energy systems of the future

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FEUP Main Auditorium

May 29 ○ 14h00

Power system with 100% renewable energy: the long wait...

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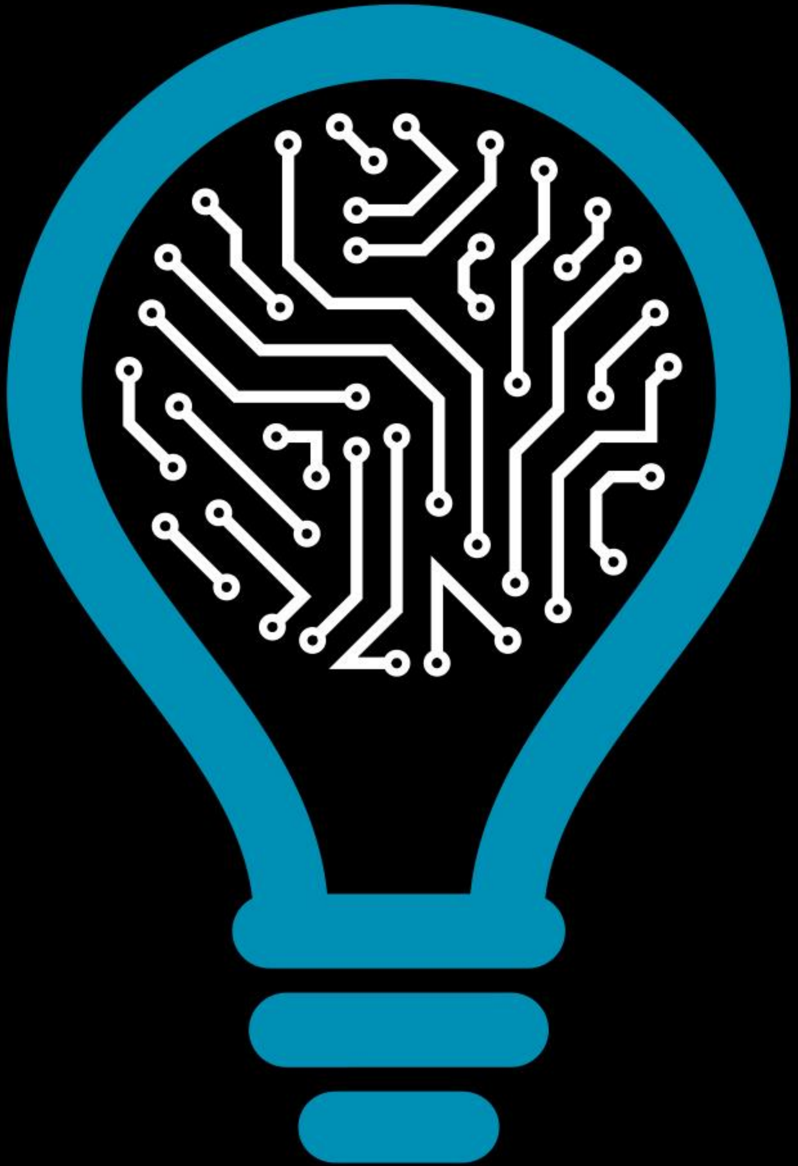
Energy Systems of the Future

