

# MEDGRID – A CO-DEVELOPMENT PROJECT FOR THE EXCHANGES OF ELECTRICITY IN THE MEDITERRANEAN BASIN

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**Abstract - Within the framework of the Mediterranean Solar Plan (MSP) of the Union for the Mediterranean, MEDGRID is an industrial initiative aiming at developing a future power grid crossing the Mediterranean Sea. Exchanging electricity between both shores of the Mediterranean requires transmission infrastructures and especially submarine HVDC cables. MEDGRID has the ambition to elaborate a Mediterranean grid master plan and to provide tools to assess infrastructure projects in this framework. MEDGRID will open up new pathways for sustainable electricity by providing a complete information on the feasibility of electricity interconnections between both shores of the Mediterranean Sea, taking into account technical and technological aspects, economic impacts and the necessary regulation and financial conditions.**

*Keywords: Mediterranean Solar Plan, MEDGRID, HVDC, economic assessment, grid master plan, regulation.*

## 1. INTRODUCTION

Electricity is at the heart of economic and social development as well as quality of life.

The exhaustion of fossil resources, the increase and volatility of prices, the effects of greenhouse gas emissions on the climate and security of supplies impose many challenges.

The demand for electricity continues to grow as a result of demographic changes, industrialization and urbanization. According to the International Energy Agency (IEA) technology perspectives, electricity consumption will triple and electricity will increase its share of the total final consumption from 18% in 2010 to 30% in 2050.

Indeed, despite significant electricity efficiency gains, some specific electrical consumption end-uses grow rapidly and electricity is preferred for better energy efficiency and more accurate control in numerous thermal processes. As a consequence, efficient low carbon electricity is increasingly used as a substitute for fossil-fuel.

In the fight against climate changes, beside energy efficiency, the development of renewable energies is also an essential element; it requires the implementation of ambitious co-development

projects to build wind and solar power plants in a large scale and to be able to transmit the electricity over long distance to consumption areas. These projects will ensure energy security and contribute to economic growth.

Important initiatives are particularly necessary in the Mediterranean basin and in Africa.

Within the framework of the Mediterranean Solar Plan (MSP) of the Union for the Mediterranean<sup>1</sup> (UfM), but also of the World Partnership on access to energy in African countries and the Less Developed Countries (LDCs), the French government decided on 20<sup>th</sup> November 2009 to prepare an industrial initiative in this domain. During 2010, twenty one partners joined the initiative to promote transmission and interconnection links in the Mediterranean basin for a large development of the exchange of electricity.

As a result a new company named MEDGRID® was created by the end of 2010 and registered in January 2011.

## 2. THE EUROPEAN UNION ENERGY STRATEGY

The European Union (EU) is developing a major strategy for the transition to a low carbon economy and wants to increase the security of energy supplies. In its directive Energy-Climate (2009/28/CE), it has set three ambitious goals for 2020: to reduce greenhouse gas emissions by 20% compared to 1990 level, to have a 20% share of renewables in the final energy consumption and to achieve 20% additional energy savings above existing measures from 2005 [1].

- The European Commission anticipates that the electricity share in final consumption would increase from 20% in 2010 to 25% in 2030. In the reference scenario, the electricity growth in the EU should stay at an annual level of 1% for the next twenty years, with power generation rising from 3300 TWh in 2010 to 4050 TWh in 2030.

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<sup>1</sup> Launched on the 13 July 2008 in the frame of the French presidency of the European Union, UfM promotes a new co-development policy in the Mediterranean region. It unites residents of the Mediterranean states and the member-states of the European Union, 43 countries.

- The European Commission also promotes the development of renewable energy generation, which would increase by 50% in the reference scenario and 100% in the green new policy scenario<sup>2</sup>. Drastic changes in the power system will require a strong evolution of the power grid, in order to integrate a large quantity of intermittent power from renewable energy (wind and later on solar).
- The European Commission wants to improve the internal electricity market, which requires increasing the exchanges and the transmission infrastructure capacities between the Member States.
- It insists on increasing the security of supply by mutual back-up of power grids of neighbouring countries and regional neighbouring power systems.

To reach these objectives, for the security of supply, for the connection of renewable energy sources and for development of the European electricity market, the European Commission has planned - for next 10 years – as a priority, the development of the infrastructures of high voltage grids in coordination with transmission system operators through four strategic projects:

- The interconnection of the Baltic countries power systems to other EU member-states systems ;
- Offshore transmission lines to connect wind farms in the North and Baltic seas ;
- The reinforcement of the interconnections in South - East Europe ;
- New interconnections between the north and south coasts of the Mediterranean Sea.

