



Challenges of Wind Energy Integration

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Agenda

Enel and Enel Green Power at a Glance

Global Wind Market

Wind Production Integration: Key Challenges

Enel at a Glance¹

Presence in
40 countries

Installed capacity
98 GW

Annual production
296 TWh

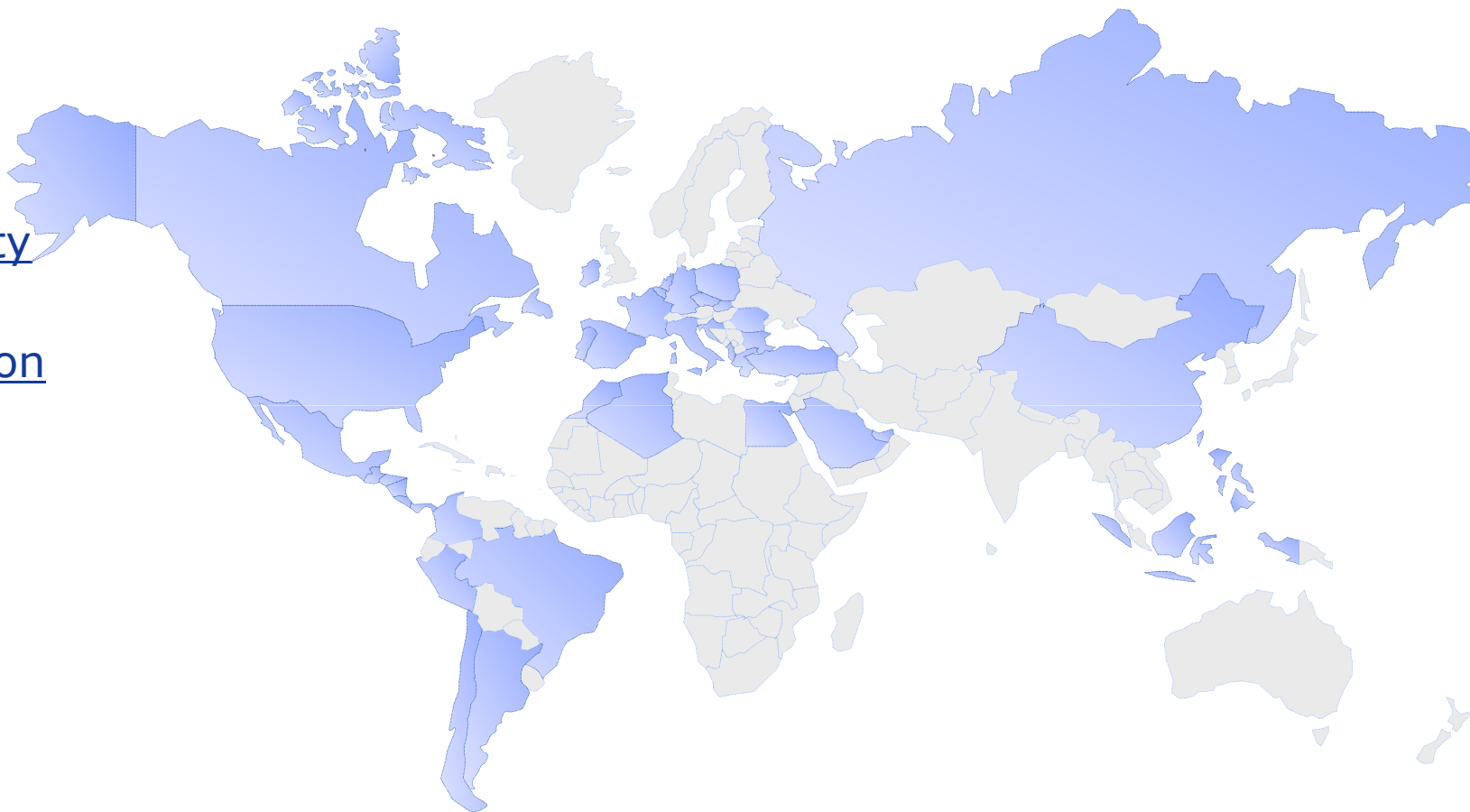
EBITDA
16.7 Bln €

Customers
61 million

Employees
75,000

Stock exchange

Enel and EGP are listed on the Milan stock exchange



¹ As of 31.12.2012 and inclusive of EGP

Enel Green Power at a Glance

North America

- Capacity: 1,239 MW
- Production: 3.9 TWh
- Technologies:



Iberia&Latam

- Capacity: 2,764 MW
- Production: 8.1 TWh
- Technologies:

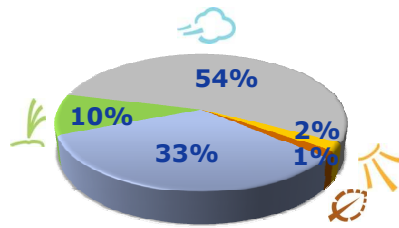


Italy&Europe

- Capacity: 3,998 MW
- Production: 13.1 TWh
- Technologies:

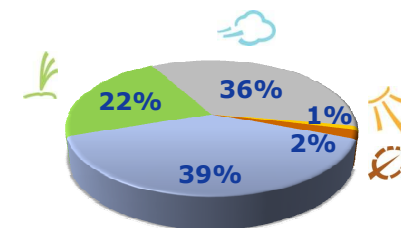


Capacity by technology



Total = 8 GW

Production by technology



Total = 25.1 TWh



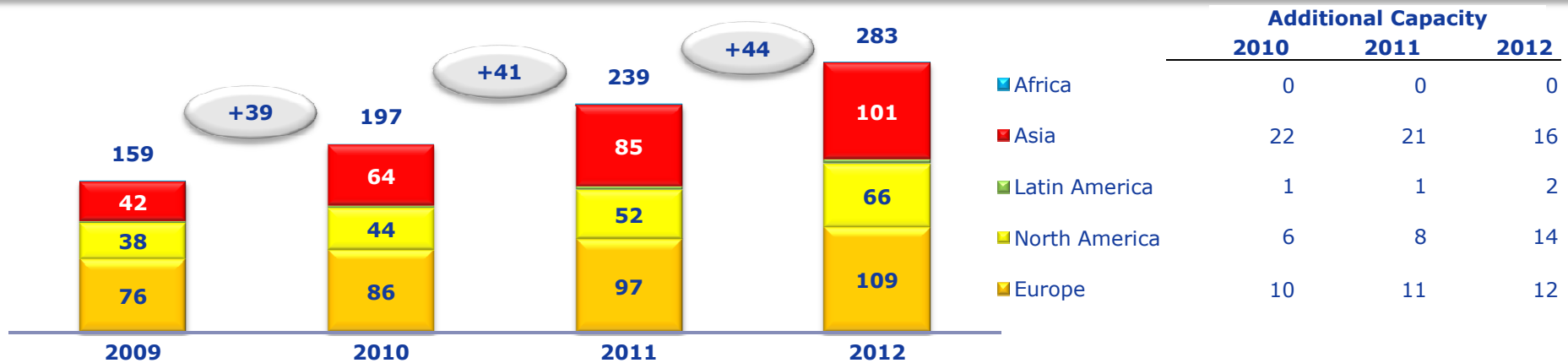
EGP FY 2012 results – Summary

€mn	FY11	FY12	%
Revenues	2,539	2,696	+6.2
EBITDA	1,585	1,681	+6.1
EBIT	1,080	1,121	+3.8
Capex	1,557	1,257	-19.3
Headcount	3,229	3,512	+8.8

Global Wind Market Overview

2009 – 2012 Wind Installed Capacity

Global Wind Cumulative Capacity 2009 – 2012 (GW)



Top 15 Wind Additional Markets – 2012 (GW)



Wind Production Integration into the electrical grid

Key challenges

The integration of renewable intermittent energy production into electrical grids becomes a challenge both considering “seconds” time frame (transitory) as well as “hours” (regime)

Transitory

The main challenges are related to

- ✓ Response to voltage dips
- ✓ Voltage and frequency control under transitory state

Regime

The main challenges are related to

- ✓ Wind production programming and potential congestion management
- ✓ Voltage and frequency control under steady state

Wind Production Integration: Spain Case Study

Regulatory and Market Design Actions

Spanish regulatory authorities developed the following measures:

- **Priority of Dispatch:** but TSO is empowered to order curtailments in case of nodal congestions
- **Programmability:** market operator must be provided with 24h production programs 24h in advance (day-ahead market). Wind farm operators can adjust their positions in intra-day markets
- **Imbalances:** wind farms must pay for imbalances as any other market player
- **Controlling Systems:**
 - Wind farms >1MW ⁽¹⁾ must be associated with a control centre in order to send real time data to the TSO
 - Wind farms >10MW must be able to receive power regulation orders by the TSO
 - Wind farms must install equipment to neutralize voltage dips ⁽²⁾
- **Sanctions:** Wind farm not complying with the above requirements may lose their Special Regime status and benefits

