Electricity interconnection projects between North Africa and Europe: challenges and opportunities

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Outline

- ❑ Background
- ❑ Status of the power systems of SEMC (Southern and Eastern Mediterranean Countries)
- ❑ MedRing closure: update and challenges
- ❑ Routes of cross-Mediterranean interconnections
- ❑ HVDC links projects
- ❑ Potential future developments: SuperGrid concept
- ❑ Benefits of EU-SEMC interconnections
- ❑ Challenges of EU-SEMC interconnections

Background

- First studies of potential European – North Africa interconnections date back to the 1970ies
- First interconnection (1997): Spain-Morocco (HVAC)
- Feasibility studies of HVDC links (1990ies – date)
- MedRing study (2000-2003)
- MED-EMIP – MedRing project update (2009-2010)
- Currently ongoing ambitious initiatives: DESERTEC, Transgreen
- EU strategy

Background: EU strategy

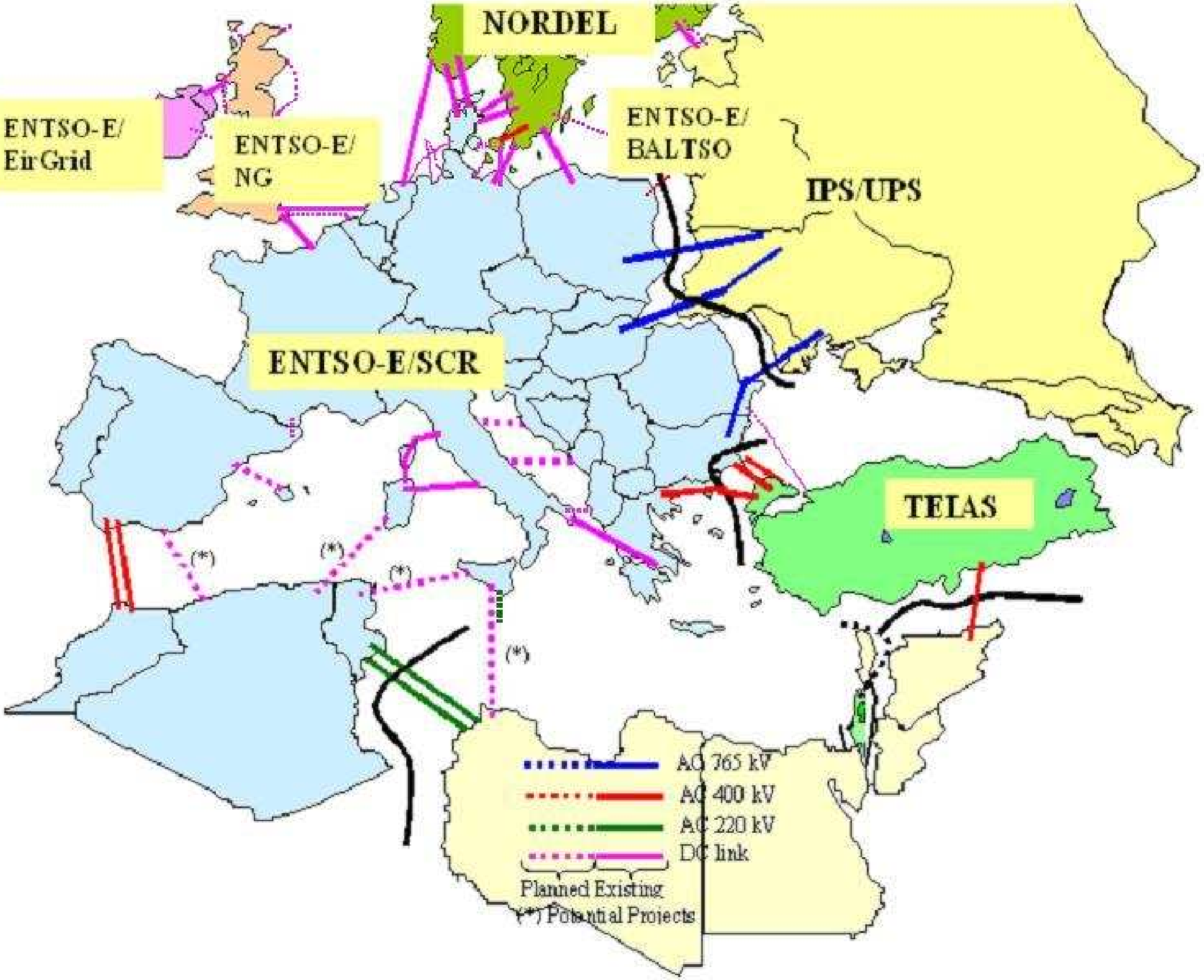
- Barcelona process (1995)
- EL.9 in TEN-E priority projects (from 2004)
- Union for the Mediterranean (2008)
- In the Second Strategic EU Energy Review of November 2008, the European Commission proposes: “A Mediterranean energy Ring now needs to be completed, linking Europe with the Southern Mediterranean through electricity and gas interconnections. In particular the Ring is essential to develop the region's vast solar and wind energy potential”.
- Mediterranean Solar Plan (MSP) (2008)

Status of SEMC power systems

- Four separate blocs:
  - ENTSO-E/SCR + Morocco + Algeria + Tunisia
  - Libya + Egypt + Jordan + Syria + Lebanon
  - Israel and the Palestinian Territories
  - Turkey

Status of SEMC power systems

- Four separate blocs:

