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

WORKSHOP DIÁLOGOS UNIÃO EUROPEIA

– BRASIL: GOVERNANÇA DA TRANSIÇÃO ENERGÉTICA –

DESAFIOS & OPORTUNIDADES

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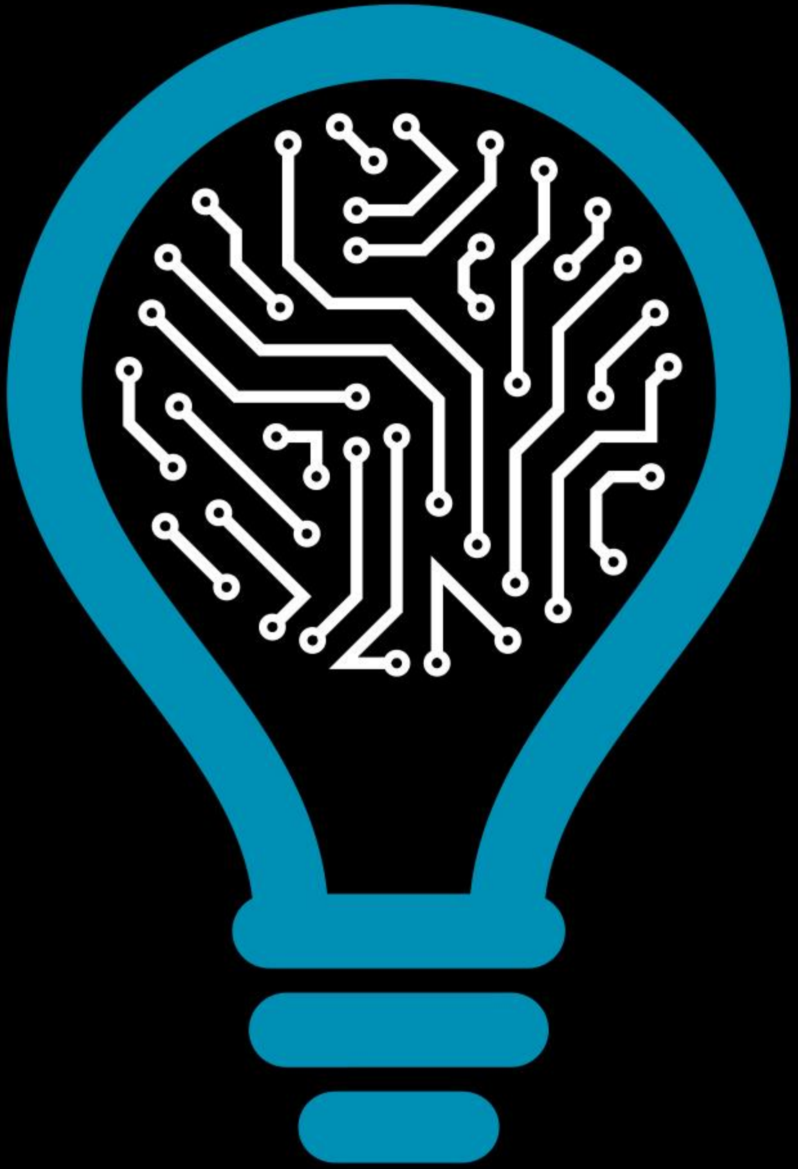
Brasilia, 18th November 2019



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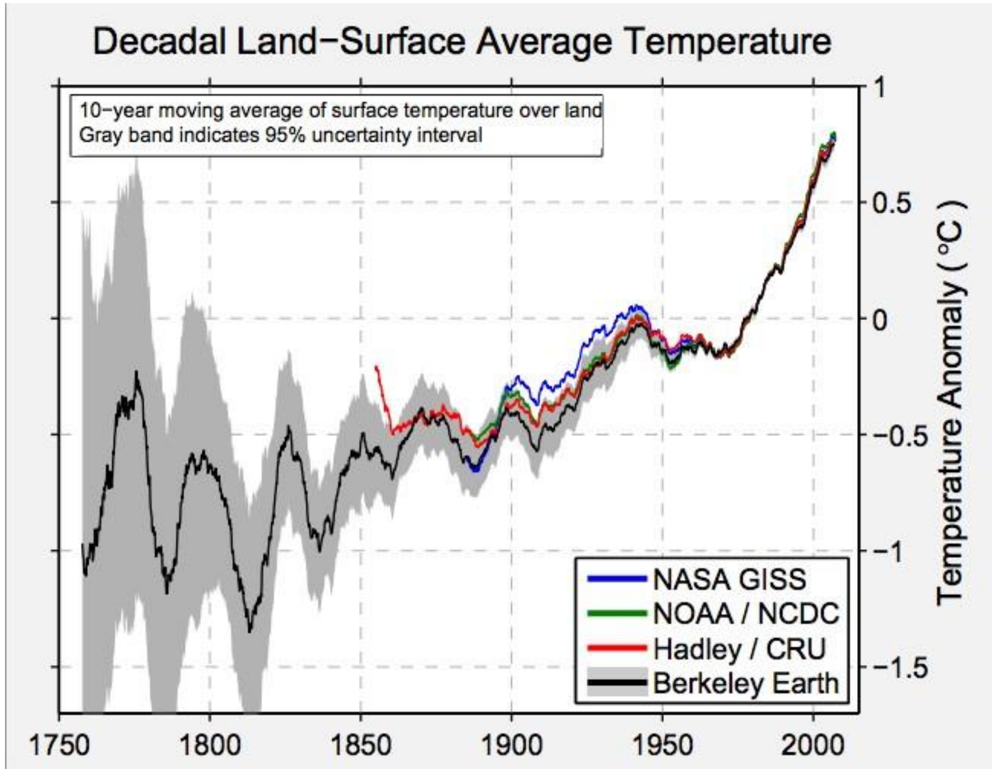
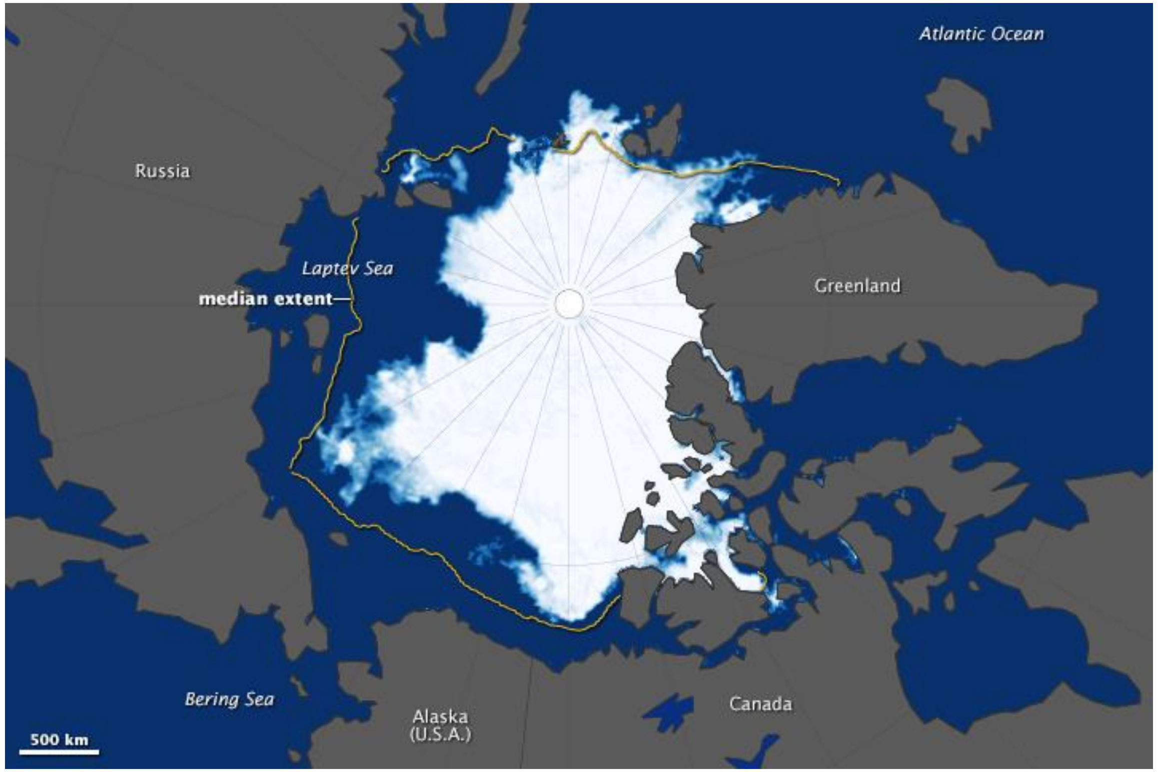
Introduction – Threats of Climatic Changes

Global earth 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?