As of 2012, Spain successfully integrated over 20 GW of wind capacity

Source: Spanish Wind Association

1)Regulatory change RD 1565/2010 (23/11/2010). Previously only plants >10MW were obliged to send real time data to TSO

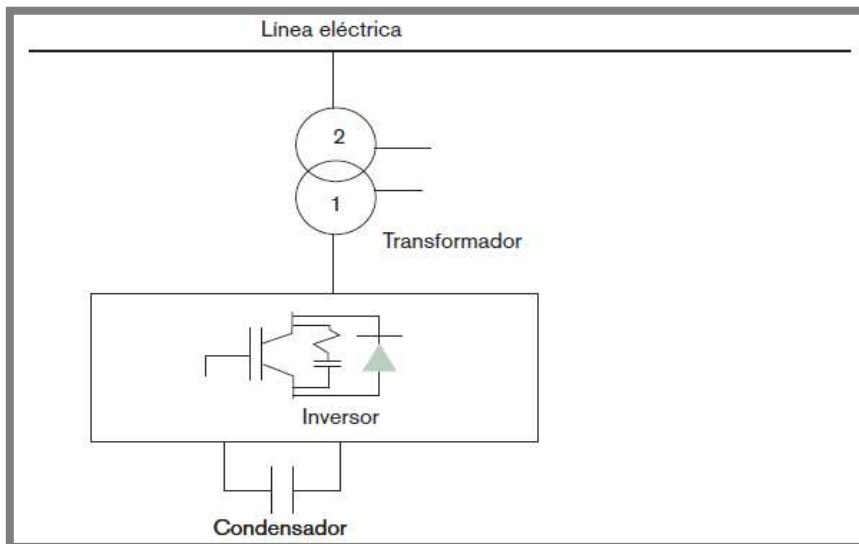
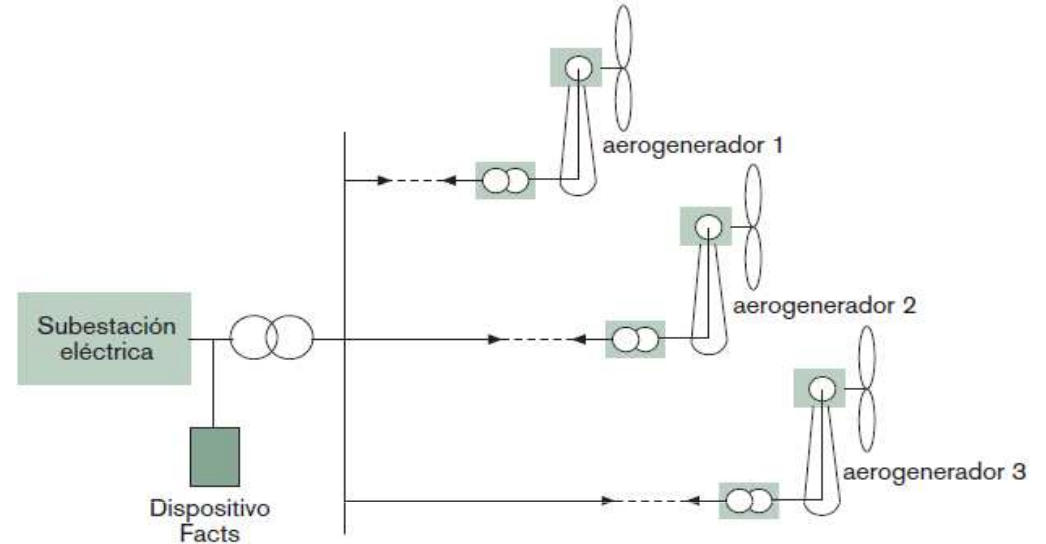
2) Compulsory only for wind turbine > 500 kW



Wind Production Integration: Spain Case Study

Equipment to neutralize voltage dips

The equipment required to neutralize voltage dips - as established by the Spanish Grid Code (P.O. 12.3) - may be installed at the substation or on each turbine



The equipment consists on electronic devices equipped with capacitors as represented in the scheme

Wind Production Integration: Spain Case Study

Focus on Curtailments and Voltage Dips

Voltage dips

Regulation:

- In order to minimize the risk of potential capacity losses due to grid contingencies, all wind¹ farms with COD after 01/01/2008 are required to install equipment to neutralize voltage dips. A 2-years transitory period (until 31/12/2009) has been given to windfarms with COD before 01/01/2008
- To meet this obligation, new equipment was installed in wind farms in operation, mostly active filters consisting of electronics and capacitors

Remuneration:

- Incentive for wind farms in operation before 2008:
3.8 €/MWh³ (as of the implementation date verified by certified body) until 01/01/2014 with a maximum incentivized period of 5 years. No incentive is due to wind farms with COD after 01/01/2008.
- Penalty for those wind farms not complying within 2010:
loss of all the benefits linked to the "Régimen Especial" legal frame, i.e. loss of all incentives.

1) Compulsory only for wind farms > 500 kW

2) Remuneration granted only if production is curtailed because of congestion in the evacuation lines and there is no risk for the stability and security of the grid

3) Indexed with CPI-0,25% till dec. 2012 and with CPI – 0,5% from Jan 2013

Curtailments

Regulation:

- All renewable energy plants (>1MW) must be connected to the TSO via a certified WGCC (Wind Generation Control Centre)
- The TSO receives online data (Active and Reactive Power) every 12 sec. and may order curtailments to plants >10MW
- Production curtailments ordered by the TSO through WGCC must be accomplished within 15 min

Remuneration:

- Incentive on the "lost production":
applicable to all market agents (renewable or not) resulting in a 15% payment of market curtailed revenues (no FIT applies to curtailed production)²
- Penalties if curtailment is not accomplished:
inspection on non-compliant WGCC, resulting in fines and the loss of WGCC certification



Wind Production Integration: Spain Case Study

The Spanish experience shows an effective case of renewables integration based on:

- Transmission infrastructure development
 - Higher % of high voltage (400kV) lines -18,800 km (49%) vs 11,800 km of 380 kV lines in Italy (18%)
- Mandatory balancing devices to sustain the system
 - All wind farms must have equipment to neutralize voltage dips (excluding only wind turbines <500 kW)
- Continuous monitoring and control of renewable energies by a dedicated control structure
 - Each wind farm >1 MW must be connected to the Renewables Energy Source Control Centre (CECRE) and those >10MW have to follow regulation orders within 15'
- Market arrangements
 - Wind producers are responsible for their deviations from the scheduled program
 - Opportunity to adjust their positions in intra-day markets

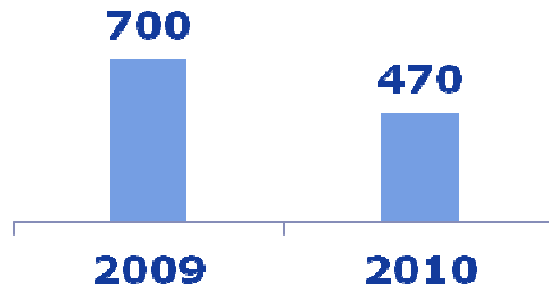
Thanks to these implementations, today the Spanish system is able to integrate almost 3.0x the wind power generation capacity in Italy



Comparison between Italy and Spain

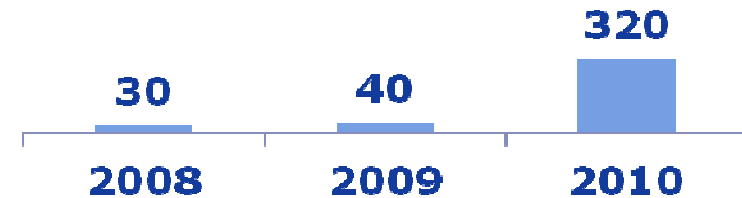
Wind power curtailments

Italy - wind power curtailments (GWh)



	2009	2010
Total wind production (GWh)	~6,500	~9,000
% of curtailments over total wind production	10.7%	5.6%

Spain - wind power curtailments (GWh)



	2008	2009	2010
Total wind production (GWh)	31,800	37,400	43,400
% of curtailments over total wind production	0.09%	0.11%	0.78%

