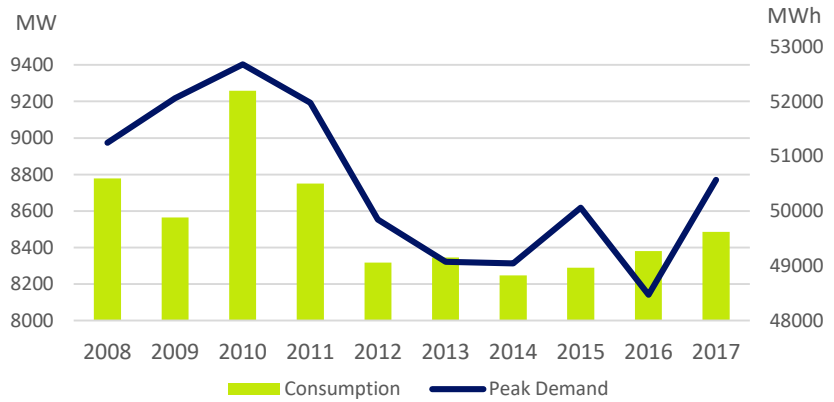
Integrating Renewables in the Portuguese National Electricity Grid System

09 de maio de 2018

Portuguese Electricity System

The main figures

- **Demand**

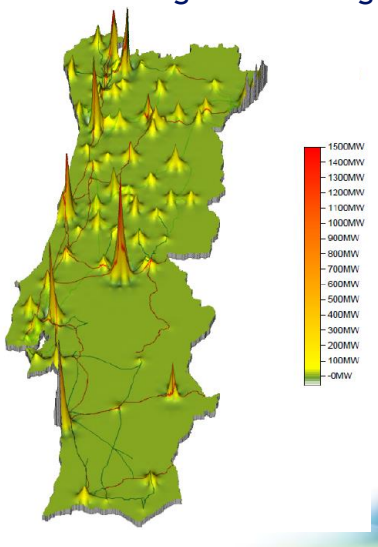


- **Generation Installed capacity**

Potência instalada no final do ano [1] (MW) / Installed capacity at the end of the year [1] (MW)	2017	2016	Var.
Total Total	19 800	19 539	260
Renovável Renewable	13 397	13 087	310
Hídrica Hydro	7 193	6 945	248
Eólica Wind	5 090	5 070	20
Biomassa Biomass	624	613	11
Cogeração Cogeneration	351	351	0
Solar Solar	490	459	31
Não Renovável Non-Renewable	6 403	6 452	-50
Carvão Coal	1 756	1 756	0
Gás Natural Natural Gas	4 607	4 636	-30
Cogeração Cogeneration	778	807	-30
Outros Others	40	60	-20
Cogeração Cogeneration	27	47	-20
Bombagem Pumps	2 698	2 437	261

- Demand is located in coast region, mainly in Lisbon, Oporto and Algarve

- Renewables are located in countryside, mainly in northern and central region of Portugal

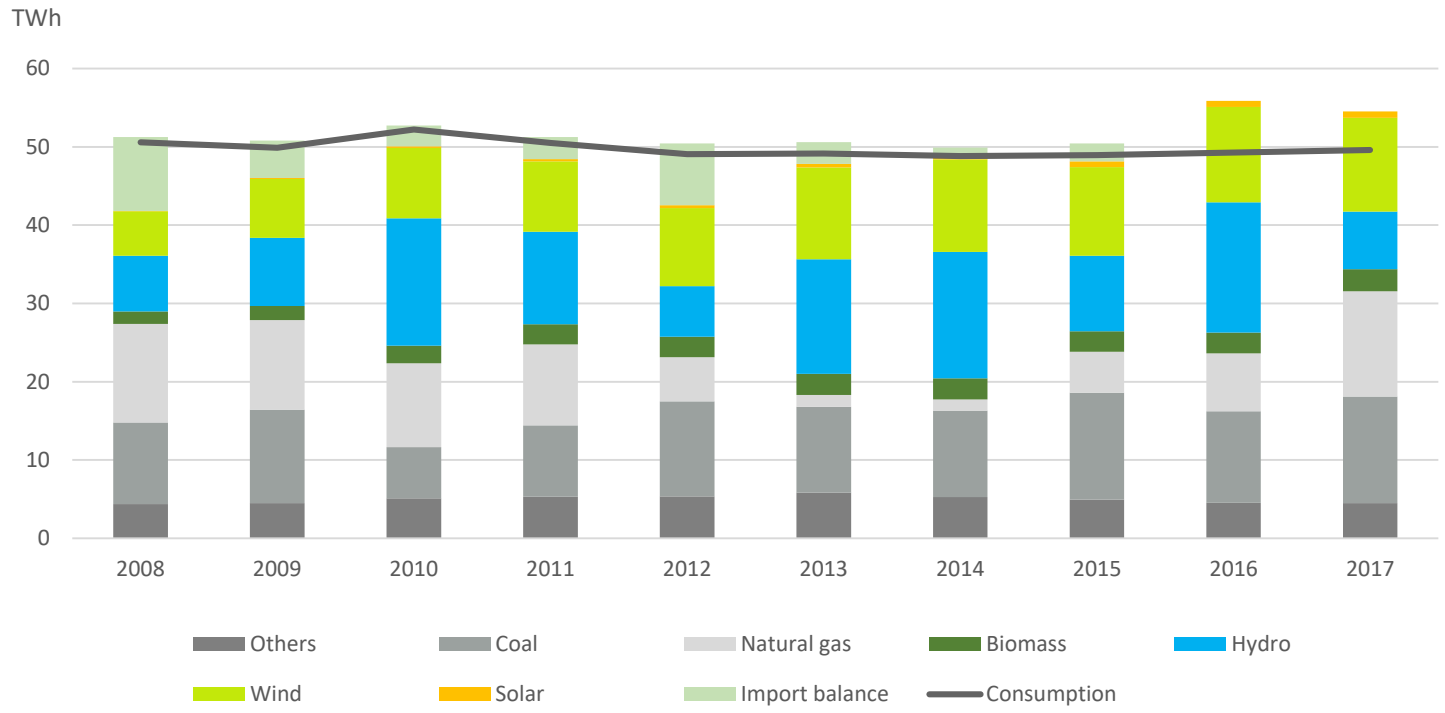


REN

Portuguese Electricity System

The main figures

- **Demand supply evolution**



- Hydro is highly dependent on wet/dry regime, whilst wind is more consistent
- Natural gas and coal supply is in counter-cycle with wet regime

