CESI

Med infrastructure: how to meet the energy potential?

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CESI Trust the Power of Experience

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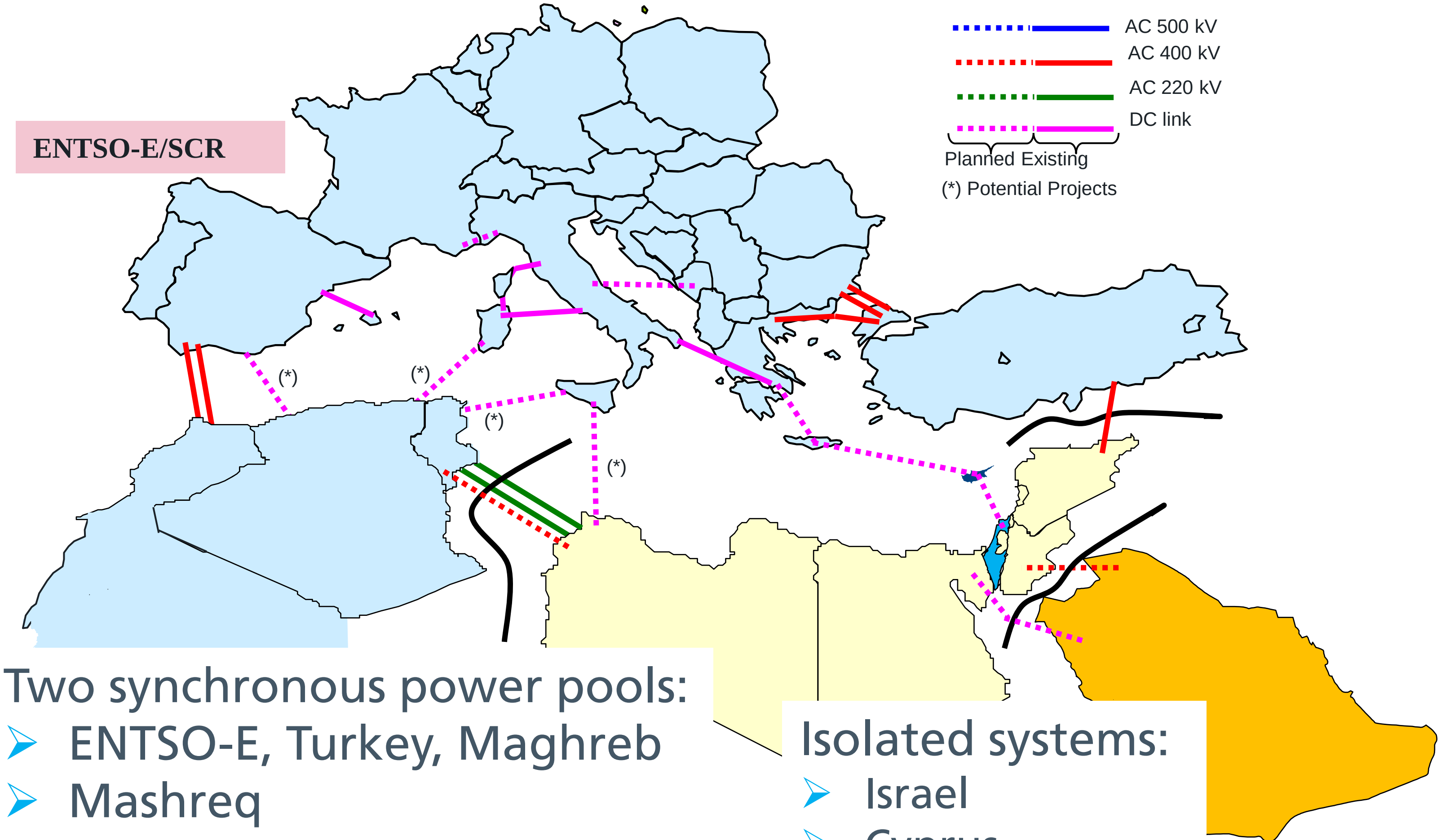
Summary

- ❑ Overview of the power sector in the countries of the Mediterranean basin
- ❑ South-South integration: drivers and existing barriers
- ❑ South-North integration: drivers and existing barriers
- ❑ Key messages from recent feasibility studies
- ❑ Conclusions and recommendations

Overview of the power system pools around the Mediterranean basin



Two synchronous power pools:

- ENTSO-E, Turkey, Maghreb
- Mashreq

Isolated systems:

- Israel
- Cyprus
- Malta
- Crete

Overview of the power system pools around the Mediterranean basin

ENTSO-E

Demand : 3255 TWh

Installed capacity: 839 GW

Turkey

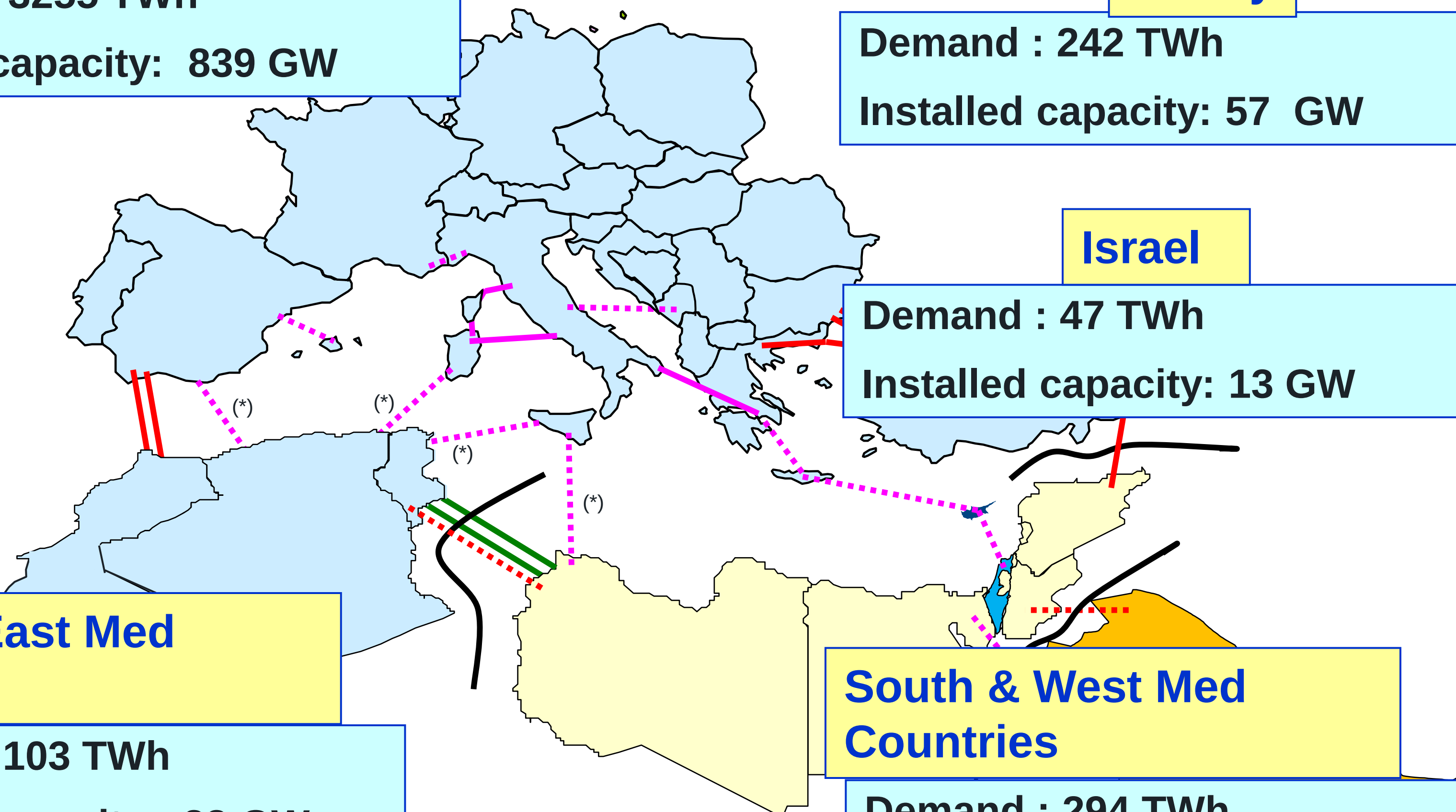
Demand : 242 TWh

Installed capacity: 57 GW

Israel

Demand : 47 TWh

Installed capacity: 13 GW



South & East Med Countries

Demand : 103 TWh

Installed capacity: 23 GW

South & West Med Countries

Demand : 294 TWh

Installed capacity: 50 GW

European Power System

- Past patterns and future trends of **demand** and **generation**

- Drivers for **network reinforcements**

Past demand pattern in Europe

Load demand trend: demand stagnation across Europe, negative in some countries

	ELECTRICITY CONSUMPTION [TWh]			
	2010	2011	2012	2013
ENTSO-E	3 360	3 339	3 336	3 255

Apparently, the demand is not the driver towards network strengthening

Fast evolution of non-programmable RES in Europe

Europe is the world leader in **PV and wind** installations

PV and wind power plant capacity			
	World (GW)	EU (GW)	EU%*
2013			
PV	139.0	81.0	58%
Wind	317.5	121.0	38%
Total	456.5	202.0	44%
2012			
PV	100.0	70.0	70%
Wind	283.0	109.0	39%
Total	383.0	179.0	47%
2011			
PV	69.0	52.0	75%
Wind	238.5	96.7	41%
Total	307.5	138.7	45%

** Percentage of installations in EU compared to the world total*

Demand trend in Europe

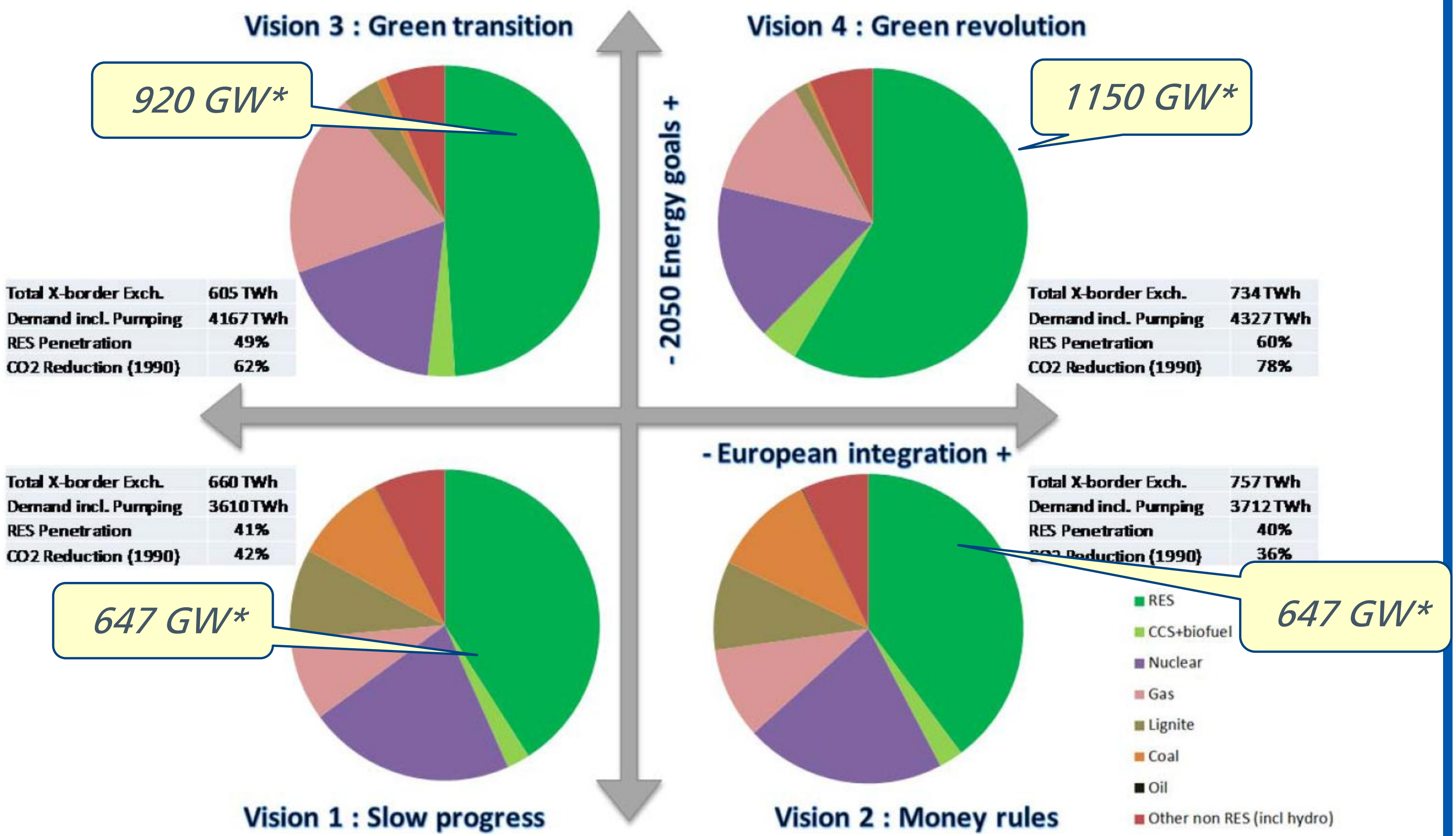
Load demand trend: four visions recently formulated by ENTSO-E

Vision	Demand incl. Pumping (TWh)	RES penetration	CO_2 reduction
V1 Slow Progress	3610	41%	42%
V2 Money Rules	3712	40%	36%
V3 Green Transition	4167	49%	62%
V4 Green Revolution	4327	60%	78%

Peak demand evolution: slow growth in the next decade. CAGR of January peak load ≈1% per year.

Change in Generation mix in Europe

Longer term trends



Source: ENSTO-E and CESI elaborations

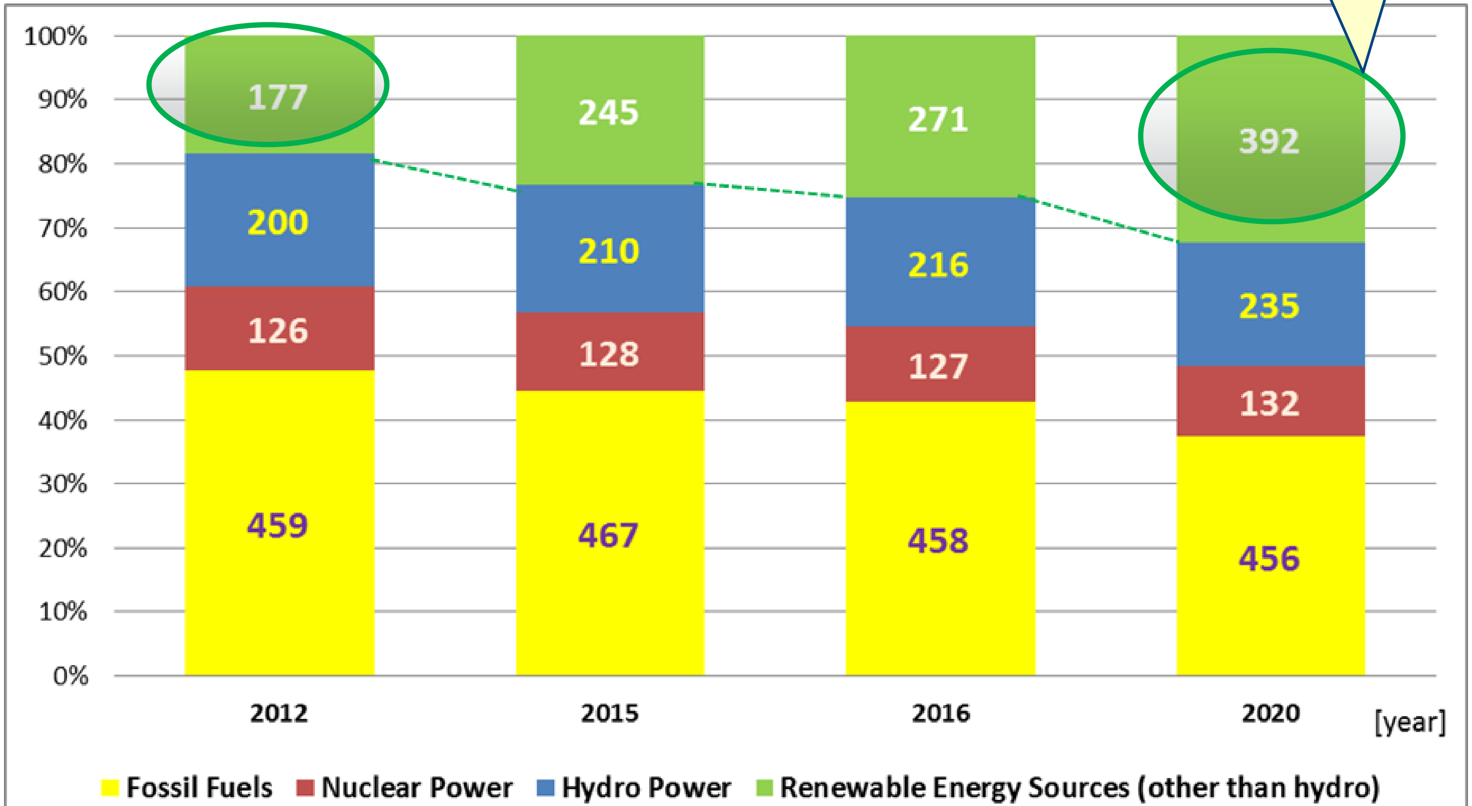
** Installed RES capacity, compared to less than 200 GW today*

Change in Generation mix in Europe

Mid term trend

RES generation: continuous trend towards an increasing share of non-programmable RES generation

120% growth in 8 years



Source: ENSTO-E and CESI elaborations

Grid development mix in Europe : drivers

1st driver: integration of RES generation

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

The TYNDP 2014 of ENTSO-E estimates about **150 bn€ of investments by 2030 in transmission grid expansion**.

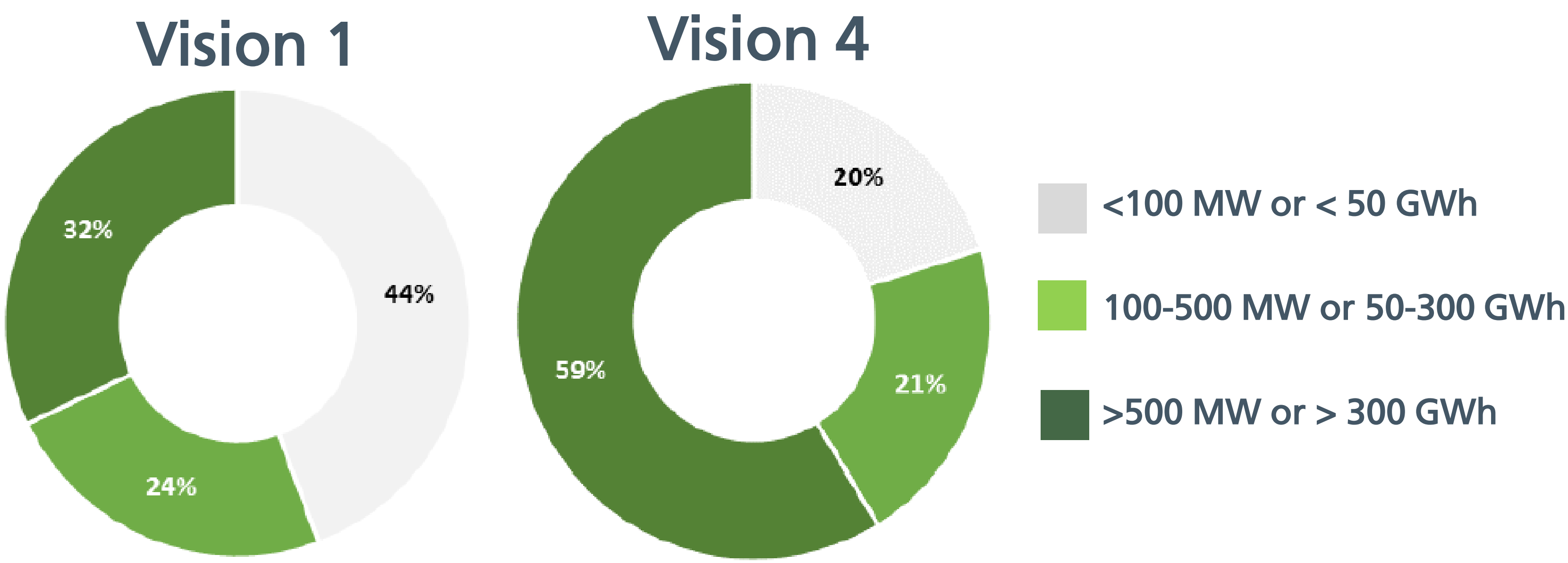
The vast majority of new transmission reinforcements is related to the integration of RES generation: "*approximately 80% of the projects of pan-European significance help integrate RES either by directly connecting RES or by transporting RES power to end-consumers*" *

** ENTSO-E TYNDP 2014*

Grid development mix in Europe : drivers

1st driver: integration of RES generation

From 66% to 80% of projects have an impact on RES integration



** ENTSO-E TYNDP 2014*

Grid development mix in Europe : drivers

2nd driver: market integration

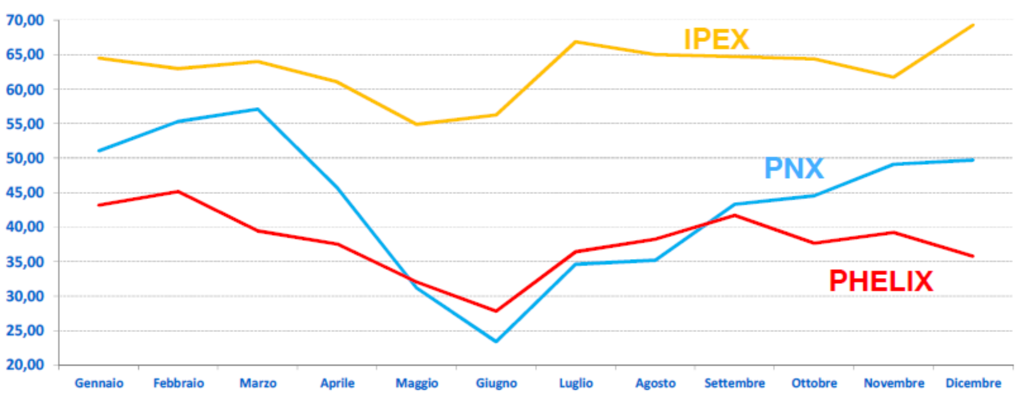
According to the EC, a full day-ahead market integration shall be achieved by 2014.

