CLIMATE CHANGE
&
FUTURE POWER SYSTEM

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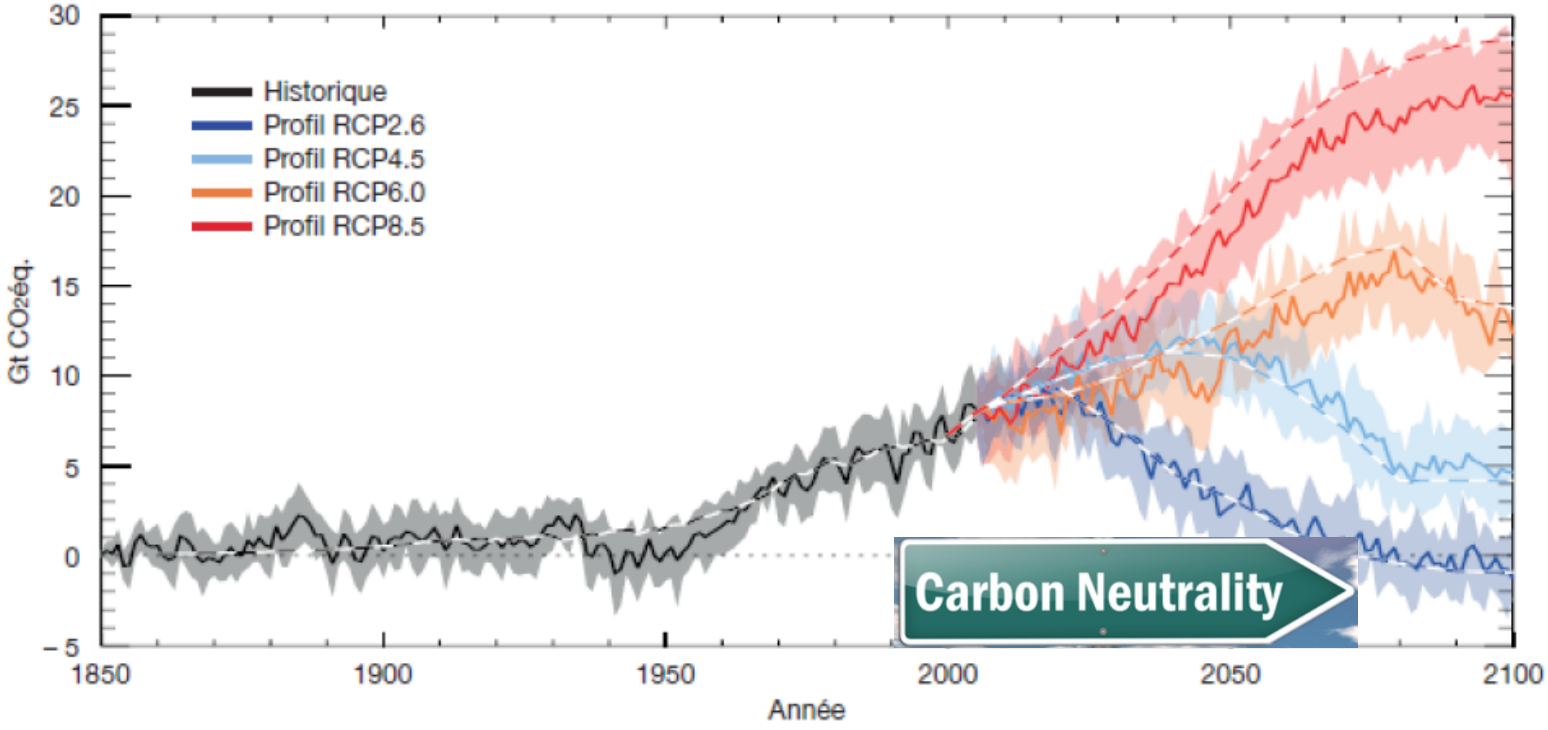
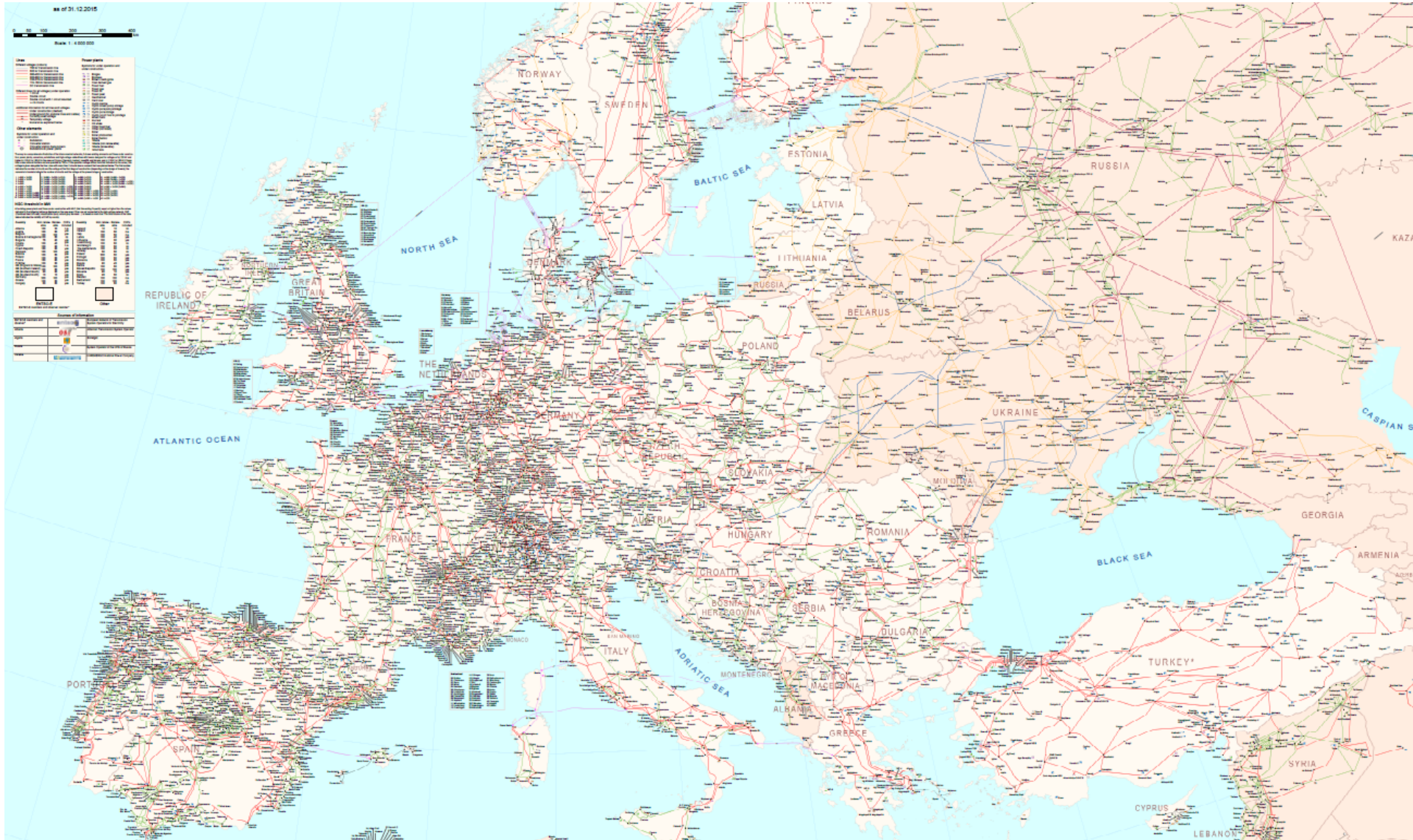
A CARBON NEUTRALITY OBJECTIVE

