Second Euro-mediterranean
Rendez-vous on Energy

January 6th 2015
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Economics of trans-mediterranean interconnections

by Arnaud RENAUD, Artelys, CEO

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CONTENT

→ Questions

- What are the **possible** trans-Mediterranean interconnection projects **by 2020**?
- What is their **economic viability** for the electricity production sector?
- Does their profitability persist **by 2030**, for ENTSO-E scenarios?

→ Contents of the talk

- The power system in 2020
- Modeling the power system
- Studied interconnection investments
- Savings and profitability of interconnections by 2020
- Robustness of interconnections economics by 2030
- Conclusion

THE POWER SYSTEM IN 2020

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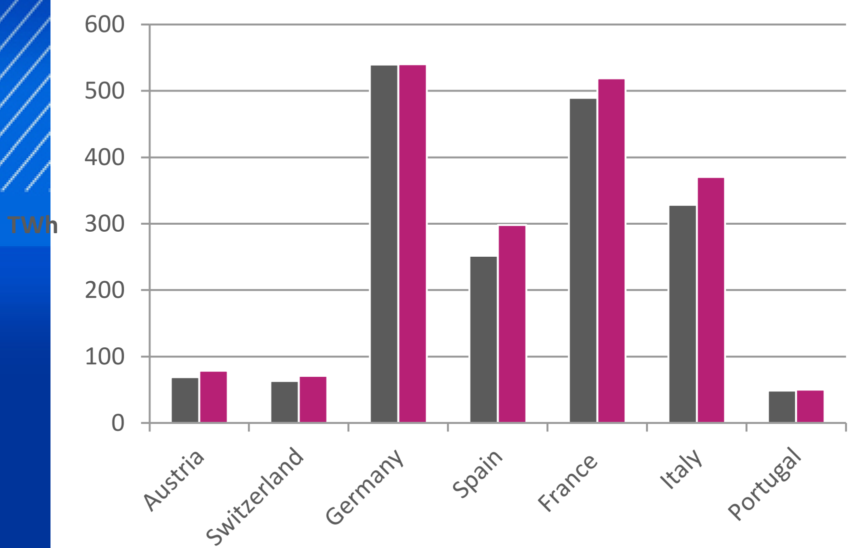
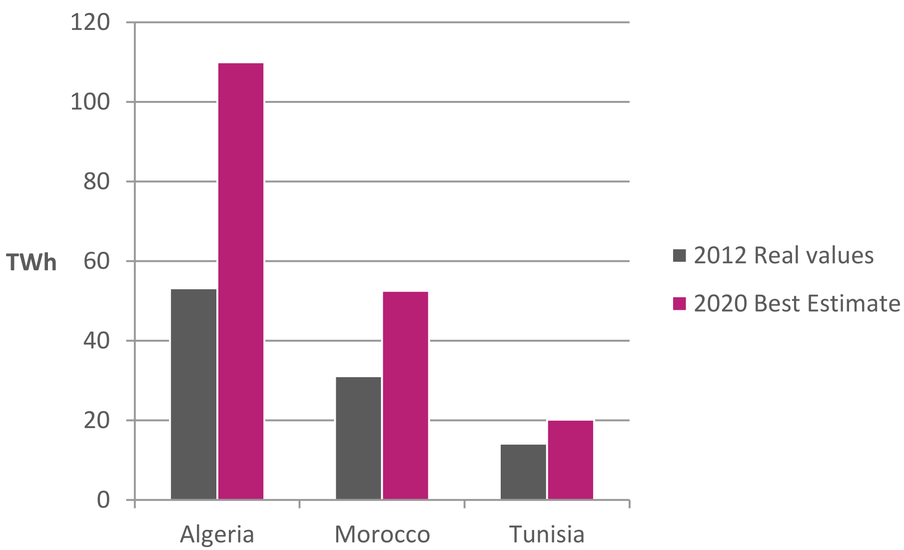
→ Annual electricity consumption grows **much faster** in Maghreb than in Europe