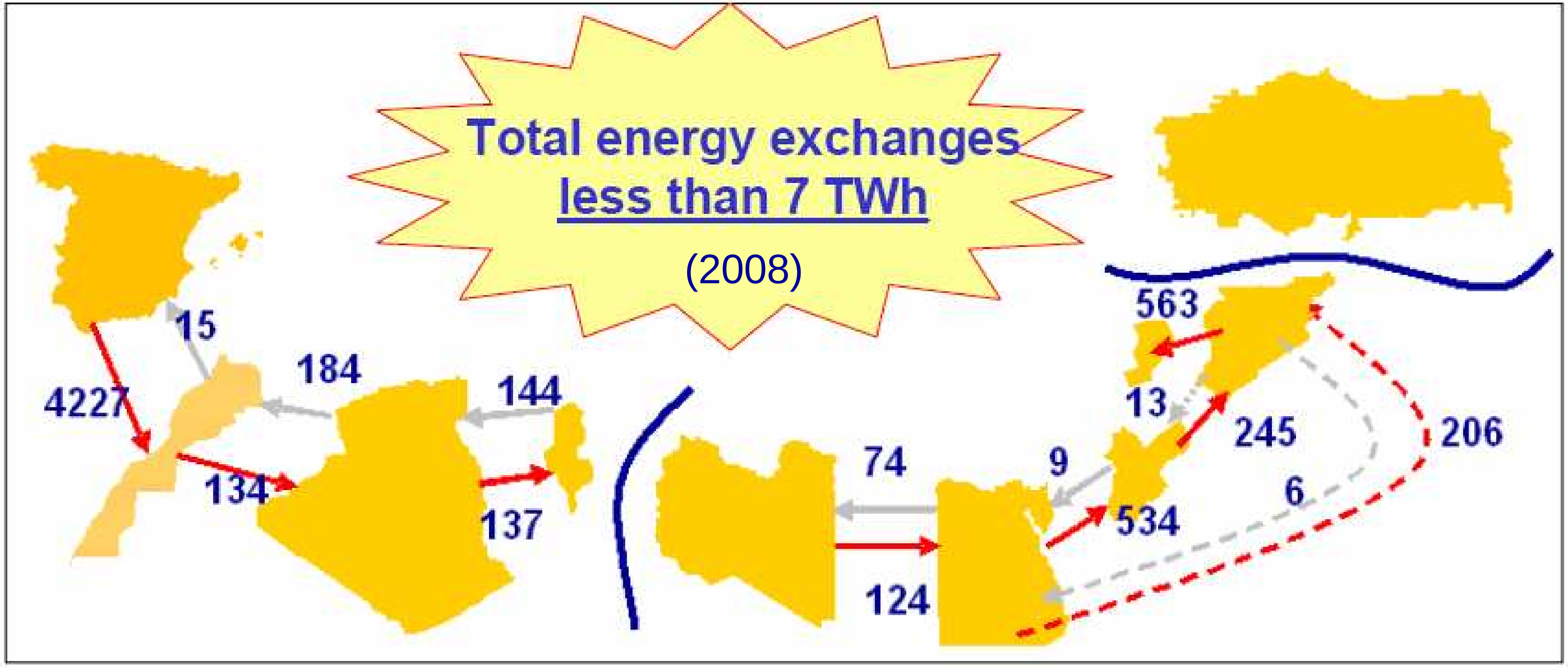


Status of SEMC power systems

- The operational reserve margin has significantly dropped over the last five years
- Morocco depends to a large extent on power supplies from Spain
- Syria and Lebanon resort to scheduled block wise load shedding
- Israel and (to a certain extent) Egypt show an increase in unsupplied energy
- There is simply not enough power capacity available in the region to satisfy domestic demand and engage in large-scale commercial export of power as well

Source: MED-EMIP (2010)

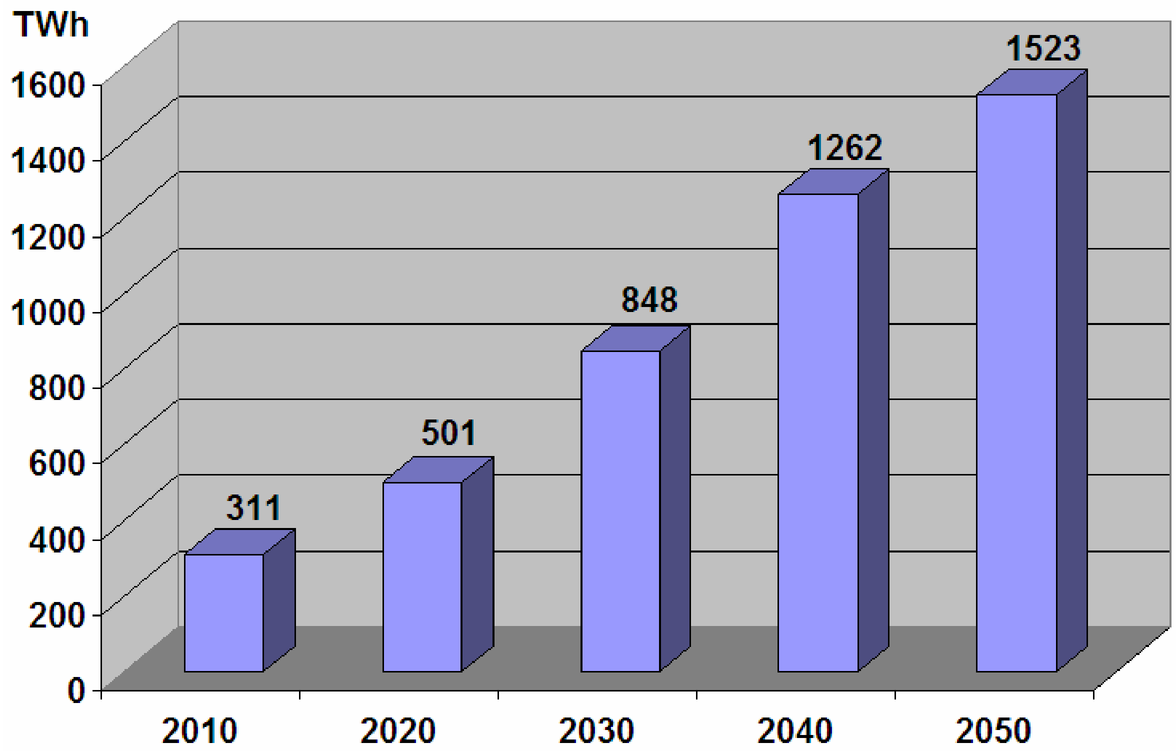
Power exchanges among SEMC



- The level of import/export in the last 8 years has not changed remarkably, except for Spain ⇨ Morocco, accounting for 4.2 TWh out of 7 TWh

Source: MED-EMIP (2010)

Forecasted electricity demand in SEMC



Source:
DLR (2009)

- Demand is forecasted to dramatically increase: fivefold by 2050, according to estimations by DLR
- … and official trend forecasts entail even higher values: 680 TWh in 2020 and 1200 TWh in 2030 (source: MED-EMIP)

Main challenge …

- Regardless of the chance of exporting electric energy to Europe, SEMC power systems will require substantial investments to cope with the rapidly increasing domestic demand
- As a (partial) alternative, significant investments in end use energy efficiency will be needed to mitigate demand growth
- A greater integration of SEMC power systems, by closing the Mediterranean Ring and increasing electricity exchanges, would be largely beneficial

Closing the MedRing

- On 28 April 2010 a second trial for a synchronous interconnection between Tunisia and Libya failed
- At the SEMC north-eastern border, on 18 September 2010 Turkey started a one-year trial period of network synchronization with ENTSO-E SCR (through Greece and Bulgaria)
- To allow synchronization of Turkey with ENTSO-E SCR, the interconnection of Turkey and Syria would not be synchronous for the time being: possibility of interconnection via full or back-to-back HVDC

