 7. Several alternatives being studied for a scenario of enhanced transfer capacity (6000 MW) between Maghreb and Europe

6. Conclusions

Two **regional development plans** for the Eastern and Western Mediterranean regions [5] have been derived from the NDPs of each country provided by the respective TSOs. They cover the decade 2013-2022 as regards the forecast of the demand, the plans for new power plant (RES included), and the new internal and interconnection lines planned or foreseen.

In both the regions, the non European countries (NECs) foresee a high rate of growth of the demand (around 8 % per year) and of the related investments in conventional generation (new 150 GW are planned with a large share of CCGT fueled by NG). The European countries (ECs) anticipate a much lower rate of development (less than 2%/yr) of the demand, very few new installations of conventional generation, a greater development than in NECs of the generation from RES.

The new transmission and interconnection links “under construction or authorized” and those “waiting for authorization”, for a total length of about 15000 km have been collected

[5] the Western area includes France, Italy , Spain, Portugal, Morocco, Algeria, Tunisia, Libya ; the Eastern area includes Egypt, Jordan, Palestine, Israel, Lebanon, Syria, Turkey, Greece, Albania . For Libya, Syria, Lebanon updated information resulted not available ; electrical interconnections with Israel was not considered

in **an archive, which constitutes the first step of a common data base** for the Mediterranean regional studies. A number of candidate lines “under consideration” for the future network expansion, in particular interconnections, have as well been collected and examined.

Common guidelines for the planning of interconnections (similar to those applied by ENTSO_E) have been discussed and shared. Work for their official formalization will continue

Two reference networks (for the West and the East Mediterranean areas) have been verified by power system analysis calculations.

The East reference network , from Egypt to Turkey and then to Greece and Albania, foresees at 2015-16 the first connection of the European System to the Eastern Mediterranean countries through two back-to back installations between Turkey and Syria and between Turkey and Iraq . Power exchanges of the order of 600 MW in both directions along the axis Turkey-Egypt become feasible. New connection to Palestine from Egypt and Jordan are foreseen at a later date. Studies at longer term (e.g. 2022) for the evolution of this reference network have been postponed.

The West reference network, studied at year 2022, includes the Maghreb block (initially isolated from Libya) and two “corridors” to Europe through Spain-Portugal-France and through Italy. The resulting transfer capacity and the necessary network reinforcements can be summarized as follows:

- A transfer capacity of 1000 MW between Morocco and Algeria and of 1000 MW between Algeria and Tunisia can be obtained by a new connections at 400 kV
- Exchanges along the Spain-France axis can be increased to 1500 MW by doubling the capacity of the Morocco and Spain connection (different solutions are under study) , by modest investments in the Spanish e Portuguese 400 kV networks and by utilizing part of the future NTC Spain France (4000 MW thanks to the planned new HVDC links)
- Exchanges Maghreb – Italy-Central Europe of 1500 MW can be obtained - without excessive reinforcements of the internal Italian network- by a new HVDC submarine link (2X500 MW, 230 km.) from Tunisia to Sicily and by an analogous link of 330 km from Algeria to Sardinia initially sized at 500 MW .The proposed HVDC links can be realized in steps of 500 MW each, thus attenuating the financial needs