Market coupling already adopted from the Iberian peninsula to Nordpool…

… nevertheless price differentials between market zones occur frequently.

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

Average monthly prices in Germany, France and Italy in 2013



Grid development mix in Europe : drivers

2nd driver: market integration

Interconnection capacity must double on average throughout Europe:

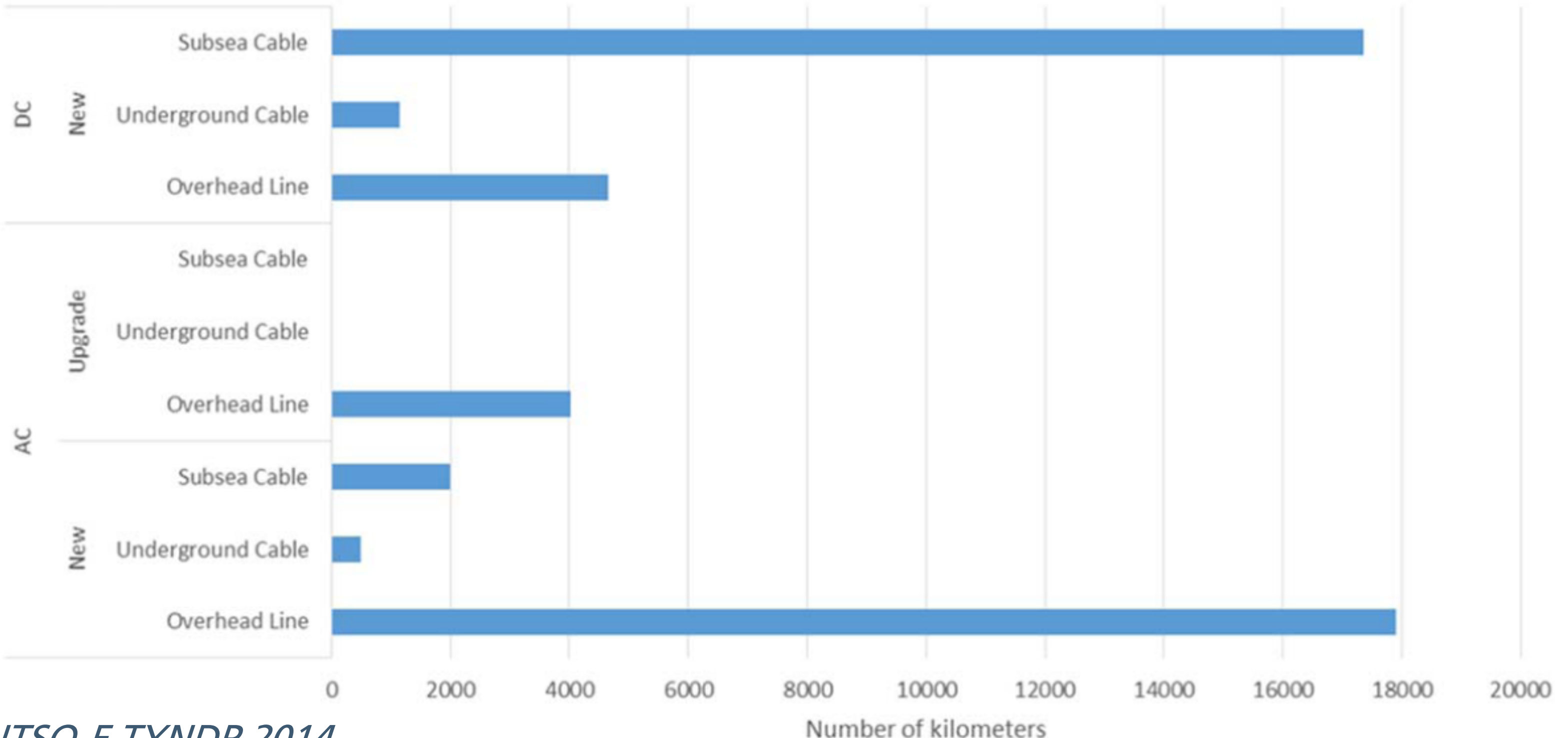
- Iberian Peninsula - mainland Europe from 1 GW in 2013 to more than 10 GW (Vision 4)
- Baltic States - EU neighbours multiplying by three (all Visions)
- Ireland and Great Britain – Continental EU multiplying by two or three depending on RES integration (Vision 1 vs Visions 3, 4)

Grid development mix in Europe : Economic effects

150 bn€ - 1% of the total electricity bill

Electricity prices mitigation from 2 to 5 €/MWh

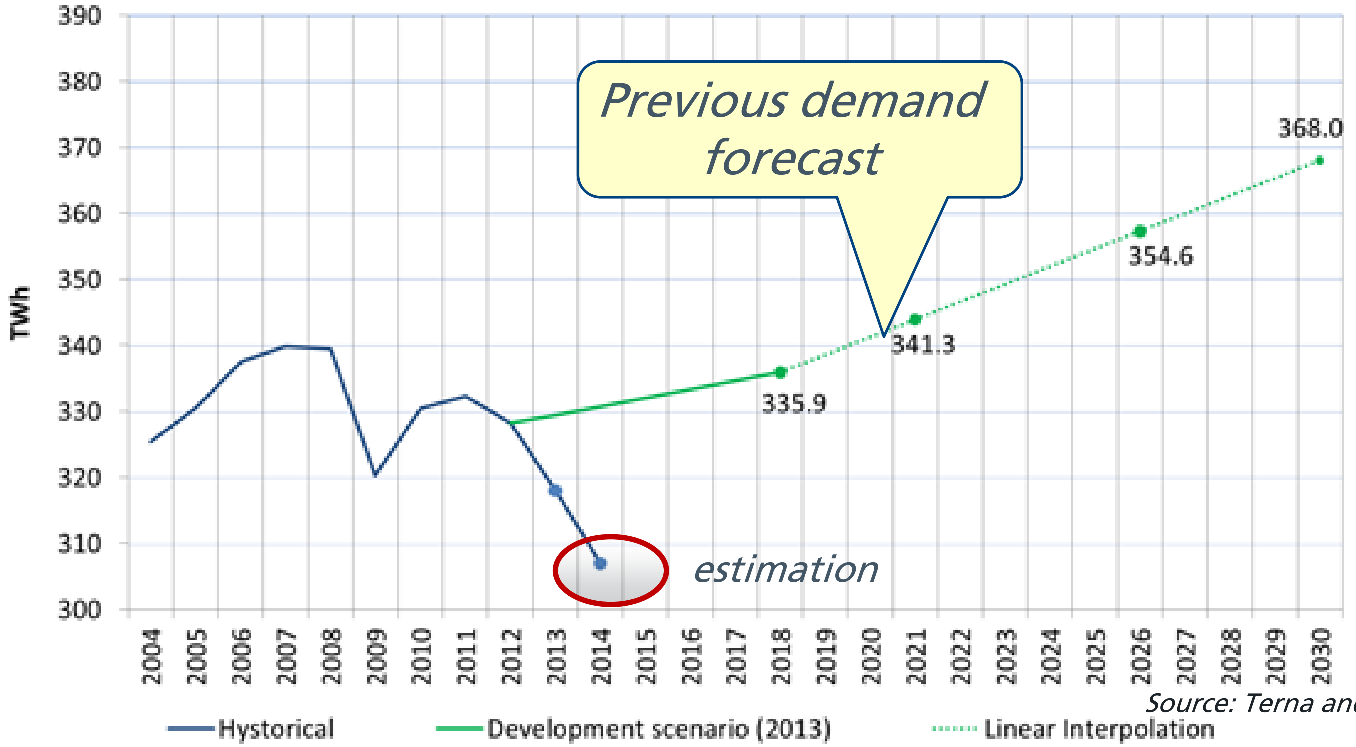
Portfolio - Mix of new OHLs and DC subsea cables



** ENTSO-E TYNDP 2014*

Demand trend: focus on Italy

Sharp decline in load demand



Source: Terna and CESI elaborations

Peak demand evolution in the next decade (year 2023):

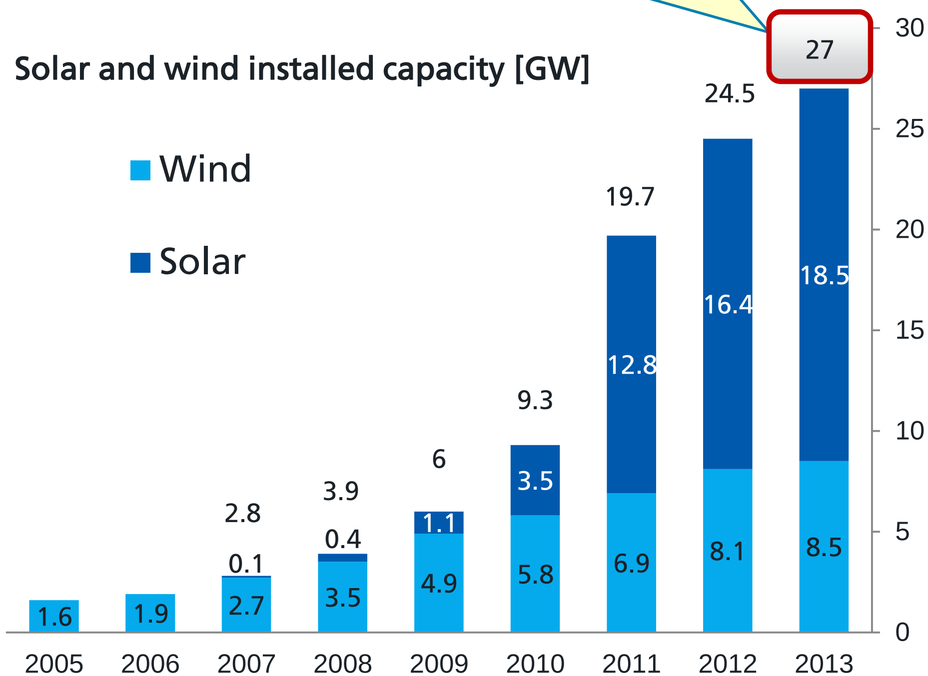
- 57÷62 GW (baseline scenario)
- 63 ÷68 GW (development scenario)

Evolution of generation mix in Italy

RES generation: non-programmable RES power plants installations are exploding

20% connected to HV
60% connected to MV
20% connected to LV

(*)



Source: Terna. and CESI elaborations

Range of load variation in Italy:

- peak: 55 GW
- minimum: 20 GW

(*) more challenging system controllability

Evolution of generation mix in Italy

Installed power of 127 GW to be compared to a demand ranging between 20 and 55 GW

- Excess of installed power
- Priority dispatch of RES generation, causing serious economic problems on conventional generation

Potential for power export outside EU

Plant category	Power connected to network (GW)	Net energy injected in the network (TWh)
Hydro units	22.0	52.5
Conventional fossil fuels	73.2	169.9
Biomass	4.0	12.5
Geothermal	0.8	5.6
Wind farms	8.5	14.8
PV	18.5	22.2
Pumping Consumption		-2.4
Total from Italian Sources	126.5	275.1
Average Import	≈5	42.0
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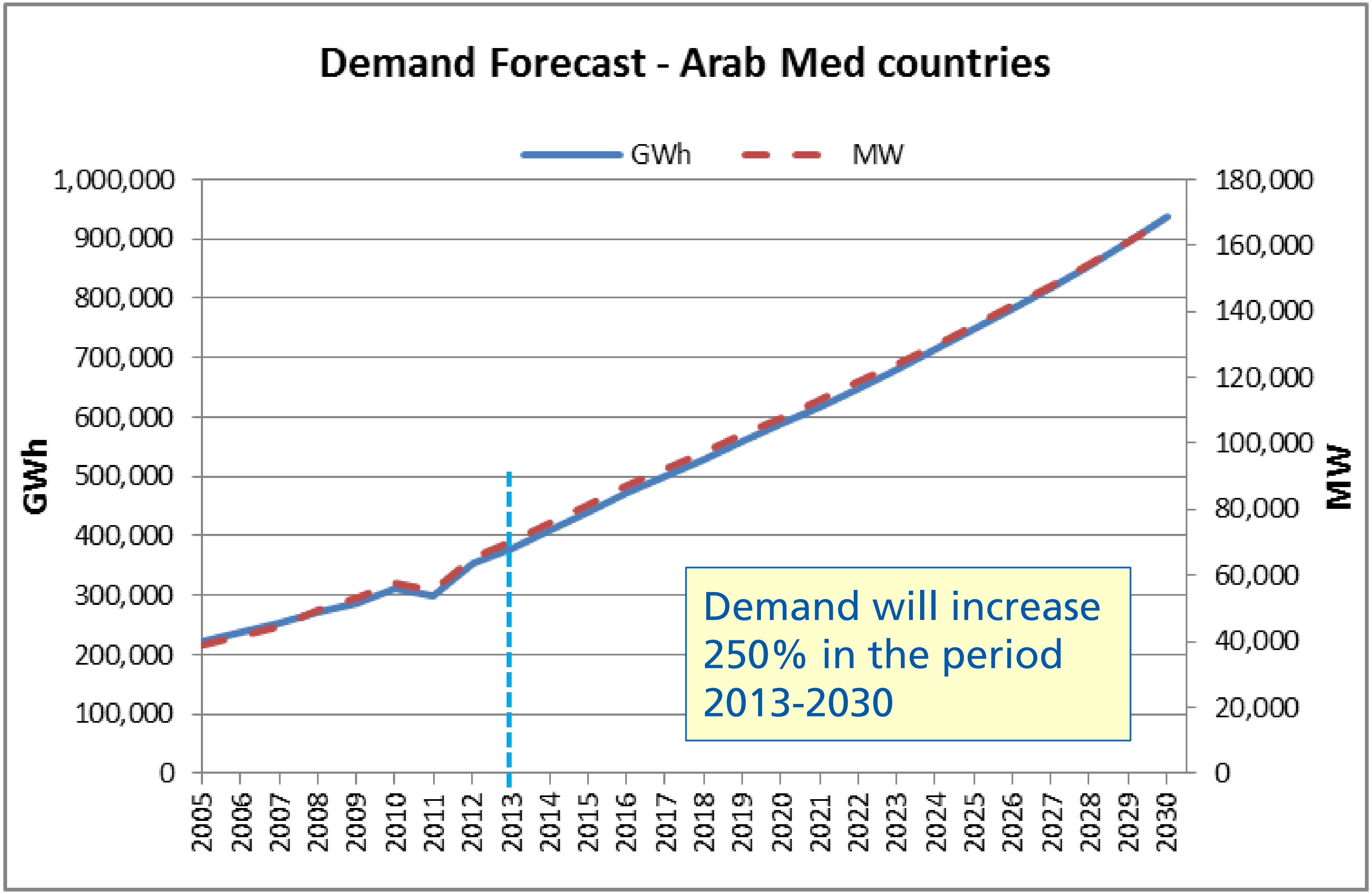
Southern and Eastern Mediterranean Countries

- Past patterns and future trends of demand and generation
- Drivers for network reinforcements

Past patterns and future trends of demand: focus on Arab Med countries



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Surge in power demand in the Southern Med countries

	2011	2030	CAGR (%)
Country	**Yearly Load (TWh)**		**Yearly Load**
Algeria	45.6	117.6	4.7%
Egypt	142.6	439.8	5.5%
Libya	28.7	100.6	6.2%
Morocco	27.4	74.4	4.9%
Tunisia	14.7	39.9	4.9%
TOTAL Demand	**259.0**	**772.3**	**5.4%**

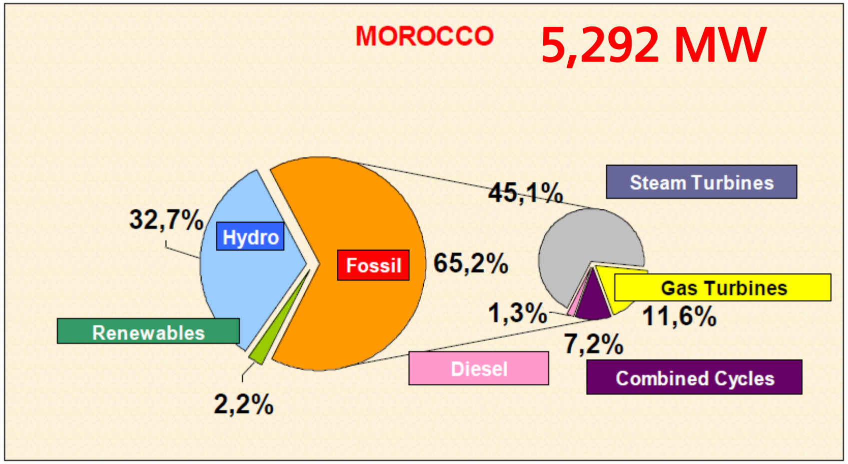
	1960	1973	CAGR (%)
Country	**Yearly Load (TWh)**		**Yearly Load**
Italy	47.6	125.8	**7.8%**

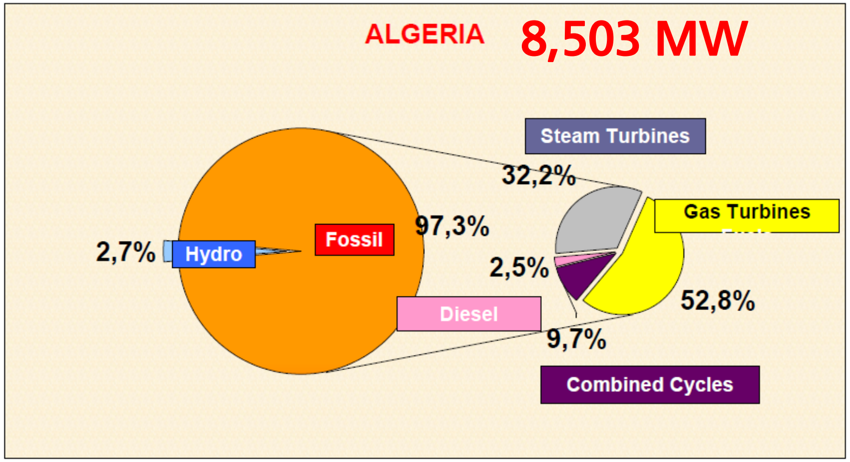
- Impressive growth in the demand, both in energy and peak load
- Situation similar to what experienced in Italy and other Western European Countries in the '60s

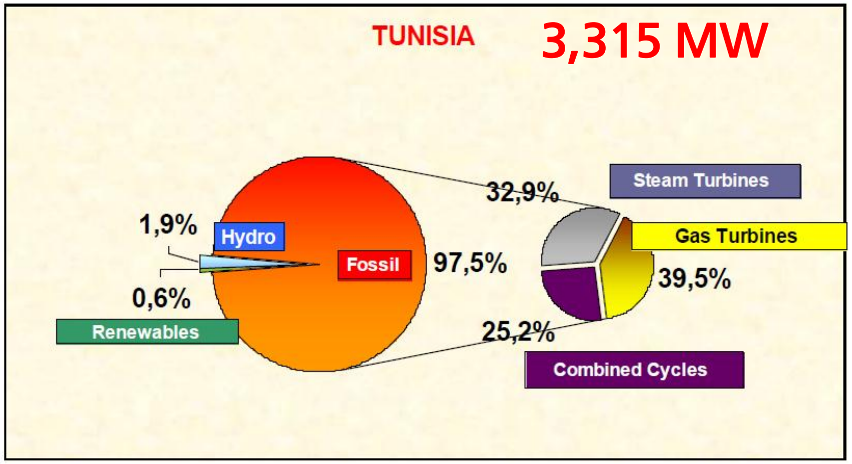
Priority: to ensure generation adequacy and a reliable transmission system