IPCC GREENHOUSE GAS EMISSIONS PROJECTIONS

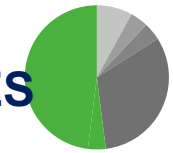
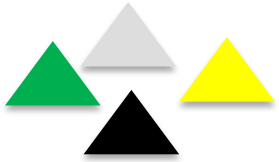
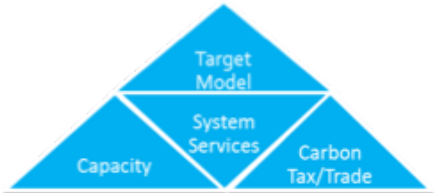
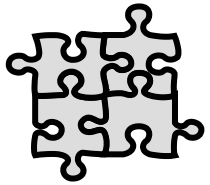


Source : Giec, 1er groupe de travail, 2013

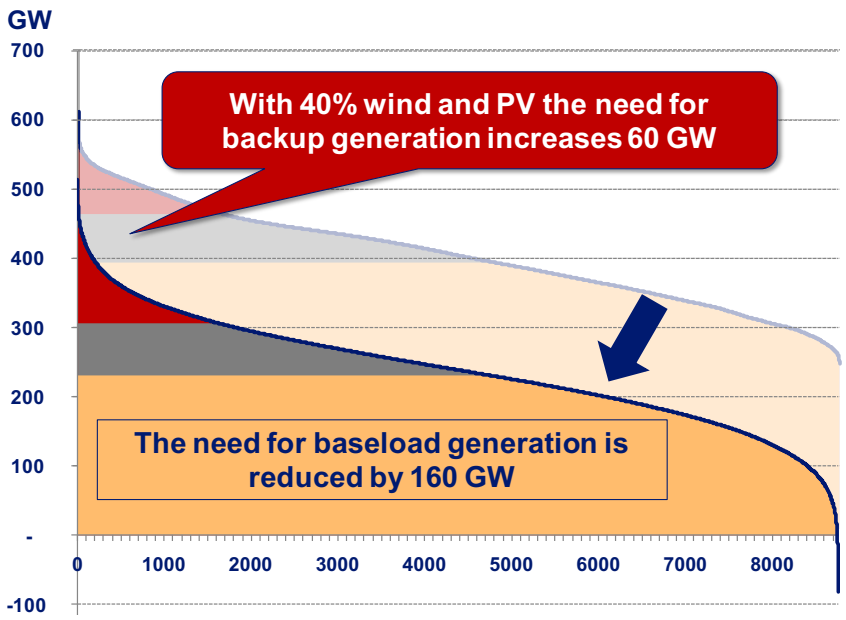
Increasing share of electricity in the energy mix (EV, Heat Pump, PtoX,…) Decarbonation of power generation

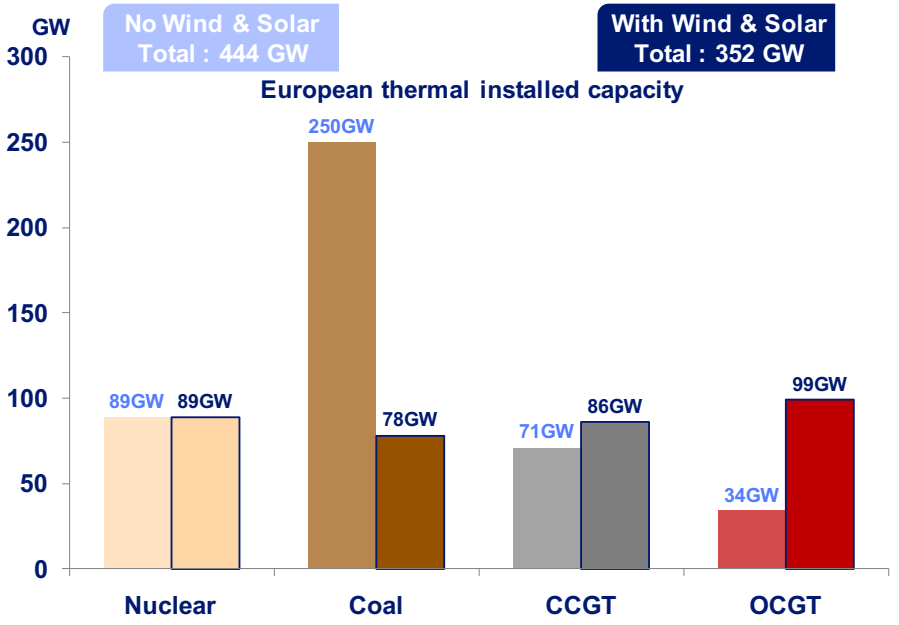


An European Power system objective of 50 % RES at 2030

	Today...	… 2030 and beyond
Renewable Levels in Electricity	 35 % VRES	50 % RES 
System Operational Complexity	13 % Wind + PV 	30 % Wind + PV 
Market Design		
Flexibility solutions		

Variable RES are key to the decarbonisation of electricity generation but the system still needs backup capacity for security of supply