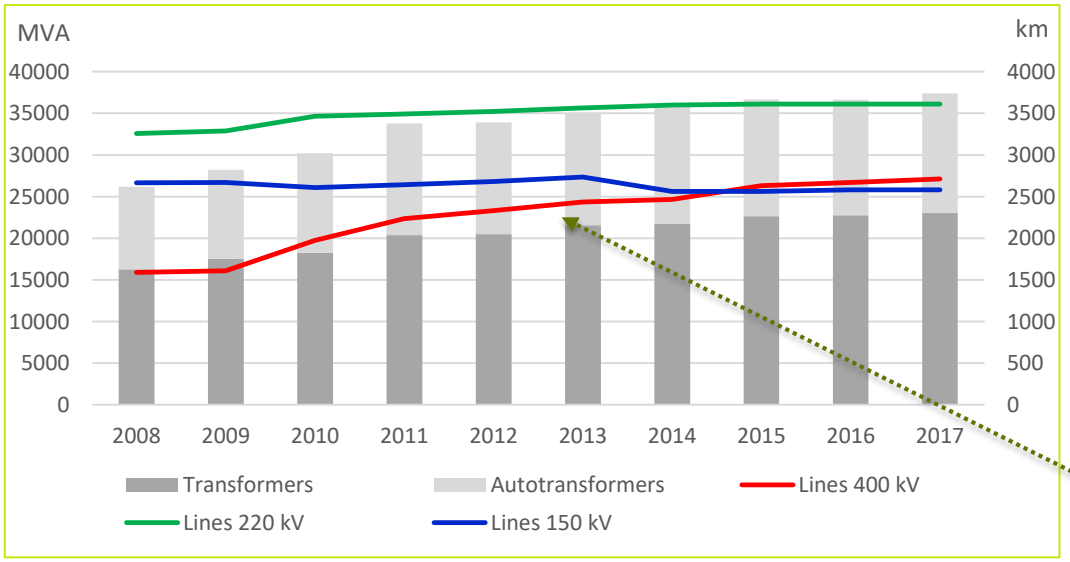
Portuguese Electricity System

The main figures

- **National Transmission Grid**

	2017	2016	Var.
Comprimento das Linhas (km) Length of Lines (km)	**8 907**	**8 863**	**44**
400 kV	2 714	2 670	44
220 kV	3 611	3 611	0
150 kV	2 582	2 582	0
Potência de Transformação (MVA) Transformer Capacity (MVA)	**37 382**	**36 636**	**746**
Autotransformação (MAT/MAT) Autotransformers (VHV/VHV)	14 340	13 890	450
Transformação (MAT/AT) Transformers (VHV/HV)	22 722	22 426	296
Transformação (MAT/MT) Transformers (VHV/MV)	320	320	0

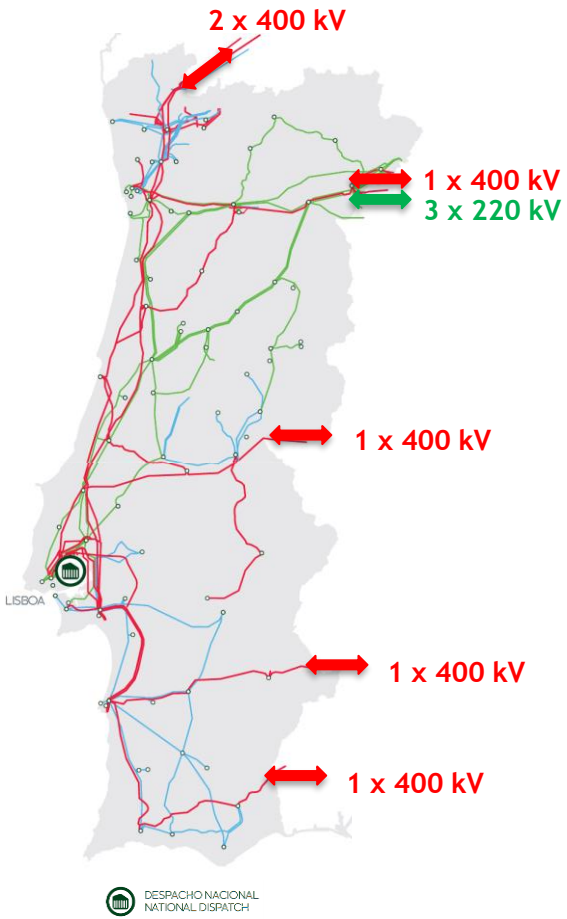
- **National Transmission Grid Evolution**



