Session 1: Toward a Common Maghreb Vision for Optimized Use of Resources in the Region

Needs for new infrastructures in the Maghreb region to cope with energy demand growth and integration of growing RES generation

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RES4MED
Summary

- The Context for integration of RE
- Mediterranean interconnections: where are we now?
- Mediterranean interconnections: key drivers
- Development of power transmission infrastructures: scenarios and CBA
- Conclusions and recommendations
The two shores of the Mediterranean Sea will have to respond to different sets of challenges

**North**
- Economic downturn and energy efficiency measures slowed power demand increase
- **Key Elements**
  - Sluggish demand growth
  - Little investment needed in new additional capacity
  - Decommissioning inflexible surplus capacity will require very high investments in the long run

**South**
- SEMCs in a phase of political transition; rapid rising electricity demand requires solutions
- **Key Elements**
  - Strong energy demand growth (increase by 81% for 2010 to 2050)
  - Population boom
  - Large general investment needed in the short term
Renewable energy targets* in SEMCs area

**RENEWABLE ENERGY INVESTMENTS**
Cumulative public and private investments in RES power plants to reach country targets

*Target as % of: total electricity and thermal energy (Lebanon); primary energy (Jordan), RES4MED elaboration. Investment figure for Tunisia (STEG data)
1. Public Competitive Bidding
Wind Target: 1,000 MW
Solar Target: 1,000 MW

Wind Tendered: 1,000 MW
Solar Tendered: 510 MW

2. Third-Party Supply

3. Competitive Bidding (EPC)
Wind planned: 3,140 MW
Solar planned: 77 MW

3. Competitive Bidding (BOO)
Wind planned: 750 MW
Wind Tendered: 500 MW
Solar planned: 450 MW
Solar tendered: 450 MW

4. Merchant Scheme
Wind planned: 920 MW

1. Feed-in Tariff
Wind planned: 2,000 MW
Solar planned: 2,300 MW

2. Public Competitive Bidding
Wind planned: 3,140 MW
Solar planned: 77 MW

3. Competitive Bidding (BOO)
Wind planned: 750 MW
Wind Tendered: 500 MW
Solar planned: 450 MW
Solar tendered: 450 MW

4. Merchant Scheme
Wind planned: 920 MW

Direct Proposal Submission
Round 1: 13 PPAs concluded at $0.17 per kWh for 210MW aggregate PV capacity
Round 2: 4x50 MW proposals have been selected (200 MW), PPAs concluded in the range $0.0613-$0.0767 / kWh

Supporting Policies for Large-scale Projects

- Feed-in Tariff
  - Wind planned: 5,010 MW
  - Solar PV planned: 13,575 MW
  - Solar CSP planned: 2,000 MW
- 1. Feed-in Tariff
  - Wind target: 1,755 MW
  - Solar PV target: 1,510 MW
  - Solar CSP target: 460 MW

- 2. Public Competitive Bidding
  - Wind tendered: 500 MW
  - Solar tendered: 450 MW

- 3. Competitive Bidding (BOO)
  - Wind tendered: 510 MW
  - Solar tendered: 450 MW

- 4. Merchant Scheme
  - Wind planned: 920 MW

ALGERIA
TUNISIA
TURKEY
MOROCCO
EGYPT
JORDAN
## Industrial Perspective to address RES growth - RES Regulatory Framework Overview

### Lesson learned

<table>
<thead>
<tr>
<th><strong>Advantages</strong></th>
<th><strong>Disadvantages</strong></th>
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<tbody>
<tr>
<td>- Attractive even for <em>low-risk investors</em></td>
<td>- <strong>No meritocratic approach</strong></td>
</tr>
<tr>
<td>- <strong>Impressive capacity boost</strong> generated by this solution</td>
<td>- <strong>Wrong tariff setting</strong> can lead to RES under- or over-development vs. target</td>
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<tr>
<td>- Simple structure, applicable to mass market technologies: <em>E.g. decentralize energy</em></td>
<td>- <strong>Limited adaptability</strong>: in case of technology rapid evolution, many changes required</td>
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<tr>
<td></td>
<td>- In case of large premium offered, <strong>high system cost</strong></td>
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</table>
| **Feed in Tariffs**
  e.g.:  
  • Italy  
  • Germany  
  • Greece  
  • France | |

| **PPA trough Auctions**
  e.g.:  
  • Brazil  
  • South Africa | |
| - **Effective use of budget** | - **Risk of not prequalified players** to under-bid disrupting competition |
| - **Specific capacity targets** can be set | - Remuneration value strongly linked to **competition level** |
| - **Meritocratic mechanism** with cheapest and higher quality projects selected | - **Not pre-defined** when a player decides to enter |
| - **Learning effect** over time for both parties | - **Not adequate for small size projects** |

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**Two different approaches to develop renewables were selected globally with substantial different effects on the national energy systems**
A combination of price competition, long-term contracts, good resources and financial de-risking measures is creating deployment opportunities in newer markets and at lower costs
The context for transmission infrastructure in a nutshell

- Deployment of power transmission corridors is a key factor for a sustainable development in the Mediterranean Area.