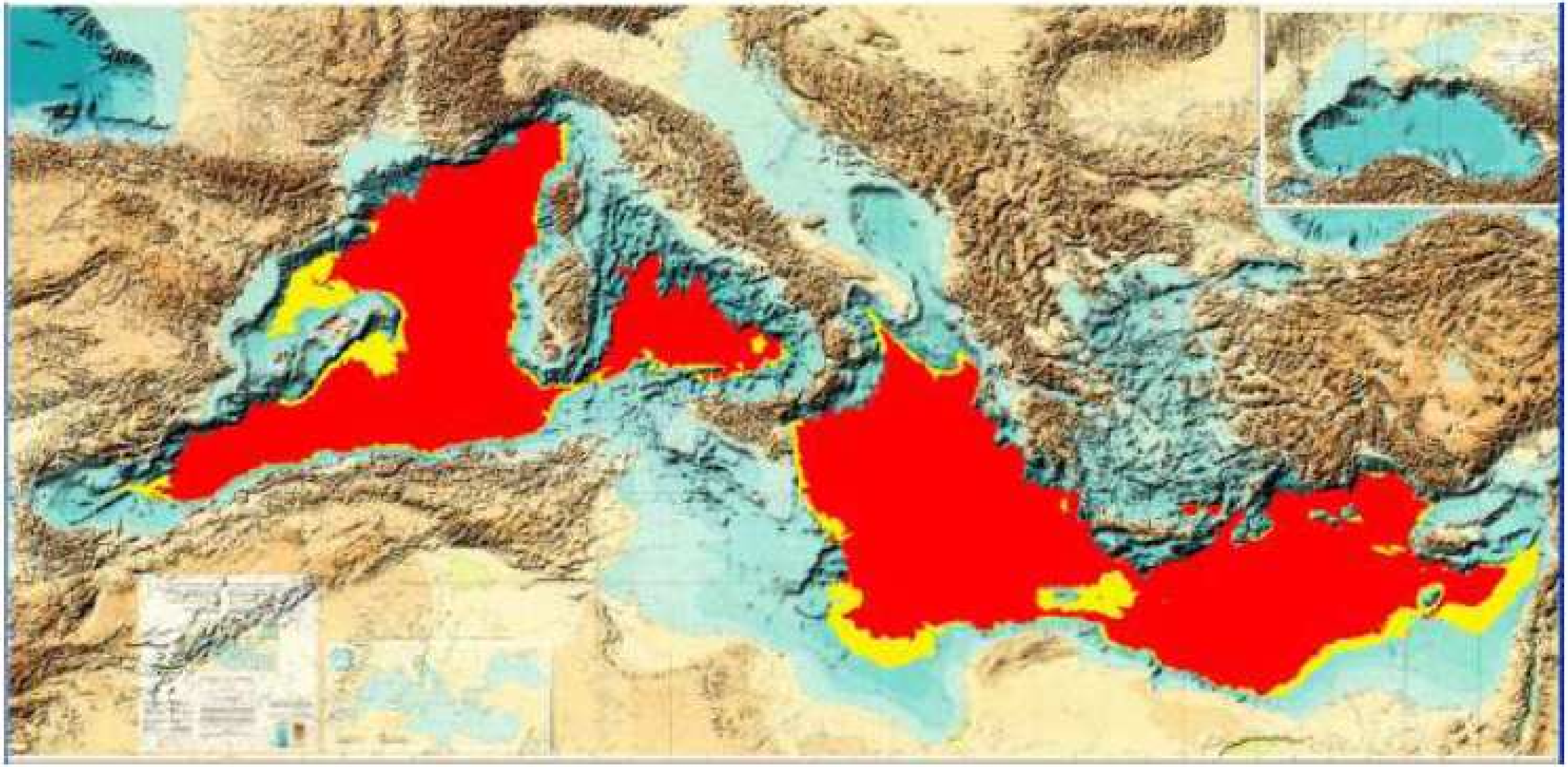
Closing the MedRing

- According to the MED-EMIP study (2010):
  - closing the Ring in AC mode is very complicated, mainly due to significant dynamic problems, that imply the adoption of high transmission reliability margins, therefore lowering net transfer capacities across the borders
  - NTCs may at best reach 400 MW at 400/500 kV
  - closing the Ring by full HVDC lines or back-to-back HVDC systems allows for higher net transfer capacities and for lower complexity in operating the interconnected systems
  - moreover, the “decoupling” allowed by the DC solutions ensures a greater “independence” of each investment, reducing uncertainties
- In any case, the MED-EMIP study (2010) concludes stating that the possibility of closing the MedRing using DC technology needs further investigation to explore its feasibility …

Routes to Europe

- In case of closure of the MedRing (and taking for granted the full synchronization of Turkey with ENTSO-E/SCR), two routes to Europe are available:
  - towards Spain at the western end of the Ring (current transfer capacity is 900 MW)
  - towards Turkey at the eastern end of the Ring
- Only two routes are not sufficient to accommodate the envisaged high RES electricity exchanges: it is necessary to cross the Mediterranean Sea by additional HVDC links
- The challenge is related to the crossed sea depth
- Current world depth record for HVDC submarine links is 1640 m, reached by the SAPEI in Italy
- 2000 m is currently considered as a technical limit

Routes to Europe

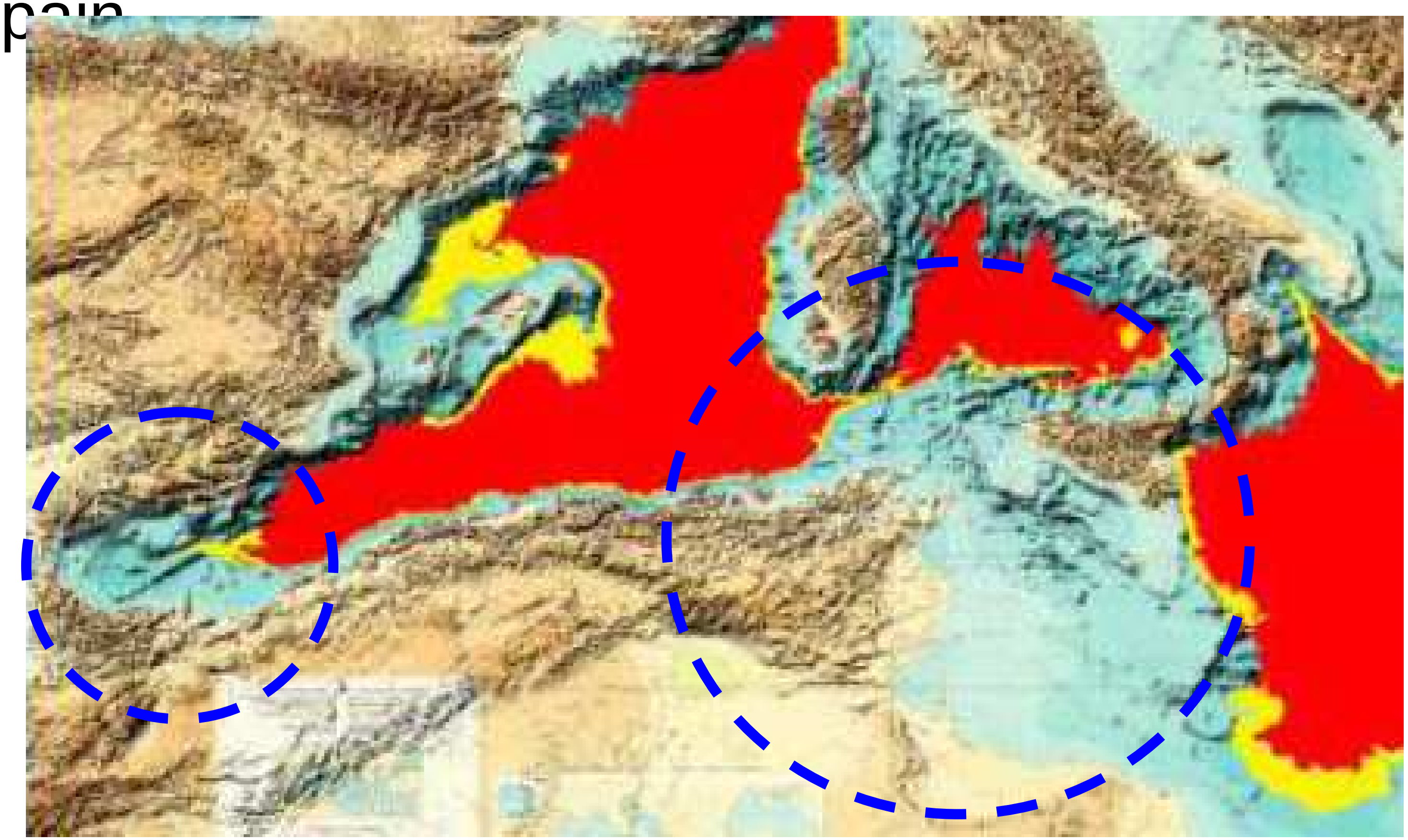


RED: depth levels exceeding 2000 m

Source: MED-EMIP (2010)

Routes to Europe

- Based on sea depth and current HVDC submarine cable technology, the feasible routes from North Africa to Europe are towards Italy and towards Spain