Largest growth in the 400 kV network

Portuguese Electricity System

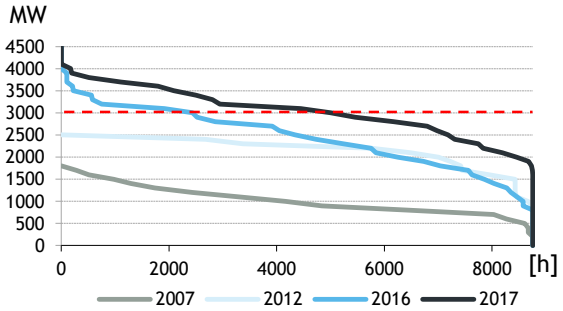
The main figures



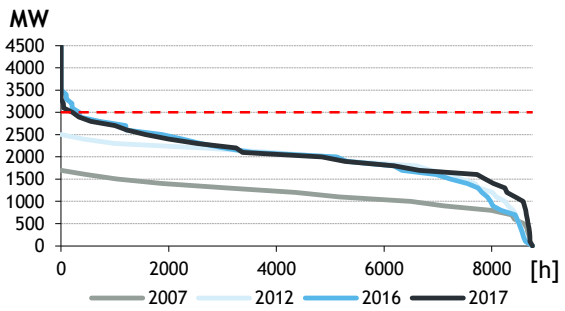
400 kV: 6 circuits **220 kV:** 3 circuits

- **Interconnections**

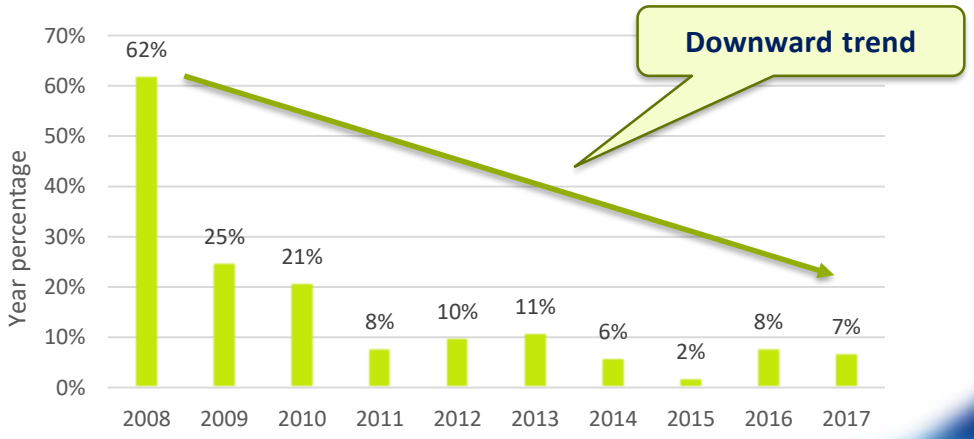
PT - > ES



ES - > PT



- **Market splitting**



Energy Policy

European and national goals

- **European goal**

The Renewable Energy Directive establishes an overall policy for the production and promotion of energy from renewable sources in the EU

- **2020 Target:** European Union intend to fulfil at least 20% of its total energy needs with renewables by 2020 – to be achieved through the attainment of individual national targets

- **2030 target:** at least a 27% share of renewable energy consumption

- **Main 2020 national goals**

31% Share of renewable energy in gross final energy consumption

It means **60%** Share of renewable energy in electricity consumption

REN

Network Planning

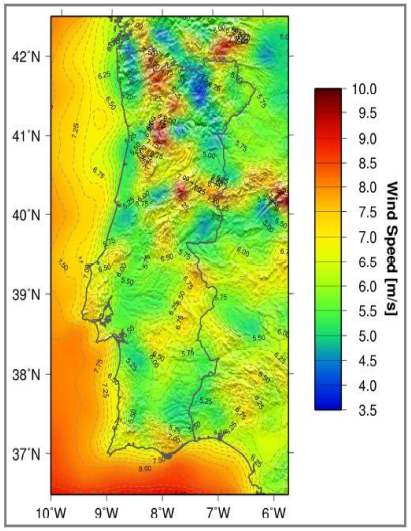
Identification of System Needs

- **Wind case study**

In 2001 the Portuguese Government set as national goal, to increase the amount of electricity generation based on renewables sources, with a special focus on the wind development

- Identification of national **wind resource potential** carried out in cooperation with the University.
- From wind resource map, identification of **areas of the territory with more potential for requests to new wind power generation projects**.
- A significant **wind resource areas are in inner countryside**, in regions with lower consumption, and where the transmission grid was less developed or did not exist (need to develop the network).
- With this challenge, **REN developed a wide study and make a Plan to reinforce the network**, in order to enable the integration of new renewables and transmit its energy from the production areas to the consumption centers.

wind resource potential



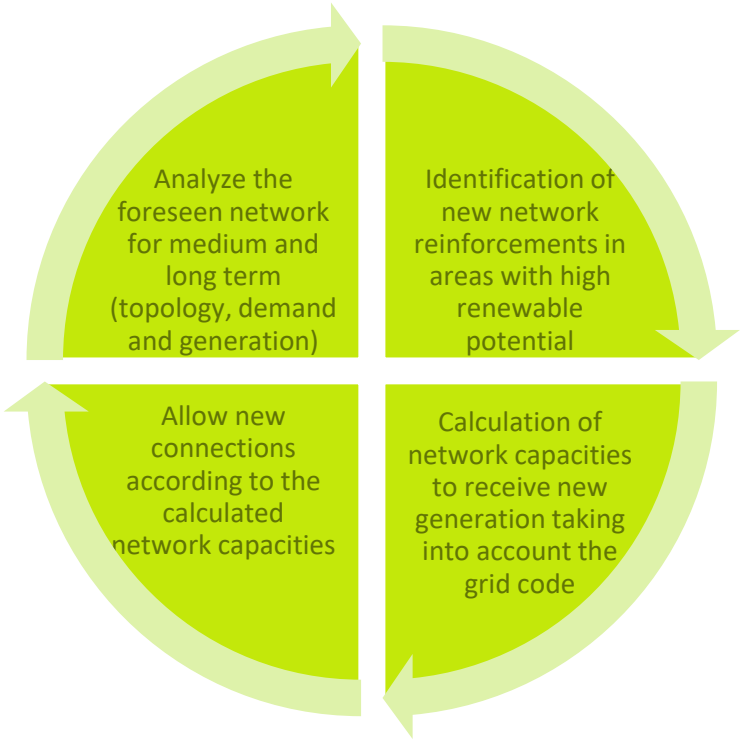
The geographic dispersion of RES generation required a strategic development of the network, including environmental and spatial planning aspects.