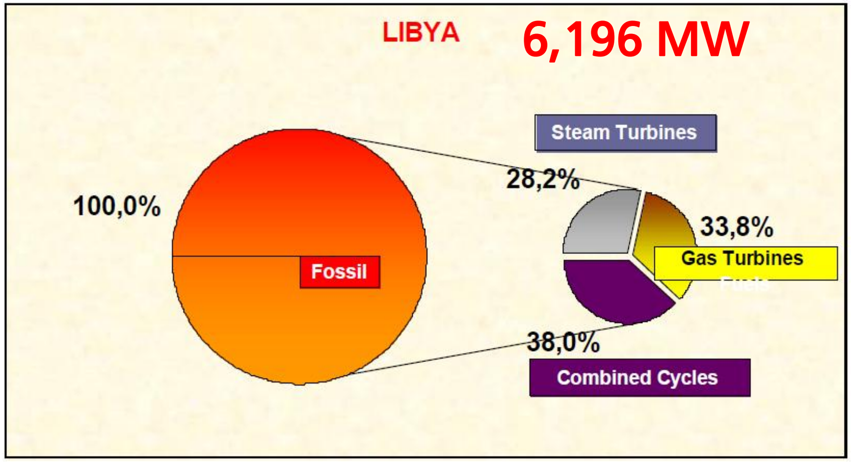
Past patterns and future trends of generation: focus on Arab Med countries

Total Installed Capacity in 2008: 58,800 MW in the Arab SEMC









Source: Euro-Mediterranean Energy Market Integration Project

Past patterns and future trends of generation: focus on Arab Med countries

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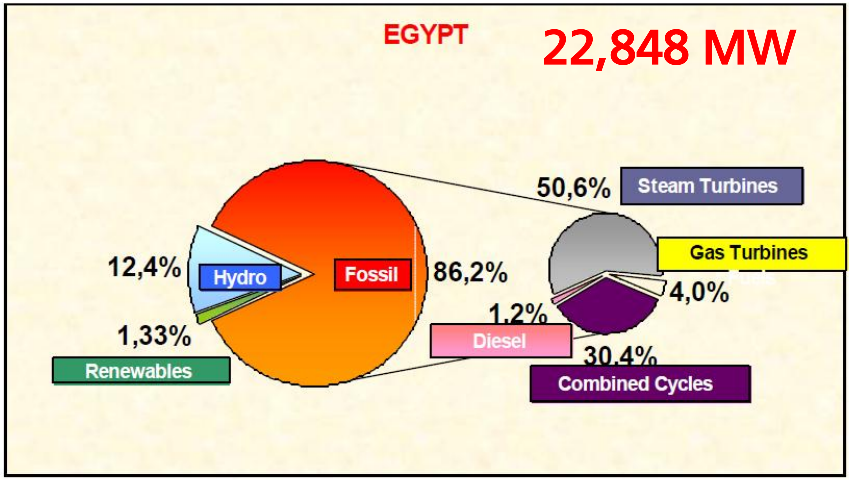
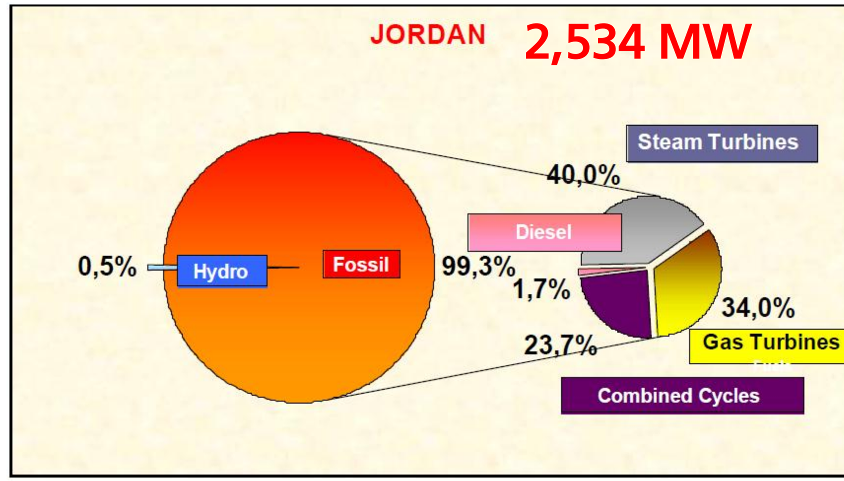
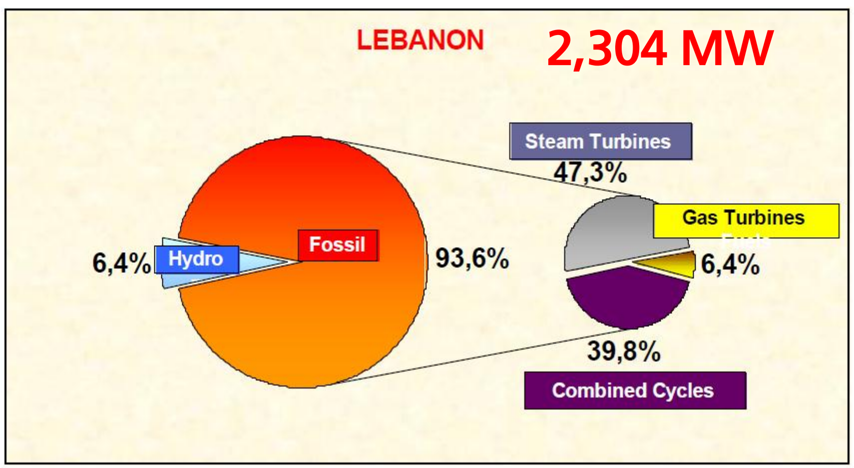
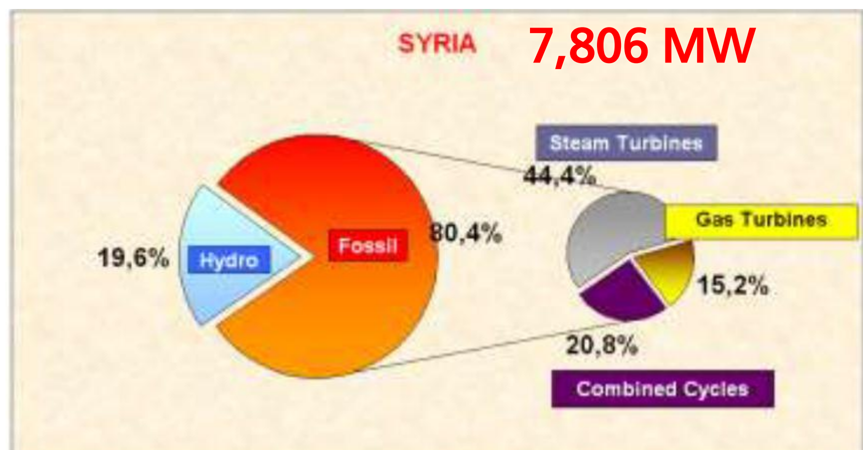




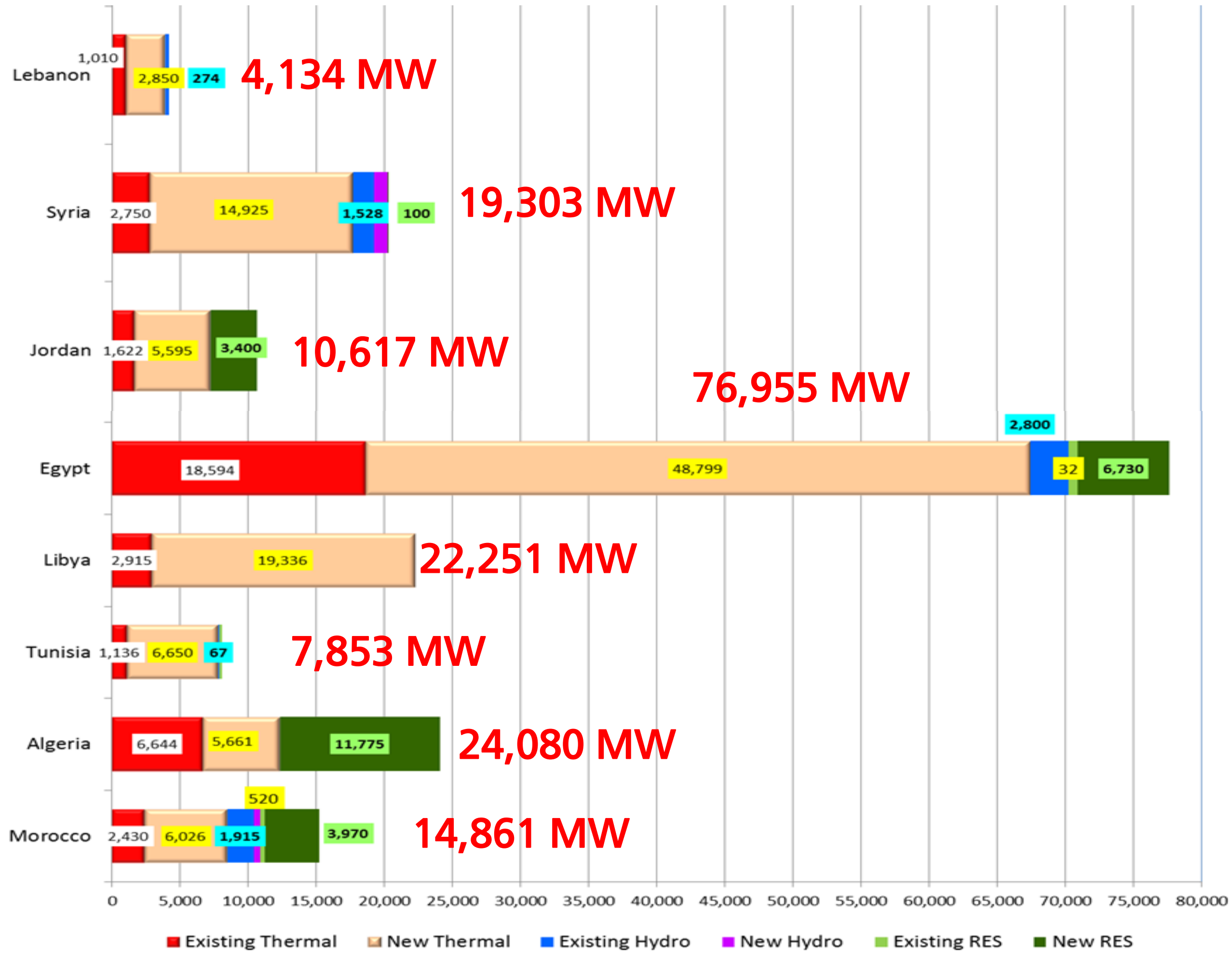




Source: Euro-Mediterranean Energy Market Integration Project

Future trends of generation: focus on Arab Med countries

Foreseen Total Installed Capacity (2030): 180,000 MW in the Arab SEMC



CESI ESTIMATION

Targets of power generation from RES

Targets of RES penetration in North Africa		
Country	**Penetration rate(*)**	**Target year**
Morocco	**42%**	2020
Algeria	**40%**	2030
Tunisia	**13.5%-22%** (**)	2030
	30% (***)	2030
Libya	**10%**	2025
Egypt	**20%**	2020

(*) Assessed as ratio of RES generation over internal demand on yearly basis
(**) previous scenario
(***) recently approved scenario

Priority: how to accommodate such form of RES generation in the North African power systems?

Growth and change in generation mix

The achievement of the RES penetration targets entails a substantial transformation of the power production compared to the current situation

Now Fossil Fuel: 95.9%

RES penetration: 0.2%

In 2030 RES penetration: ~15%

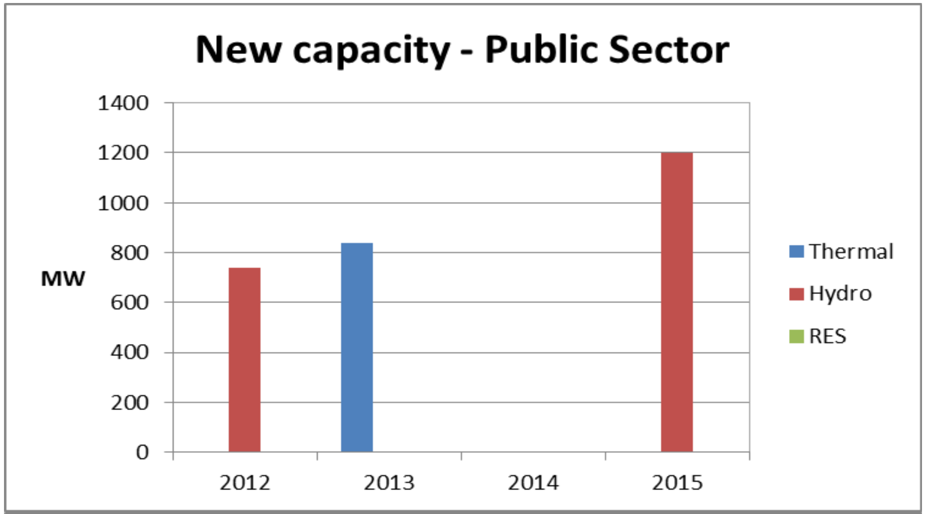
Growth of installed capacity
+
Change of the generation mix

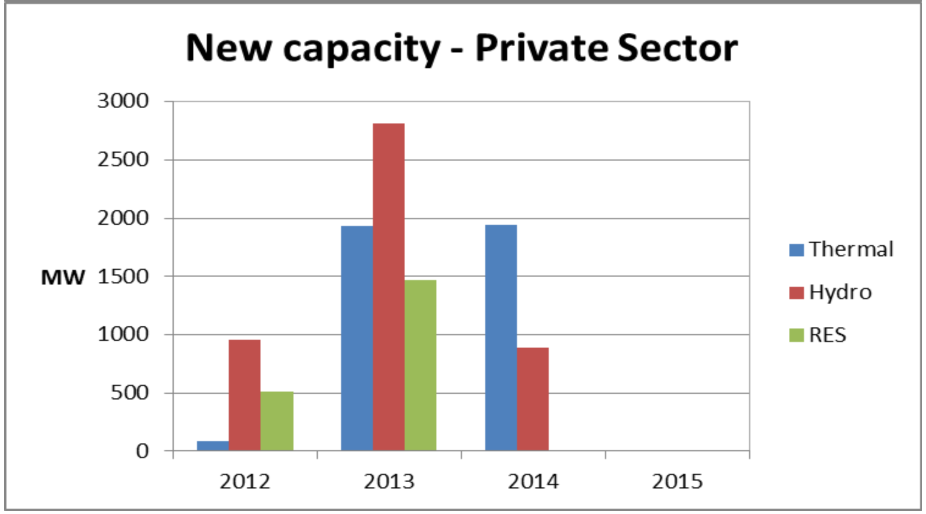
Source: AFESD project / CESI elaborations

Generation development trend in Turkey

2023 Vision

- 20 GW of new wind farms
- 600 MW of geothermal power plants
- 45 GW hydroelectric power (16 GW now)



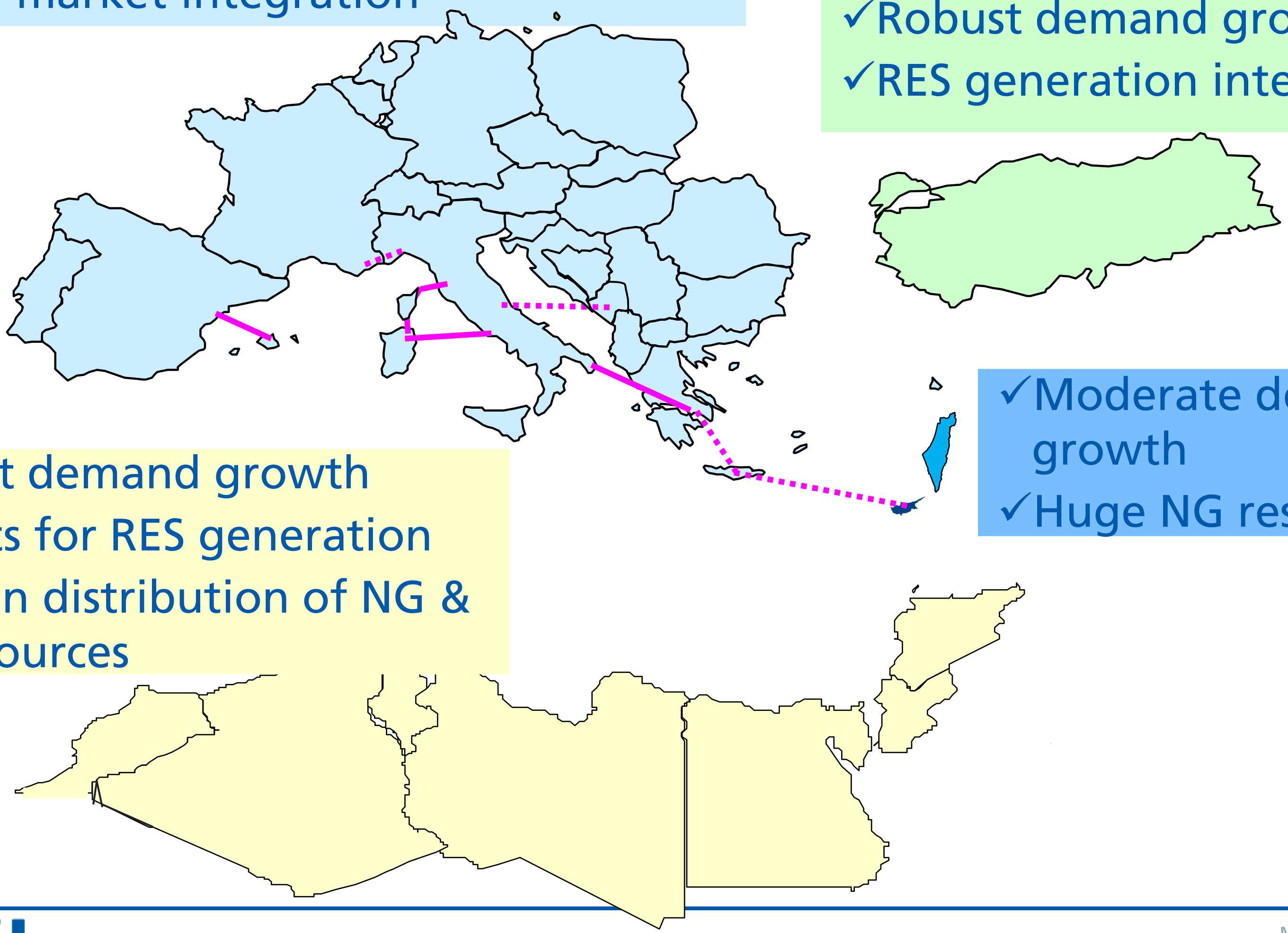


Source: TEIAS – CESI elaboration

Euro-Med area: facts in summary

✓Stagnating/declining demand
✓Targets for RES generation integration
✓Power market integration

✓Robust demand growth
✓RES generation integration



✓Moderate demand growth
✓Huge NG resources

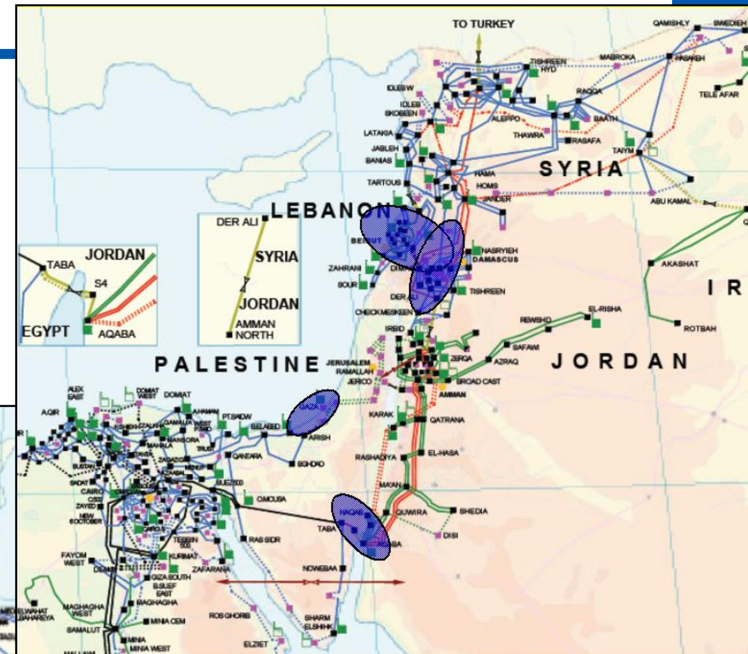
✓Robust demand growth
✓Targets for RES generation
✓Uneven distribution of NG & oil resources