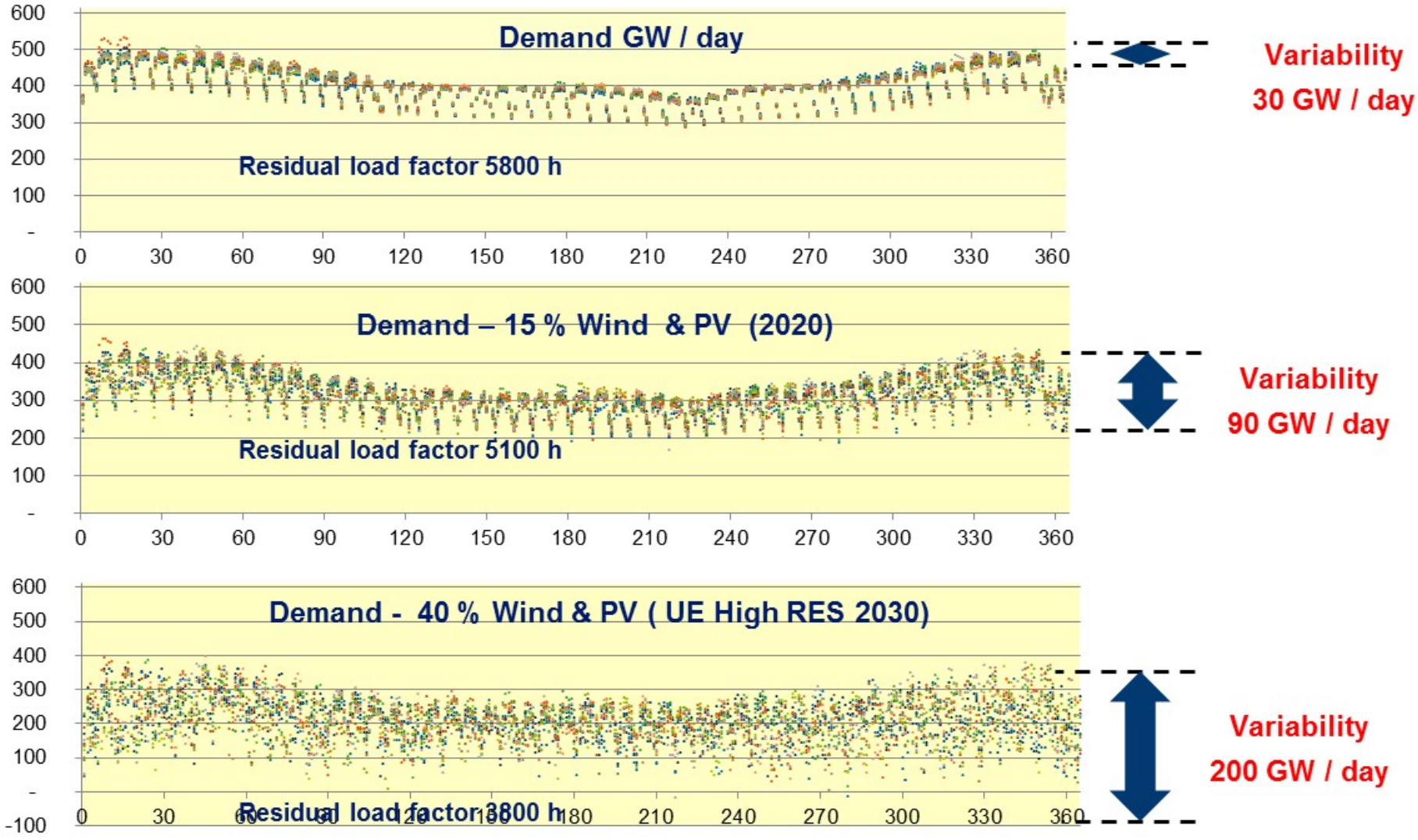


Average CO_2 with 60% RES < 100 g CO_2 /kWh

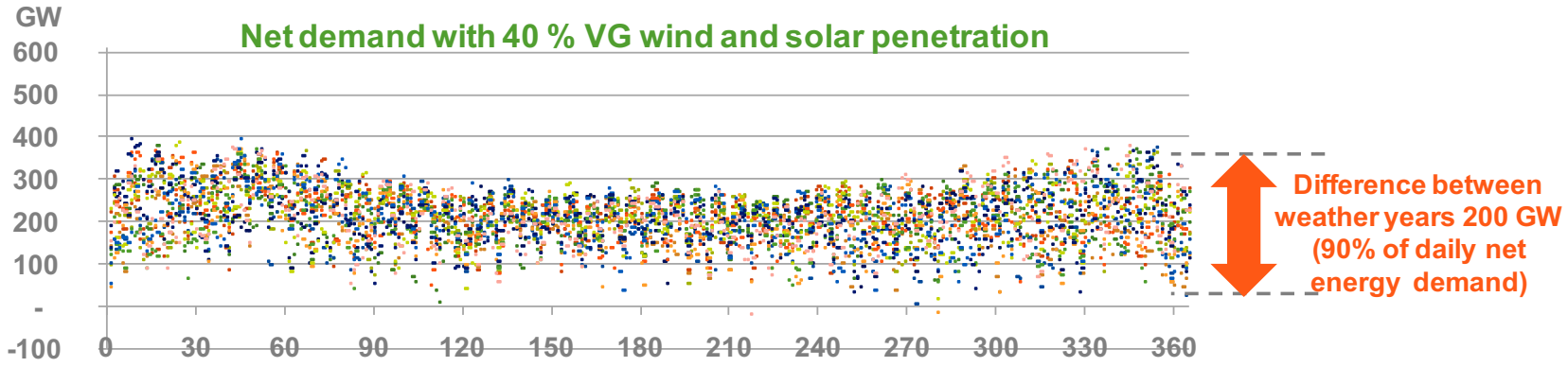
(average CO_2 today = 350 g CO_2/kWh)

Strong power system decarbonation can be achieved with a carbon free generation mix nuclear, hydro, wind and PV