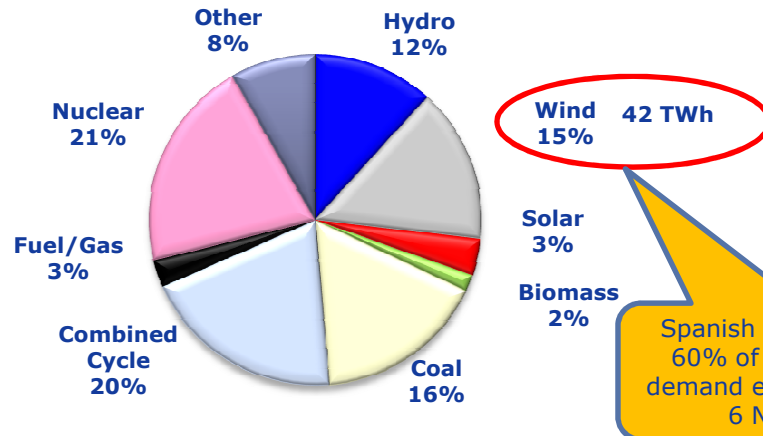
In 2010 curtailments due to congestions were < 1% in Spain and 5.6% in Italy (% of total wind production)

Wind Production Integration: Share of Wind Energy

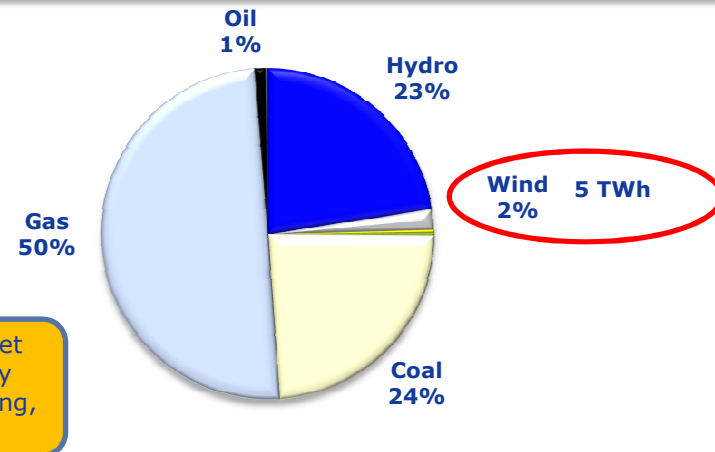
Spain, Italy and Turkey

- Geo
- Biomass
- CSP
- PV
- Wind Off.
- Wind On.
- Hydro

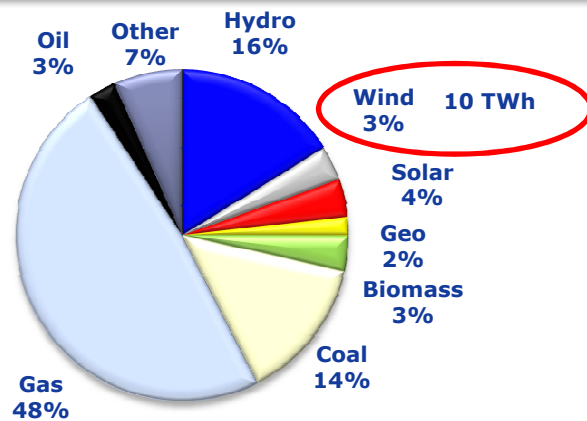
2011 Spain Production Mix: 279 TWh



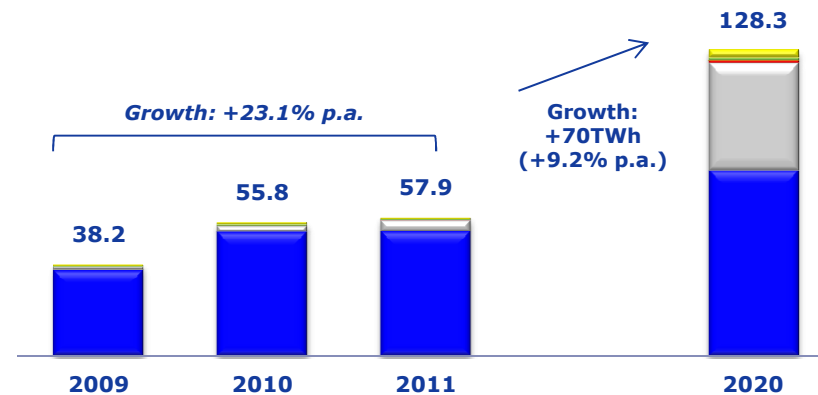
2011 Turkey Production Mix: 229 TWh



2011 Italy Production Mix: 291 TWh



RES production (TWh)





**THANK YOU
FOR YOUR ATTENTION**

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