Network Planning

Capacity to integrate new generation

- **Methodology**

- Network capacity for new generation using a methodology based on **nodal capacity calculation**, complying with network planning security criteria.
- Network **capacities periodically evaluated and published by REN**, either considering larger horizons, considering potential new network reinforcements.
- **National Directorate of Energy and Geology manage the network capacities**, giving the permits to the interested promotors when capacity exists.
- Such methodology allows a **higher network guarantee**, meaning power plants won't have production restrictions caused by network elements (unless exceptional situations).



Such methodology also allows a better quality of service, as it mitigates curtailment needs.

Network Planning

Generation Reception Capacity

- **Generation Reception Capacity at substation busbar of RNT**

Zona de rede	Barramento	[kV]	Potência já atribuída pela DGEG mas ainda não ligada	Potência cativa pela DGEG	Capacidade atual – Restrição individual	Capacidade atual – Zona(s)	Acréscimo com reforços de rede [a]
1	Riba d'Ave	400					
10	Riba d'Ave	60	17			0	
	Fafe	150					
		60	3				
2	Recarei	400					
	Vermoim	400					
	Feira	400					
		60	13				430 [f]
2 A	V. N. Famalicão	400					
8	Recarei	220 ou 60				600	
9	Vermoim	220 ou 60 [b]	42				
	Prelada	220 ou 60 [c]	4				
	Custóias	220 ou 60 [b]	12				
11	Ermesinde	220 ou 60	7				
12	Canelas	220 ou 60	2				
16	Mogadouro	220 [b]				90	
	Mogadouro	60 [c]	7		60		
	Macedo	220 ou 60	7		50		
3	Valpaços	220 ou 60	14				

- Every year REN publishes the Generation Reception Capacity at the transmission substations busbars for the short/medium term.
- These values are the basis to accommodate players in electricity market and are utilized by the Directorate of Energy and Geology to issue licenses to connect new generation.

Network Planning

Network capacity and Grid code compliance

Beyond network capacity availability, the compliance of the Network Codes and Guidelines is needed

- **Network Codes and Guidelines**

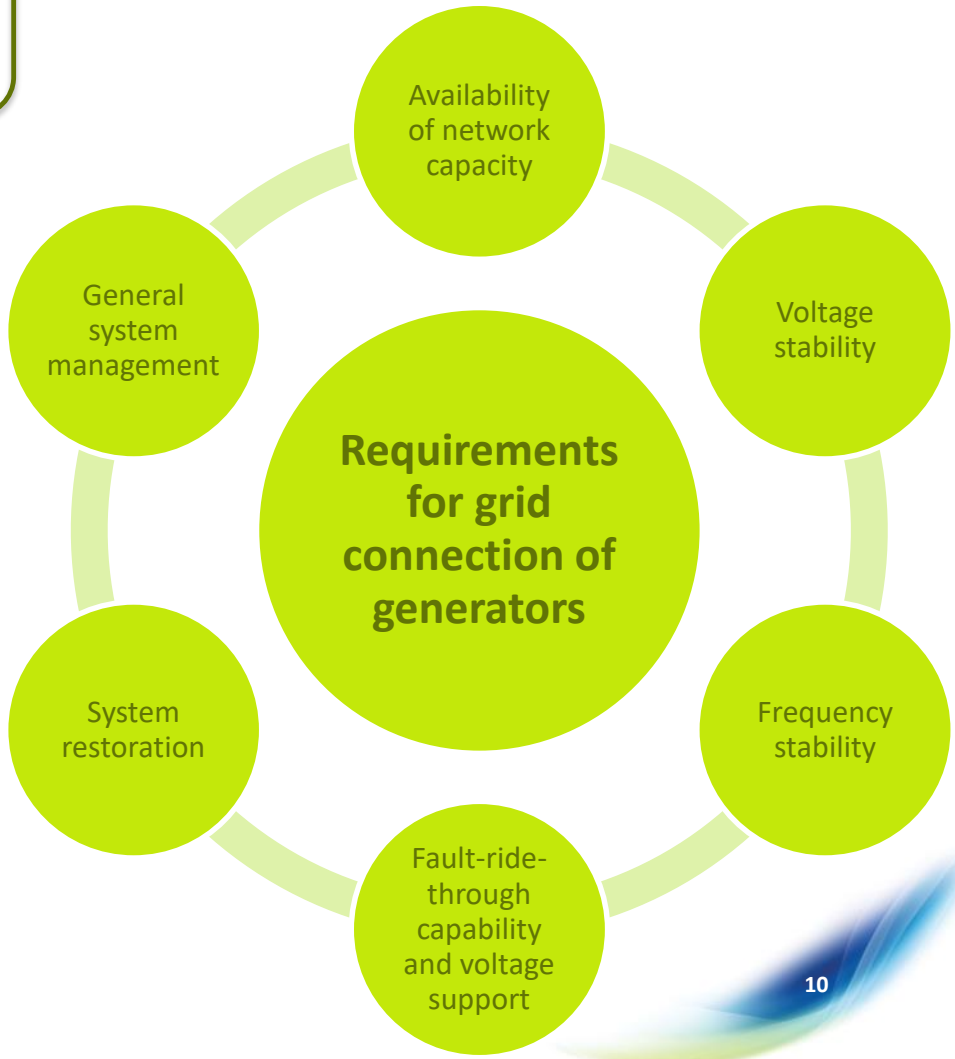
Connection and system operation codes and guidelines:

- Requirements for Generators;
- Demand Connection;
- System Operation;

Market and trading guidelines:

- Capacity Allocation and Congestion Management (CACM);
- Forward Capacity Allocation;
- Balancing.