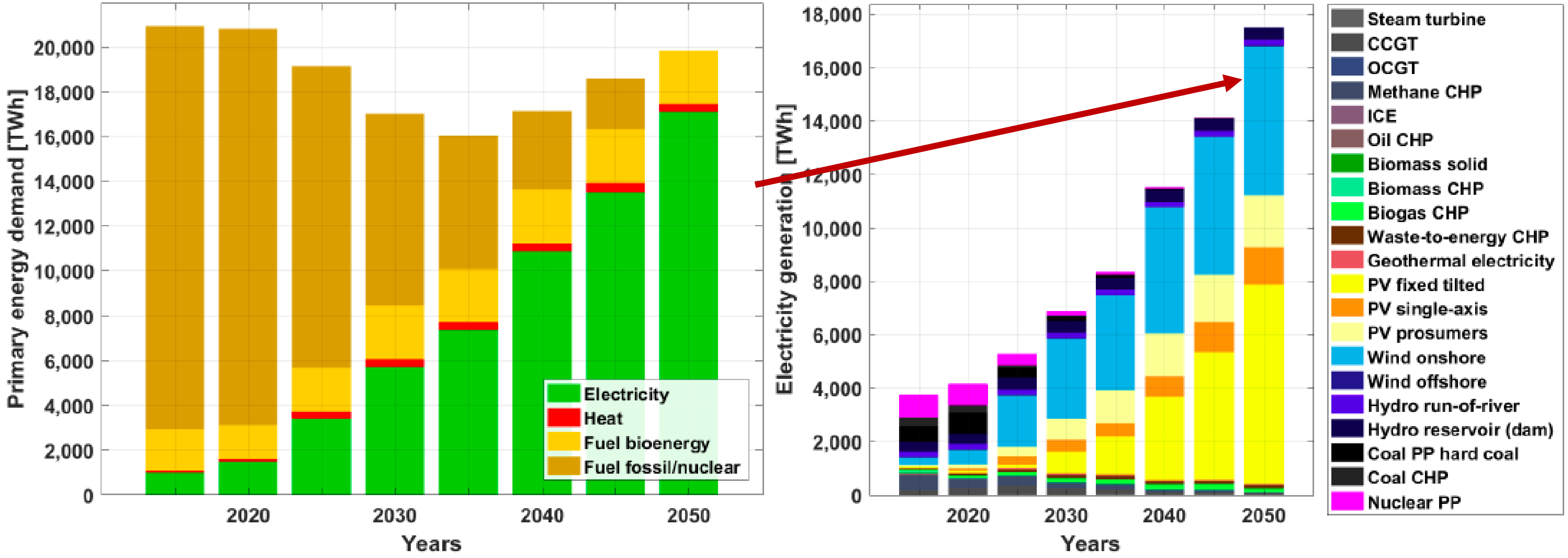

Figure KF-1: Primary energy demand (left) and electricity generation from various power technologies (right) through

RENAlliance panel, at COP 24 – Europe projections

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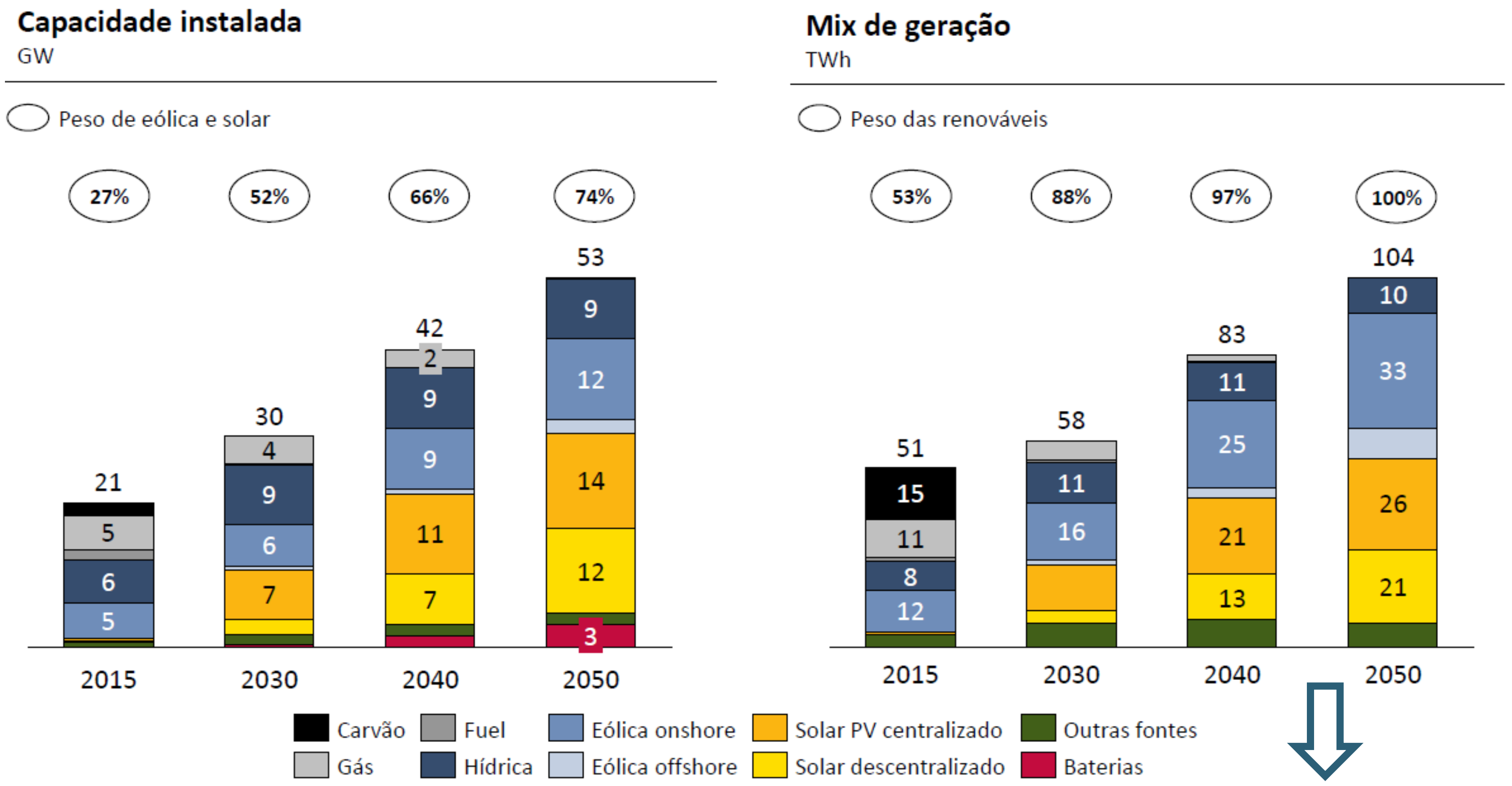
Prospective scenarios for Portugal up to 2050