Porto, 29th May 2019



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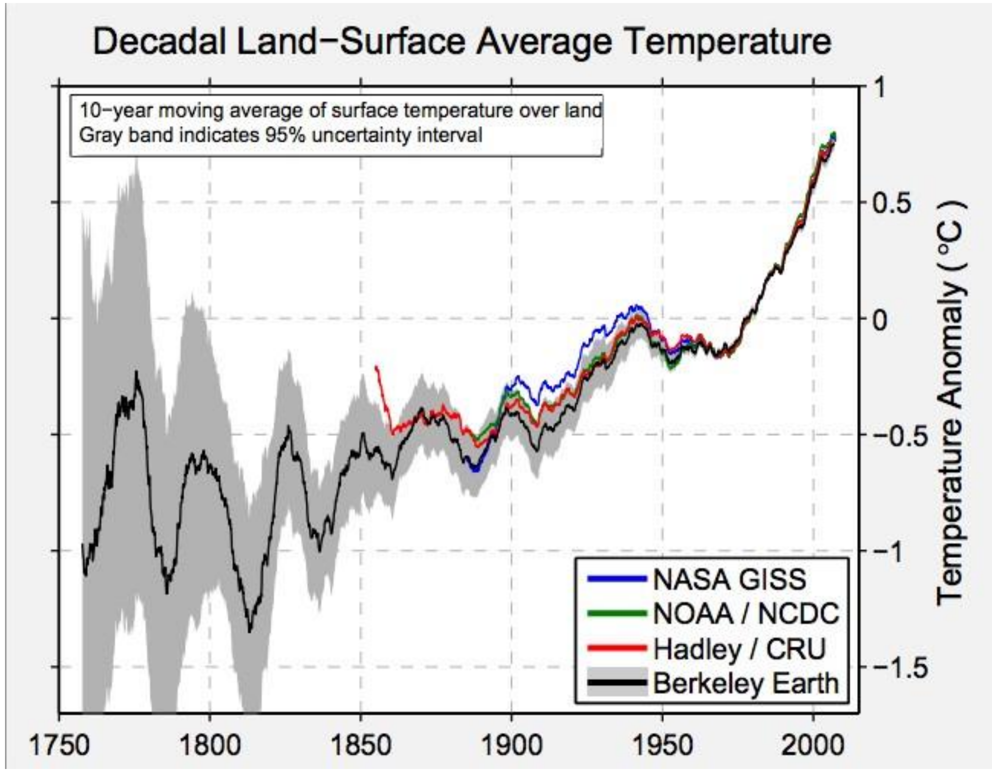
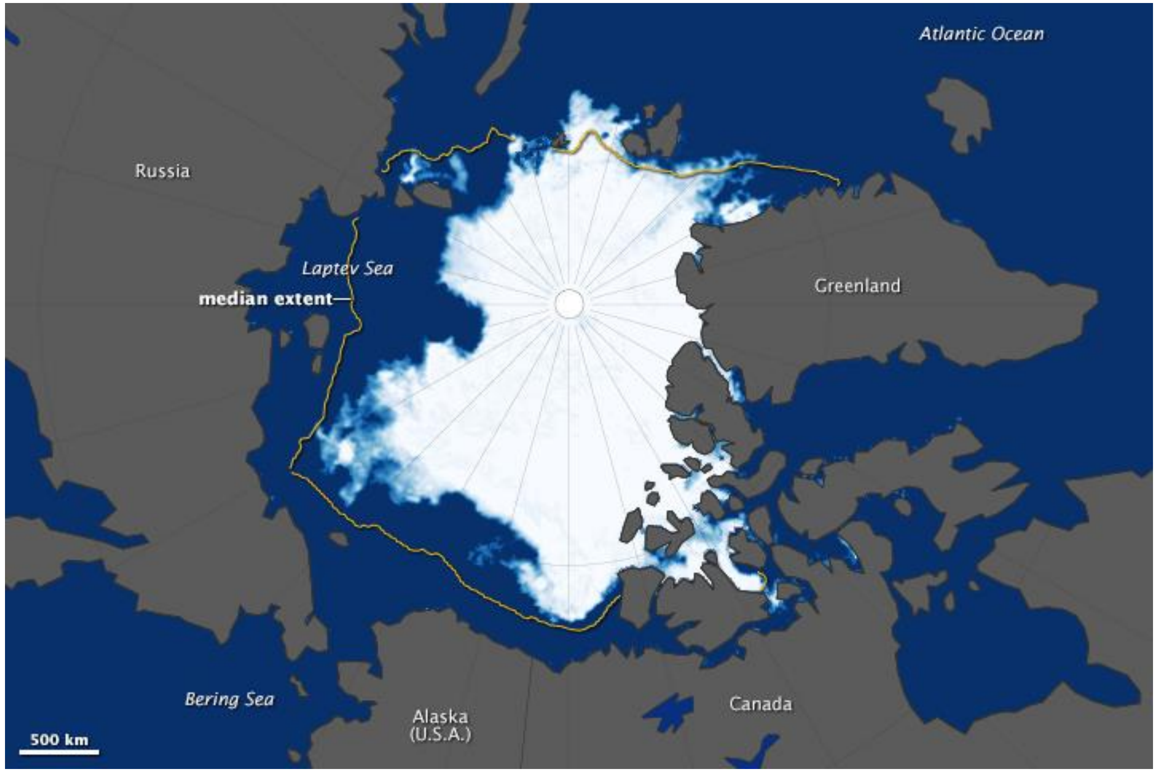
Introduction – Threats of Climatic Changes

Global land temperatures have increased by 1.5 degrees Celsius over the past 250 years





Sea ice acts as an air conditioner for the planet, reflecting energy from the sun

Introduction - Drivers

- **Threats of Climatic Changes**

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Progressive Electrification of the Economy and Society (the most efficient way)

- **Driving forces for the future development of the electric energy industry:**
  1) **Environmental issues**: meet the PARIS Climate Agreement targets
  2) **The mobility problem → Electric mobility**
  3) **Replacement of old infrastructures** (generation and grid)
  4) **Security of Supply**
  5) **Increase quality of service** (more automation and remote control)
  6) **Electricity market liberalization** (energy and services)
  7) **Consumer empowerment**
  8) **Pervasive and low cost ICT solutions**

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Achieving Utopia at the European Electrical Power System?