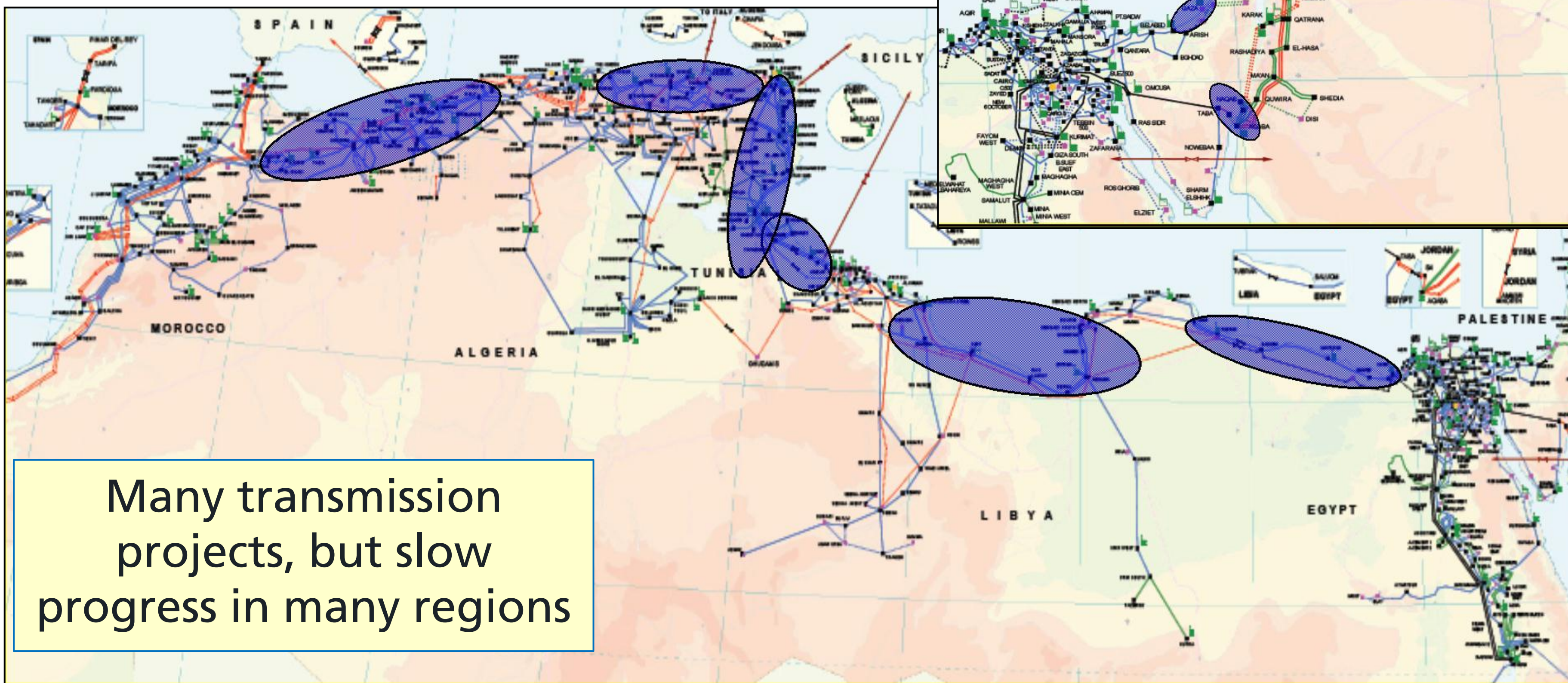
Summary

- ❑ Overview of the power sector in the countries of the Mediterranean basin
- ❑ South-South integration: drivers and existing barriers
- ❑ South-North integration: drivers and existing barriers
- ❑ Key messages from recent feasibility studies
- ❑ Conclusions and recommendations

Transmission grid in the SEMC

The transmission grid along the southern and eastern Med axis is still weak. Only recently part of the 400 kV grid from Morocco to the border with Tunisia has been commissioned.

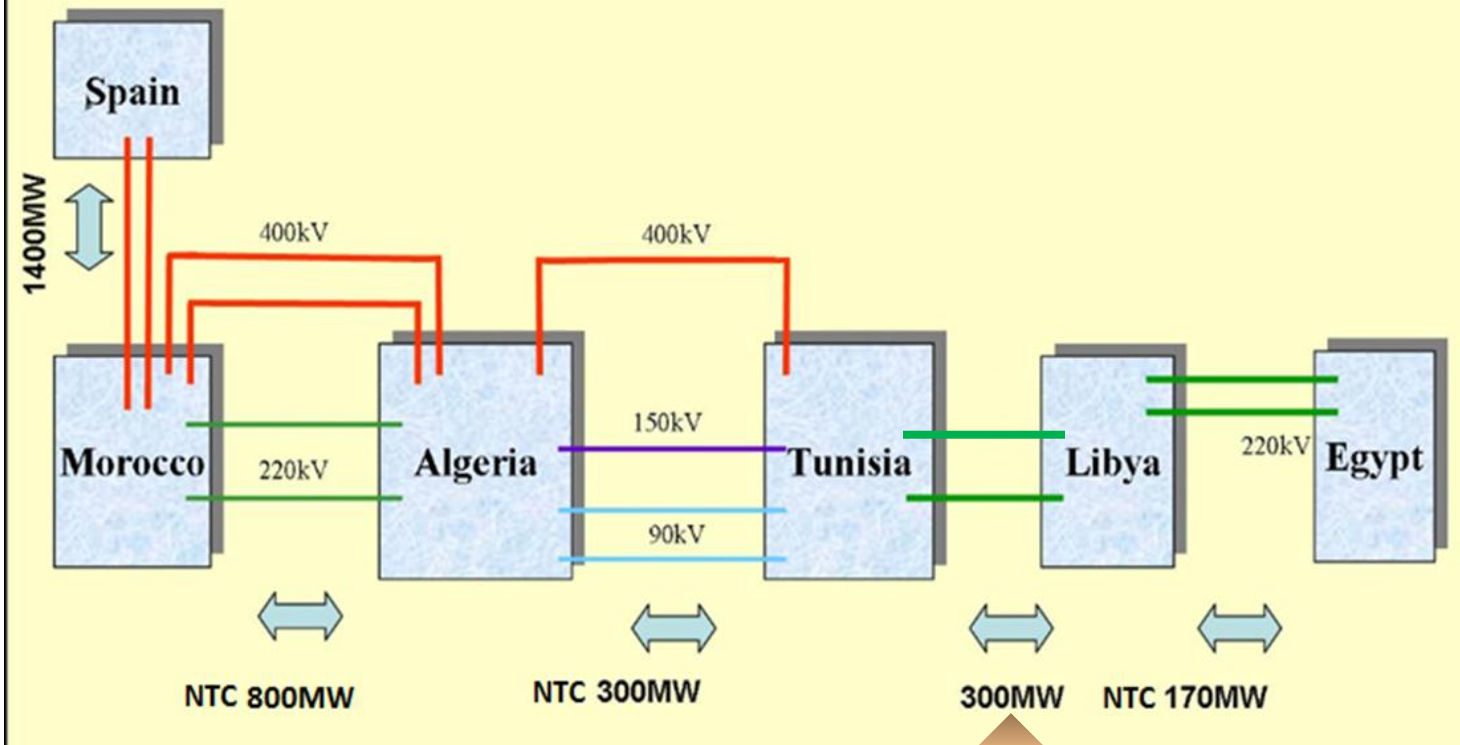




Many transmission projects, but slow progress in many regions

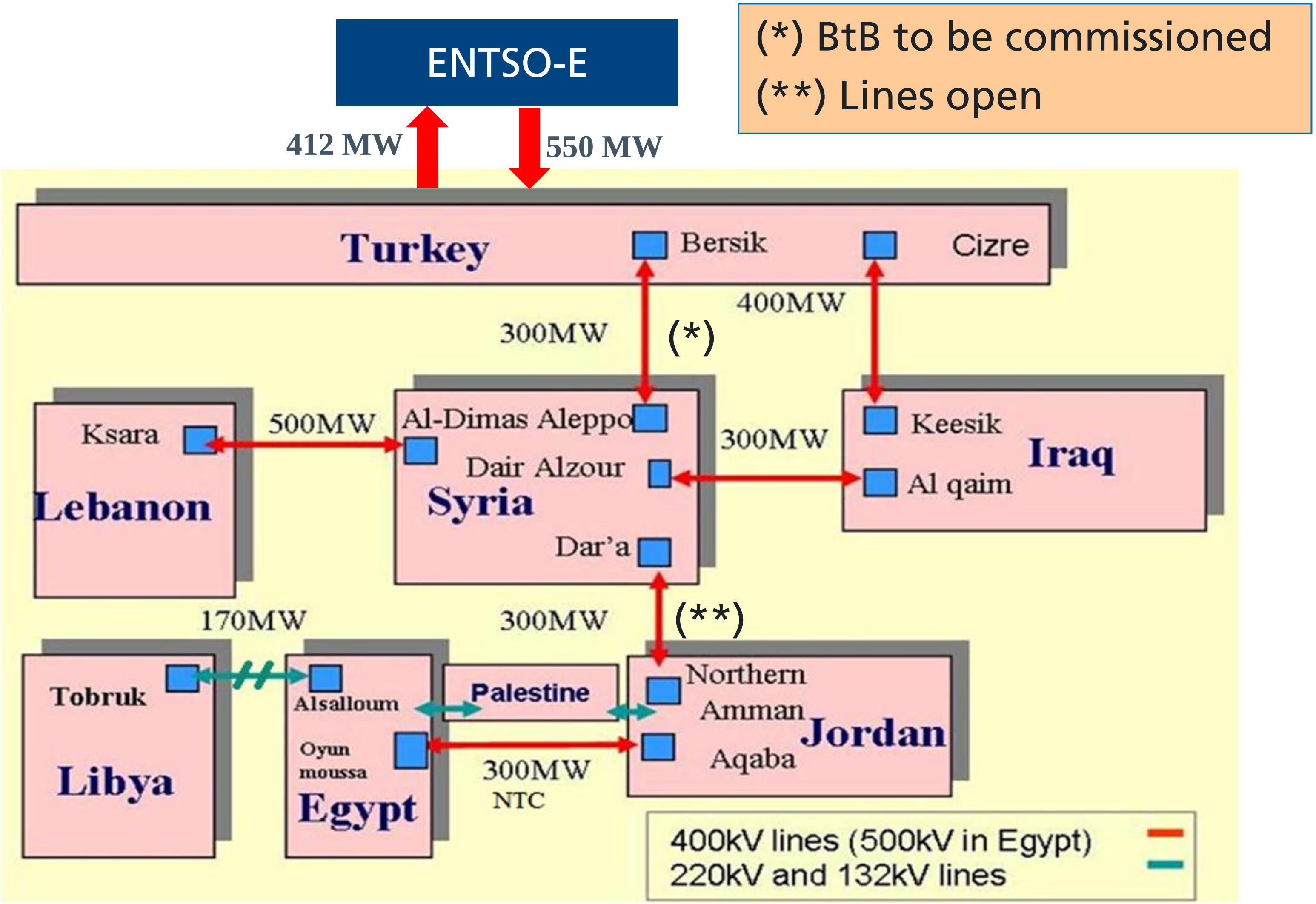
NTC - South & East Med Countries (MW)

Poor Net Transfer capacity



At present: NTC=0: lines are open

NTC - South & East Med Countries (MW)



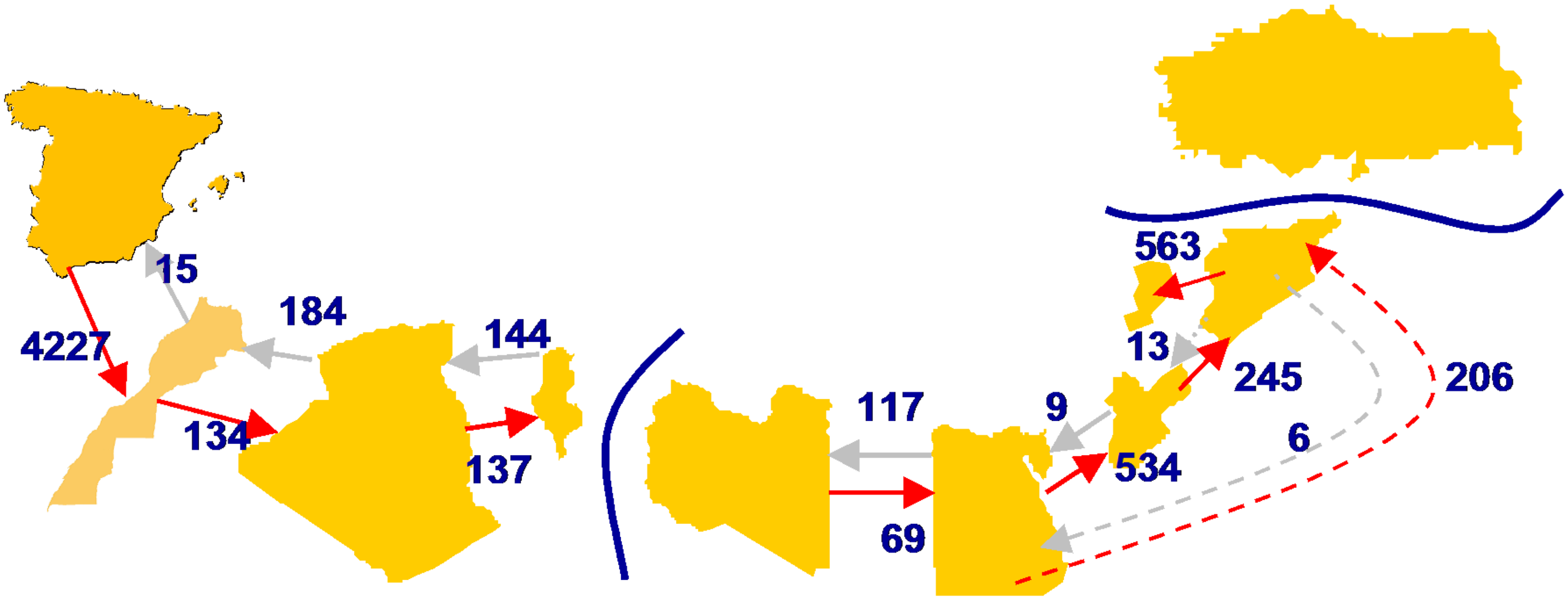
Energy exchanges between the Arab Mediterranean countries

- Lack of shared rules for the Cross-Border Trading of electricity prevents the full exploitation of the cross-border lines

- Subsidised electricity prices are a further barrier for the free trade of electricity among the SEMC

Energy exchanges between the Arab Mediterranean countries in 2008 - values in GWh

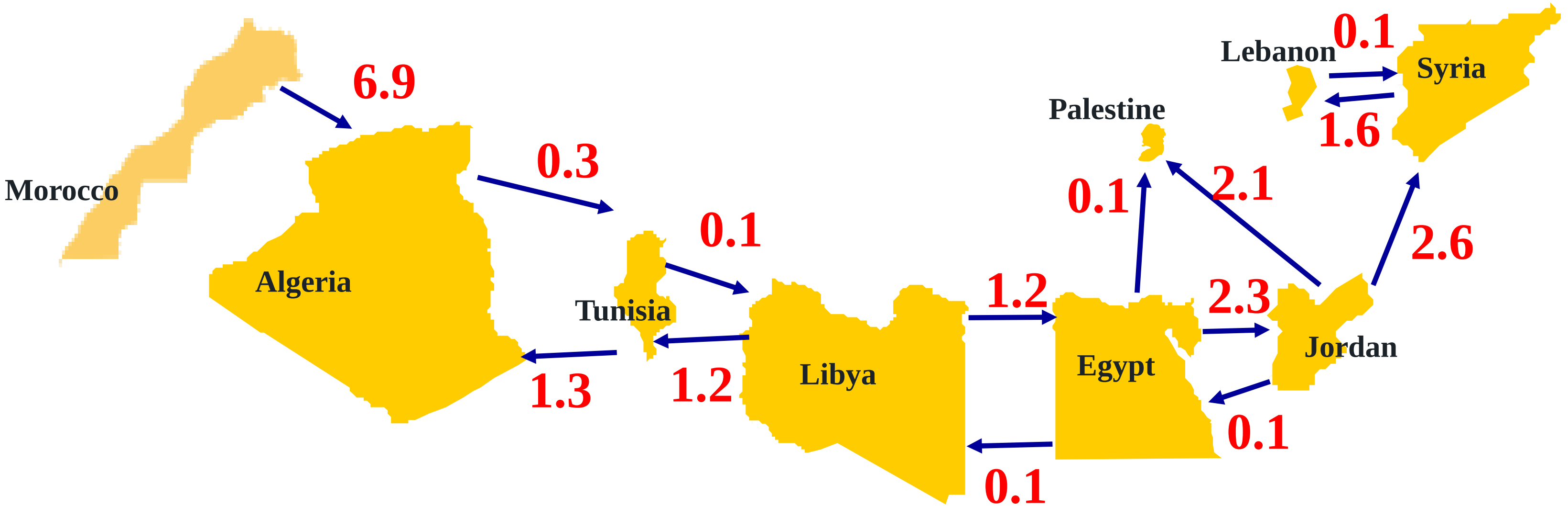
In many cases the net cross-border exchanges are nil: adoption of “remuneration in kind” to compensate the energy exchanges occurred for mutual support



source MED-EMIP and CESI elaboration

Energy exchanges between the Arab Mediterranean countries Estimation - 2015 - values in TWh

Estimation of optimal electricity exchanges when opening the borders, i.e.: adopting a free power trade mechanism



CESI estimations

Studies and roadmap for South-South interconnections

- **2001-2003: first Medring study*** (funded by the EC)
  - ✓ *Feasibility for the synchronous closing the Mediterranean ring*

- **2003-2004: ELTAM interconnection study** (funded by AFESD)
  - *Feasibility for the development of an AC 400/500 kV synchronous corridor from Morocco to Egypt*

- **2009-2010: update Medring study*** (funded by the EC)
  - ✓ *New solutions for the closure of the Mediterranean ring, including also Israel and the Palestinian Territories*

* *Public available*

Studies and roadmap for South-South interconnections

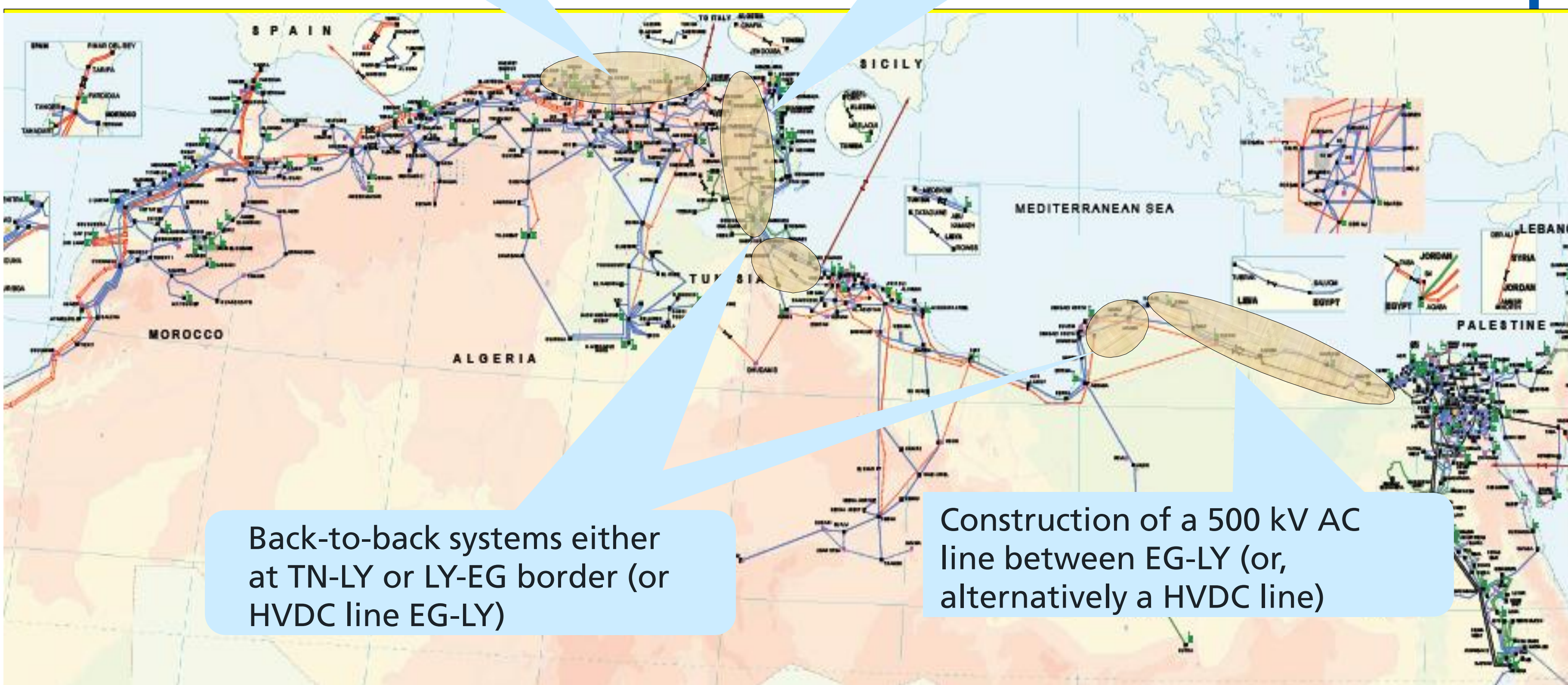
- **2012-2014: NG and electricity infrastructure and market integration** (funded by AFESD)
  - ✓ *Optimal development of NG pipelines/LNG and cross-border power lines in the framework of an integrated power market*
- **2013: first Med-TSO Master Plan**
  - ✓ *Identification of transmission projects of regional relevance, like the TYNDP worked out by ENTSO-E*