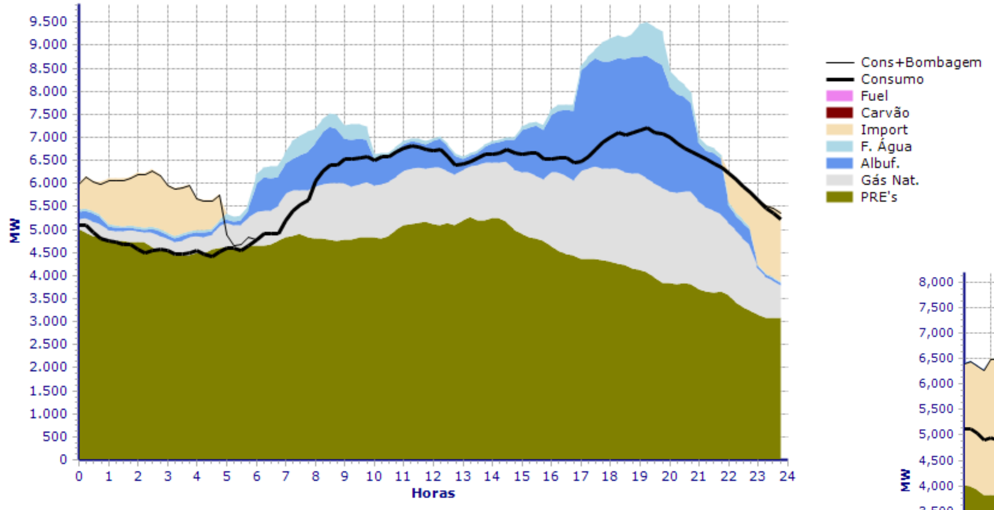
The electric system will be totally decarbonized by 2050, with renewable generation representing > 80% by 2030

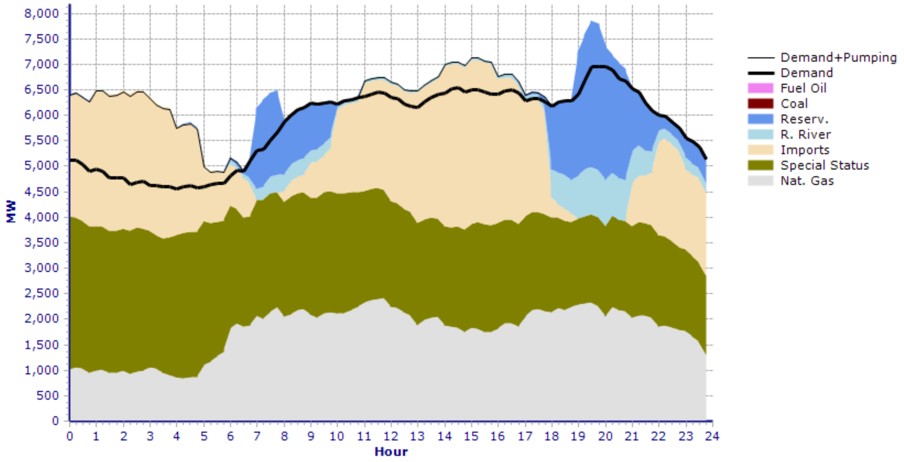


- Large Share of Distributed Generation
- Large amount of variable RES
- Grid dominated by eletronic power converters

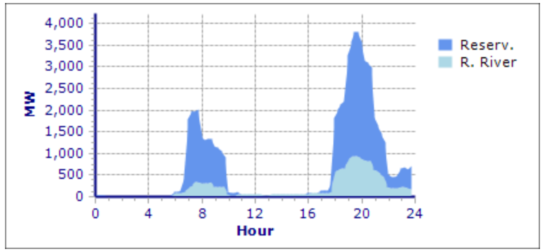
Source: PNEC2030 & RNC2050

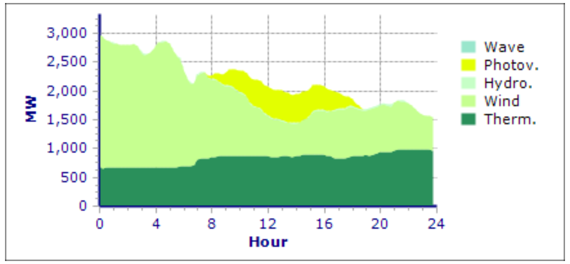
Recent operating scenarios for Portugal October 2019





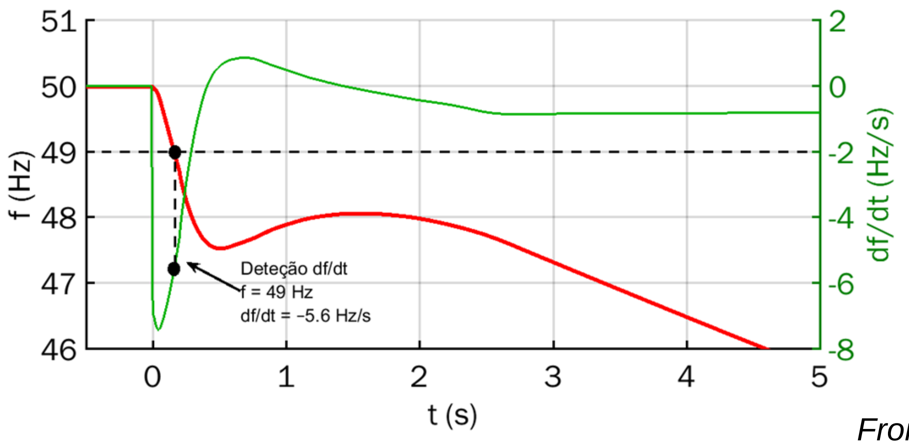
The role of hydro pumping reversible power stations





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

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System instability phenomena

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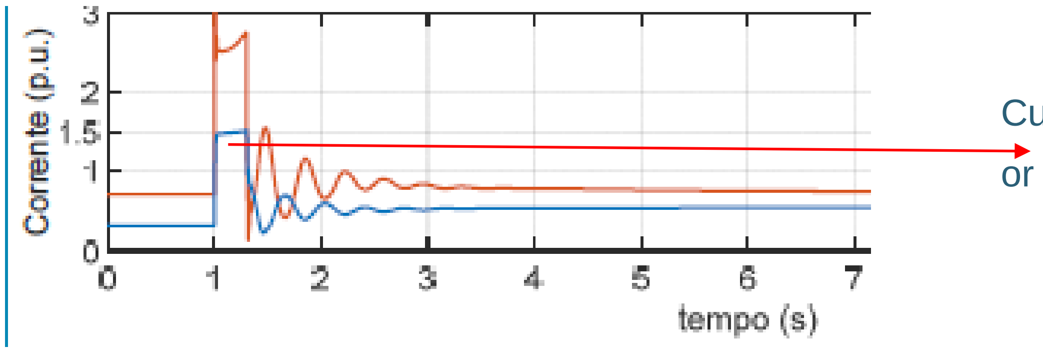
Syntetic inertia or synchronous Condendensers may be needed (hydro pumping units can provide inertia when are not generating neither pumping)