Routes to Europe

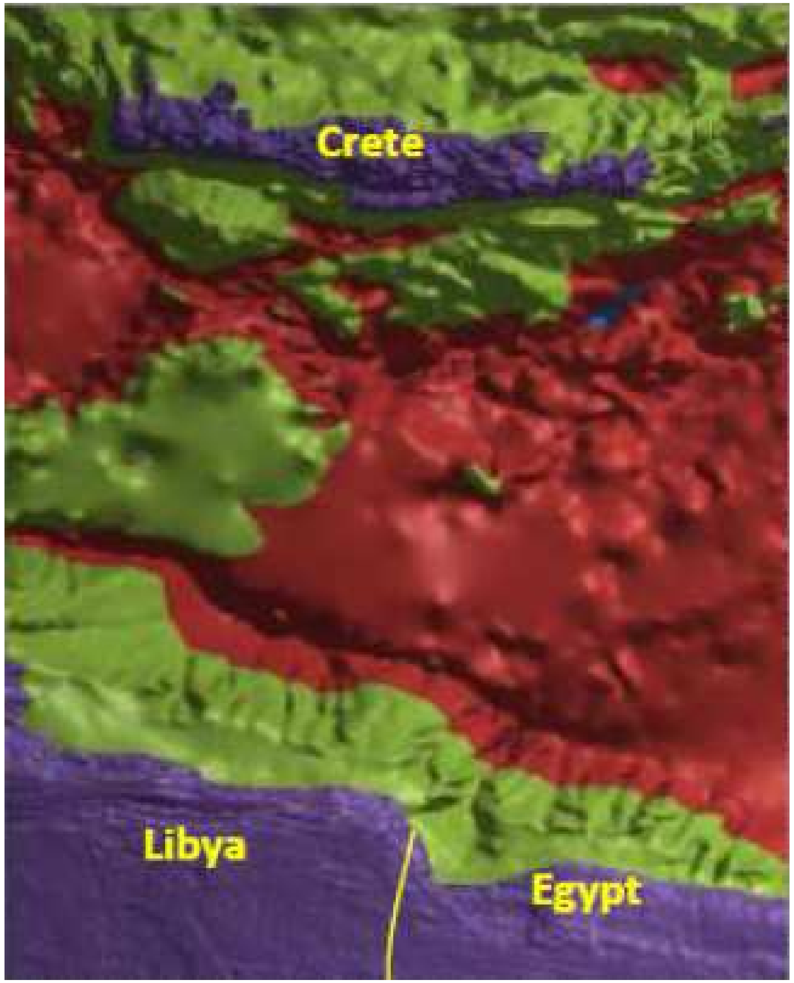
- ❑ Other routes have been considered:
  - ❖ from Libya to Crete-Greece-Turkey (DESERTEC)
  - ❖ from Egypt to Crete-Greece (Transgreen)

Source: Desertec

Source: Transgreen

Routes to Europe

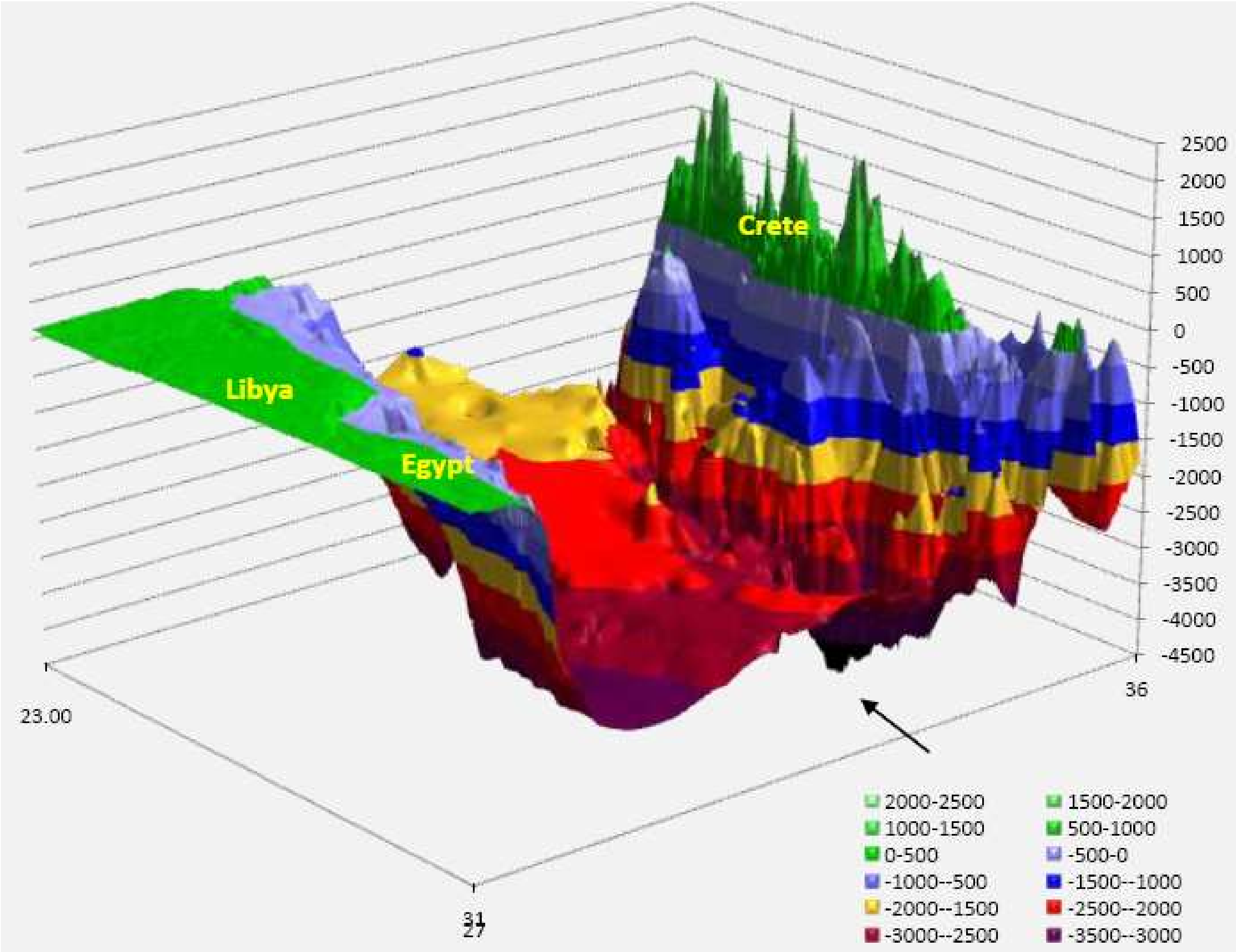
- … but they appear more challenging due to deep sea levels



RED: depth levels below 2000 m

Source: MED-EMIP (2010)