These major projects imply the addition of new interconnections within the EU grid, the extension of the existing interconnections beyond the present EU grid limits (around and across the Mediterranean Sea, with the Russian IPS UPS system), and a better efficiency of the operation of the European power grid.

### **3. THE ENERGY NEEDS AND THE SCENARIOS FOR RENEWABLE ENERGIES IN THE MIDDLE EAST AND NORTH AFRICA COUNTRIES**

In the Mediterranean South and East countries, electricity infrastructure must respond to economic growth.

According to the OME (Mediterranean energy observatory), the growth in electricity consumption is expected to be 6% per year until 2025 for the Mediterranean South and East countries (MS&E).

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<sup>2</sup> cf. European Commission : 2<sup>nd</sup> Strategic energy review (Nov. 2008) ; i.e., respectively 22% and 31% of electricity generation

This requires a significant reinforcement of their production and transmission capacities.

By 2020, power generation capacity has then to increase from 100 GW to 200 GW in these countries. Gross electricity generation in the MS&E is presently dominated by fossil-fuel (nearly 90%). Share of hydro would stay almost constant at around 12%. But other renewable sources have to contribute to a more balanced electricity mix. In the Mediterranean solar plan scenario, wind and solar share of power generation could reach 9% by 2020 (0.5% today), by adding 20 GW of new capacity to the 15 GW already predicted in the reference scenario.

The development of large-scale solar power plants and transmission lines of high capacity should enable the solar energy to be competitive. Furthermore, the deployment of these facilities represents a significant potential for jobs creation, industrialisation and economic and social development for the entire Mediterranean region.

### **4. A CO-DEVELOPMENT PROJECT FOR THE EXCHANGES OF ELECTRICITY IN THE MEDITERRANEAN BASIN**

#### *4.1 MEDGRID a major project for the Mediterranean solar plan in the UfM*

The view promoted by MEDGRID aims to mobilise the synergies between northern, southern and eastern Mediterranean countries through a co-developing energy strategy.

Two major programs should support such a view: the creation of a Mediterranean power grid linking the EU with south and east Mediterranean countries, one of the four priority projects of the European Commission for energy security, as well as the Mediterranean Solar Plan, one of six large co-development projects held by the UfM. in order to address common challenges for countries on both sides.

The southern and eastern countries of the Mediterranean have a great potential for solar and wind energy. The MSP also promotes the development of interconnections for a whole competitive power system that allows free exchanges in the euro Mediterranean area.

The whole investment is estimated to be between 38 and 46 billion euros, including 6 billion euros for the connection of power generation units and the interconnections with the EU grid.

A part of the green electricity produced (5 GW) should favourably be exported to Europe. On one hand, this would contribute to the profitability of the solar power projects installed in the Sahara because the electricity produced by solar power plants (less than 25%) could be sold to Europe at higher prices of the feed-in tariffs. On the other

hand, the EU may well increase the share of renewable energies in its energy consumption, in accordance with the commitments outlined in its third energy-climate package. Actually, Article 9 of the EU directive Energy-Climate (2009/28/CE) makes it possible to include the import of green electricity from outside the EU to reach the objective of renewable share.

This North-South cooperation is also in the process of the Kyoto Protocol that can generate carbon credits in favour of the southern states and project promoters thanks to clean development mechanisms (CDM projects).

Bringing renewable electricity to consumption areas requires local transmission infrastructures and cross border interconnections for linking generation facilities with local area networks and with Europe through underwater high voltage lines (AC or DC). Today, there is only one double AC line of 1.4 GW capacity linking Africa and Europe, under the Strait of Gibraltar, which has now reached its limits. The first line of a capacity of 700 MW and 400 kV started operation in 1997, and its capacity was increased to 1400 MW in 2006. A third line is planned to reach 2100 MW of installed capacity.

These new lines will open the European market to renewable electricity coming from the South. The interconnected network will enhance the security of supply of the electrical systems particularly in the southern countries: import and export of electricity will respond to peak demand and intermittent renewable production. Multiple exchanges through the new grid will create a large market for electricity in the Mediterranean basin to meet demands at the best cost, by using the cheapest power plants first and sharing power reserves.

On a wider scale, these infrastructure investments will stimulate growth, create new activities and jobs, helping the co-development of the countries in the Union for the Mediterranean.