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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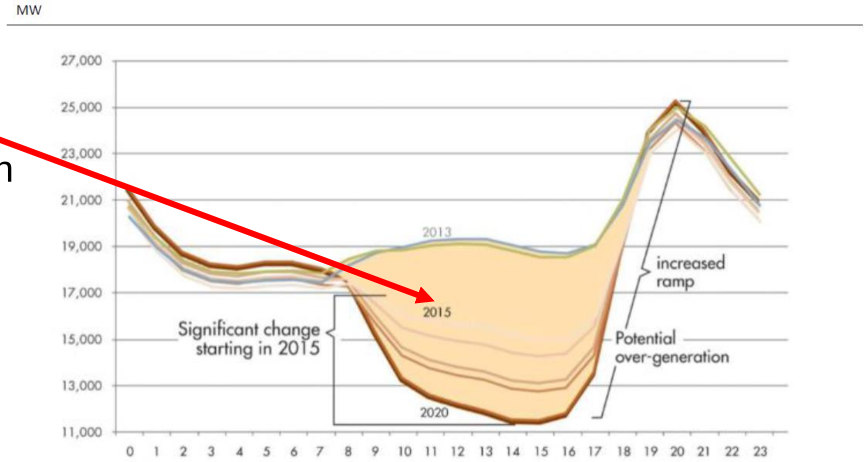
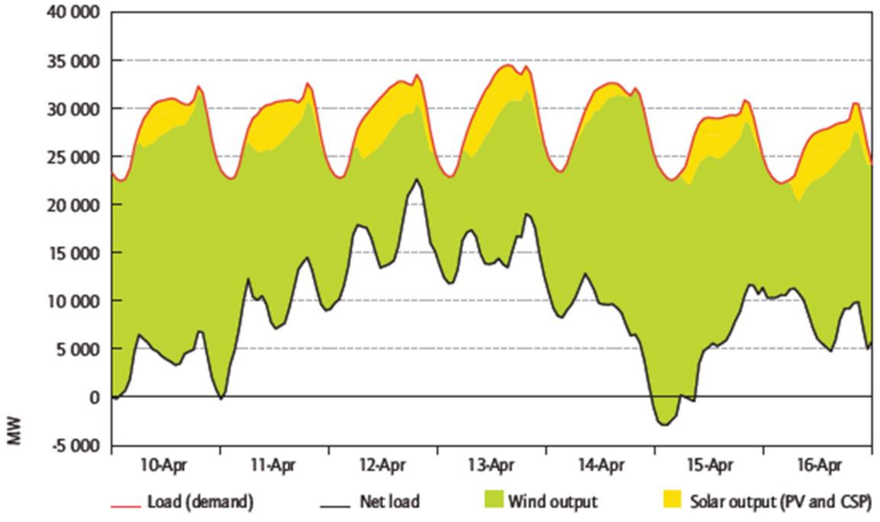
Impacts for the Operation of the System

- Large power imbalances in the system

PV generation



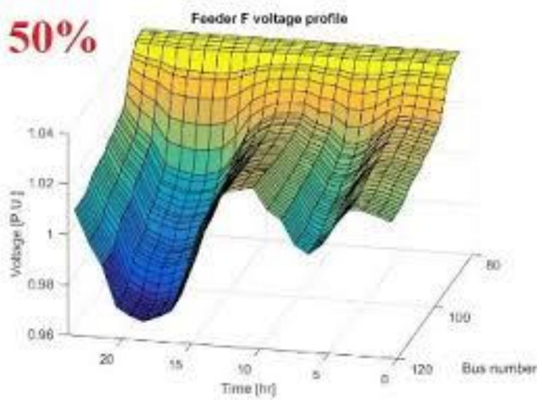
Source: CAISO

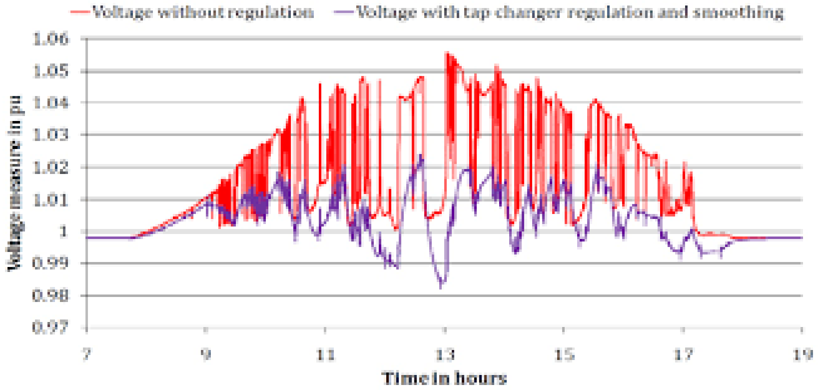


Source: GE Energy, 2010.

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

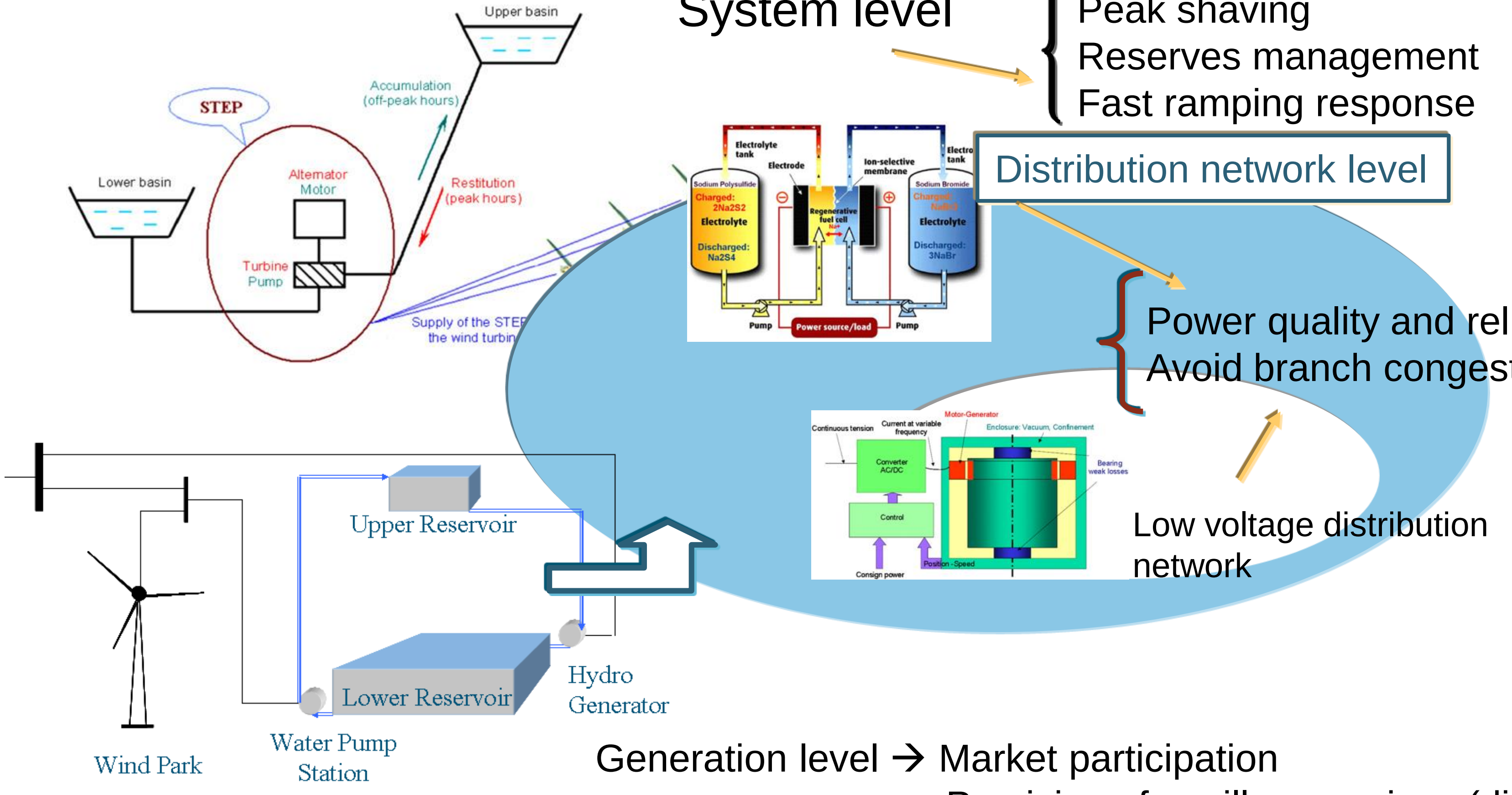
- Distribution grids will face difficult voltage regulation problems