- Construction of power transmission infrastructures takes between 10 and 15 years.

Need for building reference scenarios on the basis of which rigorous Cost Benefit Analysis of the new infrastructures is applied.
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Overview of the power system pools around the Mediterranean basin (1/2)

Two synchronous power pools:
- Maghreb, ENTSO-E, Turkey
- Mashrek

Isolated systems:
- Israel; Cyprus; Crete
- Malta (synchronised with ENTSO-E on April 9th, 2015)
Yearly energy exchanges

Source: ENTSO-E

Yearly energy exchanges just for mutual support with exception of Morocco-Spain: 5.8 TWh of energy import from Spain in 2014 based on bilateral contracts

Net transfer capacity: 1.1 GW internal + 0.7 GW between MO-SP

Net Transfer Capacity: 64 GW

14.5% of the internal demand
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Transmission network corridors Euro-Med region: axes of development

Different drivers prompting interconnection development along the various axes

North-North axis

North-South axis

South-South axis
North-North axis: key facts

<table>
<thead>
<tr>
<th>ELECTRICITY CONSUMPTION [TWh]</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENTSO-E</td>
<td>3 360</td>
<td>3 339</td>
<td>3 336</td>
<td>3 255</td>
<td>3 210</td>
</tr>
</tbody>
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- **150 TWh** of demand in 5 years, more than the total demand of Maghreb
- **Generation surplus across Europe**, which can export power to Maghreb facing on the contrary a steady demand growth
- **The European transmission system** is undergoing a rapid and profound transformation, prompted by two main drivers
Grid development in Europe: drivers (1/2)

1\textsuperscript{st} driver: integration of RES generation

The dramatic change in the generation mix is calling for substantial investments in the transmission grids.

The TYNDP 2014 of ENTSO-E estimates about \textbf{150 b€ of investments by 2030 in transmission grid expansion.}

The vast majority of new transmission reinforcements is related to the integration of RES generation:
“approximately 80\% of the projects of pan-European significance help integrate RES either by directly connecting RES or by transporting RES power to end-consumers” \footnote{ENTSO-E TYNDP 2014}
Grid development in Europe: drivers (2/2)

2nd driver: market integration

A full day-ahead market integration has been achieved in 2015.

Market coupling already adopted from the Iberian peninsula to Nordpool. Italy joined the EU market coupling in Febr. 2015,…

... nevertheless price differentials between market zones occur frequently.

Need for cross-border network reinforcements to increase the “Net Transfer Capacity”

Average monthly prices in main European regions (source GME)
Impact of growing distributed generation on the grid

In Italy electricity flow is no more unidirectional from large power plants to final clients.
Southern Med countries: surge in power demand

- Impressive demand growth, both in energy and peak load
- Similar situation to what Italy and other Western European Countries experienced in the ’60s

<table>
<thead>
<tr>
<th>Country</th>
<th>2014 (TWh)</th>
<th>2030 (TWh)</th>
<th>CAGR (%)</th>
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<tbody>
<tr>
<td>Algeria</td>
<td>63.0</td>
<td>117.6</td>
<td>4.3%</td>
</tr>
<tr>
<td>Egypt</td>
<td>181.9</td>
<td>439.8</td>
<td>6.1%</td>
</tr>
<tr>
<td>Libya</td>
<td>43.0</td>
<td>100.6</td>
<td>5.8%</td>
</tr>
<tr>
<td>Morocco</td>
<td>35.9</td>
<td>74.4</td>
<td>5.0%</td>
</tr>
<tr>
<td>Tunisia</td>
<td>18.4</td>
<td>39.9</td>
<td>5.3%</td>
</tr>
<tr>
<td><strong>TOTAL Demand</strong></td>
<td><strong>342.0</strong></td>
<td><strong>772.3</strong></td>
<td><strong>5.6%</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>1960 (TWh)</th>
<th>1973 (TWh)</th>
<th>CAGR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>47.6</td>
<td>125.8</td>
<td>7.8%</td>
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Priority: to achieve generation adequacy and a reliable transmission system
Potential outpaces progress towards national targets

- Visible momentum, but acceleration needed to achieve targets
- Lack of policies for large scale deployment of distributed PV and SHC
- An impressive amount of variable res

Annual RE additions (GW) for MENA

Targets (GW) the way to go ...for MENA in 2020

Notes: *Proposed in national roadmap, **Solar only, ***By 2016
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Problems to overcome to enhance generation from non-programmable RES

1) Difficult upward transitions: load following

Example of Italy

Difficult transitions during load ramp up/down

14 GW of load ramp in the evening to be covered by dispatchable generation and import

Gradient of generation

Load Request

Wind + Solar

Time (min)
2) Network congestions caused by RES generation:

- Sun and wind are location dependent – often remote locations w.r.t. the demand centres
- No correlation between demand and non-programmable RES generation location - power flowing on longer patterns through the network with risk of creating “scattered” congestions also relatively far away from RES generation areas