Requirements for grid connection of generators



Network Planning

How to match the network development with the progressive evolution of installed RES

- **Methodology**

Constructing double circuit lines, but installing only one circuit in the beginning when initially one circuit was sufficient.

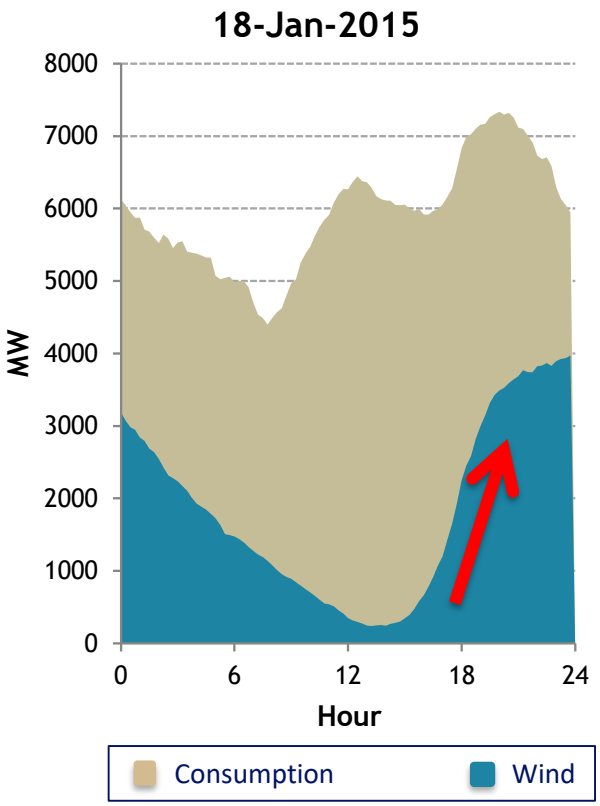
Temporary operation of some lines or substations in a lower voltage level then the ones for which they were designed and constructed.

Adoption of Phase-shift transformers to better control network flows.

RES Integration Challenges

Wind generation volatility

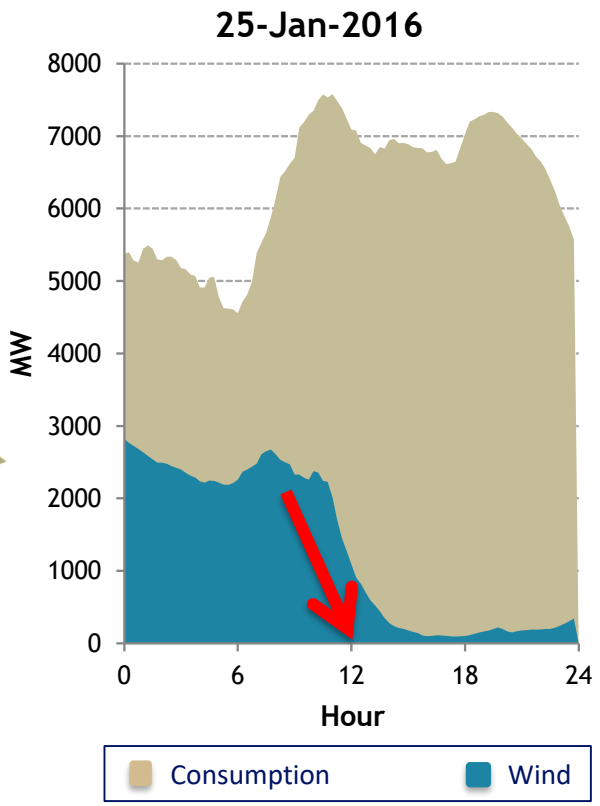
Wind generation increase



High variation

1000 MW/h

Wind generation decrease



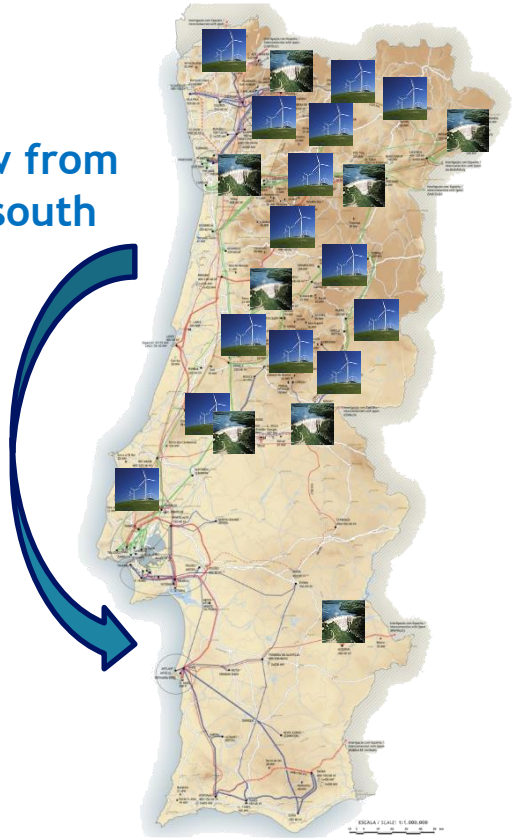
Storage to cope with wind volatility : e.g. hydro with reservoirs and pumping