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

Seasonal storage

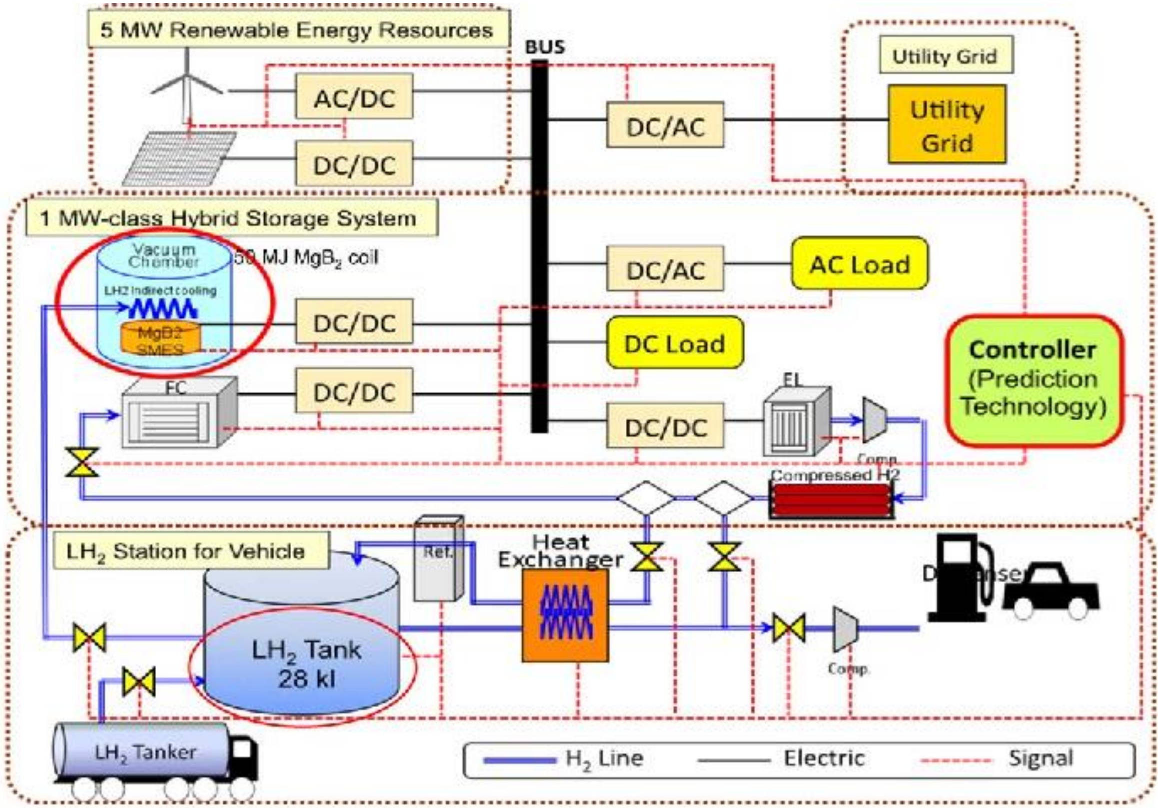
Seasonal storage capability will be required as a result of the variations on production from renewable power sources (namelly PV) during the year.

Solutions:

- **Hydro pumping stations (large upper reservoir)**

- **Investment on H2 production and storage**
    - Use H2 on transportation
    - Use of H2 on industrial heating
    - Bleding H2 + NG

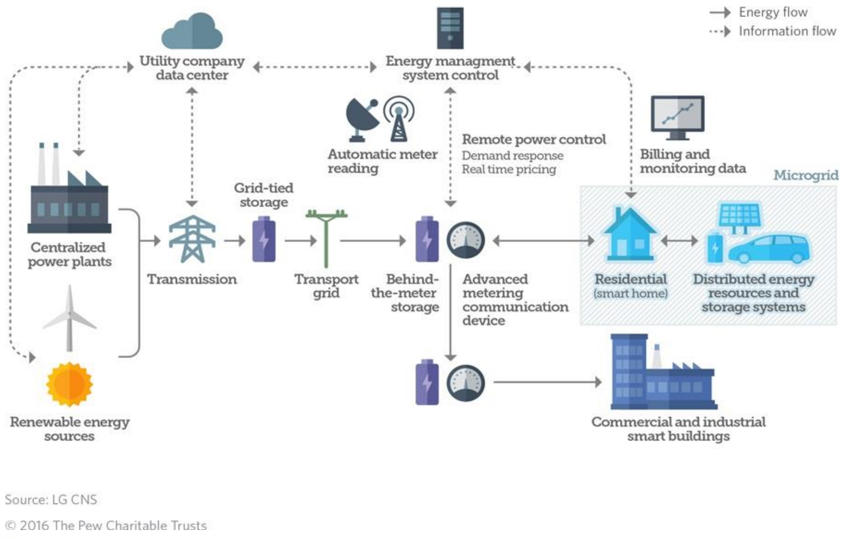
    - Use it in CCGT (assuring in this way security of supply)