Annual consumption in Europe:
+8% between 2012 and 2020

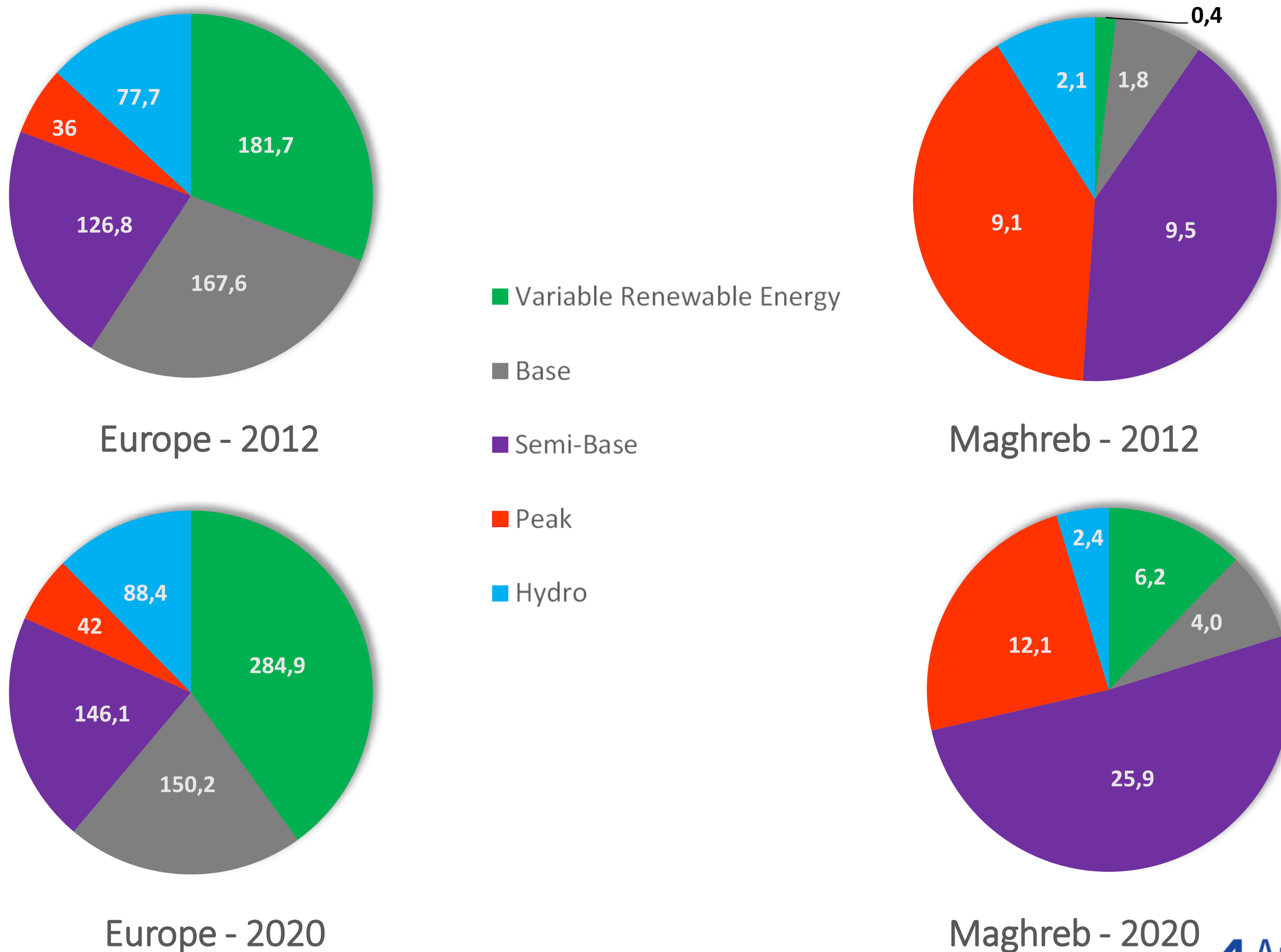


Annual consumption in Maghreb:
+86% between 2012 and 2020



THE POWER SYSTEM IN 2020

→ **Structurally different generation fleets** (installed capacities in GW)