South-South interconnections (1/2)

Main sections to be strengthened in North Africa

Commissioning of 400 kV between AL-TN

Construction of 400 kV north-south corridor in TN



Back-to-back systems either at TN-LY or LY-EG border (or HVDC line EG-LY)

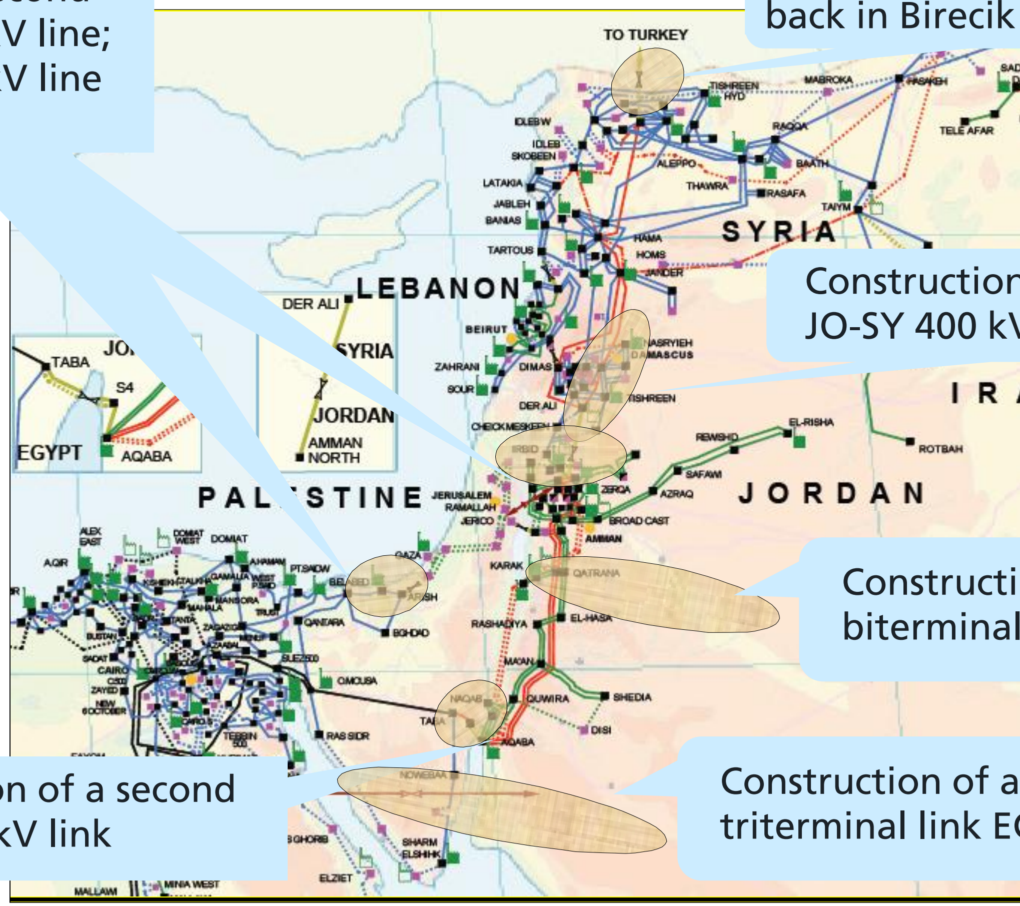
Construction of a 500 kV AC line between EG-LY (or, alternatively a HVDC line)

South-South interconnections (2/2)

Main sections to be strengthened in Eastern Mediterranean region

Construction of a second EG-Gaza Strip 220 kV line; JO-West Bank 400 kV line

Construction of a back-to-back in Birecik (TR)



Construction of a second JO-SY 400 kV link

Construction of a HVDC biterminal link JO-KSA

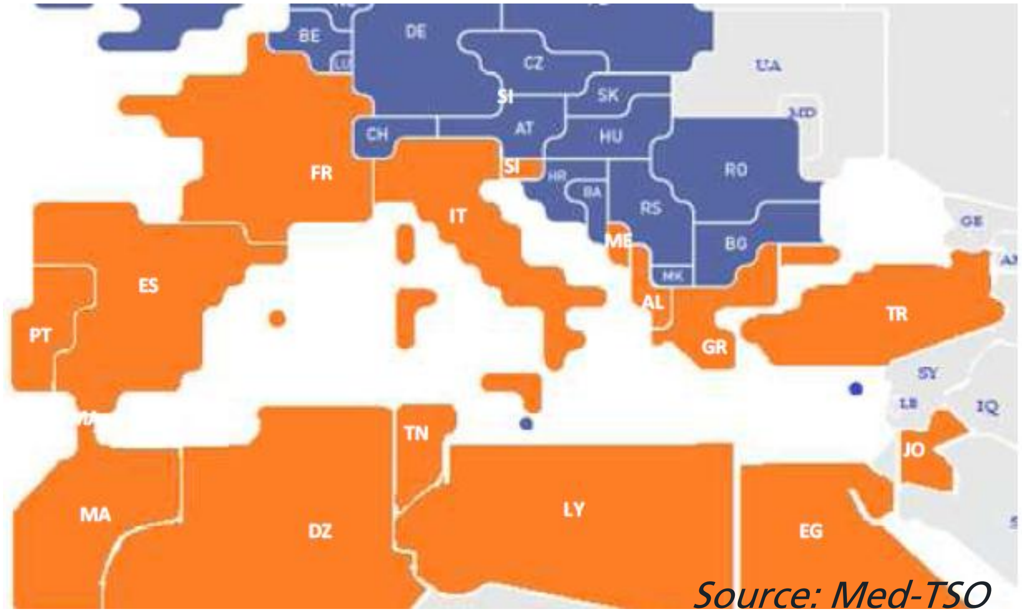
Construction of a second EG-JO 400 kV link

Construction of a HVDC triterminal link EG-KSA

Coordinated interconnection development: Med-TSO

Med-TSO: association of the Mediterranean TSO:

- set up in April 2012
- 19 TSO members
- 17 countries



Source: Med-TSO

1st **Med-TSO**: master plan issued in Dec. 2013

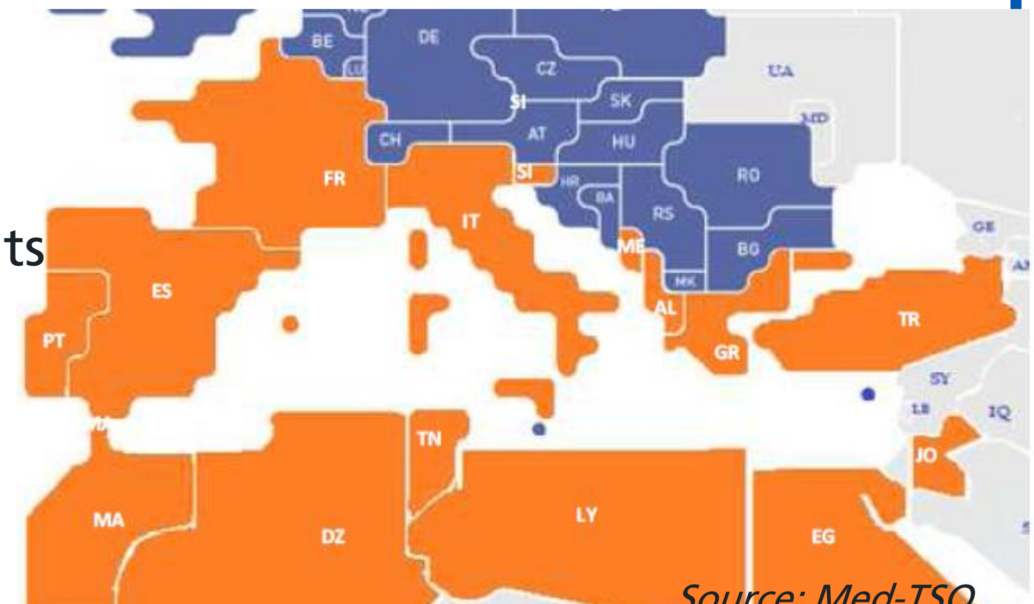
- Master plan covering the period 2013-2022
- **33.000 km** of EHV lines
- **17 bn€** of investments
- **3 bn€** of investments for the south-north trans-mediterranean corridors

Coordinated interconnection development: Med-TSO

Med-TSO master plan:

- Steady growth: **+90 GW in peak load**
- Rapid expansion of **generation capacity: +150 GW** out of which:
- 15% of RES generation (25% if new hydro capacity in Turkey is considered

- 220-250 bn€ investments in new generation



Source: Med-TSO

Priority: reinforcement of the south-south corridors as a requirement for south-north integration

Establishing new electrical interconnections: political and social aspects

- Full co-operation among electric utilities

  ⇒ know-how transfers among the utilities

- Adaptation of new partners to common standards

  ⇒ investment programs on long scale

- Cooperation and common vision.

⇓

When dealing with cross-border interconnections, the political factor is a crucial aspect that can foster or definitely kill an interconnection project

Synchronous interconnection: Turkey - ENTSO-e example

From 1990's to now

….a long way… with **multilateral agreement** and **full involvements of all concerned partners**

Europe-Turkey interconnection: lesson learned

- Multilateral agreement and involvement of all partners of the systems (ENTSO-E and TEIAS)

- Execution of detailed technical studies and simulations with checks on the real system and definition of the necessary upgrading measures in the Turkish power system

- Synchronisation test carried out in stages (Turkey isolated, non-power exchanges, increasing power exchanges and finally starting with commercial-based power exchanges)

- Multilateral agreement on common rules for the Cross-border trading of electricity.

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South-North Integration: drivers and existing barriers

Drivers:

➢ **Overcapacity in the EU**

E.g.: focus on Italy:

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Hydro units	22.0	52.5
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Total from Italian Sources	126.5	275.1
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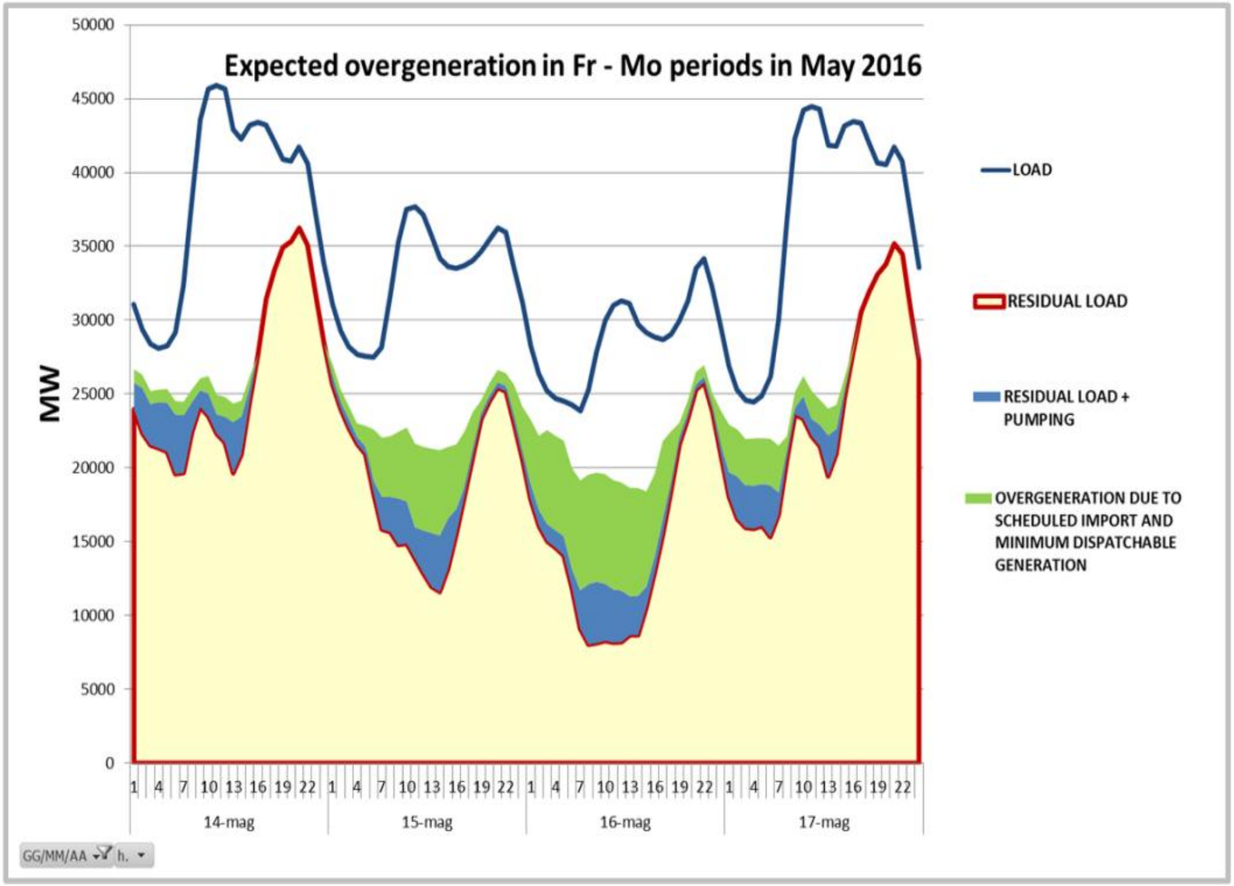
Range of load variation in Italy:
- peak: 55 GW
- minimum: 20 GW

South-North Integration: drivers and existing barriers

Drivers:

- Situations of overgeneration due to non-programmable RES generation



South-North Integration: drivers and existing barriers

Drivers:

- **Possibility of enhancing SoS for the SEMC**

- **Strong political commitment from the EU for energy integration with neighbouring region**
  - ✓ Clear legislative and regulatory framework:
    - DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the **promotion of the use of energy from renewable sources** and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC
    - REGULATION (EU) No 347/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 April 2013 on **guidelines for trans-European energy infrastructure** and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009

The action of the European Institutions: Directive 2009/28

Regulation (EU) No 347/2013 – Art. 9 -

Joint projects between Member States and third countries:

- *one or more Member States may cooperate with one or more third countries on all types of joint projects regarding the production of electricity from renewable energy sources*

↓

Trading of certified RES generation is allowed providing that an adequate power transfer capacity exists between the EU M.S. and the third countrie(s)

↓

Need for the **construction of new interconnectors**: physical link between the EU M.S. and the third countrie(s)– Support schemes foreseen in the Directive

The action of the European Institutions: PCI

Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on "**guidelines for trans-European energy infrastructure**"

Definition of the **Projects of Common Interest (PCI)**: Union list (art.3), criteria (art.4), implementation and monitoring (art.5), permitting and granting (chapt. III), incentives (art.13)

124 PCI for electricity out of which 22 PCI based on HVDC technology for a total length of 6.700 km and capacity >26.3 GW

+ **PCI cluster "Electricity Northern Seas Offshore Grid"** (NSOG): offshore submarine links with capacity **> 16 GW**

South-North Integration: drivers and existing barriers

Existing Barriers

- Lack of shared rules for the Cross-Border Trading of electricity prevents the full exploitation of the cross-border lines
  - ✓ Lack of a common ITC mechanism between TSO’s based on EU principles
  - ✓ Lack of agreed methods for cross-border capacity allocation and congestion management.
- Subsidised electricity prices are a further barrier for the free trade of electricity among the SEMC
- Insufficient implementation of transparency standards and establishment of information exchange
- Lack of market surveillance and market monitoring mechanism

No reciprocity

Summary

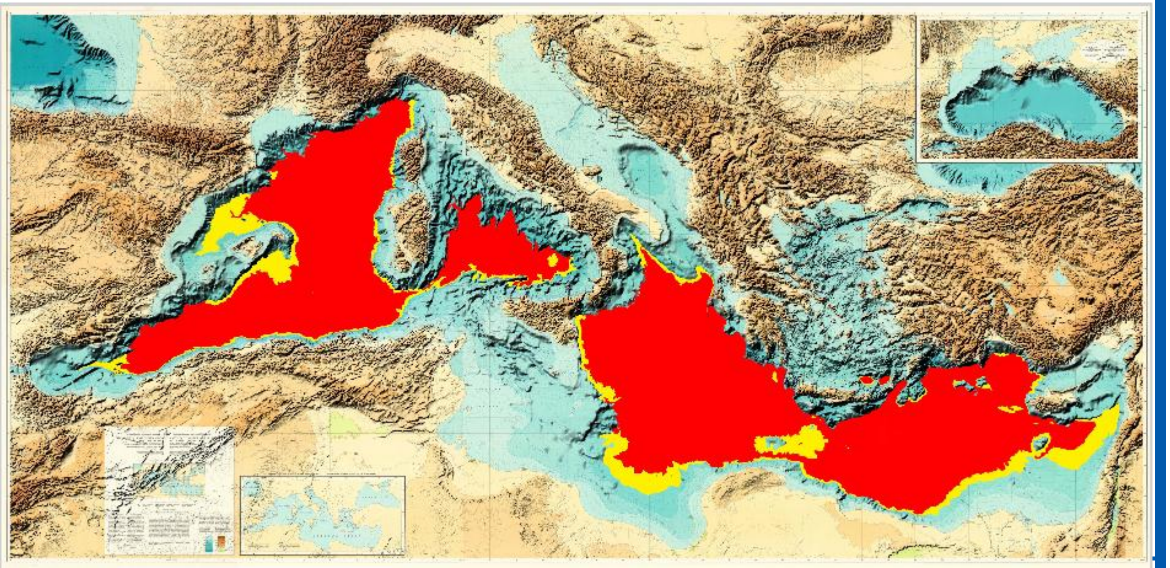
- ❑ Overview of the power sector in the countries of the Mediterranean basin
- ❑ South-South integration: drivers and existing barriers
- ❑ South-North integration: drivers and existing barriers
- ❑ **Key messages from recent feasibility studies**
- ❑ Conclusions and recommendations

Key messages from recent feasibility studies

Feasibility interconnection analyses shall address:

- ✓ a rigorous **cost-benefit analysis** with sensitivity against the most important parameters (e.g.: fuel prices, CO_2 emission costs, etc.)
- ✓ detailed **system performance studies**
- ✓ **environmental analyses** to identify submarine transmediterranean routes compliant with the state-of-the-art cable technology

Technological limits related to the sea depth for laying down cables (≈2000 m) and their rating (≈ 1000 MW per circuit)



Key messages from recent feasibility studies

Algeria-Italy feasibility study

- ✓Year: 2020

- ✓Transfer capacity:
  600/1000 MW
- ✓Submarine section length:
  ≈ 350 km
- ✓Max sea depth:
  ≈ 2000 m

- ✓ Yearly load:
- \- Algeria: ≈ 85 TWh
- \- Italy: ≈ 370 TWh

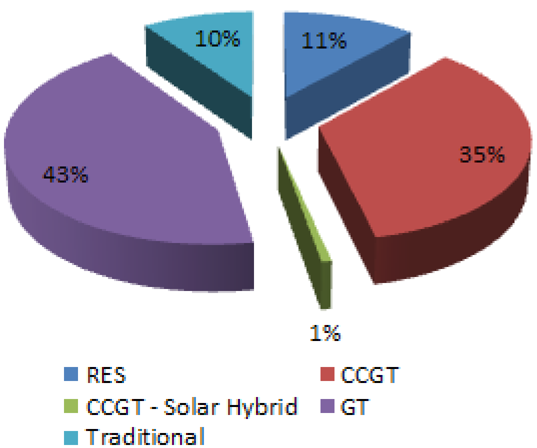
- ✓ NG prices:
- \- Algeria: 6.8 €/GJ
- \- Italy: 8.4 €/GJ

Algeria-Italy feasibility study

Foreseen Generation Mix

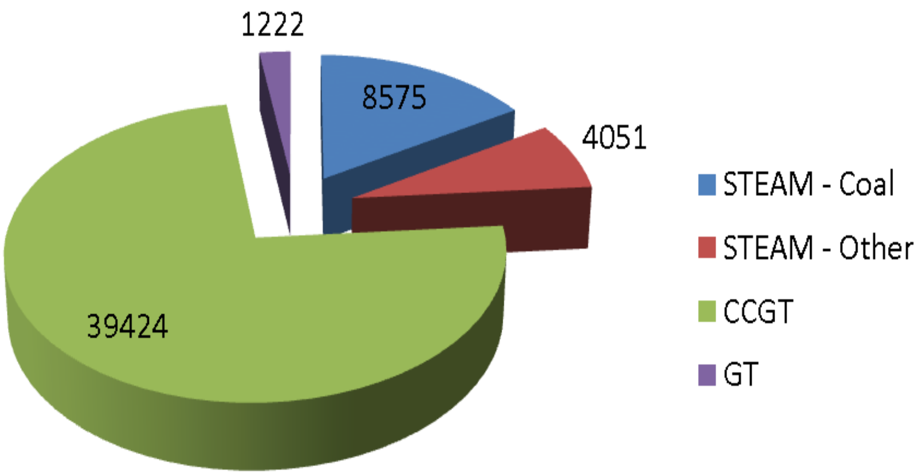
Type	Pmax [MW]	Tot. Availability	Eq.h	Estimated Production [GWh]
CSP	1475	77%	6500	9 588
Wind Farm	800	100%	2500	2 000
PV	270	100%	2000	540
TOTAL RES	**2545**			**12 128**