Routes to Europe

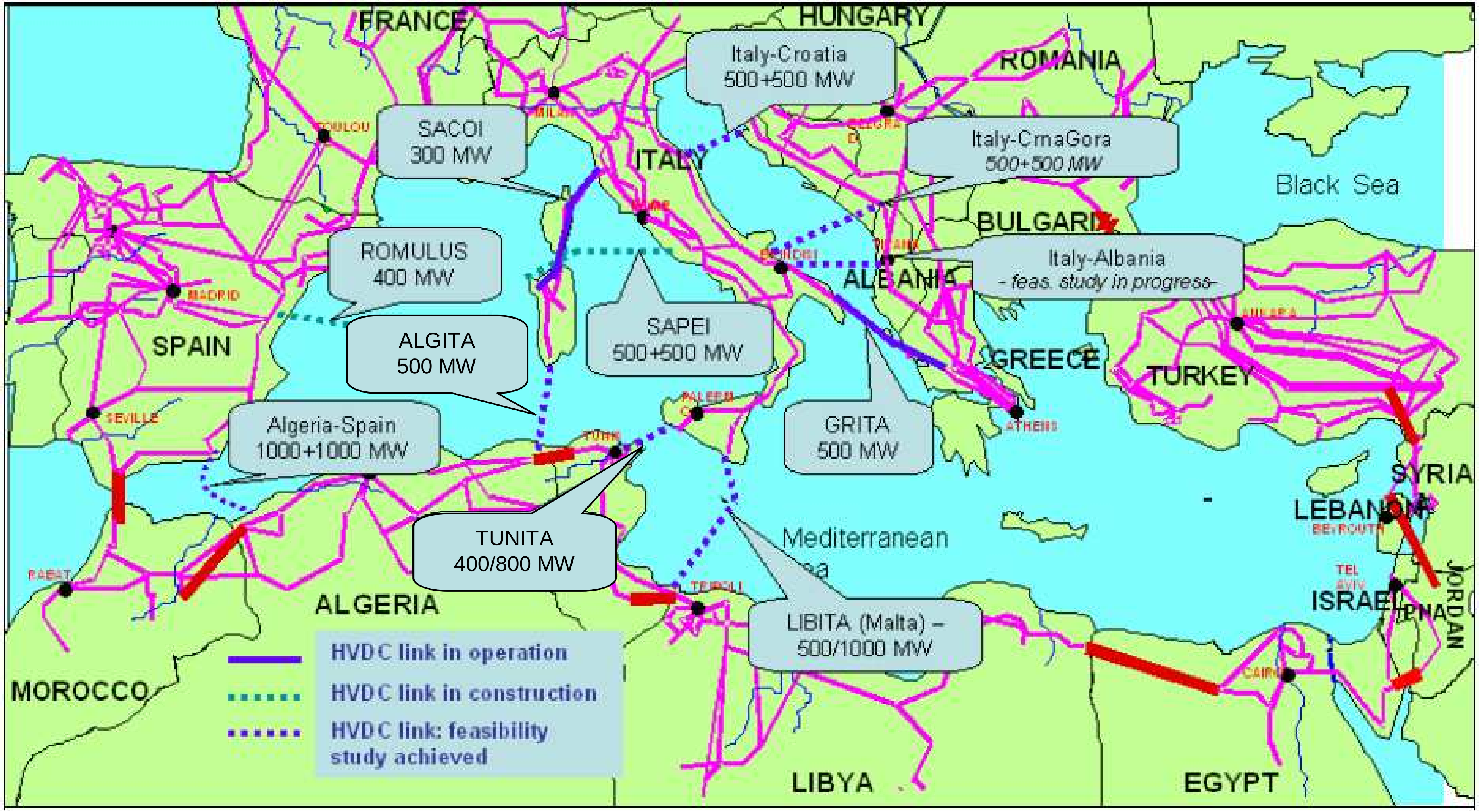


Source: MED-EMIP (2010)

HVDC links feasibility studies

- A number of feasibility studies for North Africa – Europe HVDC interconnections have already been carried out:
  - Algeria – Spain
  - Algeria – Italy
  - Tunisia – Italy
  - Libya – Italy
- All of them are based on projects aiming at exporting to Europe electric energy produced by new gas fired power plants: the possibility of exporting RES energy has not been considered yet

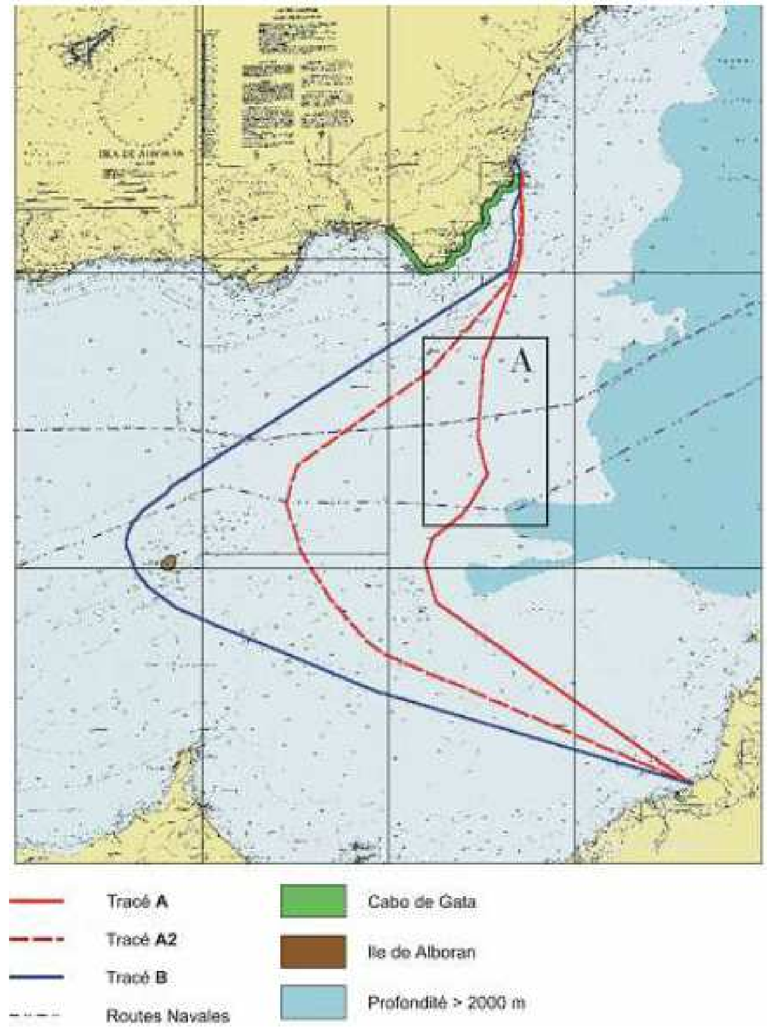
Mediterranean HVDC links



Source: MED-EMIP (2010)

Algeria - Spain

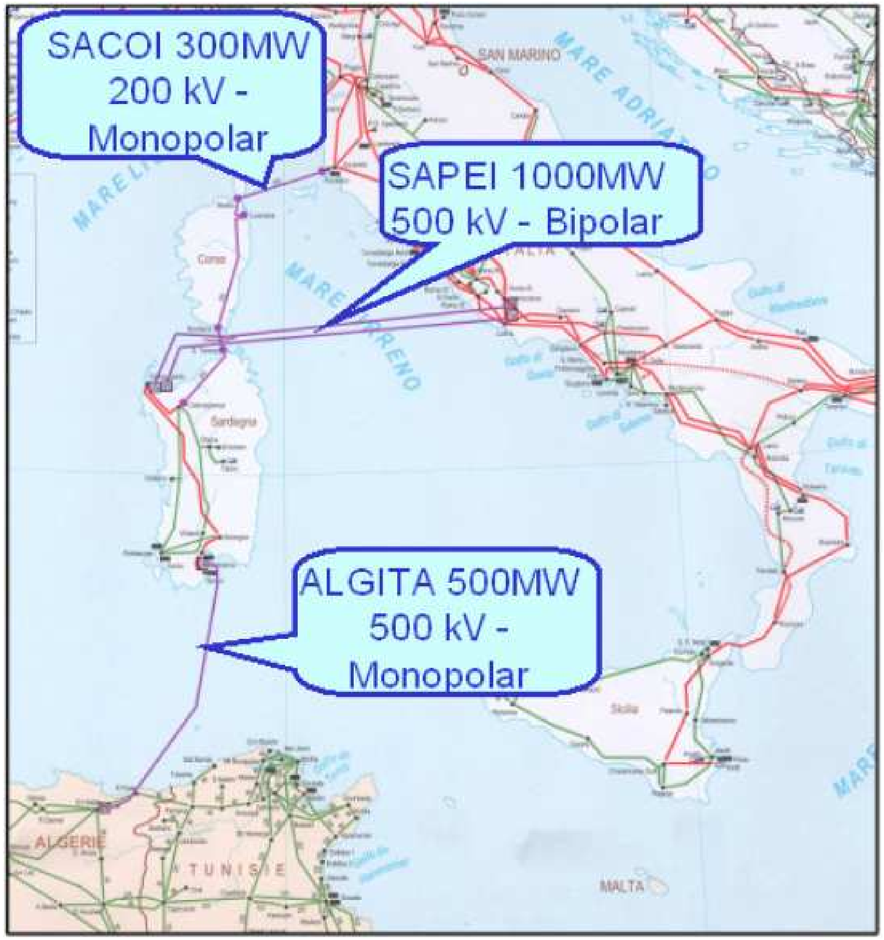
- ❑ Bipolar ±500 kV DC
- ❑ **Capacity: 2000 MW**
- ❑ Length: 240 km (optimal route A)
- ❑ Maximum sea depth: 1900 m