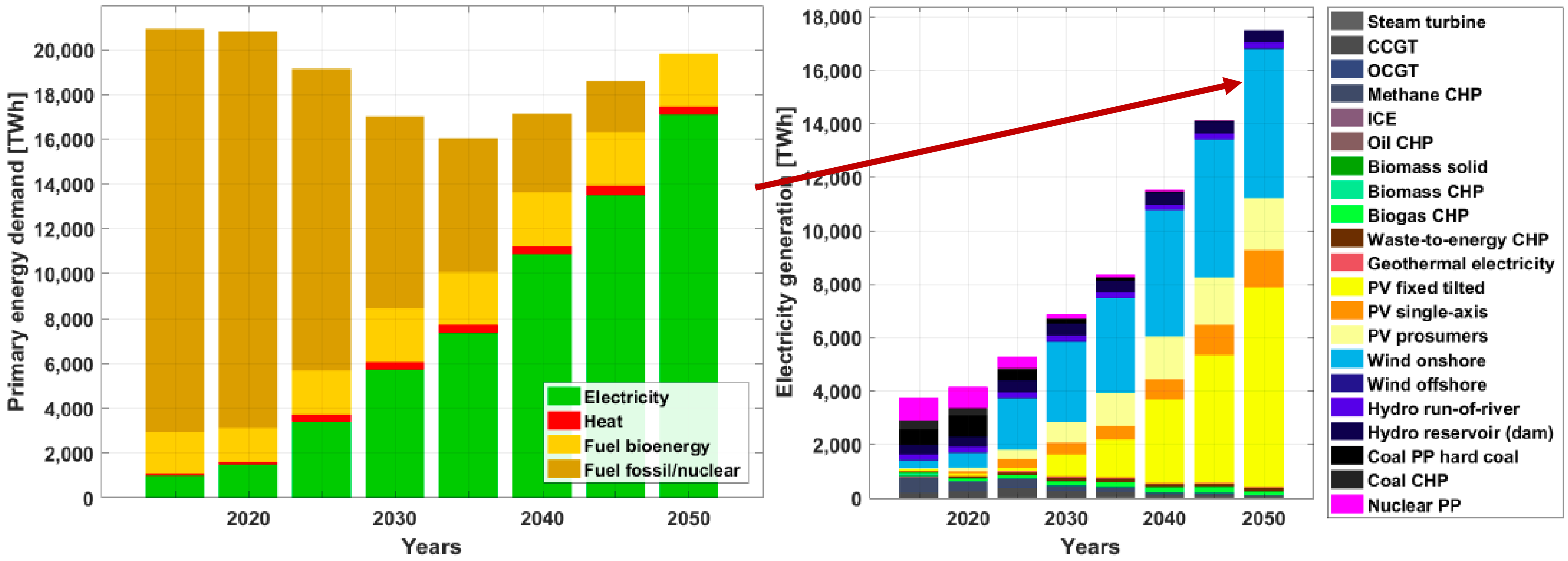
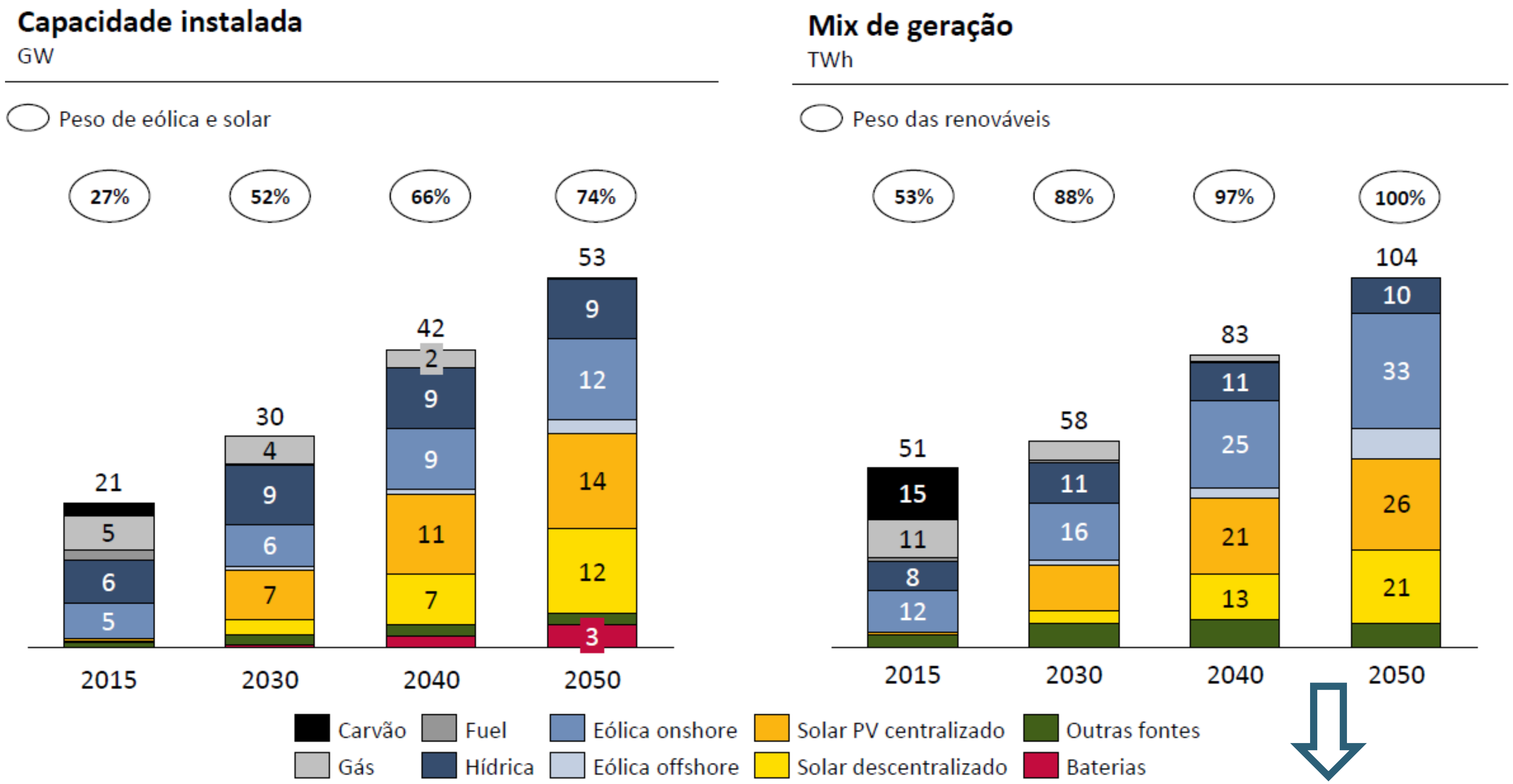