RES Integration Challenges

Impact of generation mix

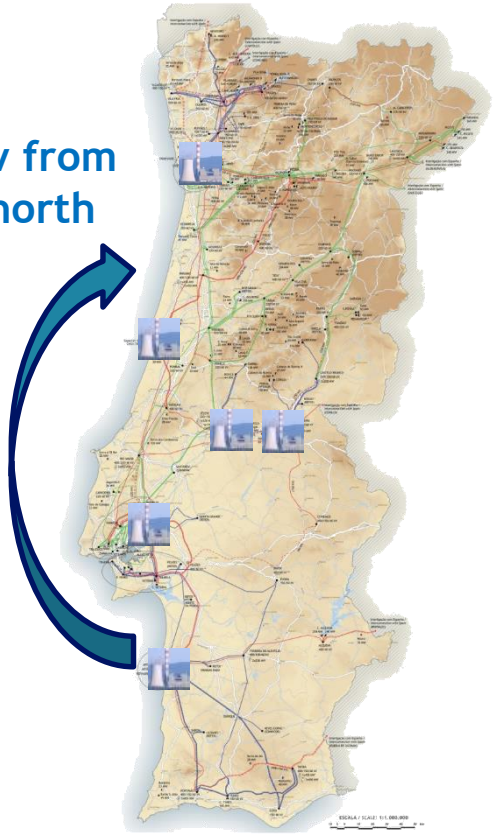
High renewable production

Power flow from north to south



Low renewable production

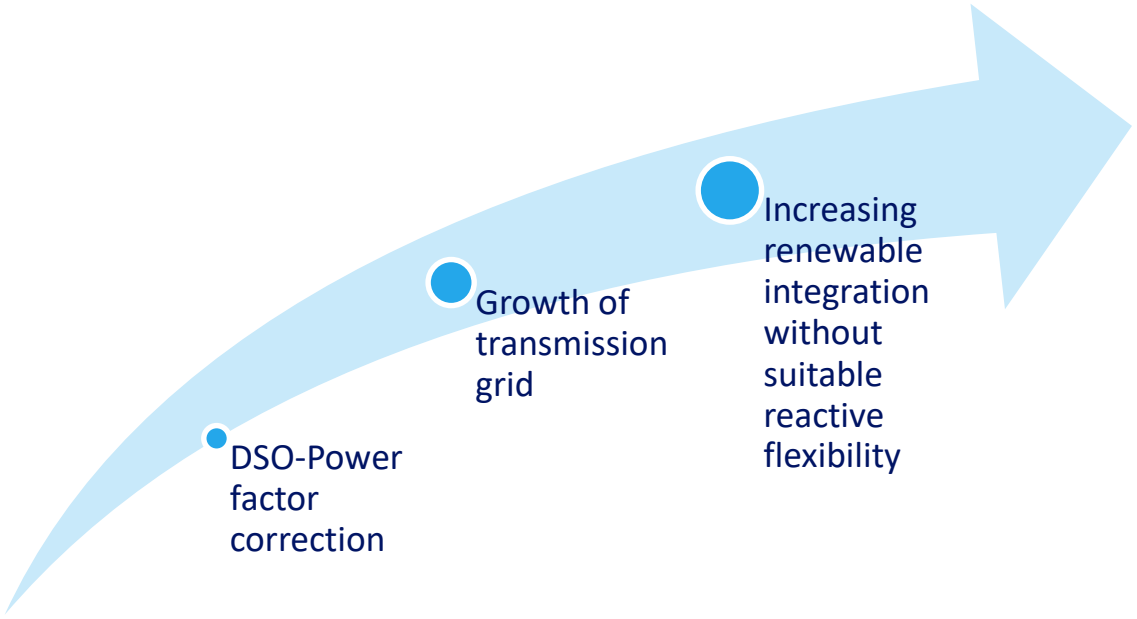
Power flow from south to north



These different generations patterns lead to different power flow behavior

RES Integration Challenges

Voltage management



New paradigm

- New reactive patterns (trend to high voltages in the network)
- Less conventional generation in the network (tipically with more reactive flexibility)

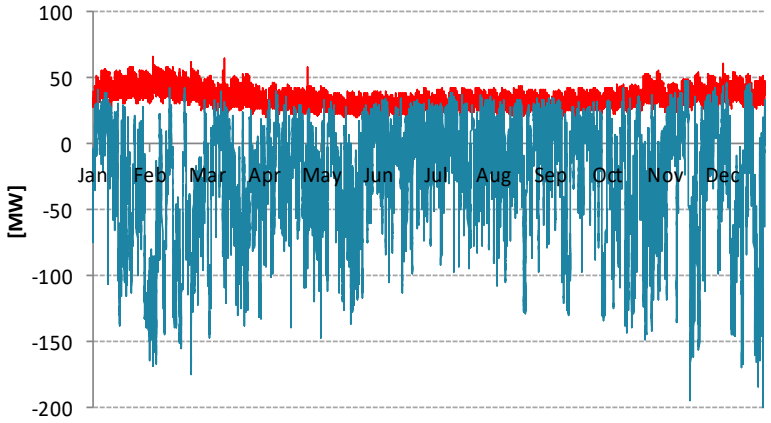
Actions

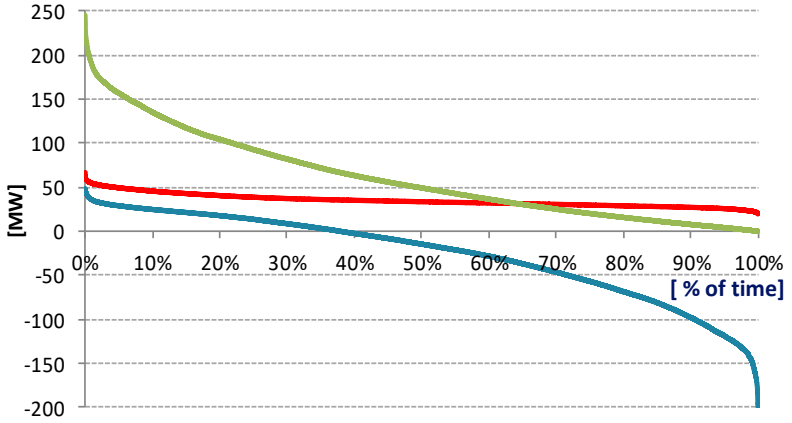
- **Reduce reactive injection from wind farms**
- **Install shunt reactors in transmission network**