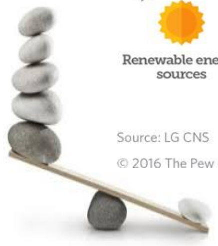


How to plan and manage a system with almost 100% RES penetration

- 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,…

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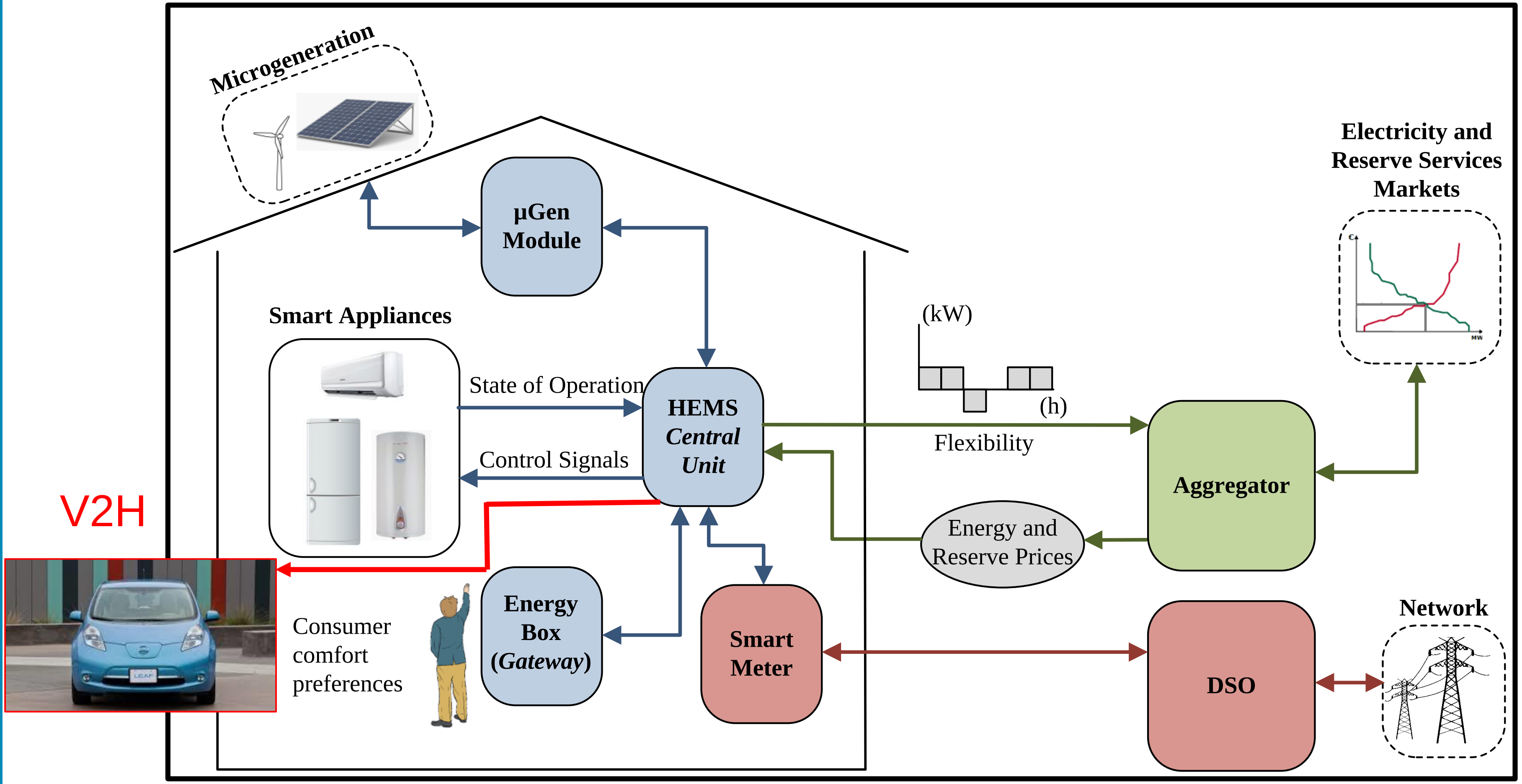
How to plan and manage a system with almost 100% RES penetration

Residential Demand Response: The Smart Home → Flexibility provision

V2H



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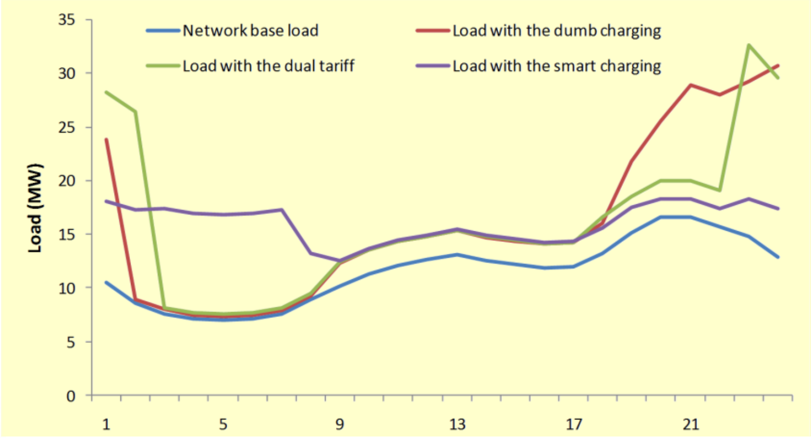
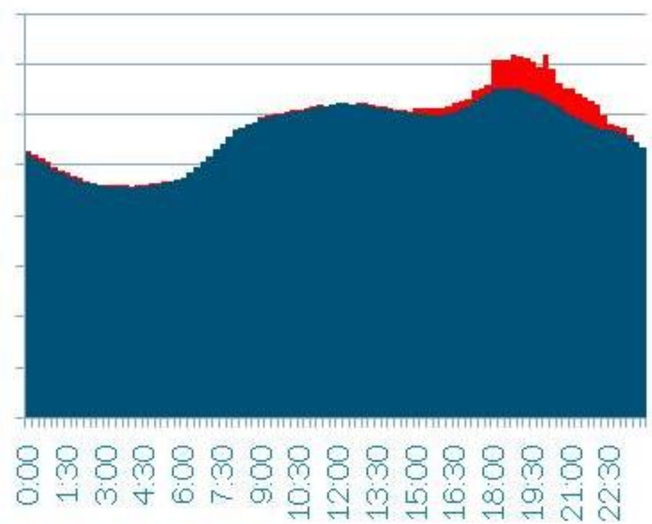
How to plan and manage a system with almost 100% RES penetration

The electric mobility will become more and more a reality (Hybrid Plug In EV, BEV).

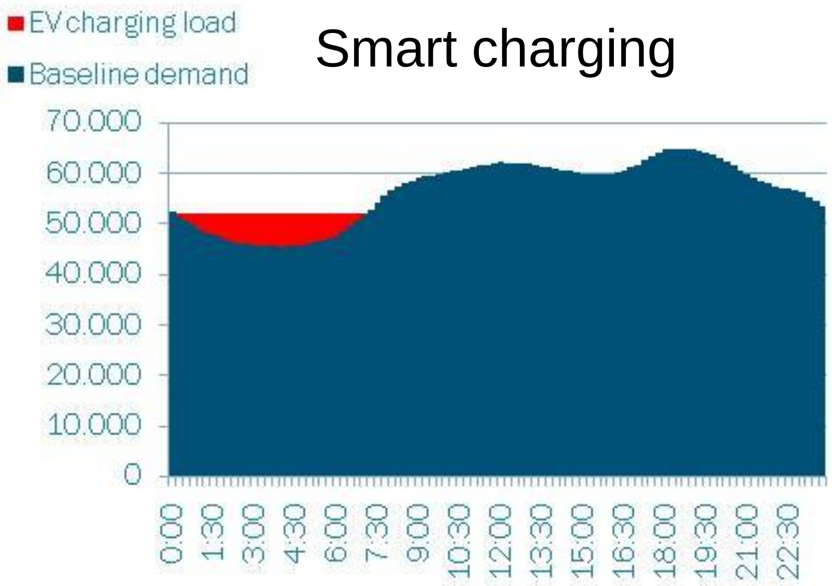
EV batteriees are flexible charges allowing to move from na uncontrollled charging to a full controlled smart charging.