Figure KF-1: Primary energy demand (left) and electricity generation from various power technologies (right) through

RENAlliance panel, at COP 24 – Europe projections

Prospective scenarios for Portugal up to 2050

The electric system will be totally decarbonized by 2050, with renewable generation representing > 85% by 2030

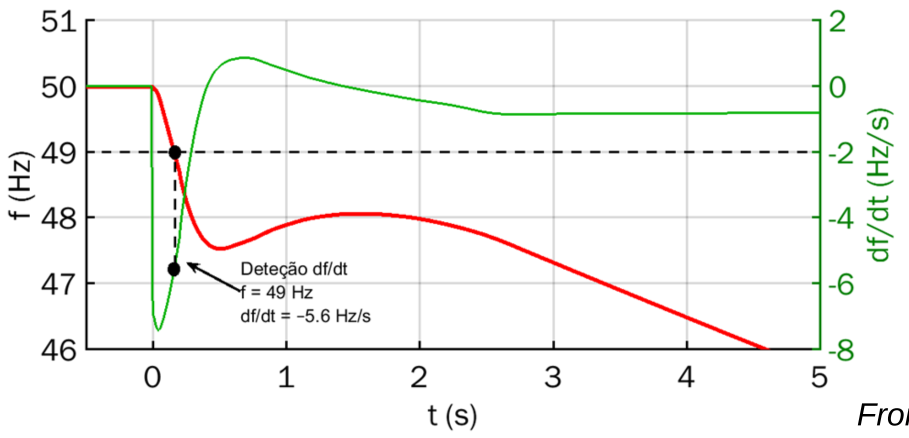


- **Large Share of Distributed Generation**
- **Large amount of variable RES**
- **Grid dominated by eletronic power converters**

Source: PNEC2030 & RNC2050

Impacts for the Operation of the System (Inverter Dominated Grids)

- Reduction of the global inertia of the system → Stability assessment becomes an issue of concern



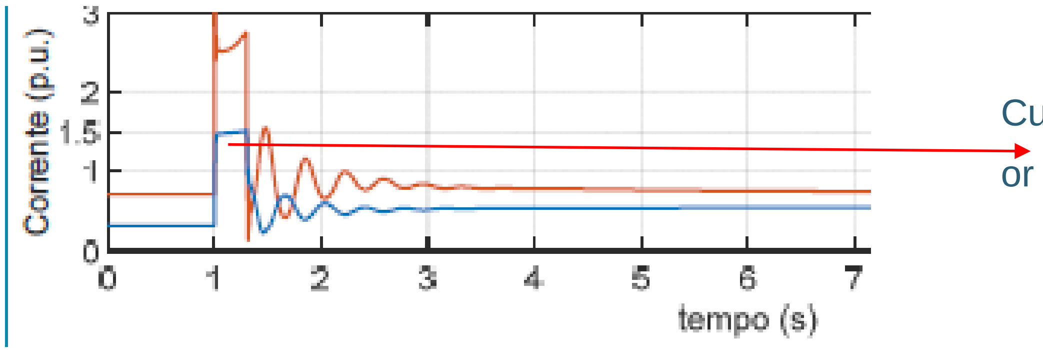
Very large df/dt

System instability phenomena

Syntetic inertia or synchronous Condendensers may be needed

From: studies for the Madeira Grid Code (EEM)

