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Management and Control Systems for Large Scale Integration of RES into the Electrical Networks

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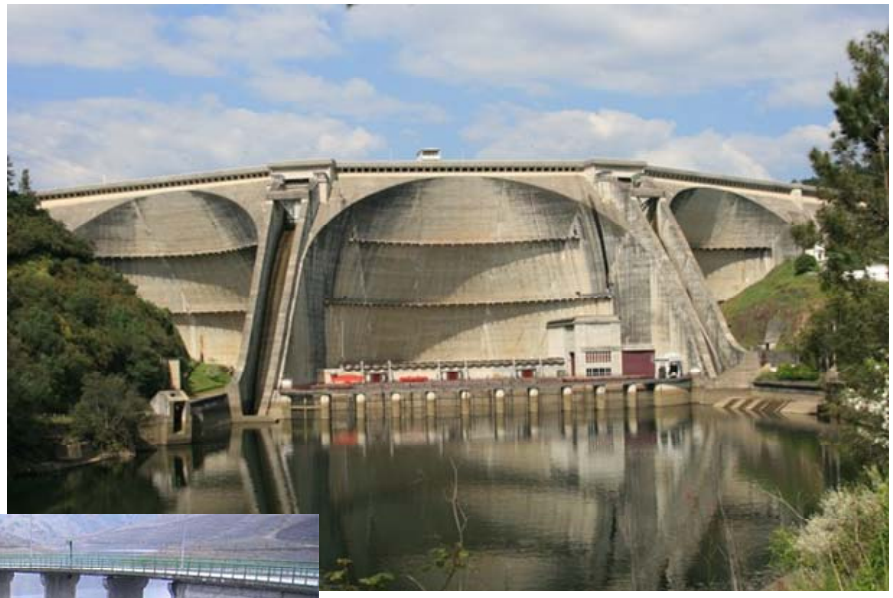
Introduction

- Driving forces for the future development of the electric power systems:
  - 1) **Environmental Issues**: meet Kyoto protocol targets (reduce emissions by replacing fossil generation by zero emission generation, reduce network losses), increase social responsibility and sustainability, minimize visual impacts and land use
  - 2) **Replacement of Old Infrastructures** (generation and grid)
  - 3) **Security of Supply**
  - 4) **Increase Quality of Service** (more automation and remote control)
  - 5) **Electricity Market Liberalization** (energy and services)

  - 1) **Increase the Integration Levels of Renewable Energy Sources (RES)**
  - 2) **Demand Side Management** (increase load consumption efficiency)

New challenges regarding power systems operation

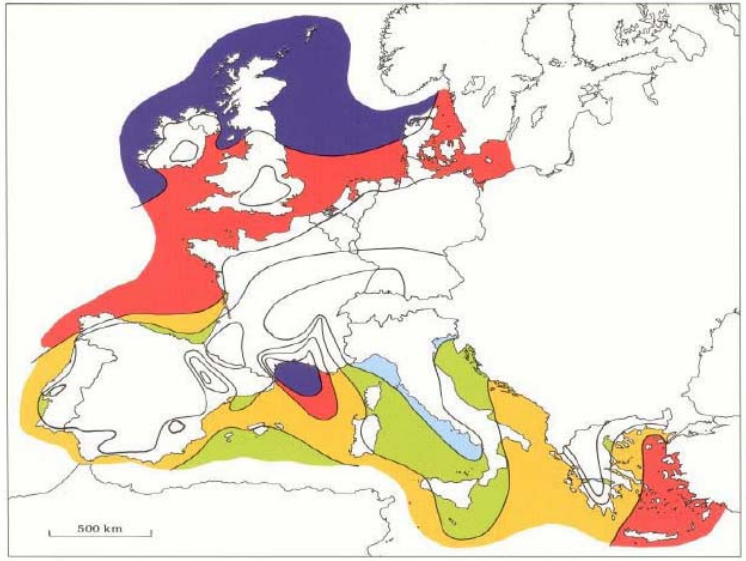
Increase Renewable Generation: Stabilized technologies