Expected congestion in the 150 kV of the Italian peninsular regions due to WF (year 2009) – (source: CIGRE, CESI-Terna paper)
Problems to overcome to enhance generation from non-programmable RES

3) Critical dynamic behavior of the system caused by

- Intermittency in RES generation causing a higher stress on the conventional units to balance the system

- Faults (e.g.: short circuits on a network component)

Risk of cascading effect leading to the system collapse

![Solar Radiation (W/m²)](image)

![Wind speed (m/s)](image)

![Frequency (Hz)](image)
4) Risks of RES generation curtailment depending on:

- In)flexibility of power plants
- (in)adequacy of the transmission /distribution infrastructures (including cross-border lines)
- Possibility of energy storage
- Demand responsiveness

Different feasible penetration levels of non-programmable RES generation
Additional reserve and balancing capability

Risk of overgeneration in low loading conditions

Difficult transitions in the ramp up/down hours

Network congestion

Voltage profile and reactive power management

Critical behaviour of the system in dynamic conditions

Curtailed RES generation !!!

Problems to overcome to enhance generation from non-programmable RES
Methodology proposed

**Methodology:** the analysis process to be undertaken to assess the permissible penetration of RES generation, either programmable and non-programmable, in the three Maghreb countries.

**Scenario:** building a “baseline” scenario for the target years (2020 and 2030).

**Factors to be considered:**
- trends of the internal demand,
- the already planned power plants, either conventional or from RES,
- the already planned transmission infrastructures
- the potential of RES generation split in the various categories (solar –PV, CPV, CPS-, wind, biomass) and geographical location (at least at a macro-scale).
Cost-Benefit Analysis (CBA) applied to transmission networks

1. Sharing of forward scenarios with all involved stakeholders

2. Execution of CBA:
   ✓ Assessment of cost components: TOTEX concept
   ✓ Identification of benefit indicators to be quantified and, as far as possible monetised.

Source: ENTSO-E TYNDP 2014
Development of the European system (1/2): scenarios

Four Scenarios (Visions) built to cope with uncertainties for target year 2030.

They:

- are to be intended as plausible future states obtained from a set of selected drivers
- shall cover a sufficient wide range of alternatives to cope with the major uncertainties

Source: ENTSO-E
Development of the European system (2/2): scenarios

- **B1. Improved security of supply (SoS)** is the ability of a power system to provide an adequate and secure supply of electricity under ordinary conditions;

- **B2. Socio-economic welfare (SEW)** or market integration is characterised by the ability of a power system to reduce congestion and thus provide an adequate GTC so that electricity markets can trade power in an economically efficient manner;

- **B3. RES integration:** Support to RES integration is defined as the ability of the system to allow the connection of new RES plants and unlock existing and future “green” generation, while minimising curtailments;

- **B4. Variation in losses** in the transmission grid is the characterization of the evolution of thermal losses in the power system. It is an indicator of energy efficiency and is correlated with Socio-economic welfare.

- **B5. Variation in CO2 emissions** is the characterisation of the evolution of CO2 emissions in the power system. It is a consequence of B3 (unlock of generation with lower carbon content).

- **B6. Technical resilience/system safety** is the ability of the system to withstand increasingly extreme system conditions (exceptional contingencies)

- **B7. Flexibility** is the ability of the proposed reinforcement to be adequate in different possible future development paths or scenarios, including trade of balancing services.
Med-TSO is the Association of the Mediterranean TSOs operating the grids of 18 Mediterranean Countries.

The mission of MED-TSO is to promote the coordination of the development plans and the electric grids operation of Med-TSO Countries.

Recent cooperation with CESI for evaluating Projects and ranking their priority in the Mediterranean Area:
- Definition of common scenarios
- CBA

Kick-off meeting held on 6th October 2015 in Rome

Source: MED-TSO
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South-South:

- **South-South integration is a key priority** to face the demand rapid growth and foster the implementation of the RES generation policies (*).

- **Existing “south-south” barriers should be swiftly overcome**: many of the barriers are costless, such as the enhancement of transparency.

- A **progressive reduction/elimination of internal subsidies** applied indiscriminately to all categories of consumers is also important to foster power exchanges.

- **Agreement on rules for the cross-border trading of electricity** is a further priority.

- When deciding new interconnections, **coordinated system analyses** should be undertaken since a reinforcement across a border can have an impact on the whole system.

(*): South-North interconnections can also improve SoS in Southern Med countries.
Conclusions and recommendations (2/2)

North-South:

- **North-South transmission infrastructures** can be very helpful for power export from Europe to Maghreb to mitigate the generation investment effort in North Africa in the mid term. These infrastructures can be later exploited for **South-North power export** following a massive deployment of RES generation in North Africa.

- **Need for shared scenarios and CBA** to help attract investments also from the private sector (see the Italy-Tunisia case).

- **RES4MED** can play a pivotal role in harmonising the policies for RES generation deployment, particularly in Maghreb.

- The ongoing **Med-TSO “Regional Market Study”** being **carried out by CESI** is an outstanding example of integrated pan-Mediterranean analysis.
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Thank You for your kind attention!

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