Source: MED-EMIP (2010)

Algeria - Italy

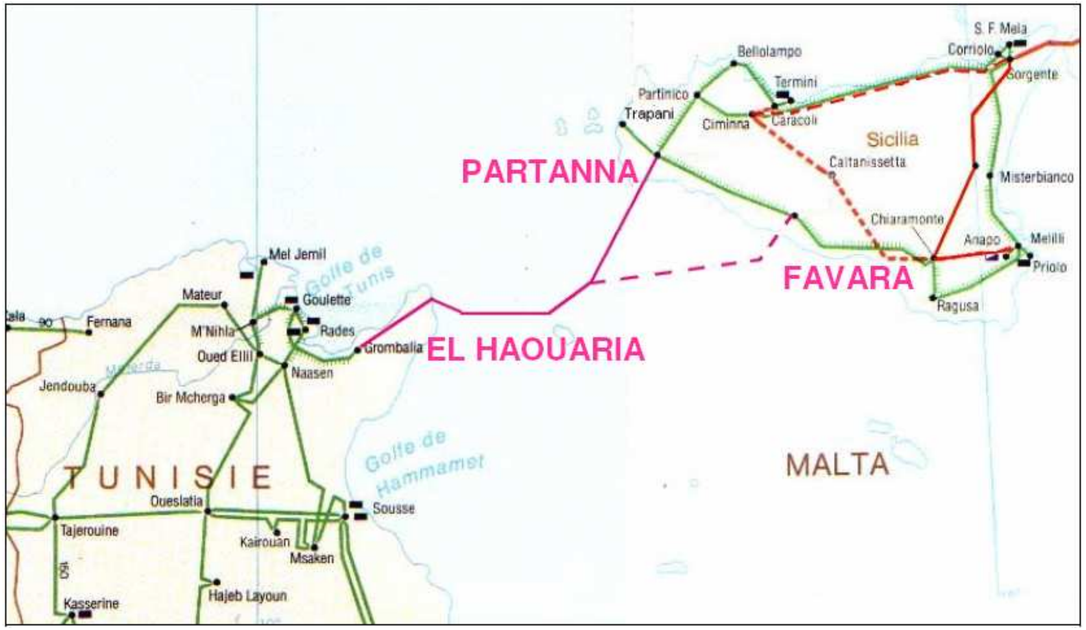
- ❑ Monopolar 500 kV DC
- ❑ **Capacity: 500 MW**
- ❑ Losses: 3.4%
- ❑ Length: 330 km
- ❑ Maximum sea depth: 2000 m (near to technical limits)
- ❑ Doubling the capacity would require doubling the 380 kV AC backbone in Sardinia



Source: MED-EMIP (2010)

Tunisia - Italy

- 1st stage: monopolar 400 kV DC – **Capacity: 400 MW**
- 2nd stage: bipolar ±400 kV DC – **Capacity: 800 MW**
- Losses: 3.4%
- Length: 194 km
- **Maximum sea depth: 670 m**
- **2nd stage requires the planned developments of the 380 kV Sicilian grid**



Source: MED-EMIP (2010)

Libya - Italy

- 1st solution: monopolar 500 kV DC - **Capacity: 500 MW**
- 2nd solution: bipolar ±500 kV DC - **Capacity: 1000 MW**
- Possibility of a third terminal in Malta is currently excluded (due to HVAC cable Sicily-Malta)
- Losses: 6-7%
- Length: 550/560 km
- Maximum sea depth: 550 m
- 2nd solution requires the planned developments of the 380 kV Sicilian grid

Source: MED-EMIP (2010)

Interconnection capacity needed

- The four above mentioned feasibility studies consider (at best) **4800 MW** of additional interconnection capacity between SEMC and Europe
- This would allow for energy exchanges in the order of max **35 TWh/year**, that is only 5% of the 700 TWh envisaged by the DESERTEC project
- This huge amount of RES energy to be exported to Europe moves the problem onto another order of magnitude!