Type	Pmax [MW]	Pmax (temp. derating)	Pmin	Tot. Availability	Eff.
CCGT	7652	7549	4750	87%	56%
CCGT - Solar Hybrid	150	150	93.75	87%	52%
GT	9451	8129	3686	88%	32%
Traditional	2125	2125	1287	81%	36%
TOTAL THERMAL	**19378**	**17953**	**9817**	**86%**	**38%**



Algeria-Italy feasibility study

Italy: generation mix



Thermal (net): 53 GW

Hydro: 19 GW

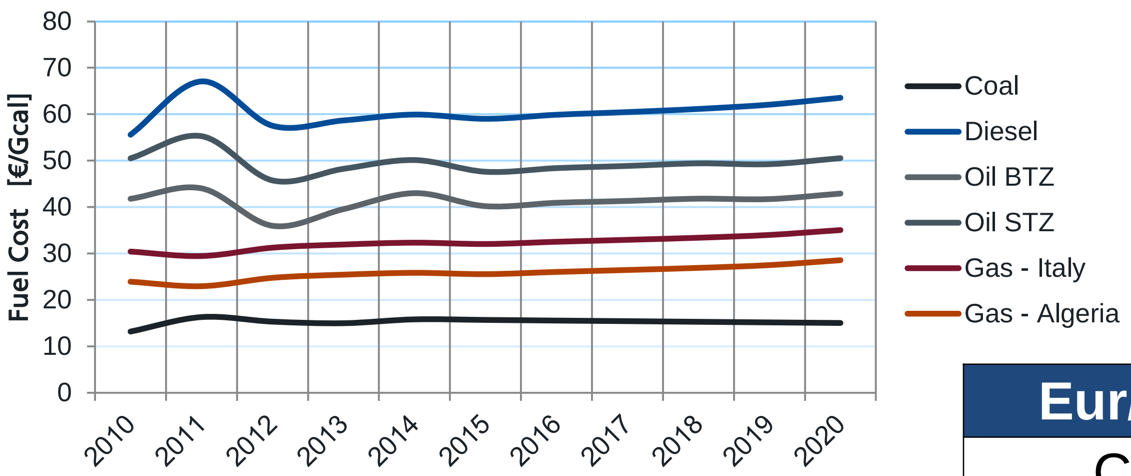
Pumping Hydro: 4,5 GW

Photovoltaic			Biomass + RSU 50%			Geothermal			Wind			Total Renewable	
Inst. Cap.	Load Factor	Energy	Inst. Cap.	Load Factor	Energy	Inst. Cap.	Load Factor	Energy	Inst. Cap.	Load Factor	Energy	Inst. Cap.	Energy
GW	h/y	GWh	GW	h/y	GWh	GW	h/y	GWh	GW	h/y	GWh	GW	GWh
30	1 200	**36 000**	**3**	4 063	**12 338**	**0,8**	6 964	**5 376**	**12,7**	1 800	**22 869**	**46,5**	**76 583**

Algeria-Italy feasibility study

Fuel price scenario

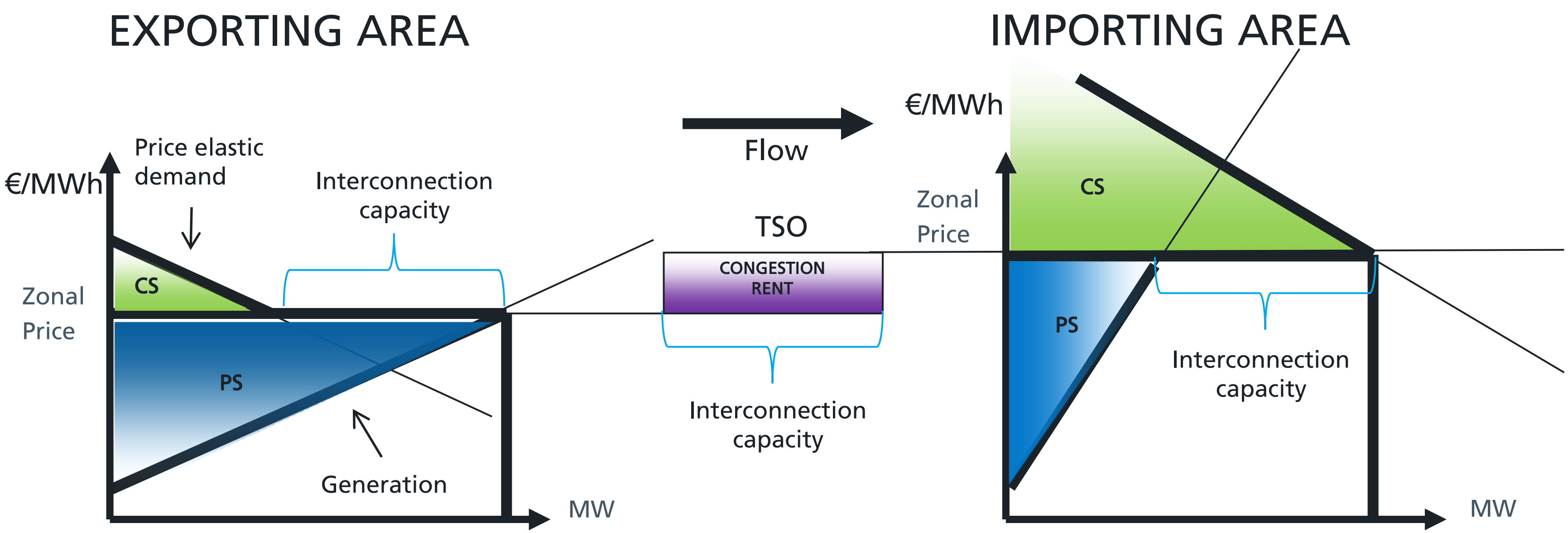
Fuel cost projection



Eur/Gcal	2020
Coal	15.01
Diesel	63.54
Oil BTZ	42.90
Oil STZ	50.53
Gas - Italy	35.03
Gas - Algeria	28.54

Analysis of the interconnection benefits: Socio – Economic Welfare (SEW) / SEW variation

- Socio – Economic Welfare can be calculated as the **sum** of:
  - **Consumers' surplus** An economic measure of consumer satisfaction, which is calculated by analyzing the difference between what consumers are willing to pay for a good or service relative to its market price
  - **Producers' surplus** An economic measure of the difference between the amount that a producer of a good receives and the minimum amount that he or she would be willing to accept for the good.
  - **Congestion rents** Calculated as the price difference times the flow over a network constraint. Typically, Congestion rent is collected by those who transfer the energy over the constraint



Simulation tool: Promed *grid*

PROMED carries out an **optimal coordinated hydrothermal scheduling** of the modeled electric system generation set, over a period of **one year**, with an **hourly detail**.

Optimization is based on a deterministic model considering both the **technical and economic characteristics of the power systems**

Thermal Generation set
For each generation company in each market zone: minimum and maximum power, fuel mix, start-up flexibility, maintenance plan & failure rate, generation constraints (must-run, cogeneration constraints, bilateral contracts)

Fuel Prices
Monthly reference price for each type of fuel.

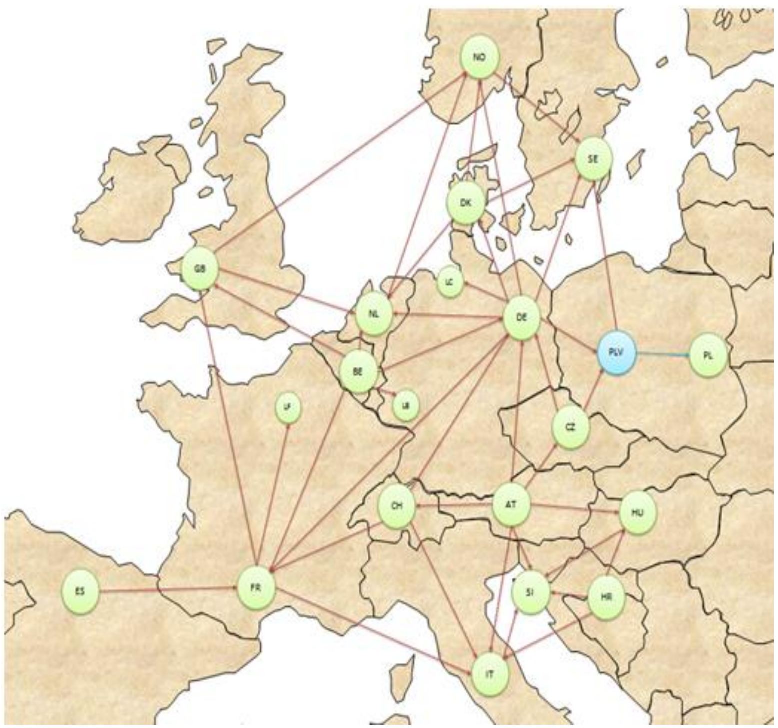
Hydro Generation set
For hydro reservoir plants optimization consists in find the best allocation of water resources along the year respecting the basin constraints. The models takes into account:

- pumped-storage HPP
- hydro equivalents for reservoir and for run-of-river HPP;
- minimum/maximum deliverable power,
- efficiency of the hydraulic/electric energy conversion,
- reservoir volume, initial and final amount of water (on a yearly basis), weekly natural inflows and minimum and maximum amount of water

Promed *grid*

Promed *grid* is the market simulator owned and developed by CESI

Promed *grid* is the market simulation tool adopted by the Italian TSO (Terna) for the market benefits assessment of network reinforcements both at the Italian and European levels.



Network transmission constraints

Following recent trends three alternative ways to handle the network transmission constraints have been implemented in Promed *grid*:

- a pure flow-based (FB) approach,
- a pure Available Transfer Capacity (ATC) based approach and
- the hybrid one.

CIGRE 2012

C5 - 101

"**Market integration in Europe**: a market simulator taking into account different market zones and the increasing penetration of RES generation"

Algeria-Italy feasibility study: results

Variation of the SeW – case with «No Losses»

HVDC 600 vs. No HVDC

M€	Italy	Algeria	Others	To be allocated
Gen Surplus	-55		-6	
Consumer surplus	60			
∑ Surplus	**5**	**16**	**0**	**0**
Balance Surplus		**21**		
Internal CR	7.03			
Congestion Rent HVDC				33
Other CR				0
∑ CR	**7**	**0**	**0**	**33**
Balance CR		**40**		
WELFARE		**+61.0**		

HVDC 1000 vs. No HVDC

M€	Italy	Algeria	Others	To be allocated
Gen Surplus	-76		-7	
Consumer surplus	80			
∑ Surplus	**3**	**37**	**0**	**0**
Balance Surplus		**40**		
Internal CR	15			
Congestion Rent HVDC				23
Other CR				0
∑ CR	**15**	**0**	**0**	**23**
Balance CR		**38**		
D-WELFARE		**+78.1**		

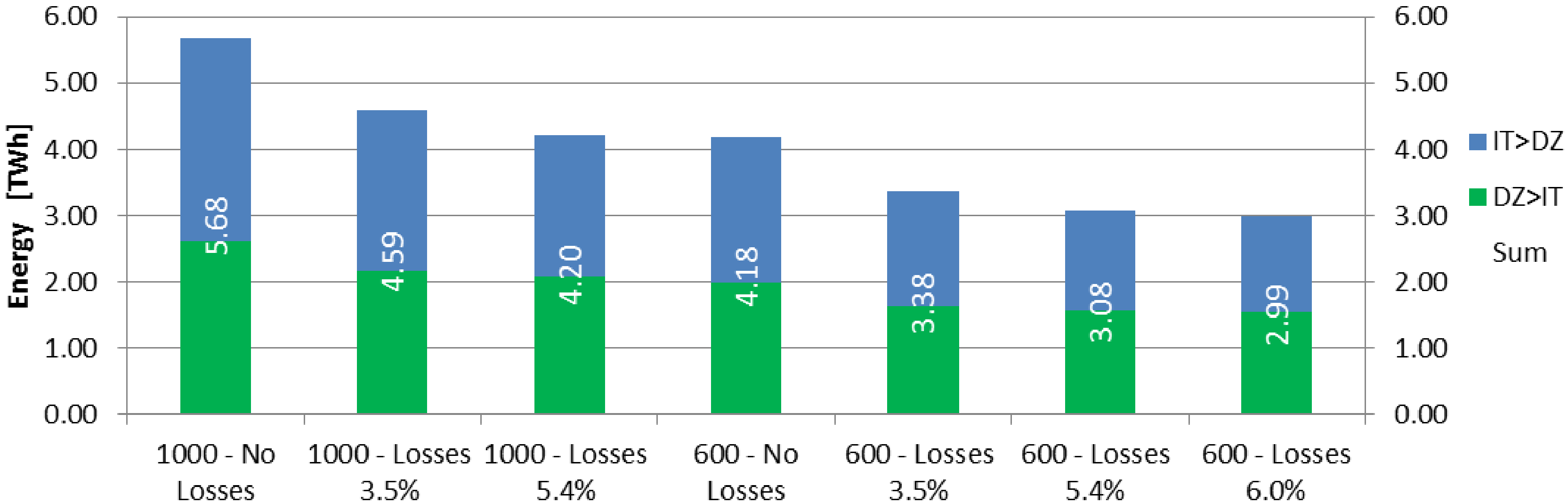
Algeria-Italy feasibility study: results

Yearly exchanged energy

Exemplificative results

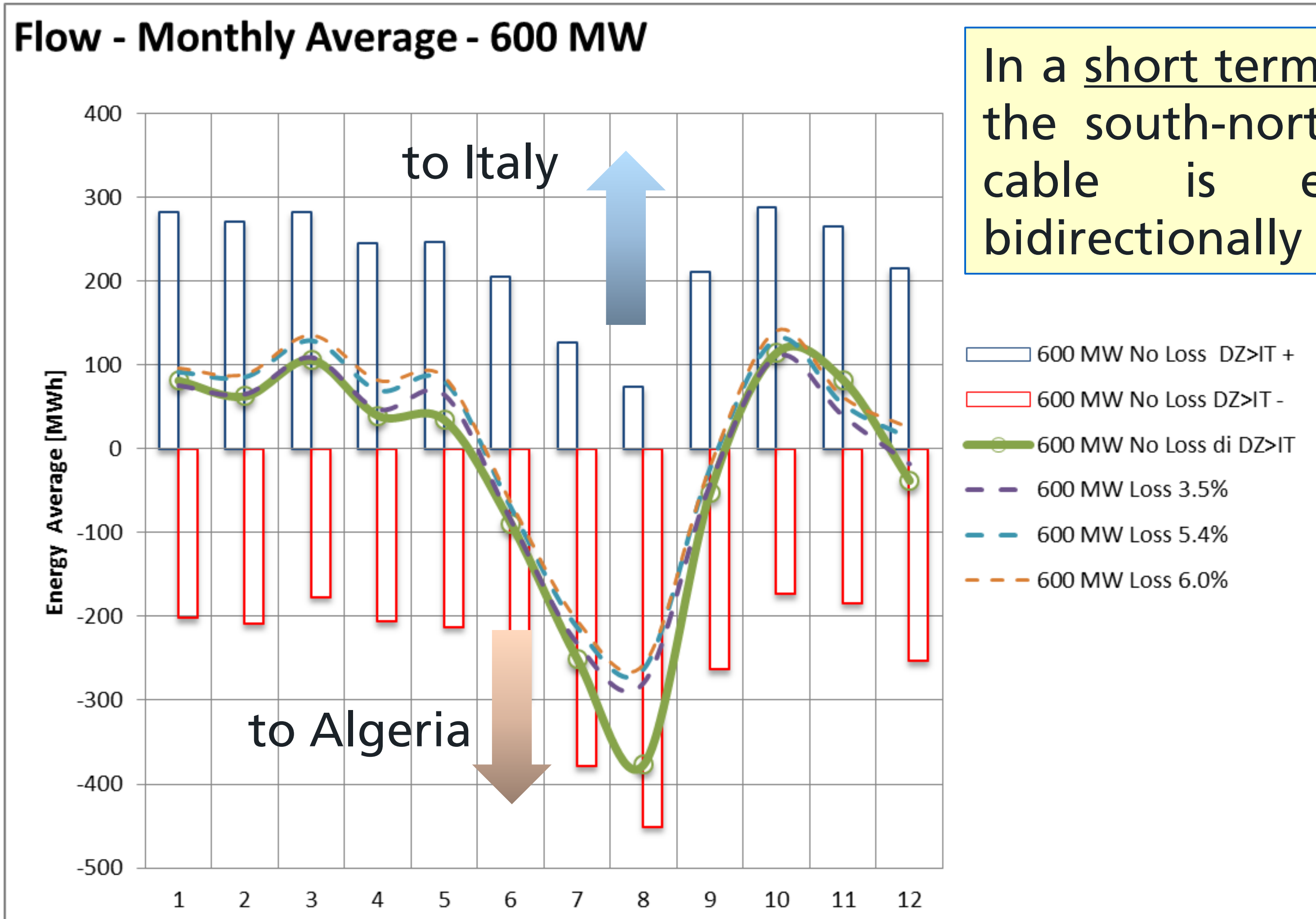
Energy flow potential across Algeria-Italy HVDC

within losses scenario result has been evaluated also the unavailability of cable/s, 7.8 % each year



Algeria-Italy feasibility study: results

Energy Flow Annual Average – Monthly Detail



In a short term horizon the south-north HVDC cable is exploited bidirectionally

Mid-term projects: the Medgrid initiative

Mid-term scenario: year 2022

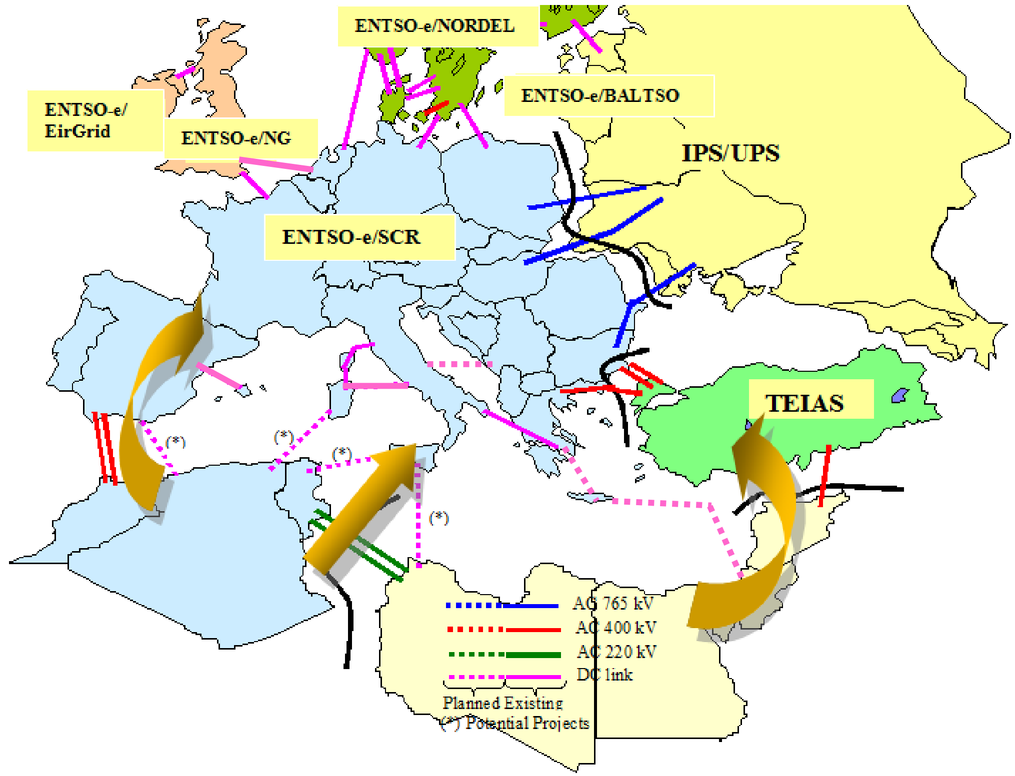
Aim: explore feasibility of transmission corridors between MENA and Europe