#### *4.2 MEDGRID, an industrial initiative*

MEDGRID consortium joins partners coming from eight countries in the EU and Middle-East North Africa; the consortium combines leading partners in the business of electricity generation, transmission and distribution (operators and technology providers), and of financing of infrastructures and services, from the public and private sectors.

Their common ambition is to open up new pathways for sustainable electricity by studying the feasibility of electricity interconnections between northern and southern shores of the Mediterranean.

These projects will bring together many stakeholders over ambitious, technological, economic, industrial and societal objectives. MEDGRID partnership is open to other companies, particularly those in MS&E. The energy transition towards low carbon electricity is a task which opens

up tremendous prospects for all. The shareholders of MEDGRID want to participate in it and implement projects by mobilizing their synergies.

MEDGRID aims to work closely with the authorities of related countries, the European Commission, the scientific community, banks and development funds and nongovernmental organisations.

MEDGRID will consider the energy policy objectives to be put into effect by 2020 in the EU third energy-climate package and in the solar Plans of the MS&E.

### **5. CHALLENGES TO BE FACED BY MEDGRID**

In order to support the development of a transmission grid across and around the Mediterranean Basin, MEDGRID has five commitments:

- The elaboration of the Mediterranean Grid Master Plan with time horizons of 2020 and 2030 ;
- The promotion of a regulatory and institutional framework for the exchange of green electricity ;
- The assessment of the profitability of the interconnections and the benefits of electricity trade on growth, economic activity and employment ;
- The development of technological and technical cooperation with South and East countries in the area of power grids ;
- The promotion of advanced high voltage direct current (HVDC) technologies for power transmission.

In order to share a common vision with its partners and stakeholders on the results of all these commitments, MEDGRID has to consider the large amount of works already carried out in the last 15 years to study the development of network infrastructures around and across the Mediterranean Sea.

Therefore the consortium has to cooperate with a certain number of existing initiatives and organisations dealing with similar subjects: ENTSO-E (European Network of Electricity Transmission Systems Operators), EU funded projects (REALISEGRID, TWENTIES, Paving the way for the Mediterranean Solar Plan), OME (Observatoire Méditerranéen de l'Énergie), COMELEC (Committee of Electricity companies from Algeria, Libya, Morocco, Mauritania and Tunisia), MEDELEC (Liaison Committee of electrician's associations of the Mediterranean basin), AUE (Arab Union of Electricians).

Moreover, MEDGRID's work is conducted in coordination with other MSP projects, with DII

(DESERTEC Industrial Initiative) which promotes the creation of large wind turbines and solar plants in North Africa and the Middle East [2]; the MEDGRID initiative working in the field of transmission networks and DII are complementary.

## 6. MEDGRID WORKING PROGRAM TO FACE THESE CHALLENGES

In all the domains that will be considered by MEDGRID, the first step of the works will be to collect the available studies, information and data, and to identify the types of activities to be carried out to reach the objectives.

### 6.1 Master Plan

National generation and transmission grid master plans including the renewable energy national master plans from all the Mediterranean countries are necessary to prepare the Mediterranean Grid Master Plan. Updating those national plans when necessary is a part of the consortium works.

A commonly agreed approach will be defined in order to have homogeneous plans compliant with similar criteria, e.g. satisfaction of power needs at peak load and high reliability standards.

The next step will be the detection of opportunities for power exchanges, exploiting the different peak load periods of the different countries, the non-synchronous daily peak load, the energy mix with different production costs and the different environmental performances (CO<sub>2</sub> emissions).

For each identified opportunity, the feasibility and cost of the infrastructure project to take advantage of this opportunity will be assessed.

This assessment will consider the results of the existing feasibility studies of projects across the Mediterranean Sea carried out recently (figure 1): ELMED HVDC link between Sicily and Tunisia (1000 MW), the HVDC link between Italy and Algeria (1000 MW), the HVDC link between Italy and Libya (1000 MW) [3], the link between Italy and Malta [4], and the MEDRING studies [5] [6] and their update [7] [8] [9] [10].



Figure 1: existing submarine links and potential transmission projects in the Mediterranean basin.

### 6.2 Economic analysis

Based on existing data and updated national generation and grid master plans, opportunities of power exchanges will be studied. The objective is to elaborate reliable methods and tools to assess the economic performance and profitability of the interconnection and transmission infrastructures, based on relevant business models: combined generation and transmission investments, transmission projects invested by TSOs, or transmission merchant lines by private investors.