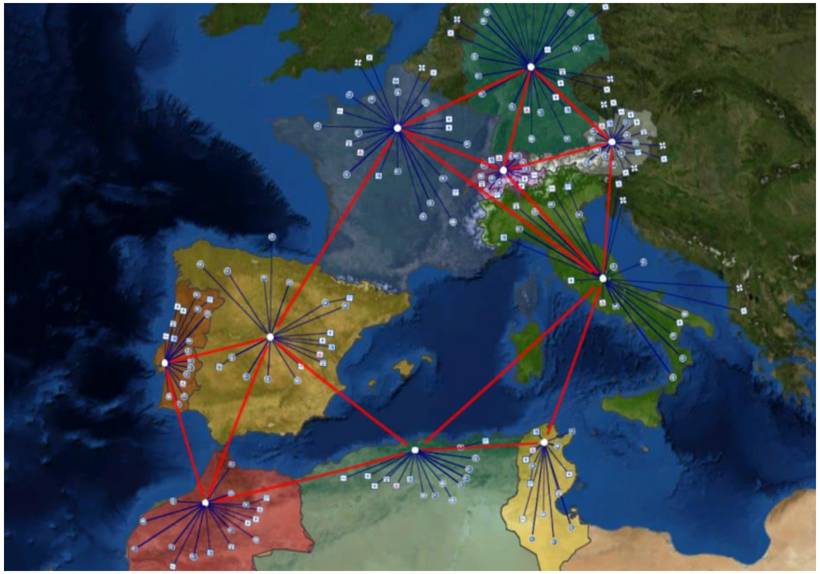


MODELING THE POWER SYSTEM

MODELING THE POWER SYSTEM

→ Performed simulations **minimize the variable costs of production** (including fuel costs and CO2 costs) for the whole zone, in order to meet the system needs:

- Electricity consumption
- Reserve needs, to face unplanned disturbance
- Load following



→ While taking into account:

- Variable renewable energy (VRE) production profile
- Hydro storage short and long-term management
- Thermal generators availability profiles
- Physical constraints of production plants (maximum gradients and minimal power for nuclear and coal)
- Energy losses due to interconnections

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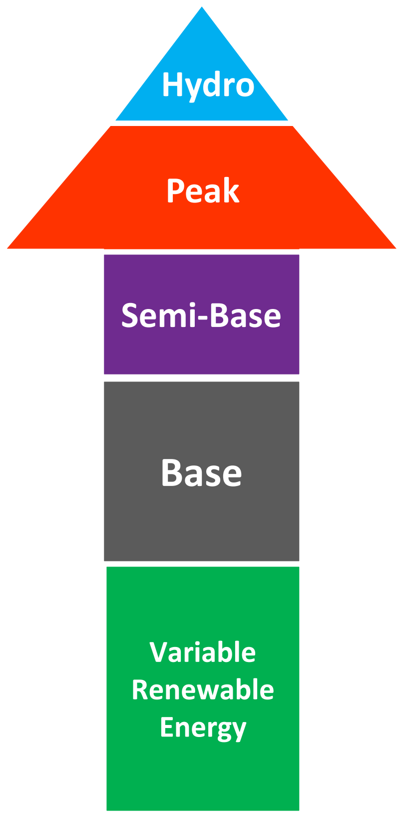
MODELING THE POWER SYSTEM

→ Production facilities in each country are represented **by fleets**

High variable cost



Low variable cost

Technology	Variable cost in 2020, excl. CO2 (€/MWhe)	Variable cost in 2020, incl. CO2 (15,6€/t) (€/MWhe)
Pumped storage	-	
Seasonal storage	-	
Diesel-fired GT	287	298
Gas-fired GT	101	108
Steam turbines	95	102
CCGT	57	61
Coal	24	38
Lignite	15	26
Nuclear	6	6
Renewable Thermal	-	
Run-of-the-river	-	
Wind	-	
Solar	-	