Three corridors

- Western corridor
- Central corridor
- Eastern corridor

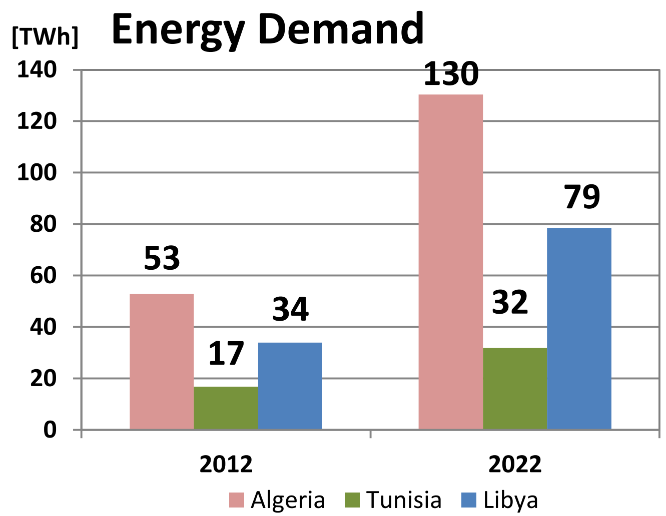
Target Transfer Capacity

1 GW to 3 GW



Medgrid - Central Corridor

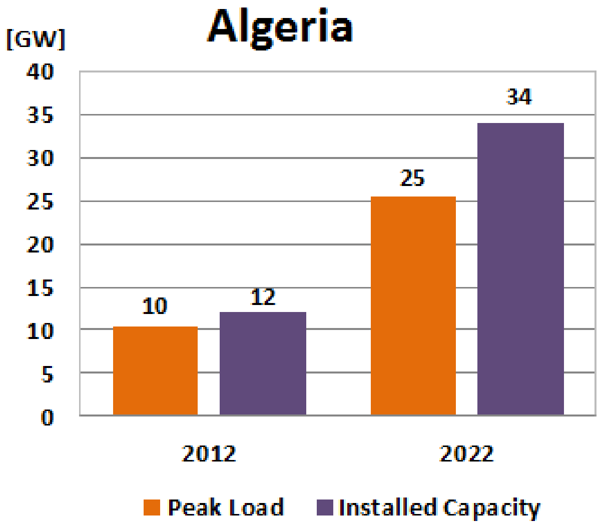
Trend of electricity demand in Maghreb

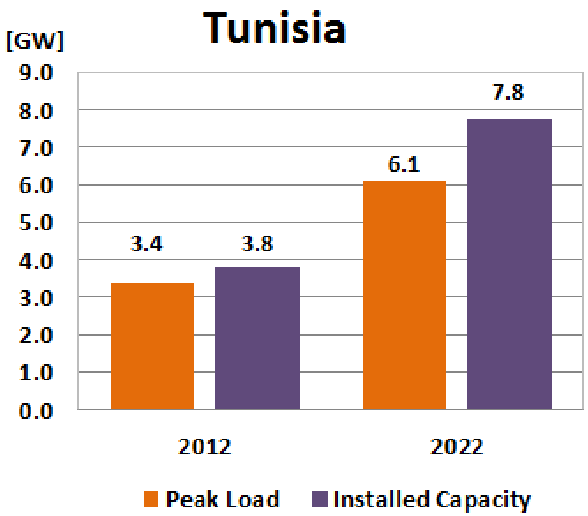


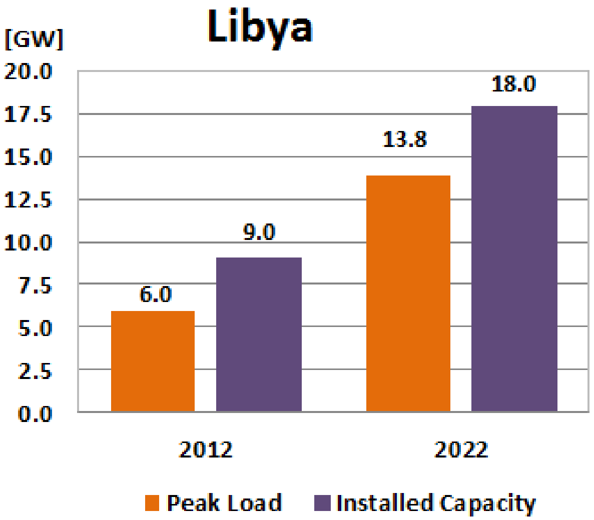
AL: +9,4%

TN: +6,5%

LY: +8,8%



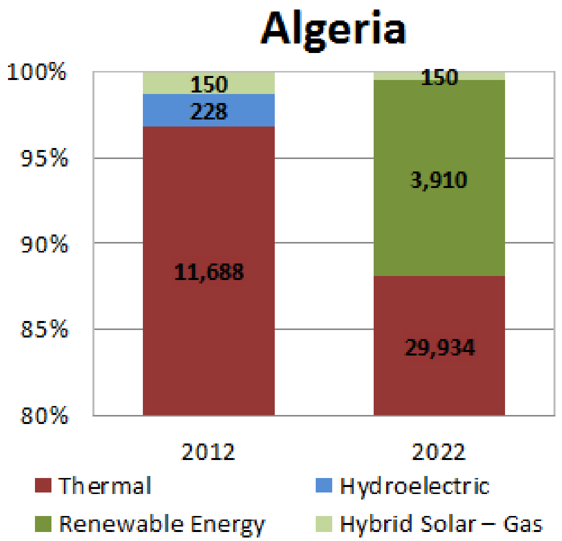


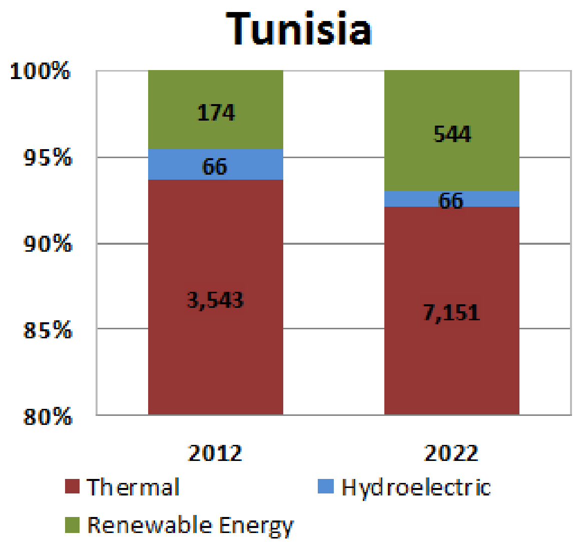


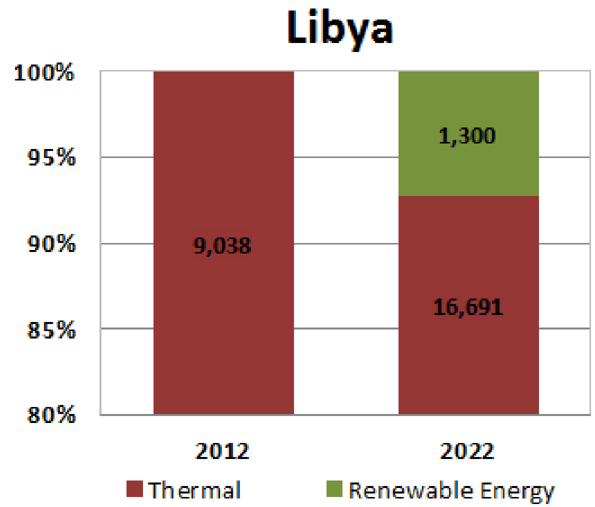
Peak Load growth: 20.5 GW (CAGR 8.7%) - New Installed Capac.: 35 GW (CAGR 9.2%)

Medgrid - Central Corridor

Evolution of the generation mix







RES capacity from 600 MW to 6000 MW in ten years

Medgrid - Central Corridor

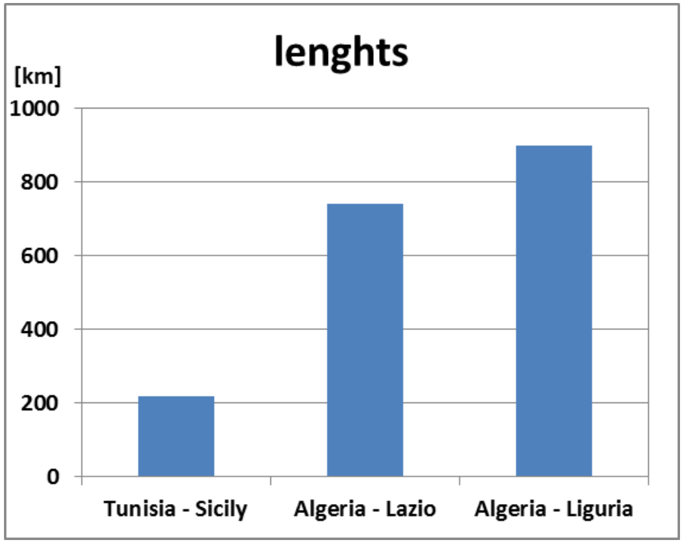
Preferred links between Maghreb and Italy

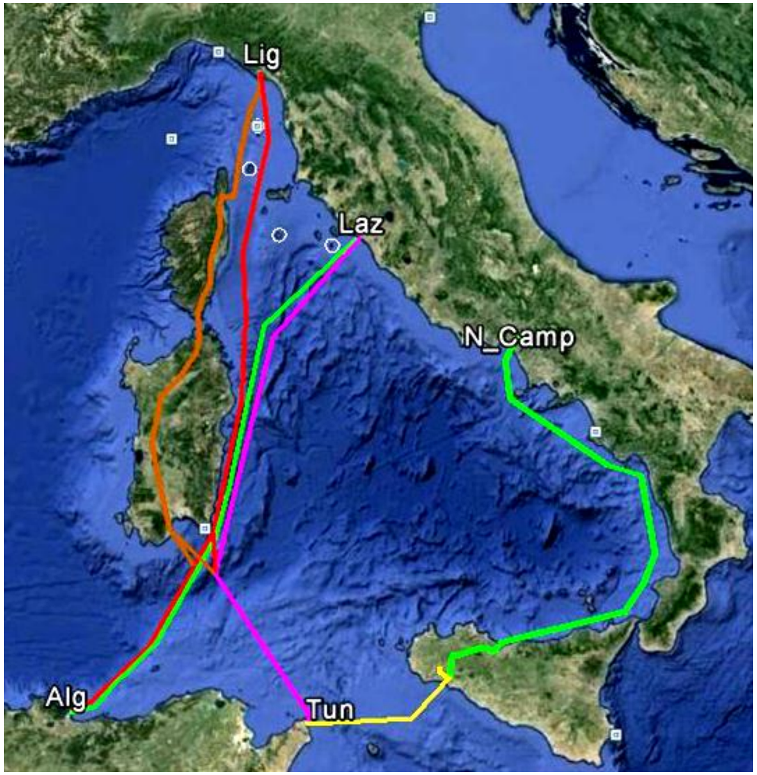
HVDC:

- 1 GW bipoles modules
- LCC technology

Undersea cables:

- 220 to 900 km
- 700 to 2000 m under sea level

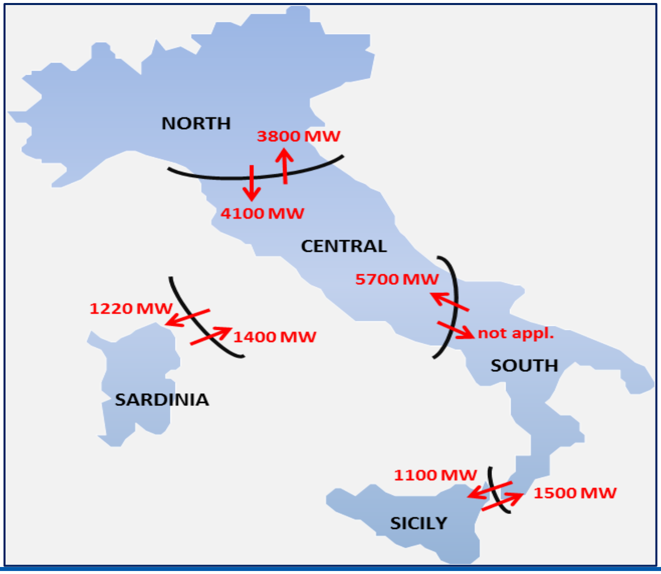




The Italian reference system at 2022 (large share of Res)

Large amounts of generation from RES is transmitted from the South to the Central & Northern Areas along two main corridors : the Adriatic and the Tyrrhenian

Power Injections from Maghreb into the South of Italy are in « competition » with the usual transits South to North through the « critical Sections » of the Network



Selected Solutions: main characteristics

Link name	Tracks		Under sea	Depth	Terrestrial
	From	To			
Tun - Sic	Tunisia	South West Sicily	192 km	≤ 700 m	32 km
Alg - Laz	Algeria	South Sardinia	262 km	≤ 2000 m	2 km
	South Sardinia	Lazio	480 km	≤ 1500 m	2 km
Alg - Lig	Algeria	South Sardinia	262 km	≤ 2000 m	2 km
	South Sardinia	Sardinia-Corsica	325 km	≤ 700 m	-
	Sardinia-Corsica	Liguria	315 km	≤1000 m	3 km

Top ranked solutions

Scenario 1: Yellow path

Scenario 2: Yellow and green path

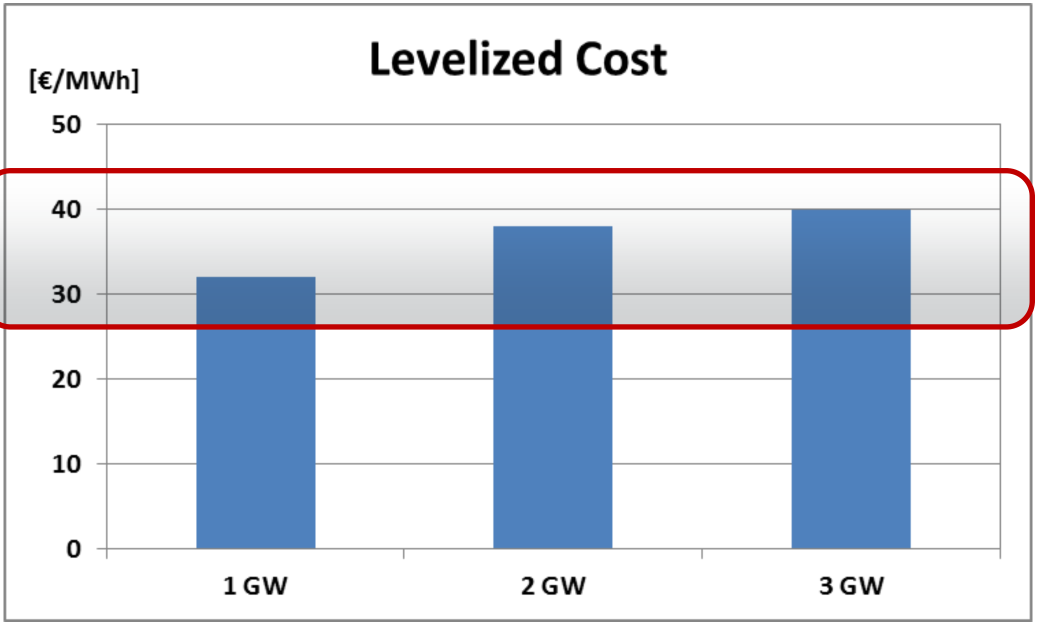
Scenario 3: Yellow, green and red path, or yellow and double red path

Source: MedGrid

Medgrid - Central Corridor

Levelized Cost of Transmission

- CAPEX, OPEX, including cost of losses for the HVDC equipment and the AC upstream/downstream transmission reinforcements
- Equivalent hours at full power: 4000 h/y



LCOT in the range of 32÷40 €/MWh

Mid-long term perspectives

RESEDIGN

Redesign of the European transmission grid building a new transmission layer in DC overlapped to the existing AC EHV grid: concept of e-highways.

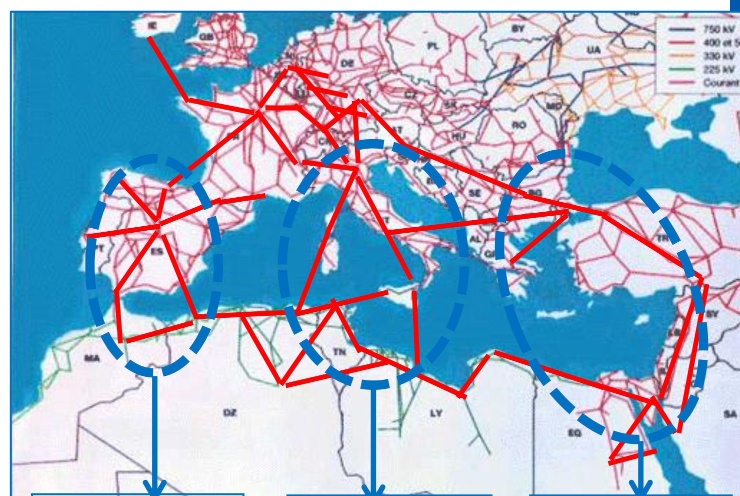
Several initiatives ongoing:

If the network reinforcements and the European Supergrid do not keep up with the RES generation deployment, the power system stability can be at risk

Mid-long term perspectives: the Dii initiative

Horizon period: 2030-2050

The EUMENA transmission system now	EU: TYNDP-2012 MENA: national master plans Medgrid initiative	Dii : CESI-Comillas mid-term pre-feasibility study	Dii : CESI-Comillas mid-term pre-feasibility study
NTC-2012	**NTC-2020/2025**	**NTC-2030**	**NTC-2050**