The assessment of the benefits brought by new transmission links will capture all the potential benefits not only limited to the export of green power from the south to the north, such as the reduction of local capacities for peak demand, the sharing of power reserve, and the economic energy exchange in both directions (outside the peak periods), the reduction of transmission congestion costs (in a meshed system).

Other criteria as suggested by REALISEGRID study [11] may be considered, such as social welfare, reduction of wind overproduction, of load shedding, of CO<sub>2</sub> emissions and of the cost for external fuel as proposed by REALISEGRID.

### 6.3 Finance aspects

The consortium aims to give recommendations on relevant financing models taking into account the different risks of capital intensive projects resulting from the Master Plan.

The market perspectives and the revenue models associated with merchant lines or infrastructures owned by transmission system operators in a context of subsidized renewable energies will be studied to clarify the business plan of the interconnections.

### 6.4 Regulation aspects

An adequate regulation framework in all the Mediterranean countries should allow and facilitate the exchanges of power between them. The model of revenue may differ significantly according to the regulation model if it is based on availability (when imbedded into the existing systems) or on the energy transmitted through capacity allocation mechanisms.

In this perspective, MEDGRID will promote a harmonized regulatory environment to support the construction and operation of interconnections around and across the Mediterranean Sea, regarding the exchanges of electricity, the implementation of Article 9 of the EU Directive 2009/28/CE and the rules for merchant lines.

### 6.5 Technologies for HVDC transmission in the Mediterranean basin

A number of transmission infrastructures already exist in the Mediterranean Sea. With one exception, the existing links use the HVDC technology. This is due to the fact that HVDC is a more economical solution than HVAC in submarine options where distances are greater than about 50 km.

This technology is well proven for transmitting large amount a power under the sea, as for example is the case for the Cross Channel 2000 MW HVDC link between the French and British grids [12].

The oldest Mediterranean transmission link was commissioned in 1965: it was the SACOI link between mainland Italy, Corsica and Sardinia, which became in 1987 the first multi terminal HVDC scheme by the addition on the 200 MW / +/- 200 kV main link of a 50 MW tapping station in Corsica [13]. The mercury arc valves of the old converter stations were replaced in 1992 by thyristor valves when the main converter stations were upgraded to 300 MW [14].

The first interconnection through the Mediterranean Sea is the Morocco-Spain HVAC scheme (2 x 700 MVA / 400 kV) commissioned in 1997 and 2006.

The next transmission schemes in the Mediterranean all used HVDC technology: GRITA between Italy and Greece (500 MW / +/- 400 kV) commissioned in 2001 [15] [16] [17], SAPEI between mainland Italy and Sardinia (2 x 500 MW / +/- 500 kV) commissioned in 2009 and 2011 [19], and Romulo between mainland Spain and the island of Mallorca (400 MW / +/- 250 KV) commissioned in 2011 [19] [20].

The promotion of technical solutions adapted to the specific conditions of the Mediterranean basin will require new developments to go beyond the existing performances:

- increasing the transmission capacity by using higher DC voltages;
- designing deep sea cables to have the possibility to consider more options for cable routing;
- large power multi terminal HVDC schemes or HVDC grids in order to have possible options when several connections could benefit from utilizing partly the same infrastructure.

In the area of technologies, MEDGRID will consider the results of other initiatives such as for the North and Baltic Seas grids. But this will mainly apply to the development of HVDC grids and associated equipment (VSC converters, polyethylene cables, DC circuit breakers and protections).

In the Mediterranean Sea context, the feasibility of deep water cables is a specific concern, and the actual record of 1650 meters was reached for the SAPEI HVDC project.

MEDGRID will consider all the options to speed up the development of these technologies.

## 7. CONCLUSION

Interconnections in the Mediterranean basin are at a very early stage, presently limited to a Morocco-Spain link. Clearly, all the following key factors are in favor of a large modern grid in the Mediterranean basin: electricity from renewable energies to limit the climate change, exploitation of essential valuable and unlimited renewable energy resources based on sun and wind, economic and social growth, recent technological and industrial progress.

The roadmap of MEDGRID is focusing on 2020, in accordance with objectives of the European energy-climate package and of the South and East countries' solar plans; the Mediterranean master plan of the trans-Mediterranean interconnections by MEDGRID has also got to be designed for the doubling of the electricity consumption in the south and east countries by the date set.

MEDGRID is a co-development project, which creates the best conditions for materializing this vision of the future Mediterranean grid and electricity market.

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