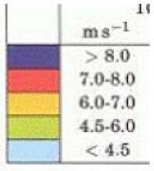


Increase Renewable Generation: Some promising technologies

- Some promising technologies

Increase Renewable Generation: Some promising technologies



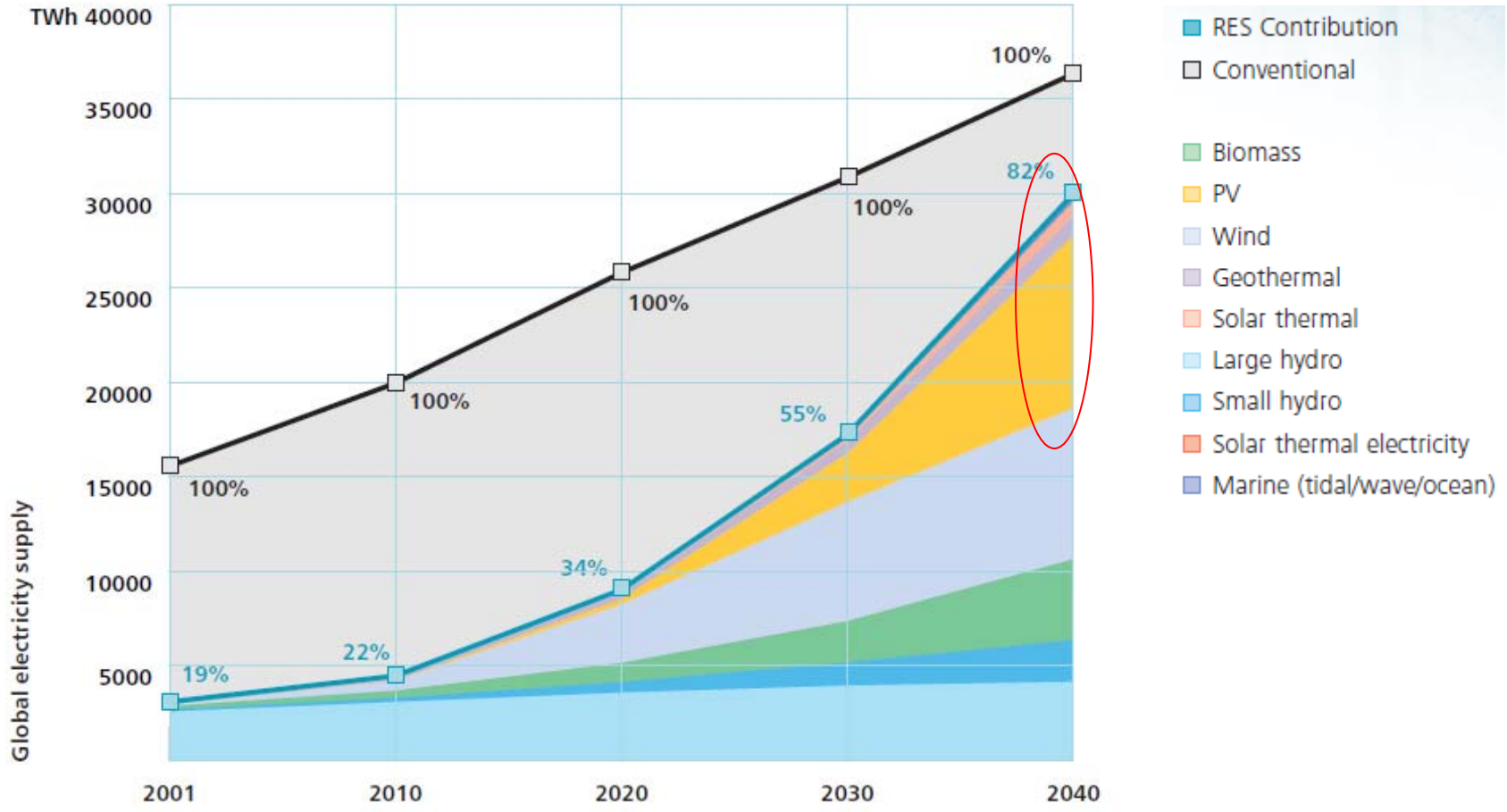


20 20 20 Twenties
Transmitting wind

Transmission system operation with large penetration of Wind and other renewable Electricity sources in Networks by means of innovative Tools and Integrated Energy Solutions