- Reduction of the short circuit currents → Re-evaluation of the protection solutions and settings



Current from the inverter (no sub-transient or transient currents), limited to 1,5In

From: studies for the Graciosa and Santa Maria BESS (EDA)

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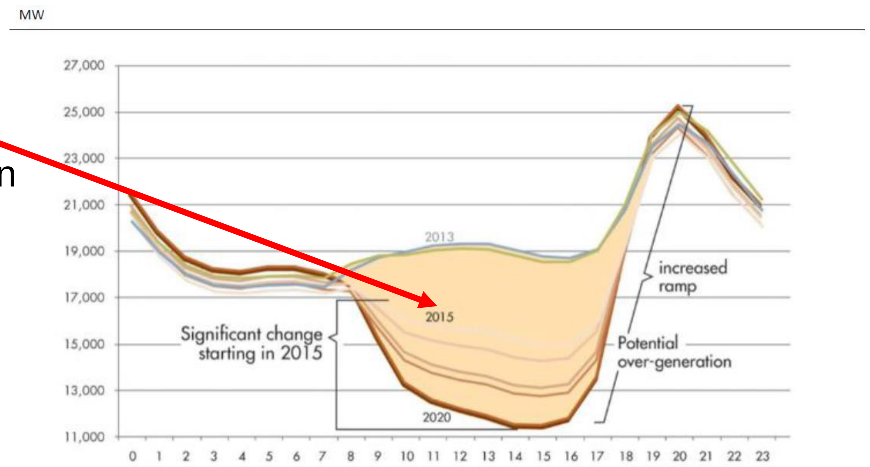
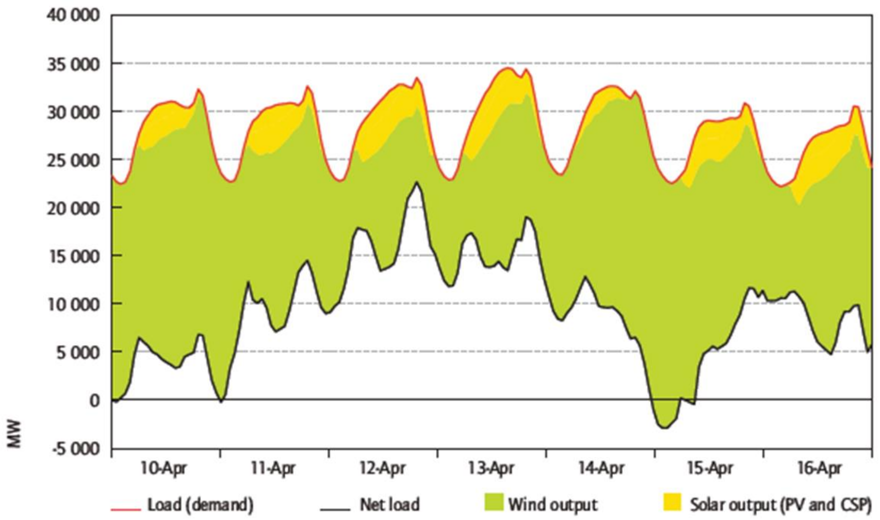
Impacts for the Operation of the System

- Large power imbalances in the system

PV generation



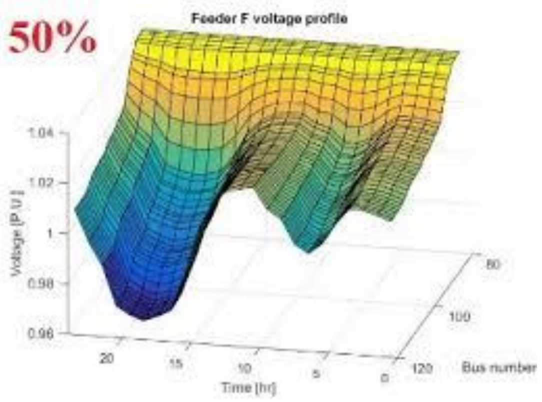
Source: CAISO

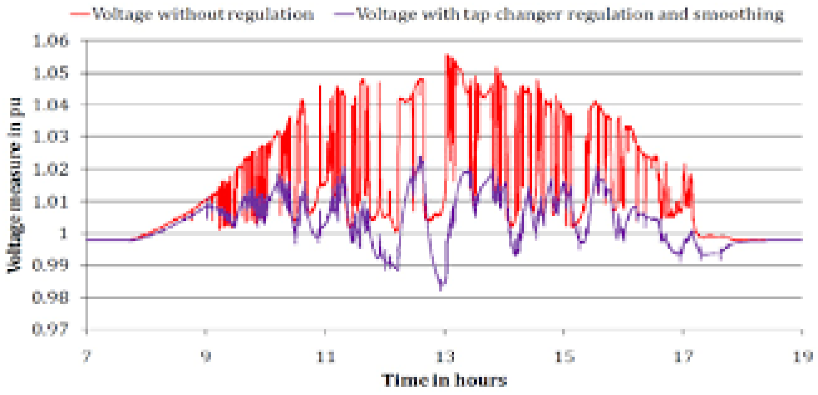


Source: GE Energy, 2010.