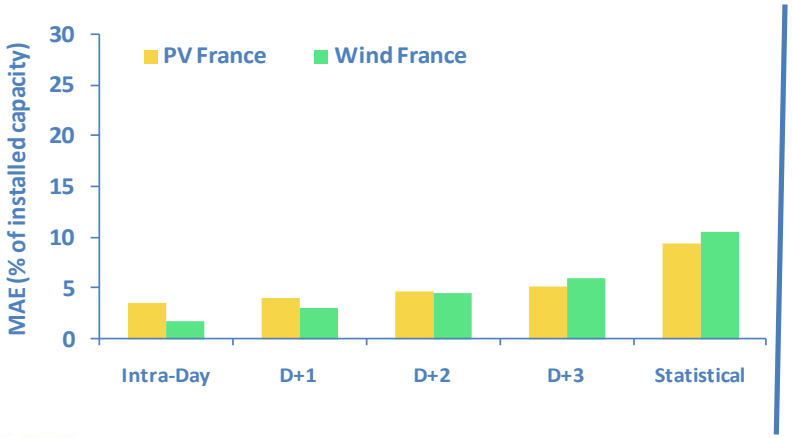
Power system balancing
RES variability > a much more volatile residual demand

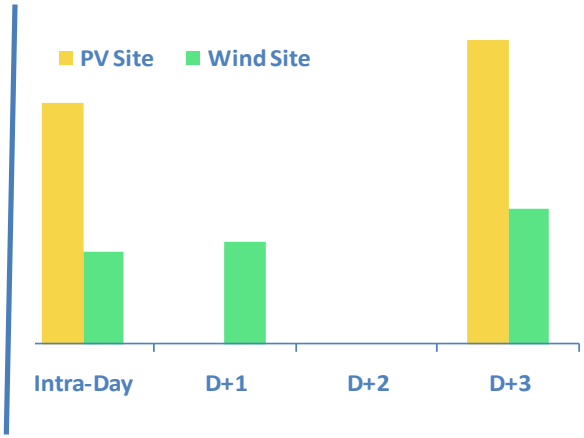


The exposure of the load-generation balance to weather uncertainties increases significantly