Expected Contribution of RES

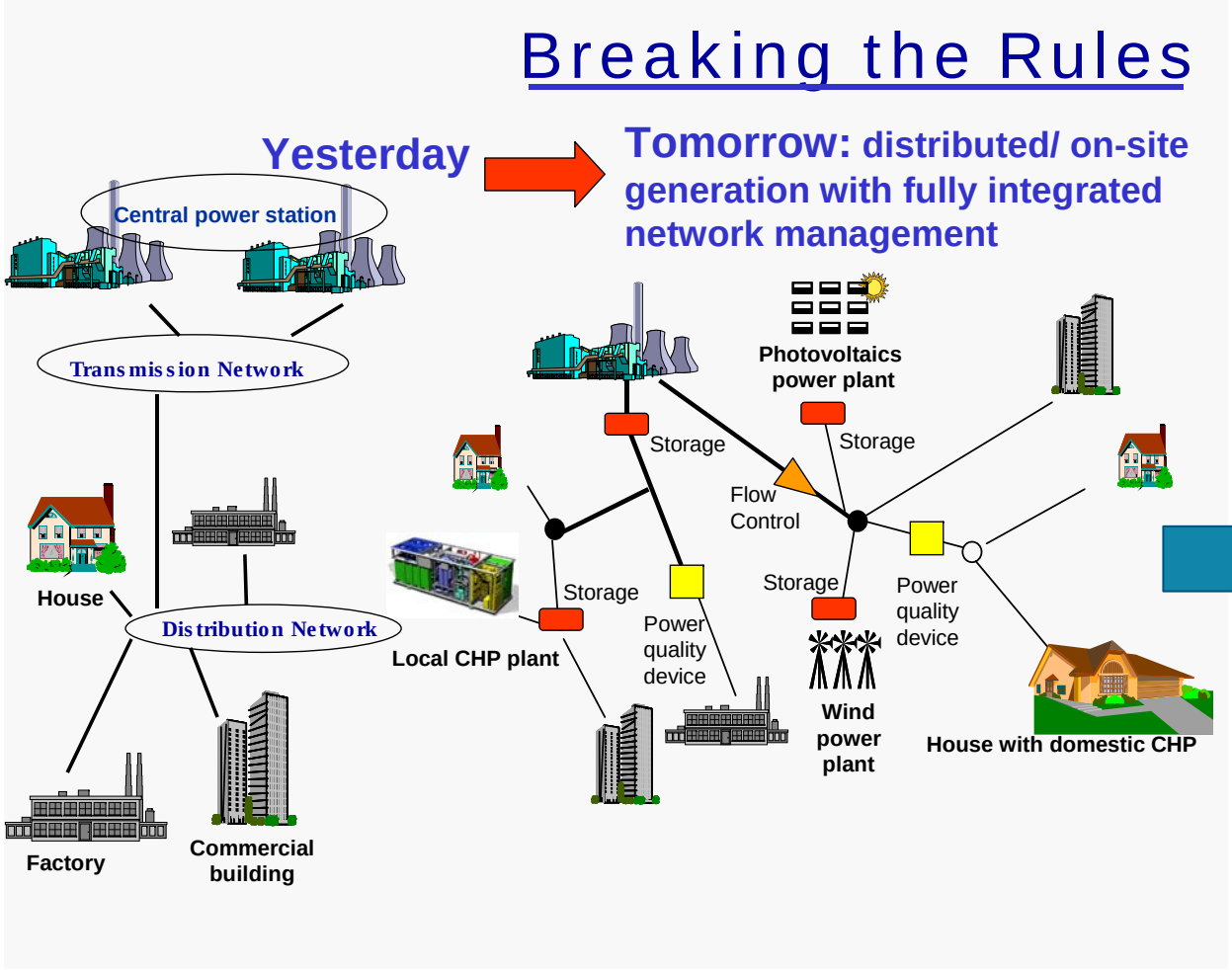
- Some scenarios: Prospects for renewable electricity generation