- Operational reserves need to be carefully assessed in order to guarantee an effective load balancing in the system

- Distribution grids will face difficult voltage regulation problems



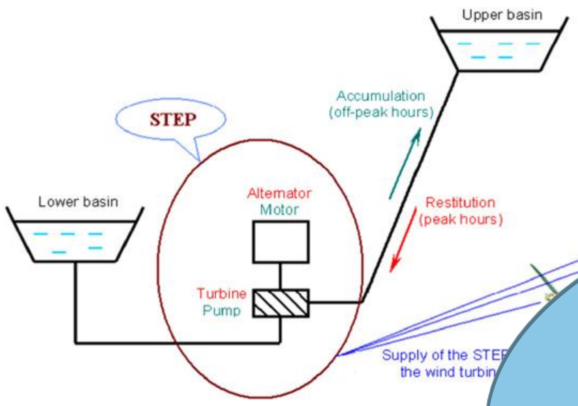


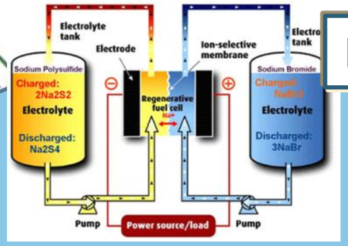
How to plan and manage a system with almost 100% RES penetration

Storage will provide part of the needed flexibility and it should be managed at diferent Levels → Multi-level management storage

System level

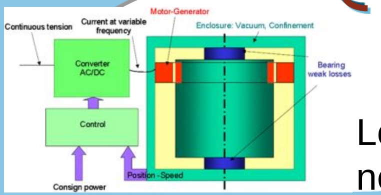
- Peak shaving
- Reserves management
- Fast ramping response



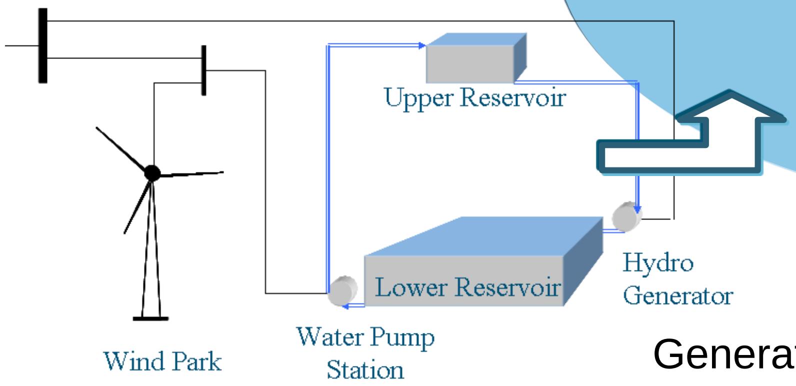


Distribution network level

- Power quality and reliability
- Avoid branch congestion



Low voltage distribution network



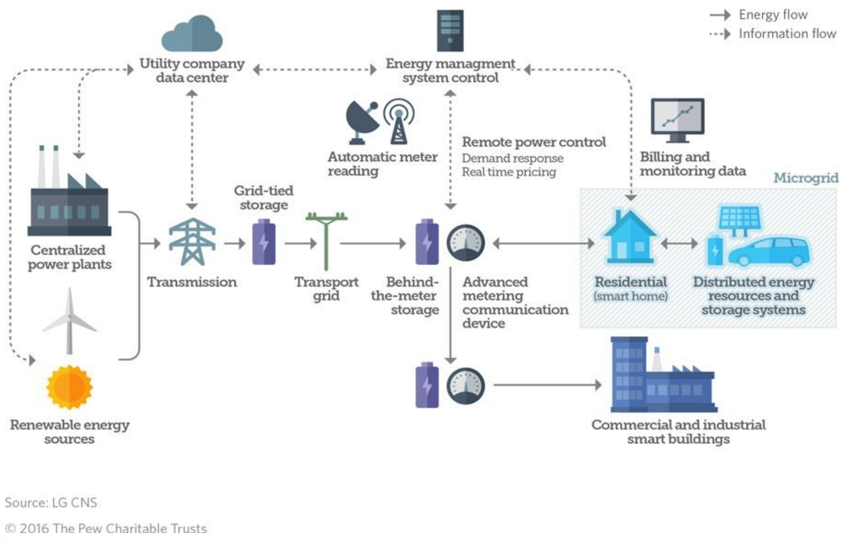
Generation level → Market participation
Provision of ancillary services (different technologies)