Source: IEA World Energy Outlook 2013 and DECC

MODELING THE POWER SYSTEM

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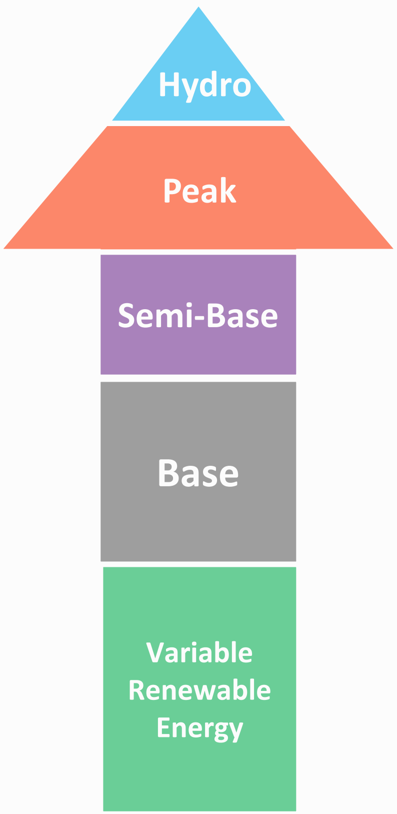

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For instance, substitution of 1TWh from gas-fired GTs by CCGTs leads to savings of 47M€.

Source: IEA World Energy Outlook 2013 and DECC

STUDIED INTERCONNECTION INVESTMENTS

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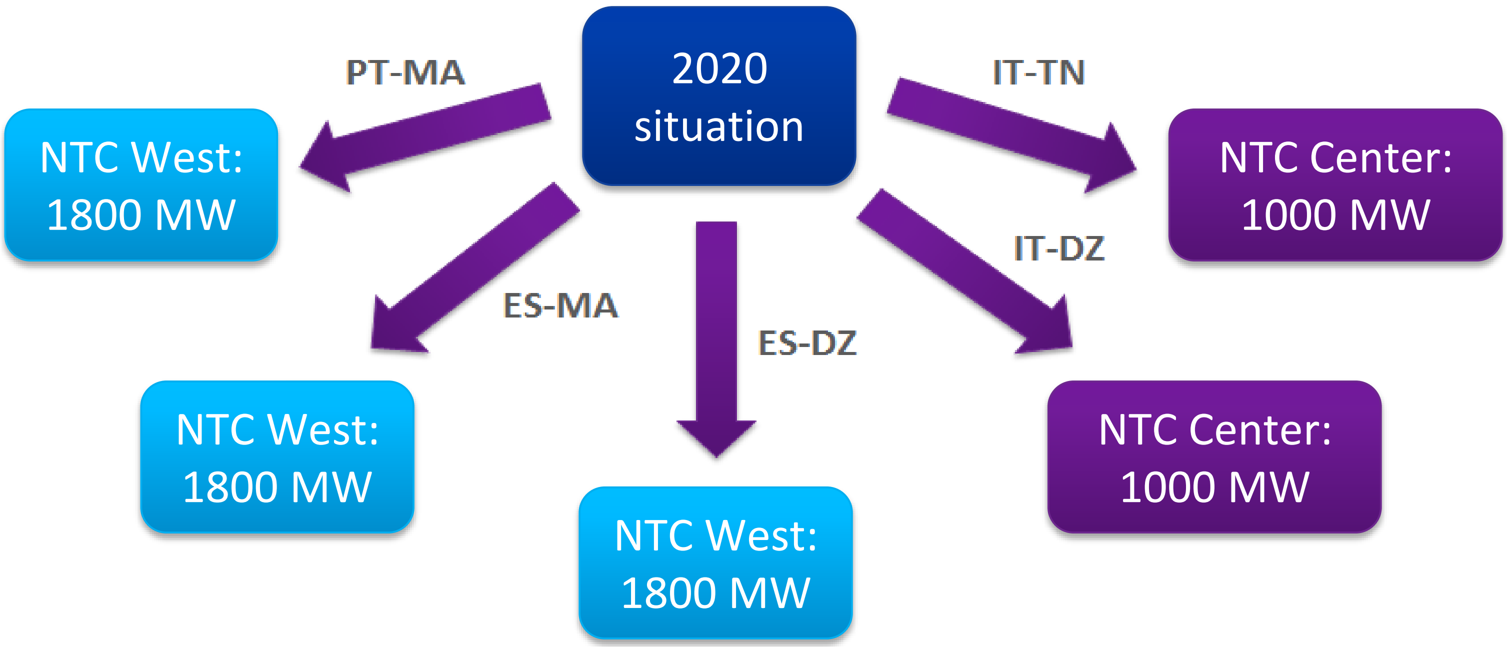


Simulations show that:

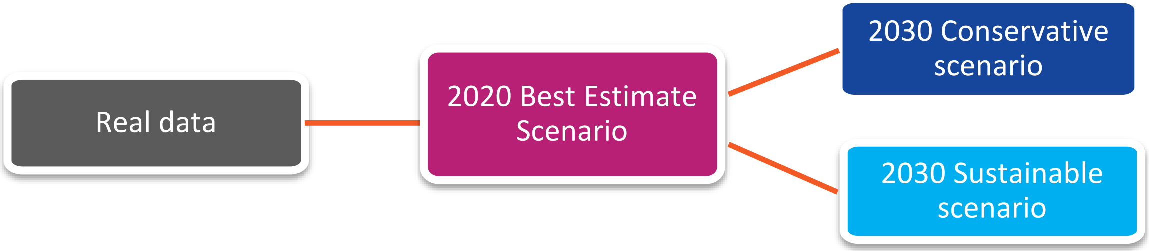
- gains from investments in western and central corridors are additive;
- gains from investments between FR and ES and in western corridors are additive

STUDIED INTERCONNECTION INVESTMENTS

→ Approach:

- Investments profitability by 2020
  - Using installed capacity and consumption data from ENTSO-E « **Best Estimate** Scenario » and estimations from Maghrebian operators

- Study the robustness of the results by 2030, using contrasted scenarios
  - **Conservative** scenario, built using ENTSO-E scenario “Slow progress” and additional data from Maghrebian operators
  - **Sustainable** scenario, built using ENTSO-E scenario “Green transition” and additional data from Maghrebian operators



SAVINGS AND PROFITABILITY OF INTERCONNECTIONS BY 2020

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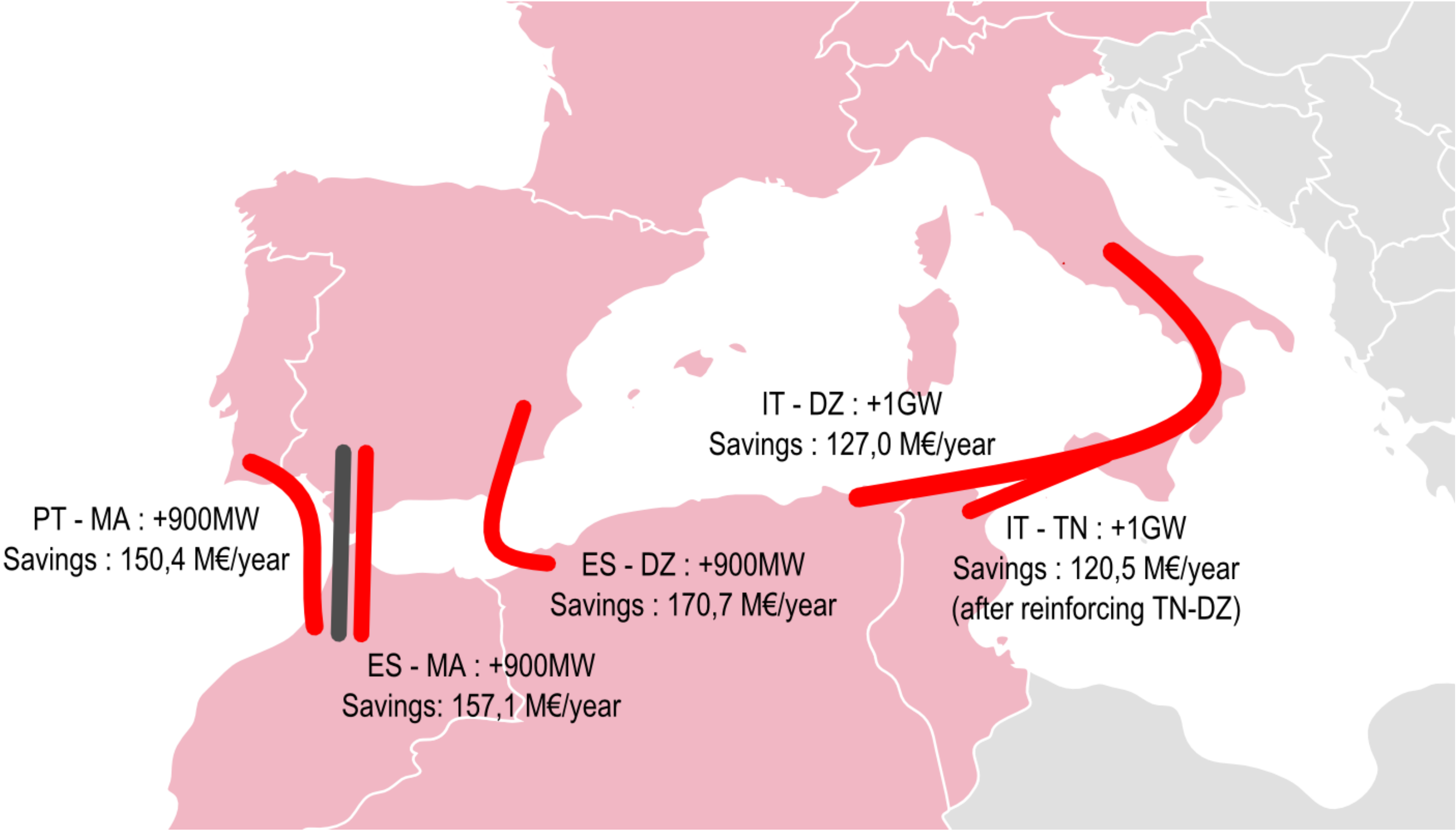
→ Annual savings:



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SAVINGS AND PROFITABILITY OF INTERCONNECTIONS BY 2020

→ Savings obtained with an interconnection come from:

- Better use of cheaper production
  - Cheap baseload and semi-baseload production from Europe replaces peak fleet production from North Africa
- Variable renewable energy is better integrated in the whole system
  - Interconnections allow a reduction of VRE curtailment
- Increase of the security of supply
  - Interconnections allow a reduction of loss of load, but this is not observed in our simulations as capacity expansion planning of each North African country is designed to cope with national peak

SAVINGS AND PROFITABILITY OF INTERCONNECTIONS BY 2020

→ Economic profitability of each investment realized alone, by 2020:

	PT – MA (DC)	ES - MA (AC)	ES - MA (DC)	ES - MA (AC+DC)	ES – DZ (DC)	IT – TN (DC)	IT – DZ (DC via Sicily)
Additional capacity (MW)	*900*	*900*	*900*	*900*	*900*	*1000*	*1000*
Reinforcement costs Europe (M€)	*75,6 - 193,5*	*117*	*117*	*117*	*117*	*282,4**	*282,4**
Reinforcement costs Maghreb (M€)	*63,7*	*63,7*	*63,7*	*63,7*	*67,3*	*104*	*31,9*
Line + Converters costs (M€)	*478,1*	*133,1*	*192,6*	*320,9*	*564,8*	*388,9*	*600,5*
Initial investment costs (M€)	**617,4 - 735,3**	**313,8**	**373,3**	**501,6**	**749,1**	**775,3**	**914,8**
Operation and maintenance costs (M€/year)	*7,75*	*4,0*	*4,2*	*5,1*	*9,7*	*10,5*	*16,5*
Savings (M€/year)	*150,4*	*157,1*	*157,1*	*157,1*	*170,7*	*120,5*	*127,0*
Immediate profitability rate (%)	**19,4% - 23,1%**	**48,8%**	**41,0%**	**30,3%**	**21,5%**	**14,2%**	**12,1%**

* this cost covers the upgrade of internal networks in order to cope with maximum power flows in both directions, throughout the year

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SAVINGS AND PROFITABILITY OF INTERCONNECTIONS BY 2020

→ Economic profitability of two **simultaneous** reinforcements on the western corridor, by 2020

	ES-MA & PT –MA	ES-MA & ES-DZ
Initial investment costs (M€)	868,4 – 982,3	882,2
Operation and maintenance costs (M€/year)	12,2	14,8
Savings (M€/year)	229,1	298,1
Immediate profitability rate (%)	**22,1% - 25,0%**	**32,1%**