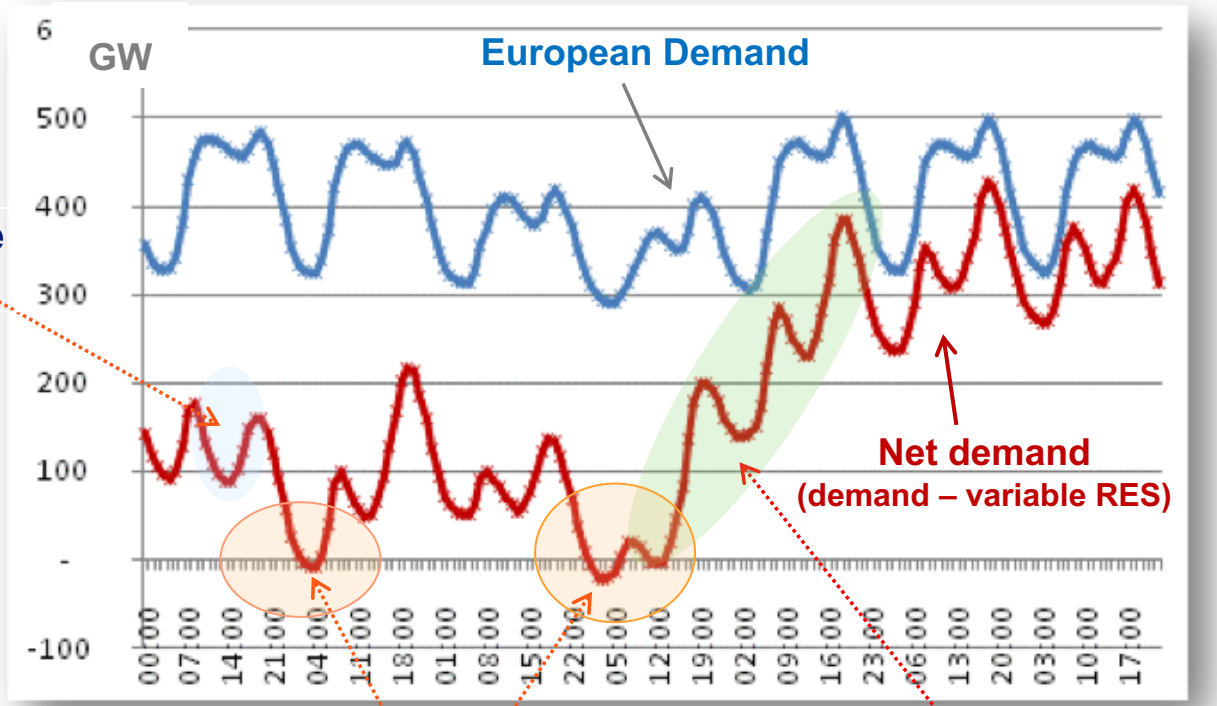
Observability and forecasting are essential to reduce the operation margins required to handle load-generation balancing





The average mean forecast error at farm level is 2 to 3 times higher than at a country level

Not only conventional generation, but also variable RES, will contribute load-generation balancing