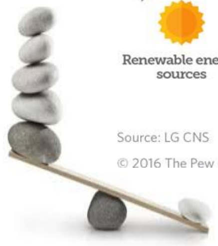
Storage will be key issue to assure the success of the energy transition

How to plan and manage a system with almost 100% RES penetration

- Exploit and develop the concept of **flexibility** in order to accommodate the variations from the generation (offer), dealing with:
  - **Capacity of the load to become adaptable to variations from generation** → requires a careful analysis of the industrial processes, electric mobility charging and consumption in buildings and homes → Development and use of battery smart charging, IEMS, BEMS, HEMS;
  - Deal with **behavioral management of consumers** to have them participating actively in the load response;
  - Having **generation units capable to respond fast to variations of RES** (ramping up and down), activating fast reserves → Batteries and Hydro reversible units (may require the revamping of some hydro power stations).

- **Accelerate the development of the smart grid** → deploy smart meters and develop control procedures to leverage efficient operation of the distribution grid, accommodating the energy community concept.





Knowledge gathered from the participion in several projects:
InovGrid, MERGE, AnyPLACE, SuSTAINABLE, SENSIBLE, InteGrid,…

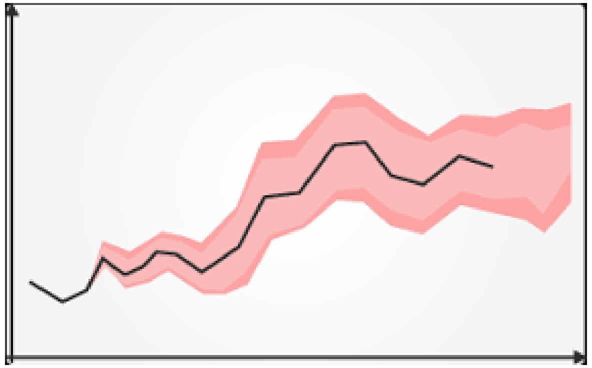
How to plan and manage a system with almost 100% RES penetration

- **Advanced Grid Codes** with RfG to obtain adequate responses from all generation units to grid disturbances

  Project: Madeira Grid Code

- **Security of Supply** will become a critical issue to assess → Utilization of chronological Monte Carlo Simulation tools capable to include the stochastic behavior of RES and flexibilities

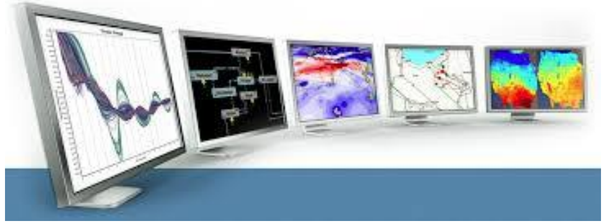
  MORA project: REN
  VEARREN203 project: DGEG



- **Better forecasting tools** (RES and load) → ML/AI

  EU Projects Anemos Plus & Smart4RES

- **On-line dynamic security assessment,** using namely ML/AI techniques by exploiting functional knowledge



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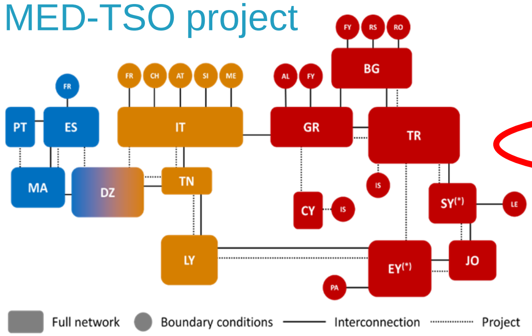
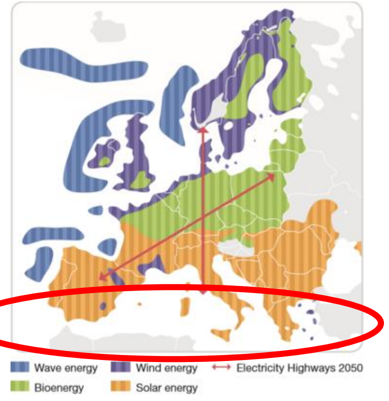
How to plan and manage a system with almost 100% RES penetration

- **Increase Interconnection capacities**
  - **(HVDC the enabling technology)**

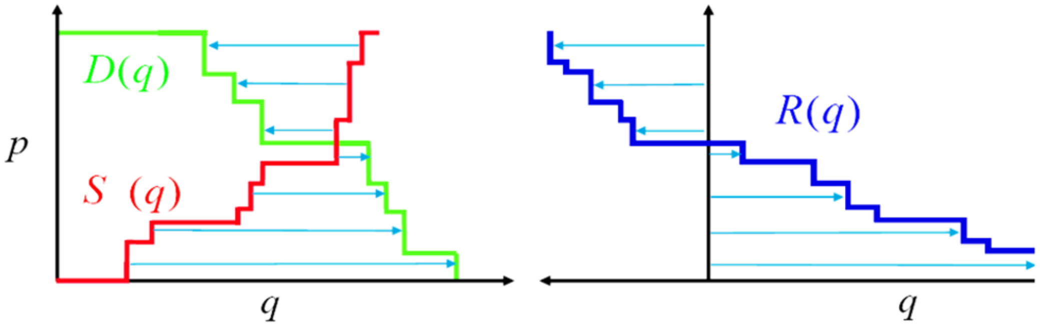
    Example: the INELFE cable linking France and Spain (HVDC, 2000 MW), expanding the interconnection capacity from 1.4 GW to 2.8 GW.