Dumb charging

Smart charging

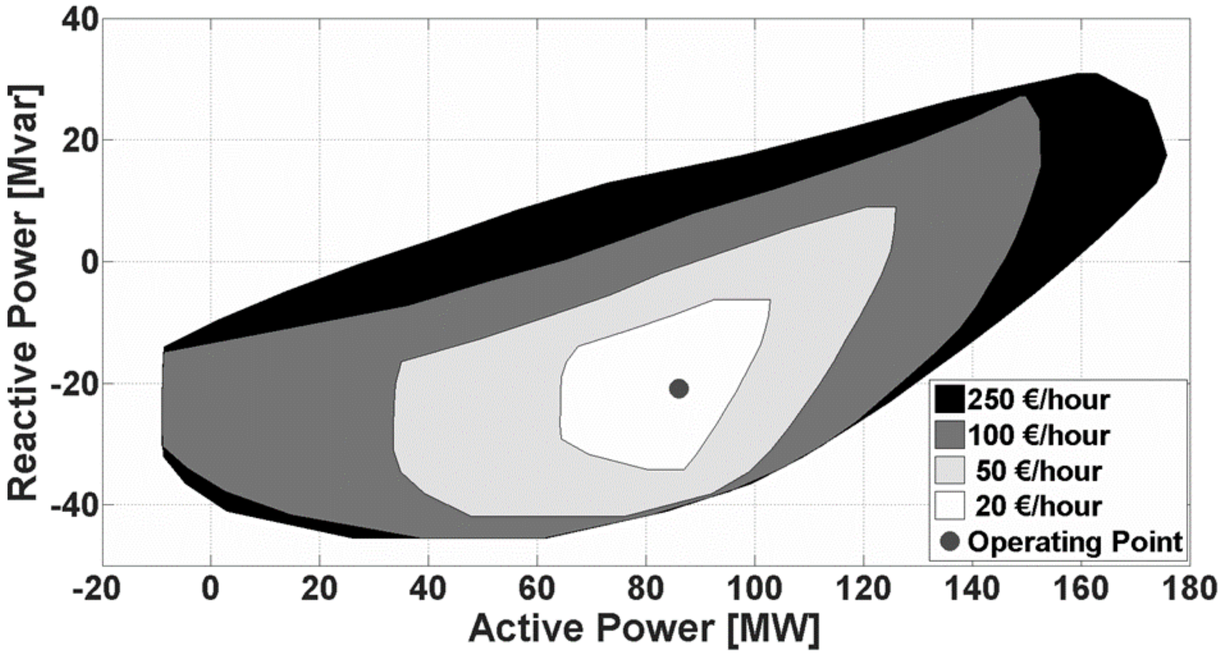


How to plan and manage a system with almost 100% RES penetration

Increase the interaction between TSO/DSO by coordinating control actions (which requires exchange of information) in order to ativate the DER.

It involves costs when when activating these measures (for each hourly step)

Flexibility Diagrams per bus

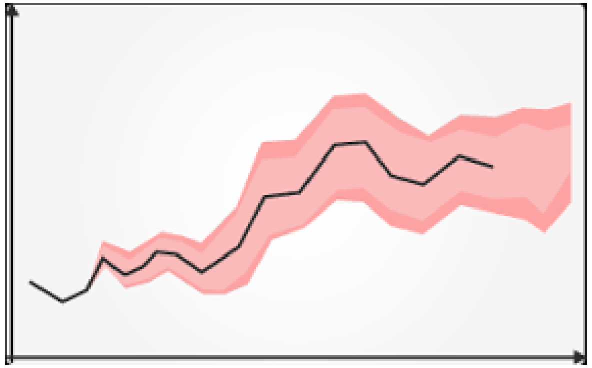


How to plan and manage a system with almost 100% RES penetration

- **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

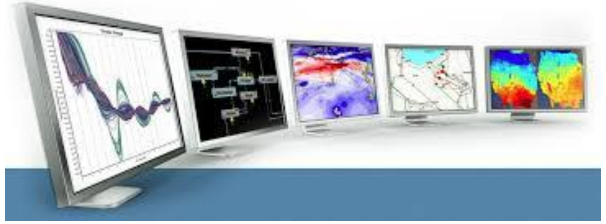
MORA project: REN
VEARREN203 project: DGEG



- **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

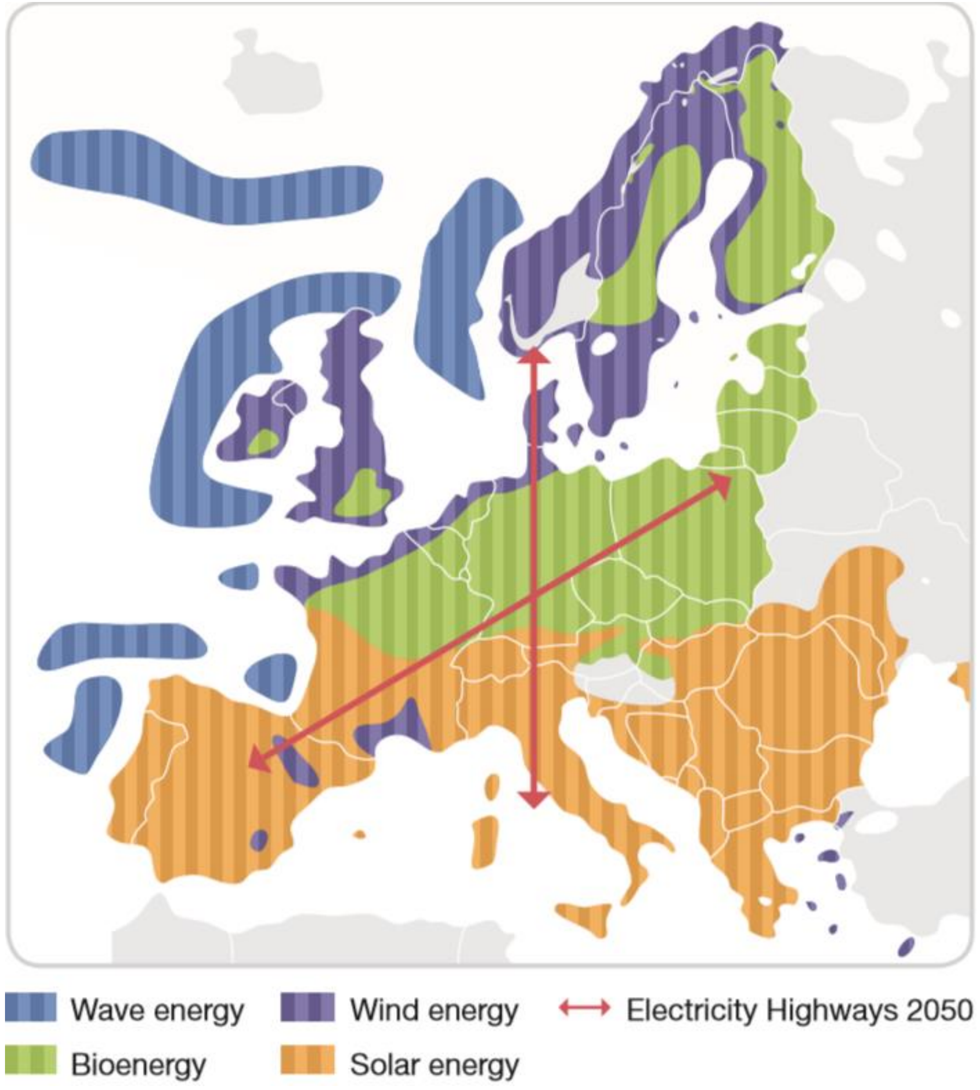


How to plan and manage a system with almost 100% RES penetration

A Trans-European electricity grid is required in order to facilitate the future transport of wind energy from the North Sea and solar power from south of Europe / north Africa or biomass electricity from Russia, for example, to consumption centers via electricity highways.