RES Integration Challenges

TSO-DSO coordination

Flows at TSO-DSO boundary





Flow in Transmission/Distribution transformers

Local load (without accounting local generation)

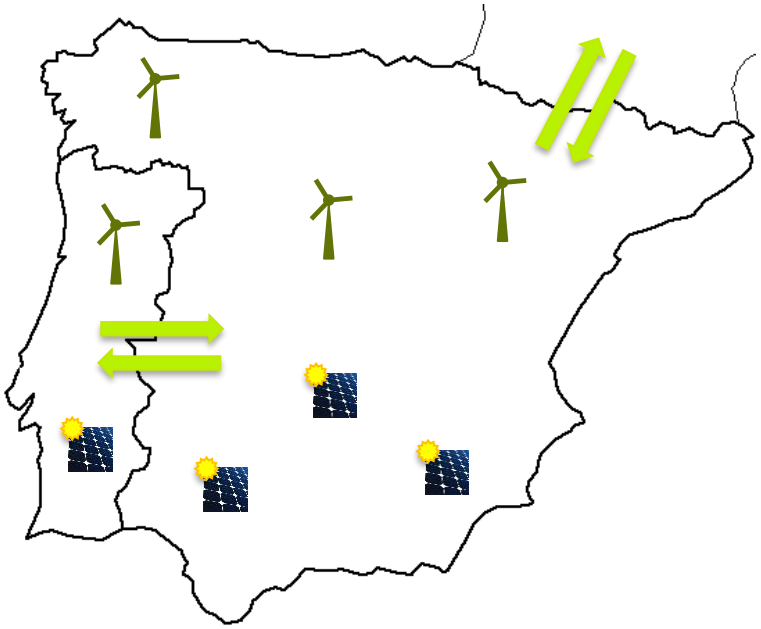
Generation in Distribution network

In some TSO-DSO substations main flows are from the Distribution to the Transmission network

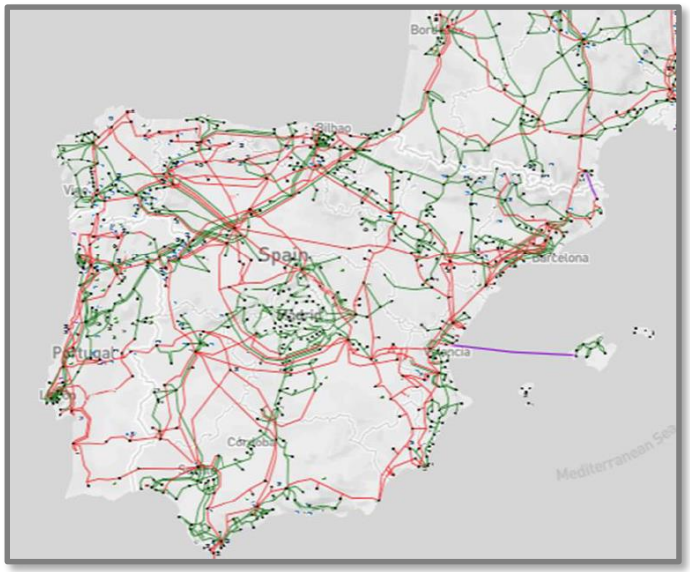
RES Integration Challenges

Interconnection capacity

- **Interconnection capacity supports renewables integration**



Iberian Peninsula Network



Interconnection capacity increase system security as it can provide support for lack of intermittent power generation or a way to export excess of energy that can't be stored (namely wind).

Despite the Challenges of Integration RES…

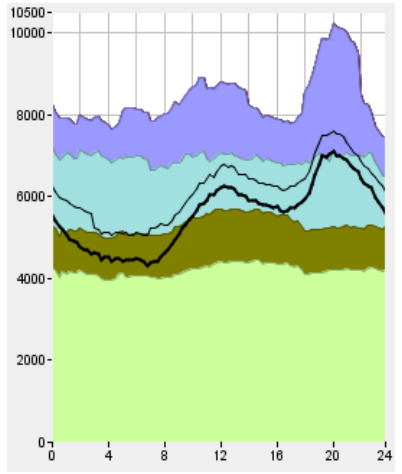
Portugal runs on Renewable Energy alone

2018

March 9 (20:30) — March 10 — March 11 — March 12 (12:00)

- **Main achievements**
  - National consumption was fully ensured by renewable energy during 63 hours
  - Main contribution came from Hydro and wind farms
  - No coal and natural gas production
  - Portugal had a positive export balance