ROBUSTNESS OF INTERCONNECTIONS ECONOMICS BY 2030

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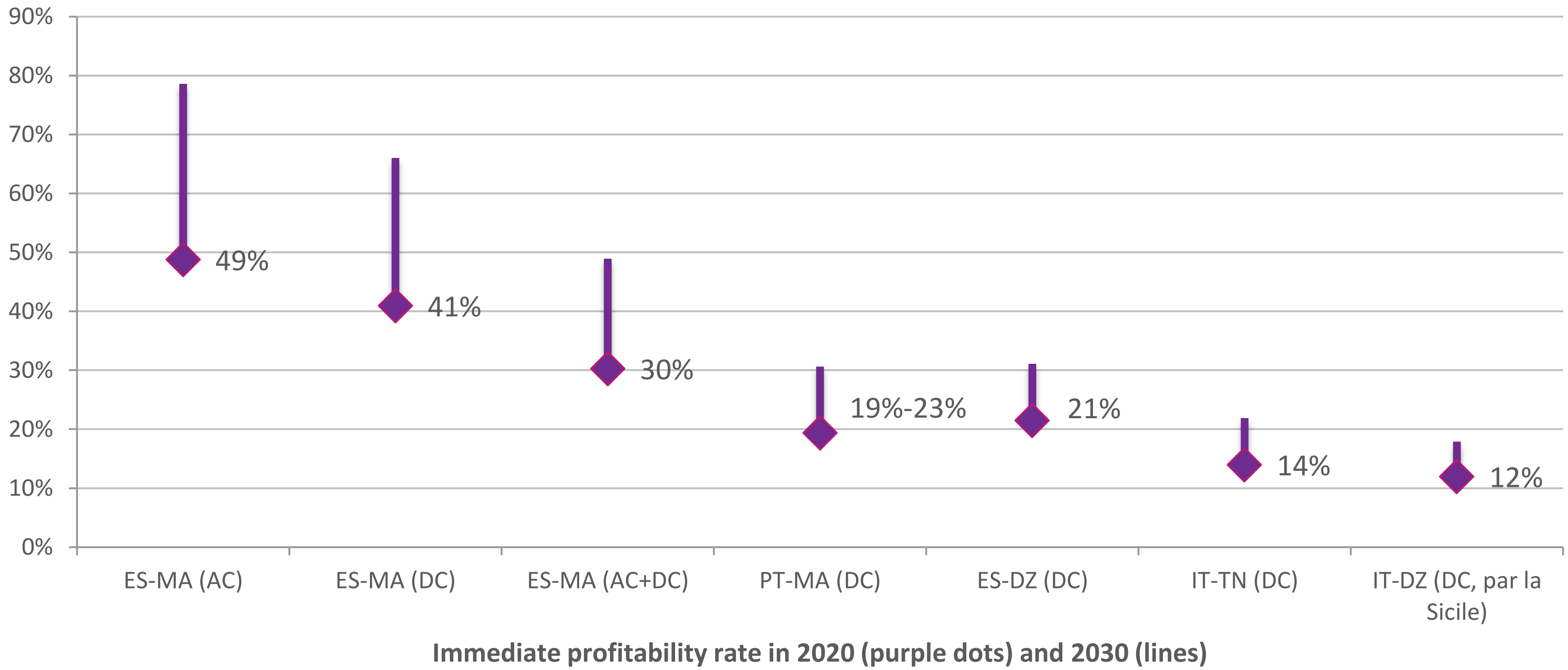
ROBUSTNESS OF INTERCONNECTIONS ECONOMICS BY 2030



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CONCLUSION

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→ All studied investment projects are profitable by 2020.

→ Their profitability persists and grows in most scenarios by 2030.

→ There is room for two simultaneous 1GW investments in the western corridor.

→ Cheap baseload and semi-baseload production from Europe replaces peak fleet production from North Africa in the Western corridor.

→ In the central corridor, power exchanges are more balanced.

CONTACTS

Medgrid

38, avenue Hoche
75008 PARIS
FRANCE

www.medgrid-psm.com

Artelys | OPTIMIZATION SOLUTIONS

Artelys France

12 rue du Quatre
Septembre
75002 PARIS
FRANCE

Artelys Canada

2001 rue Université,
bureau 1700 H3A 2A6 –
MONTRÉAL, QC
CANADA

Artelys USA

150 N Michigan
Avenue, Suite 800
60601 – CHICAGO, IL
ETATS-UNIS

support-AE-Medgrid@artelys.com

www.artelys.com

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