HVDC is the enabling technology:

- Power flow in a DC transmission line can be precisely controlled
- It can contribute to stabilize the backbone of the system, thus improving grid resilience
- DC is the only option for the underground and underwater transmission of power over distances of more than about 50 kilometers



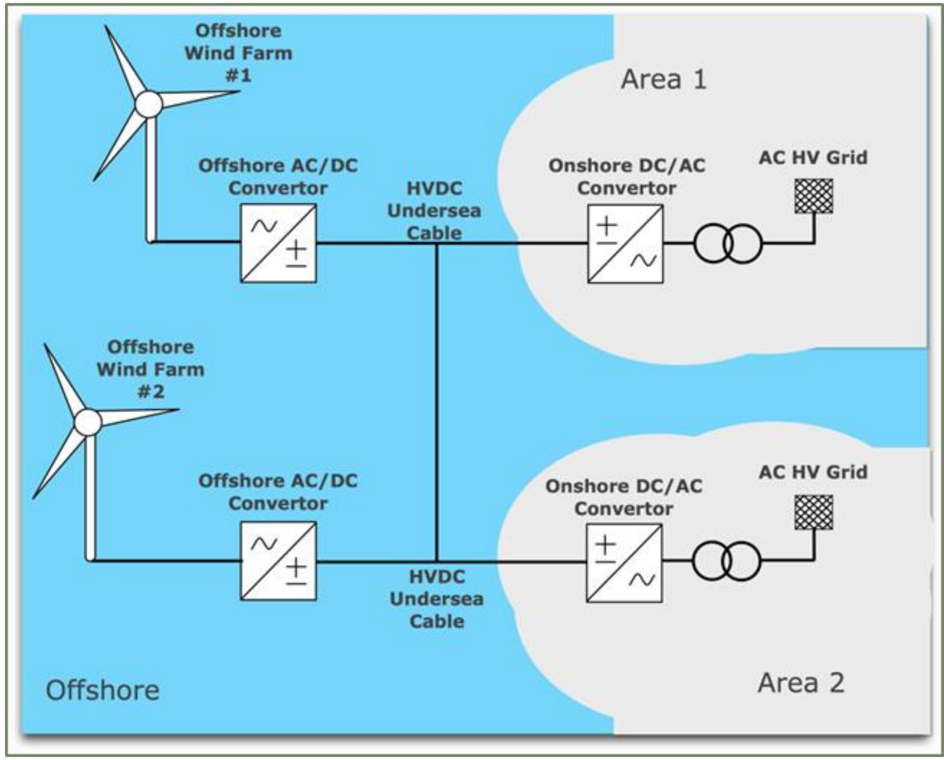
How to plan and manage a system with almost 100% RES penetration

Harvesting off-shore wind power in the ocean

Multi-port off shore HVDC grids:

- VSC converters
- No inertia system → Problem

- Allowing control of power flows
- Providing primary frequency control
- Participating in damping of small oscillations
- Fault ride through capability
- Emulation of inertia



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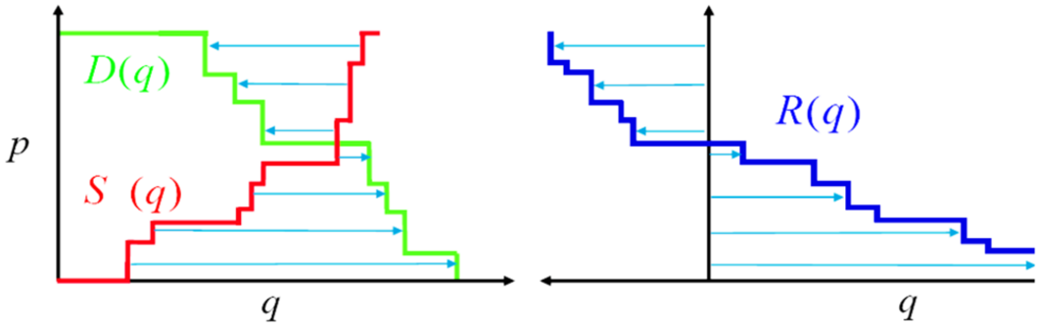
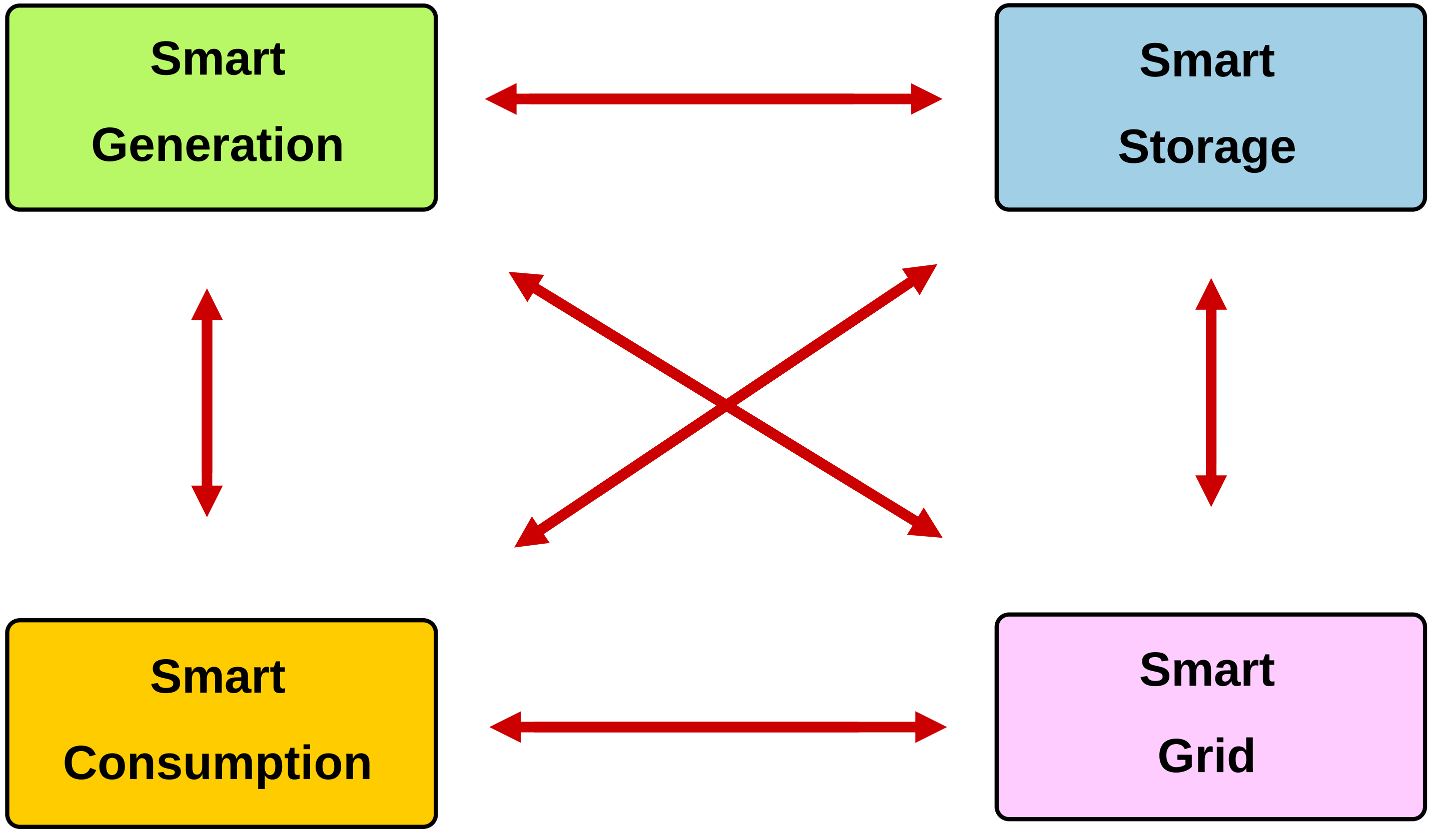
How to plan and manage a system with almost 100% RES penetration

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

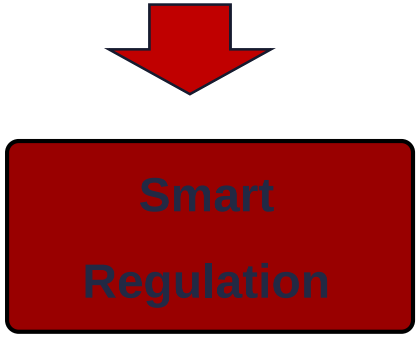


- **Address also local trading using block chain via peer to peer platforms to allow consumer, producers and prosumers to trade electricity with their neighbors within energy communities**

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



The success of the shift requires:



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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