MED-TSO project



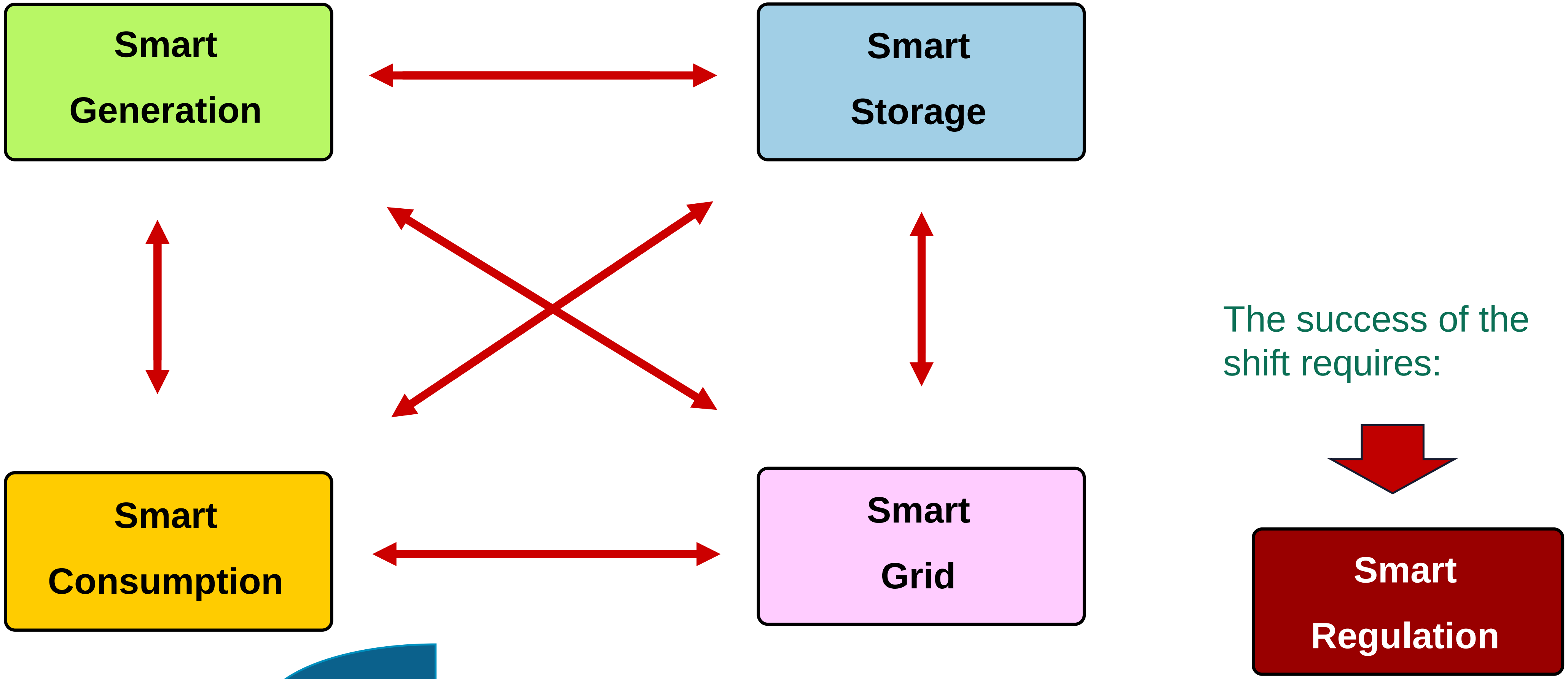


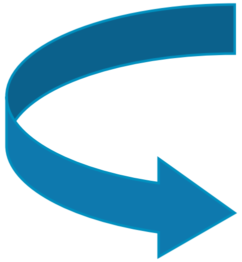
- **Redesign of the electricity market structure:**
  - **Do marginal markets still make sense?**
  - **Fast response reserve markets**
  - **Capacity Markets?**
  - **Flexibility Markets?**
  - **New ancillary services markets**
  - **Local markets**
  - **Carbon markets (carbon price)**



- **Address also** local trading using block chain via peer to peer platforms **to allow consumer, producers and prosumers to trade electricity with their neighbors within** energy communities

Conclusions: Smart Players will be vital for the success of the energy transition





Distribution system operators need to manage **Flexibility** from consumers, DG and network (including new ancillary services) energy systems of the future

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