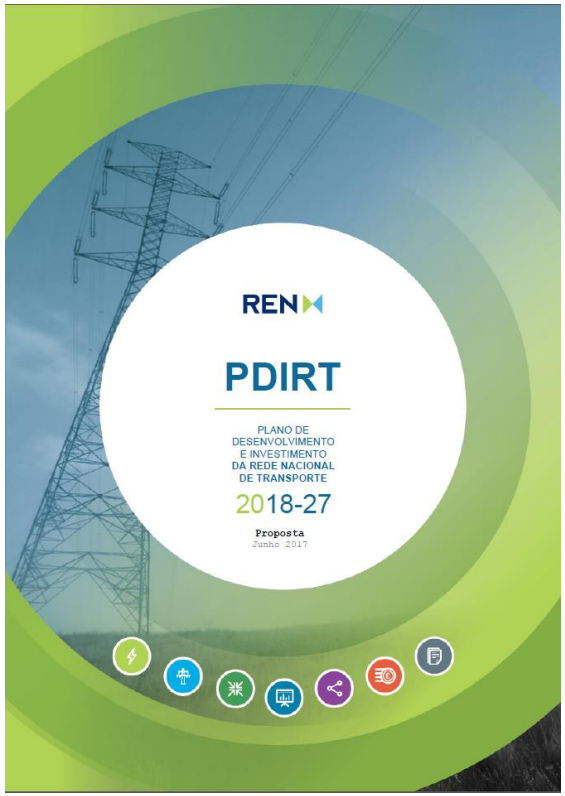
2018-03-11

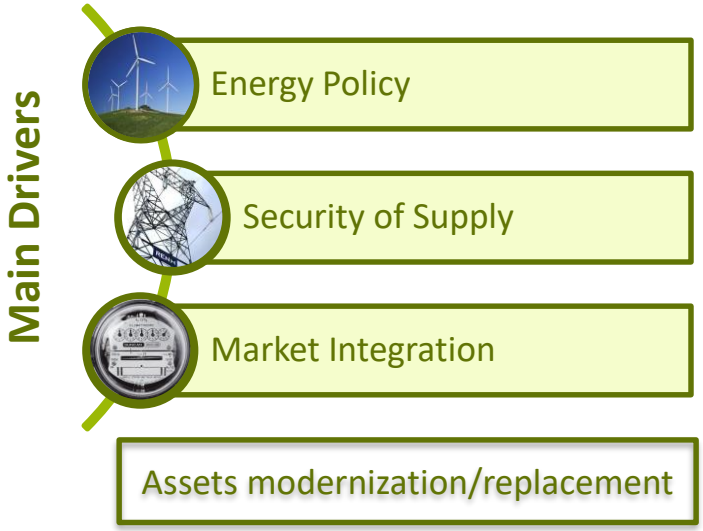


Planning for next decade

National Development Plan

National Development Plan (PDIRT 2018-2027)





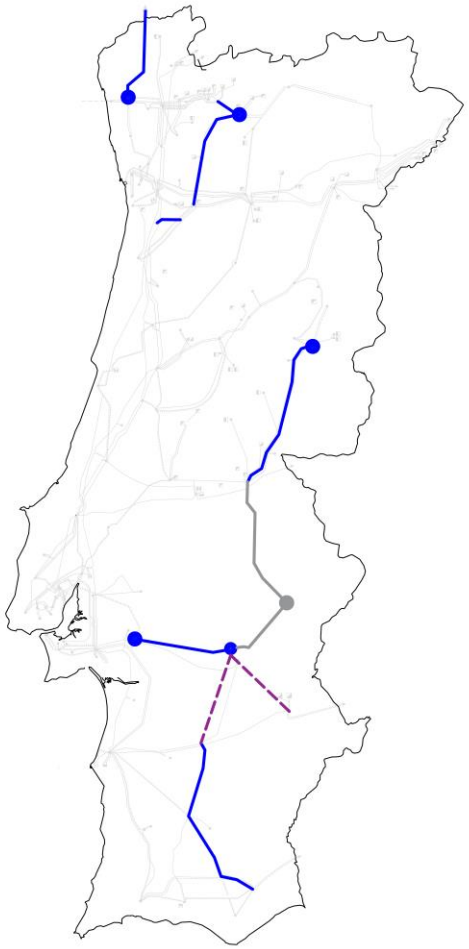
- The elaboration of the Transmission Network Development Plan (NDP) in Portugal is under the responsibility of REN, the Portuguese TSO
- National Development Plan (NDP) should be prepared every two years, covering a 10 years timeframe

NDP incorporates network development solutions that allow the integration of renewables in the Portuguese National Electricity Grid Systems

Planning for next decade

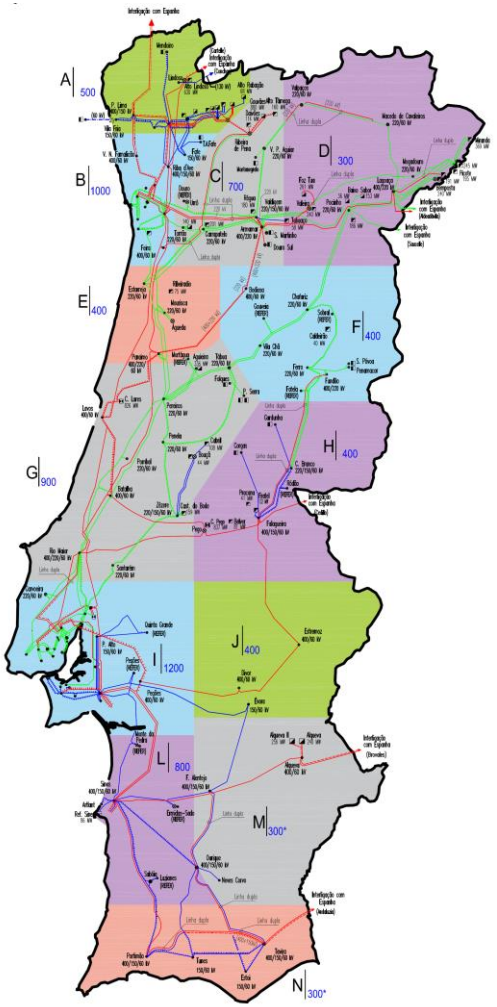
National Development Plan

Main reinforcement projects with significant impact on the capacity to integrate new generation



Output of NDP

Estimative of Long Term Network Capacity for new Generation Reception



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