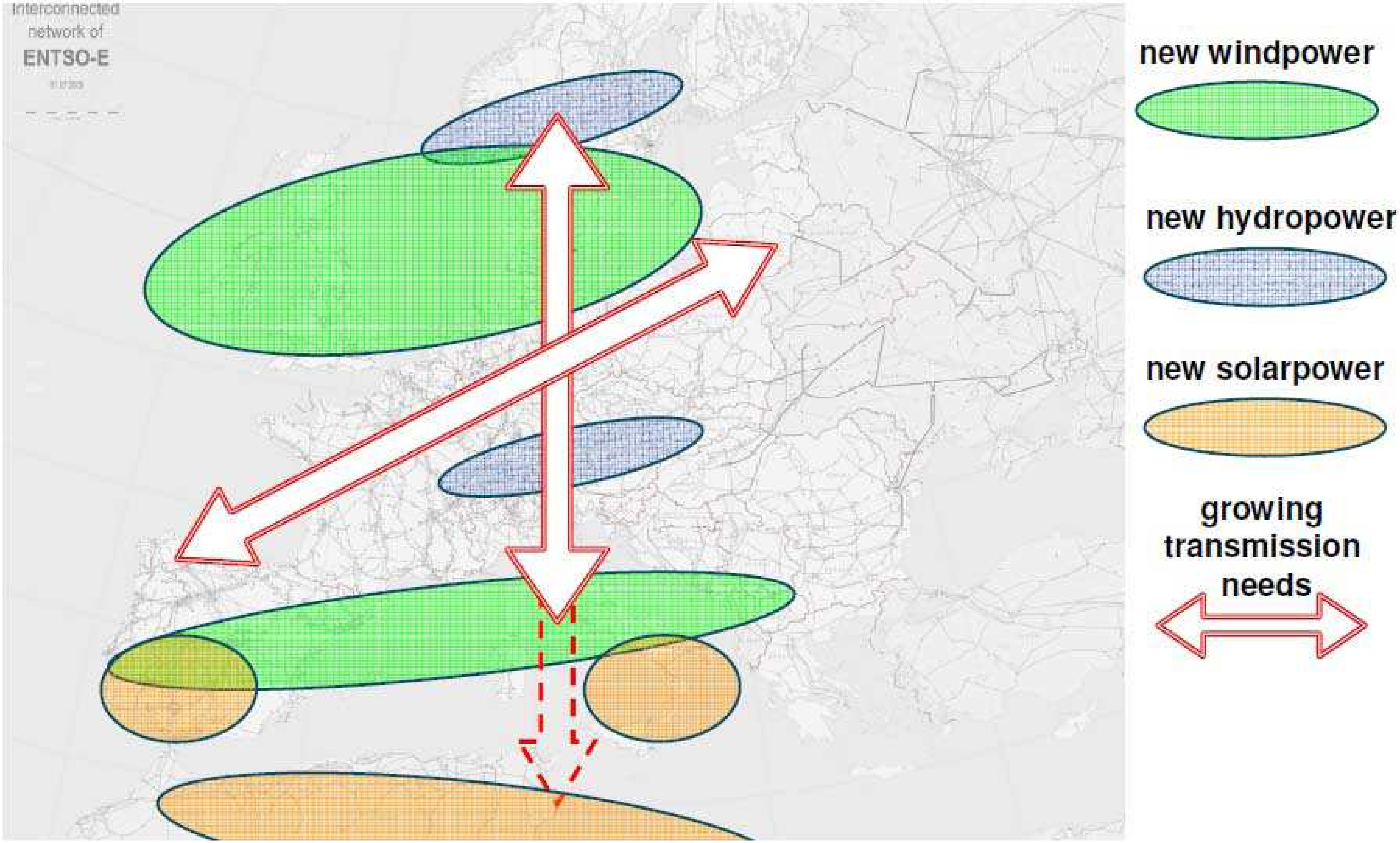
A new paradigm …

- This new order of magnitude requires not only a far larger interconnection capacity (~ 100 GW) …
- … but also a complete redesign of SEMC grids, establishing large dedicated corridors for RES generation …
- … as well as a strong reinforcement of the European grid, whose current structure does not allow the injection of such a large amount of power from the south

A new paradigm: SuperGrid

- A new paradigm - a **SuperGrid** - is needed.
- The Supergrid concept may be considered as a potential long-term (2050) option for combining offshore (HVDC/HVAC) grids, enlarged HVAC continental network, DESERTEC/Transgreen and MedRing as parts of the pan-European transmission grid, with the objective of integrating large-scale RES into the grid.
- The SuperGrid will connect RES generation sites with the largest demand centers in Europe

ENTSO-E vision for SuperGrid



(Source: ENTSO-E)

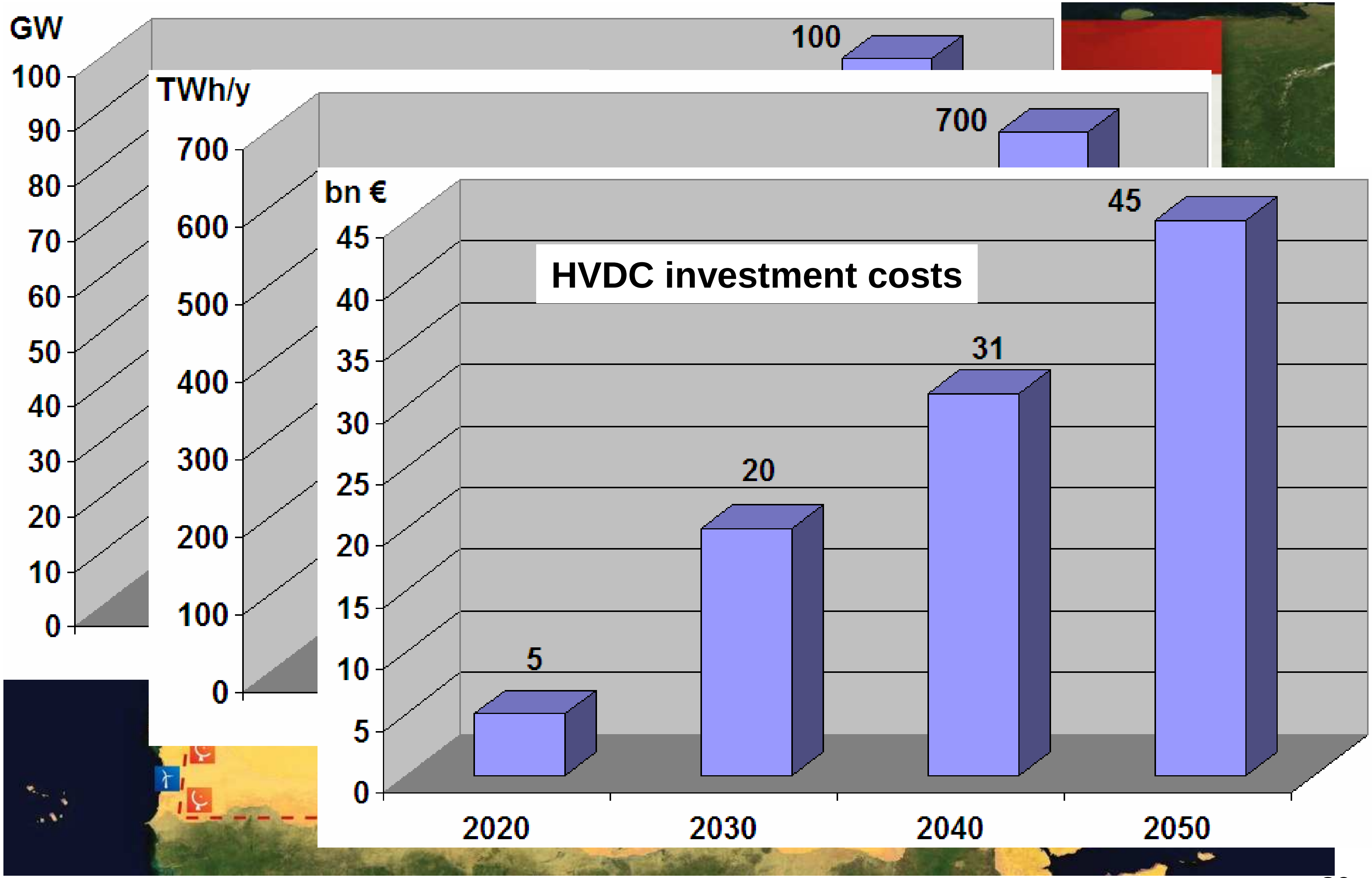
DESERTEC SuperGrid

- ❑ Huge technical, economic, regulatory and political issues exist for DESERTEC project, which is a long-term (after 2030) vision