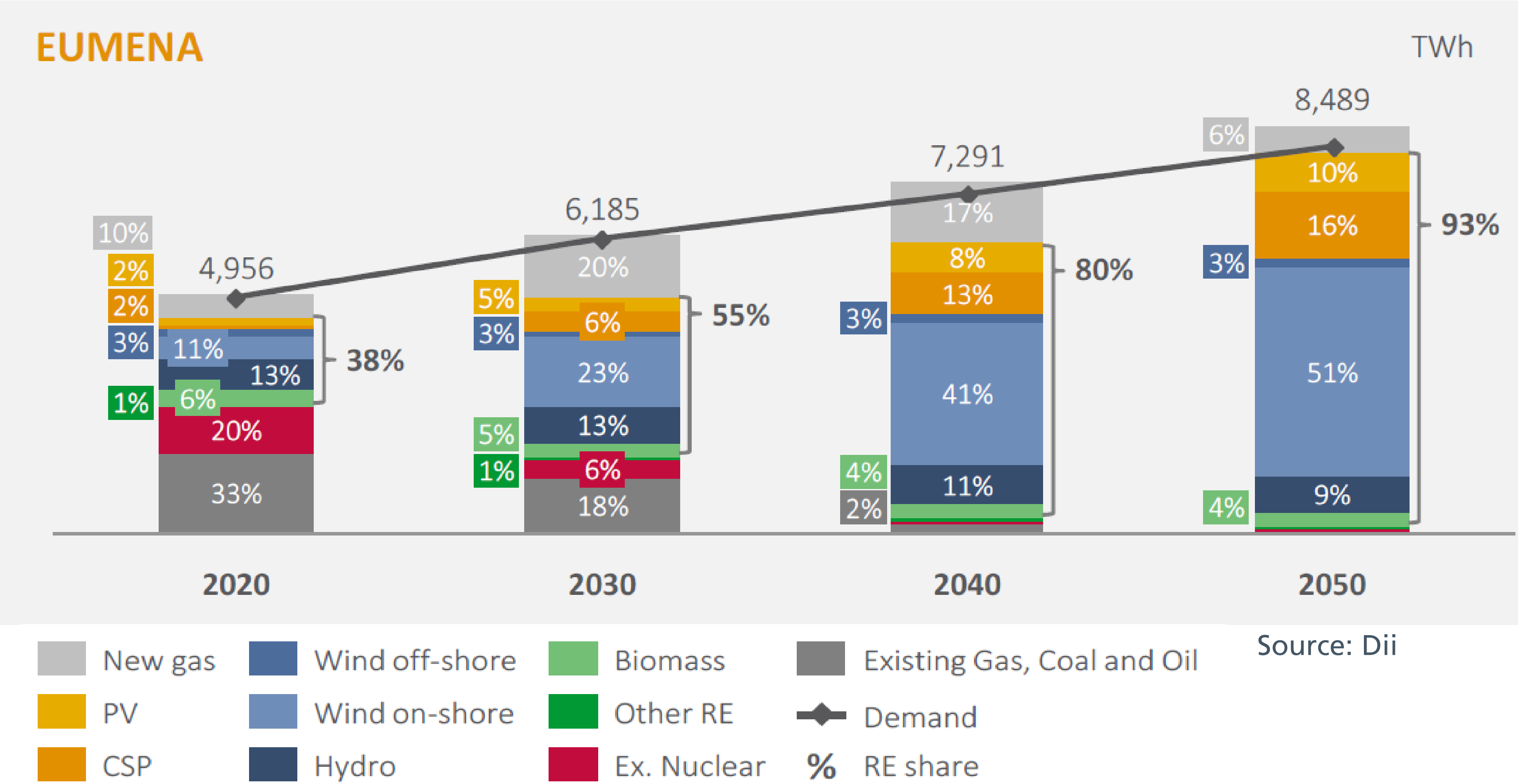


EU-MENA power highways: a seamless process for their deployment

Mid-long term perspectives: the Dii initiative

Evolution of the generation mix in the EUMENA region

Short term	Mid term	Long term
Until 2020	2020-2030	Post-2030



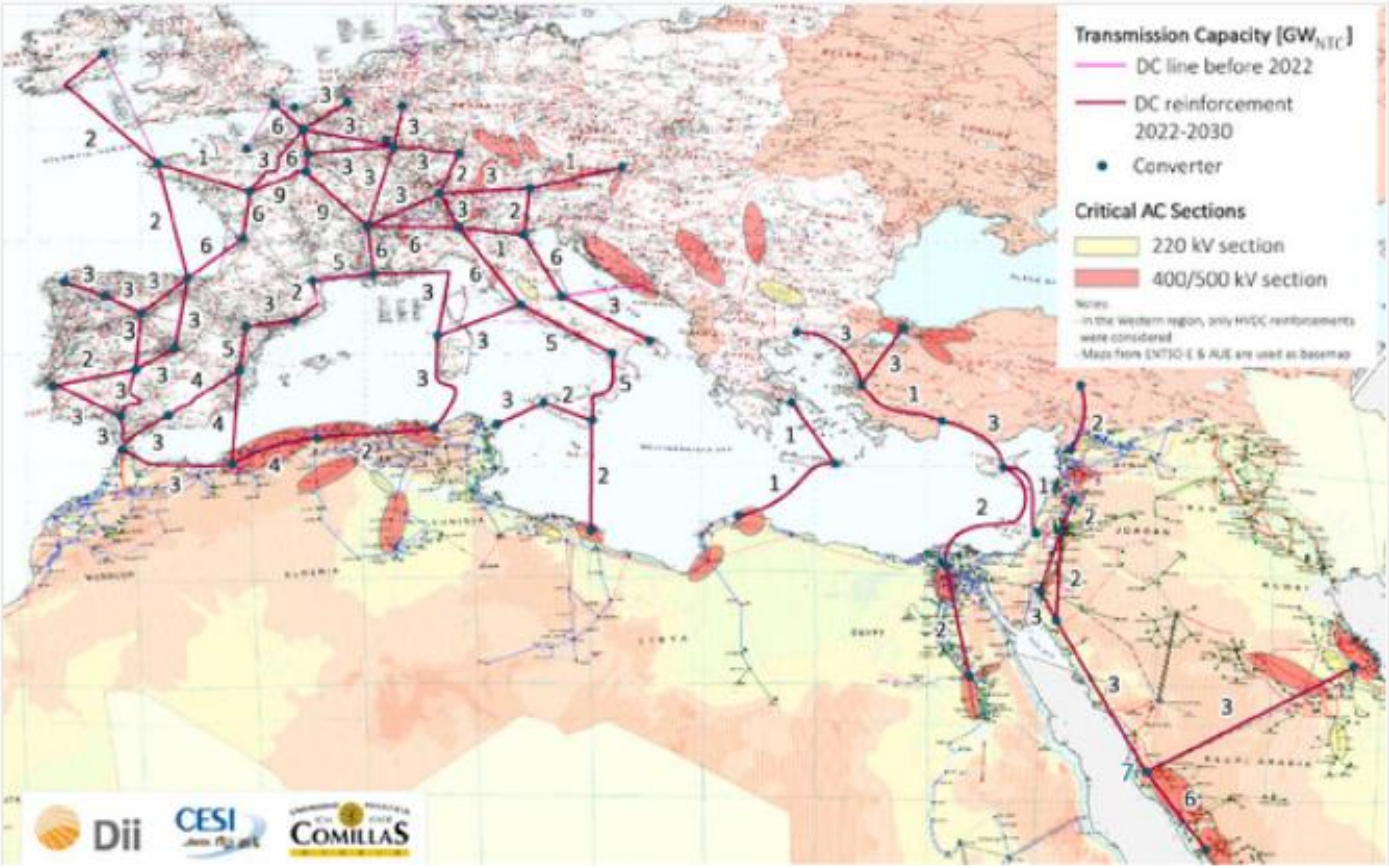
Source: Dii

CESI Trust the Power of Experience

Mid-long term perspectives: the Dii initiative

Year 2030

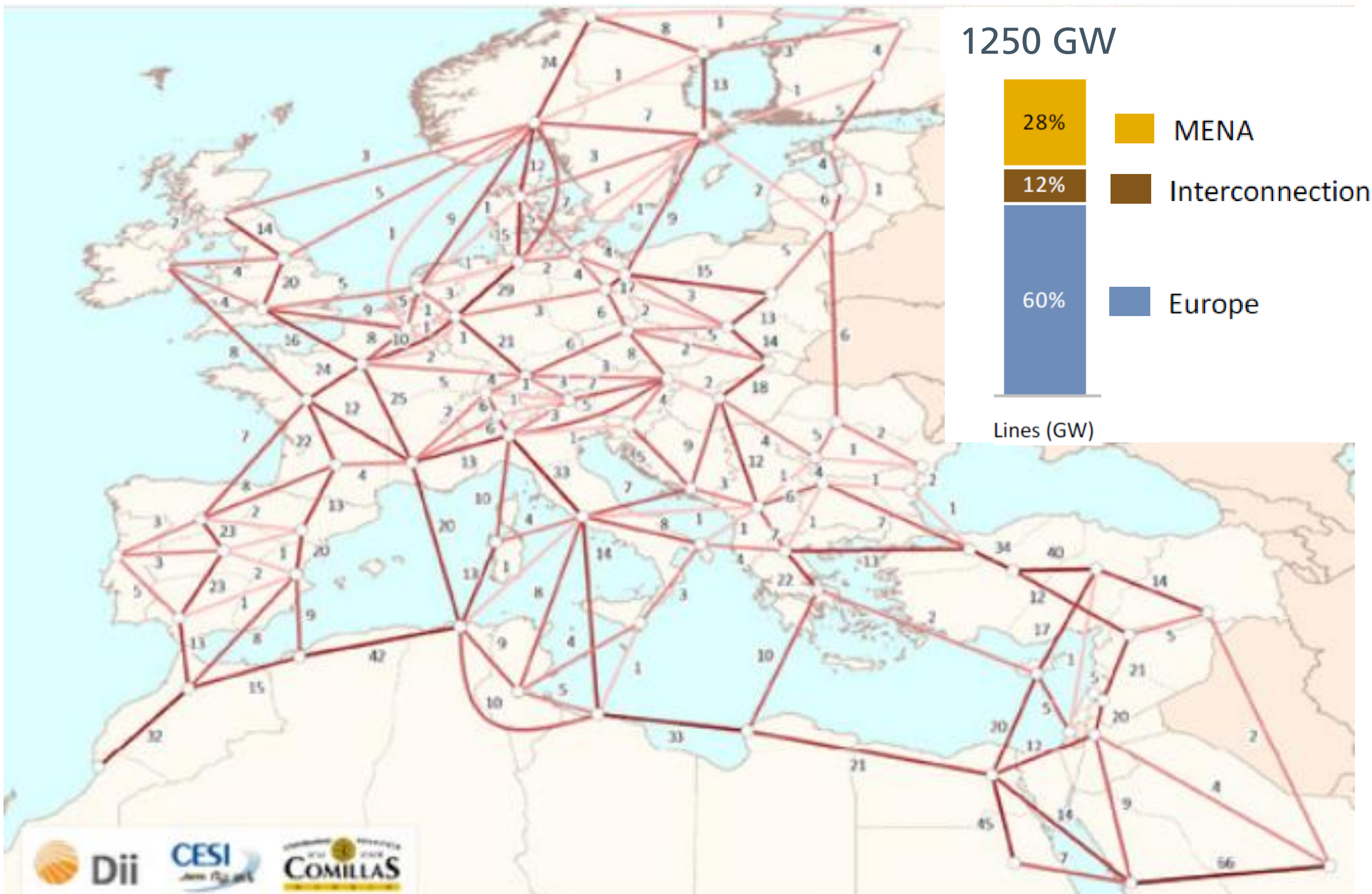
Source: Dii



Mid-long term perspectives: the Dii initiative

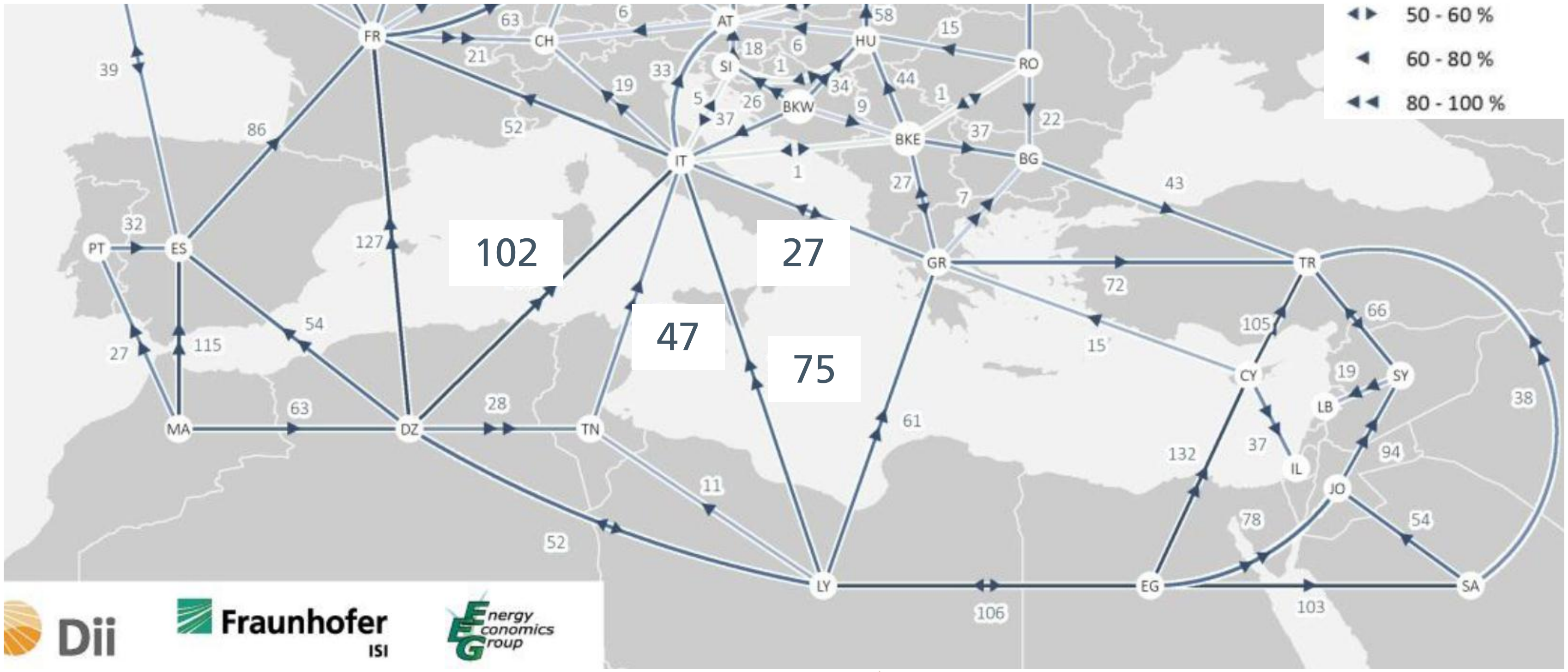
Year 2050

Source: Dii



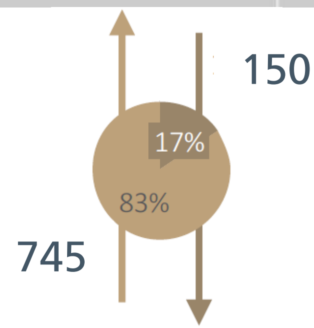
Mid-long term perspectives: the Dii initiative

Energy exchanges (in TWh)



Source: Dii

EU-MENA exchanges (in TWh)



Mid-long term perspectives: the Dii initiative

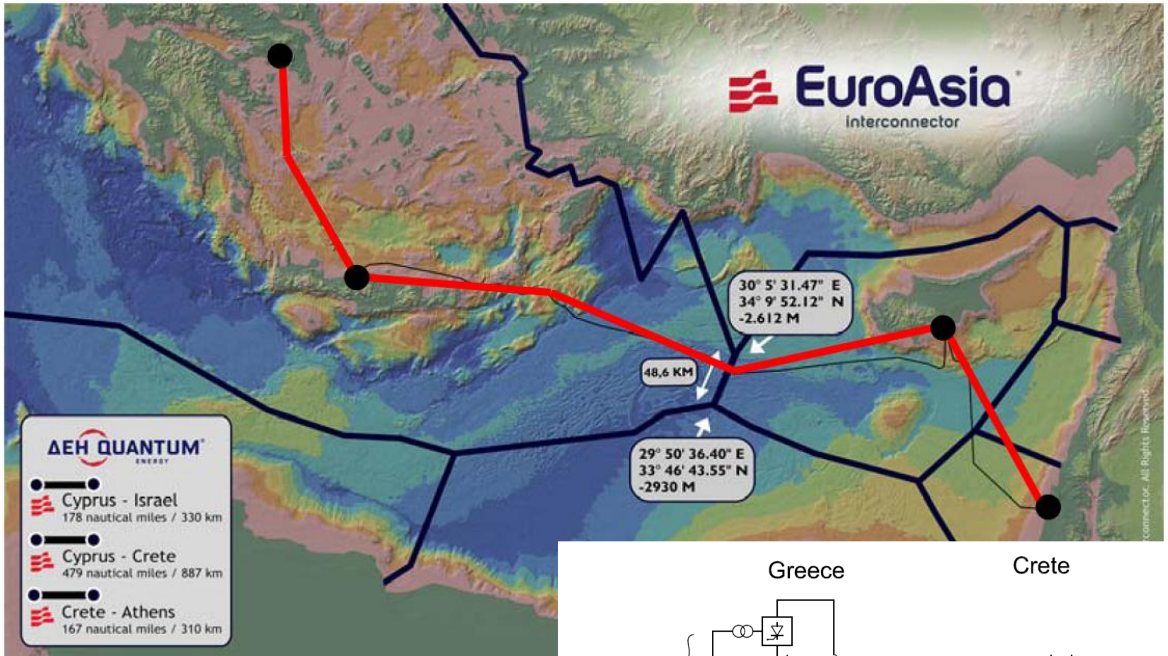
Assumptions for new e-highways:

- HVDC technology (VSC)
- Links:
  - Submarine links: 100% cables
  - EU: 50% OHL / 50% underground cables
  - MENA: 90% OHL / 10% underground cables

Estimated investments (period 2022-2050)

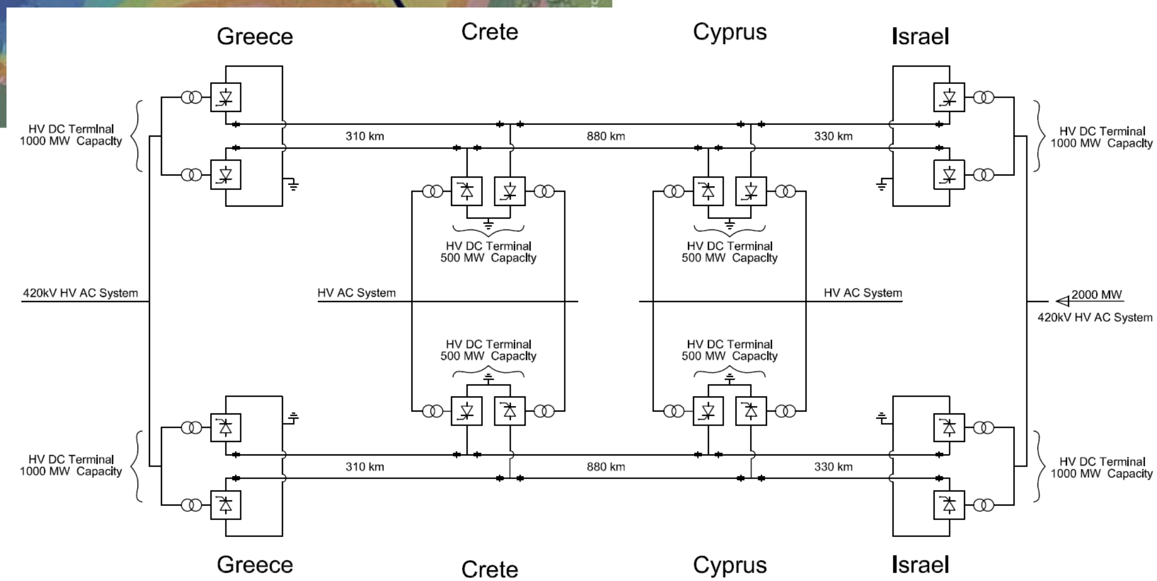
Transmission line / cable investments		Converter investments	
Total (bn€)	Annual (bn€/yr)	Total (bn€)	Annual (bn€/yr)
436	**32.2**	**118**	**8.7**

The Euroasia Interconnector: from Israel to Europe



2000 MW from Israel to Continental Greece through Cyprus and Crete

4-terminals HVDC-VSC



Summary

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- ❑ South-North integration: drivers and existing barriers
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- ❑ Conclusions and recommendations

Conclusions and recommendations

Drivers for systems development:

- **RES integration** and **Market integration** in Europe
  - ✓ Interconnection enhancing

- **Demand growth** and **RES integration** in MENA
  - ✓ South-South integration
  - ✓ Agreement on rule for the cross-border trading of electricity is a further priority
  - ✓ Removing barriers for energy exchanges
  - ✓ Progressive reduction/elimination of internal subsidies applied indiscriminately to all categories of consumers is also important to foster power exchanges
  - ✓ Coordinated system analyses shall be undertaken when developing interconnections

Conclusions and recommendations

Mid to Long term perspective:

- South-North integration

- Develop a **legislative framework** to favour power exchanges and implement new interconnectors with the neighbouring regions

- South-north transmediterranean interconnections will be exploited in the mid-term mostly for power export from Europe: SEMC shall be ready to **purchase energy at international prices**

- Develop technology for **e-highways / SuperGrid**

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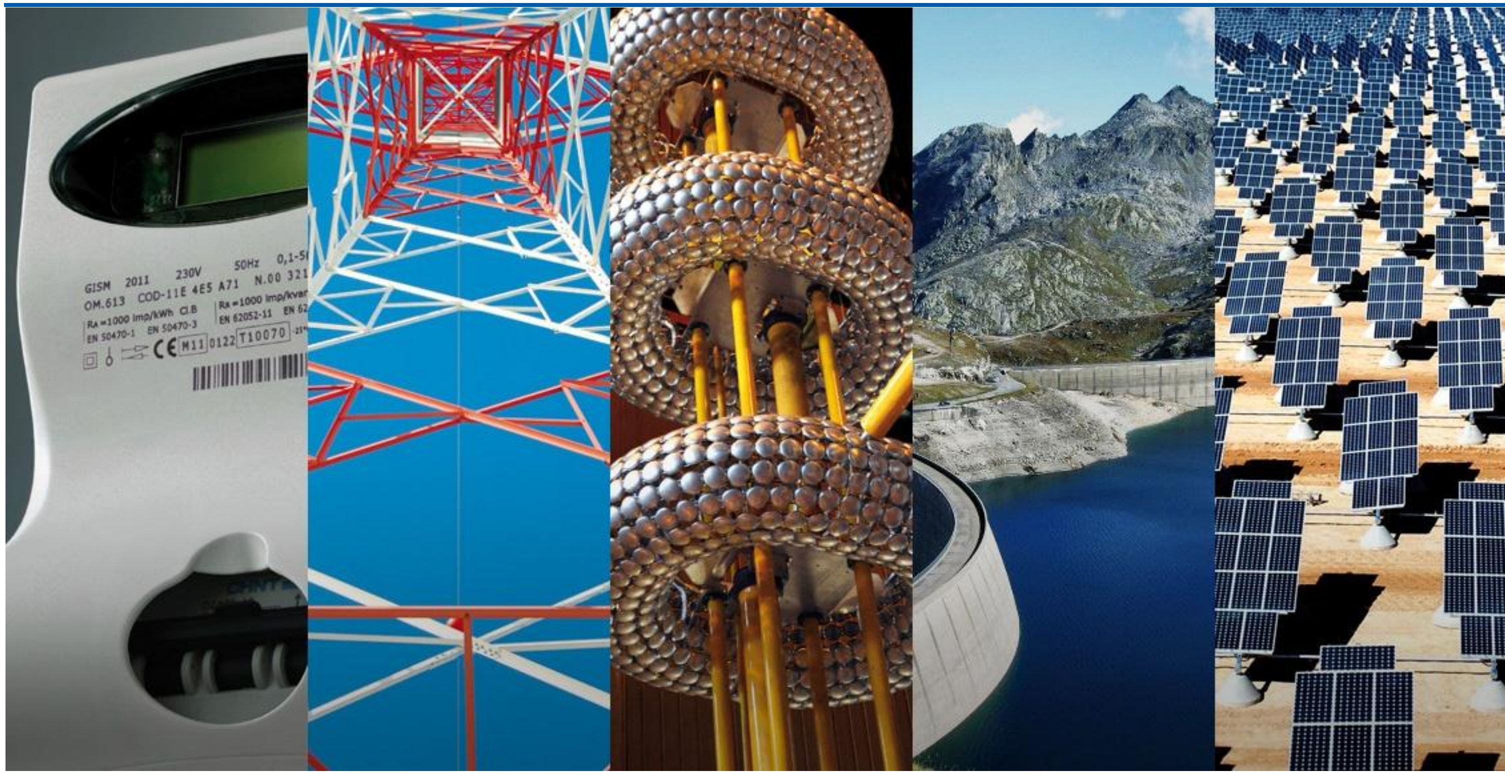

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