Net demand changes between:
- 100 GW, +500 GW

Demand changes between:
240 GW, 600 GW

Middle of the day valley

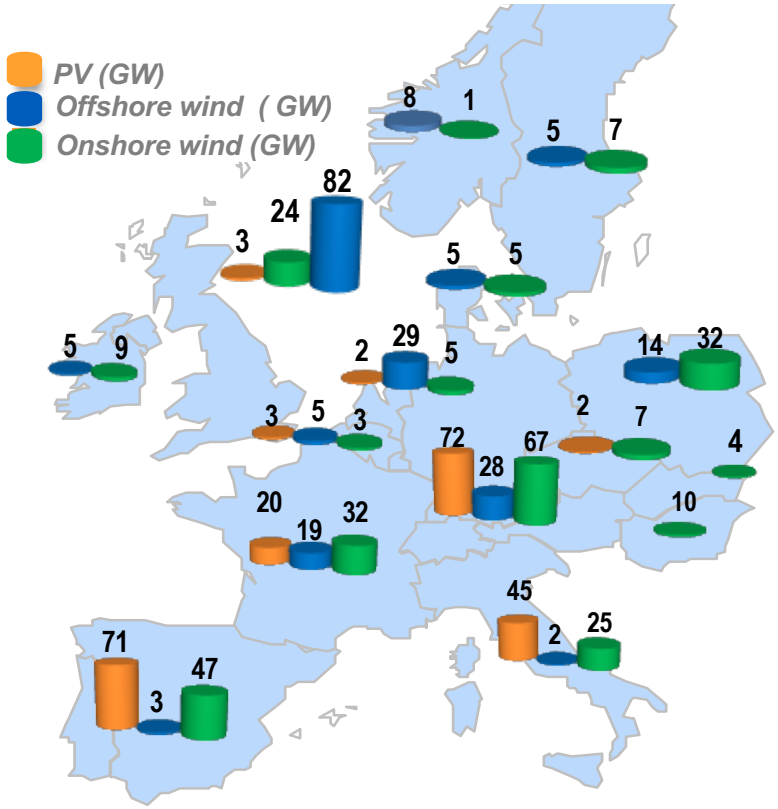
Penetration of RES > 100 %

400 GW ramp between Sunday and Monday

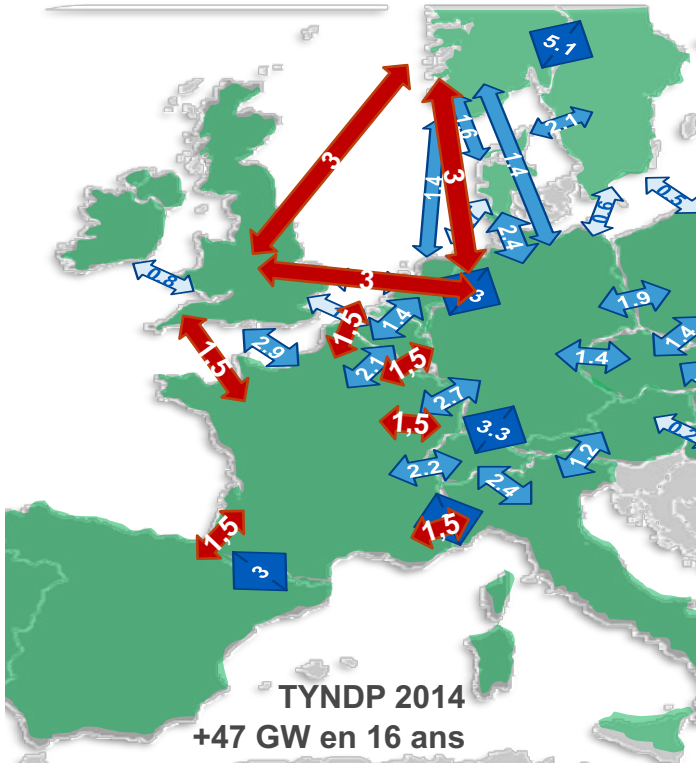
RES need to provide flexibility and services essential for system security

Integrating a large share of variable RES requires a coordinated development of RES and networks

RES geographical distribution



Network development scenario



Interconnection reinforcement (GW) similar to TYNDP 2014

Interconnection reinforcement TYNDP 2010 (GW)

Need to cope with lower system inertia

Due to lower inertia a reference incident leads to

- a risk of load shedding (f< 49 Hz)
0,8 % of the time

- a violation of ENTSO-E security limit (f< 49,2 Hz)

25% of the time

Preventive curtailment of VRES to avoid stability problems during critical periods can only be limited if system have the technical capability to provide kinetic energy and fast frequency response

SHORT TERM MARKET
A MULTI-DIMENSIONAL APPROACH HARNESSING THE CAPABILITIES OF BOTH EXISTING ASSETS AND NEW TECHNOLOGIES

Characterize the needs of power system when RES-E exceed 50%

- Identify technical challenges and economic shortfalls using advanced system planning and simulation tools

Enhance market design and regulation to enable innovative business solutions

- Design new services/ products/ procurement/remuneration
- Evaluation of new market designs using advanced market simulation

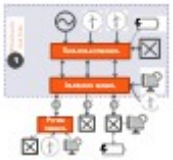
Demonstrate innovative approaches to coordinate centralised and decentralised low carbon flexibilities responding to systems needs

Develop a flexibility roadmap to support the implementation of solutions

Projets EU H2020 avec la participation d'EDF

EU-SysFlex TDX-ASSIST plan4res

Market Design : Key issues



1

- Wholesale market
  - Short term
  - Long term

➔ How to **articulate long-term and short-term** decisions, considering in particular **the allocation of risk** and the **impact on capital cost?**

2

- System and networks
  - Organization and roles
  - Interfaces

➔ How to **articulate regulated activities and activities in competition**, considering in particular the **frontier** between them and the **interfaces (services definition and tariffs design)**?

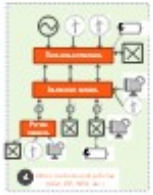
➔ How to **coordinate systems composed of several zones (cross border interactions)?**

3

- Retail market and DER

➔ How to **articulate centralized and decentralized worlds ?**

- Network & market access and intermediation
- End user price design



4

- Other energy and climate policies

➔ How to **articulate** public **policies,** considering in particular **the interactions with the electricity system?**