Source: DESERTEC

HVDC lines transferring bulk power to Europe through three main corridors

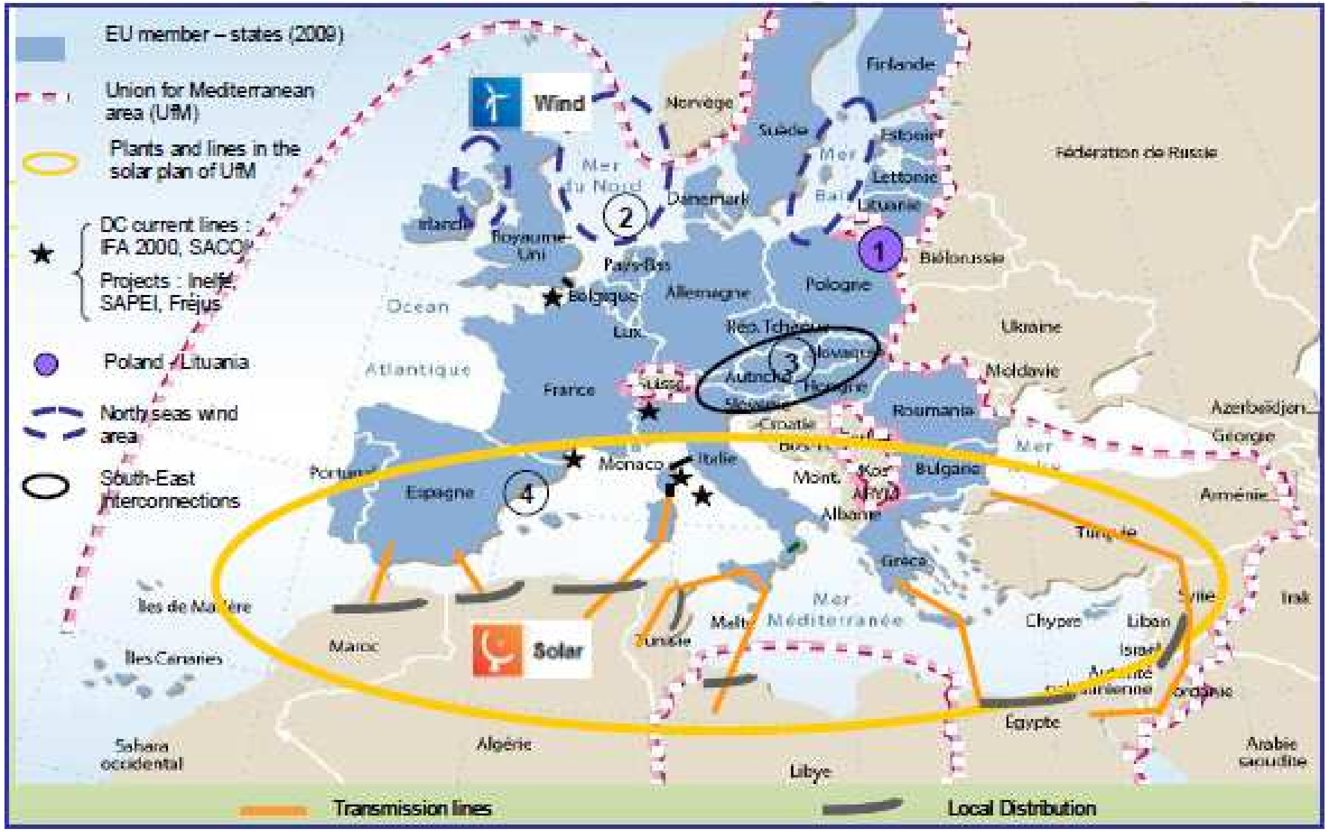
DESERTEC SuperGrid



Source: Desertec

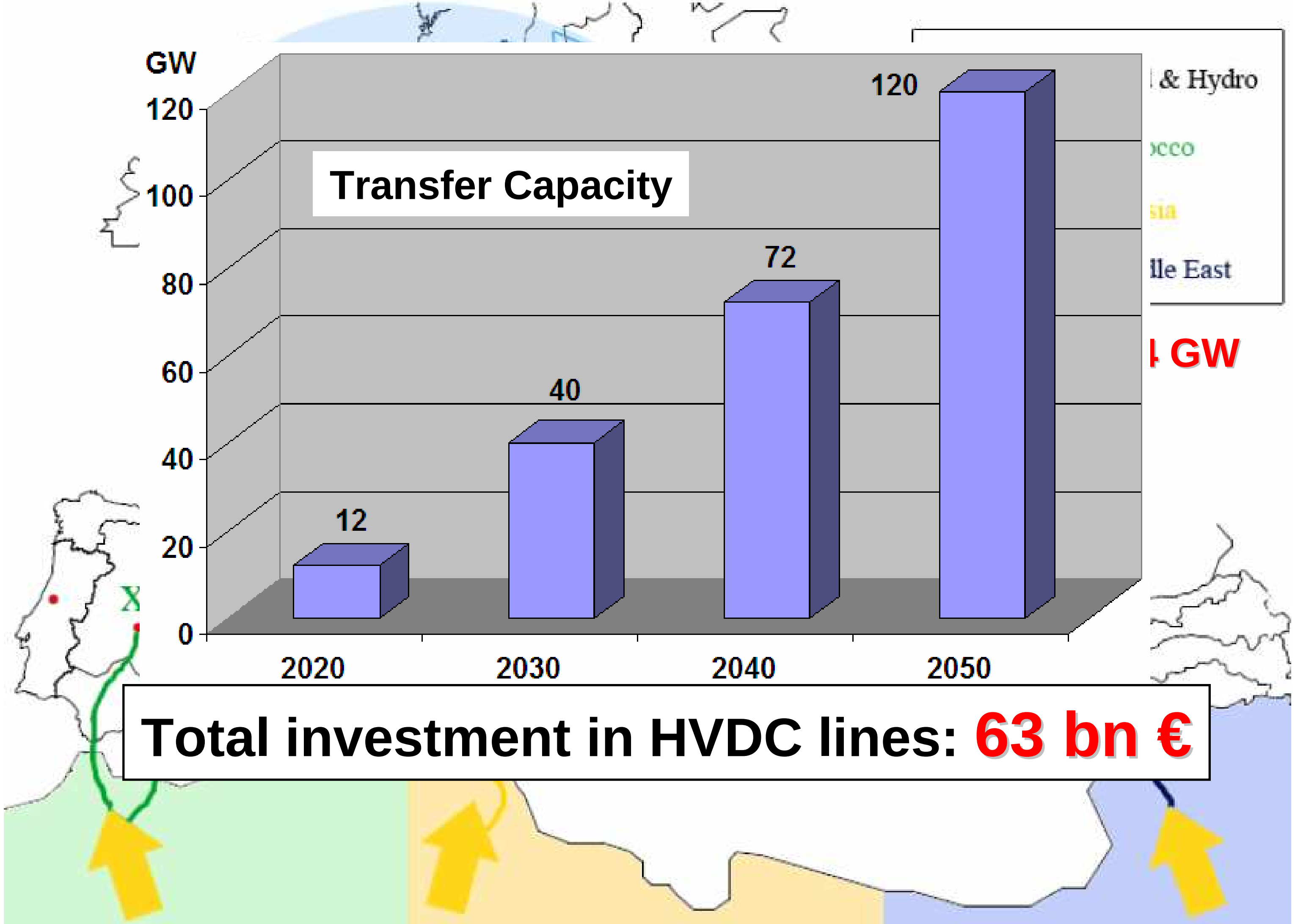
Transgreen SuperGrid

- Infrastructure development of electricity transmission: 4 major strategic projects of the EU



Source:Transgreen

EEA-MENA SuperGrid



Source: TU Dresden (2009)

Benefits of EU - SEMC interconnections

- Greater diversification for EU electricity supply, hence greater security of supply
- Greater regional integration of SEMC in the EU energy market with an increased amount of commercial exchanges
- Environmental benefits due to greater exploitation of RES in the interconnected power system
- Greater optimization of electricity generation in a larger and more integrated power system
- Better technical performance of SEMC power systems

… but with several challenges

- Need for a strong political support to set up an adequate legal, institutional, regulatory, economic, organizational and technical environment to give certainty to investors and to "make things work"
- Examples:
  - definition of a sound financing framework and business model
  - necessity of incentive schemes to RES generation in SEMC, at least in the first phase
  - definition of shared and harmonized rules on network access, capacity allocation, congestion management and inter-TSO compensation
  - allocation and remuneration of the backup reserve / storage capacity to cope with imported RES volatility
  - definition of appropriate emergency procedures to cope with the possible sudden loss of a large (several GW) interconnection
  - …

Main References

- MED-EMIP (2010)
- DLR (2009)
- TU Dresden (2009)
- ENTSO-E TYNDP (2010)
- DESERTEC (2009)
- Transgreen (2010)
- SECURE FP7 project http://www.ec-secure.eu
- REALISEGRID FP7 project http://realisegrid.erse-web.it
- SUSPLAN FP7 project http://www.susplan.eu

Thank you for your attention!

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