Source: EREC. 2005 – European Renewable Energy Council
(http://www.erec.org/fileadmin/erec_docs/Documents/Publications/EREC_Scenario_2040.pdf)

System Operation Challenges: New Grid Management

- New paradigms are under development



Current distribution grid management practice needs to be changed from passive to active

DG control paradigm

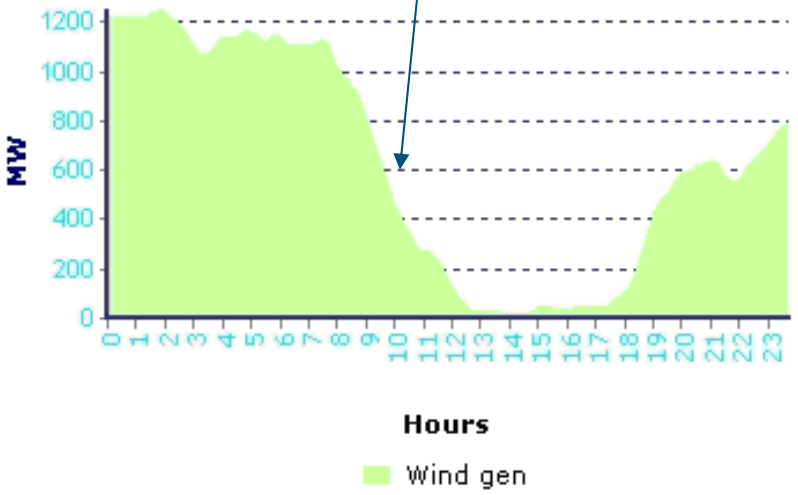
Power System Requirements for High Wind Penetration

- Balancing Requirements
  - Fluctuations of wind generation demand for controlling and balancing power;
  - Wind power prediction systems are highly required.
- Active power control is required for frequency regulation
  - The fulfilment of power and frequency control schemes requires the provision of reserves;
  - Grid codes of several countries are being updated in order to include the participation of wind power in frequency control.
- Reactive power control is required for voltage regulation
  - Grid codes have issued operational range for the voltage and power factor at the point of connection.
- Fault Ride-through capability is required to avoid loss of wind generation

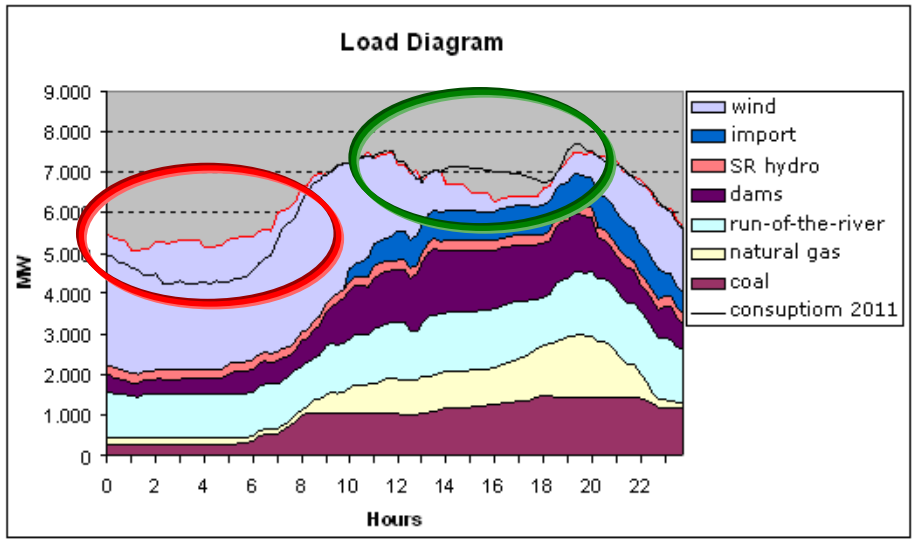
The Need for Central Active Load Management

- Large scale renewable energy sources deployment (PV or wind) requires either central storage management or active load management (increasing consumption):
  - To increase load
  - To deal with reserves management

Storage and/or consumption management is needed



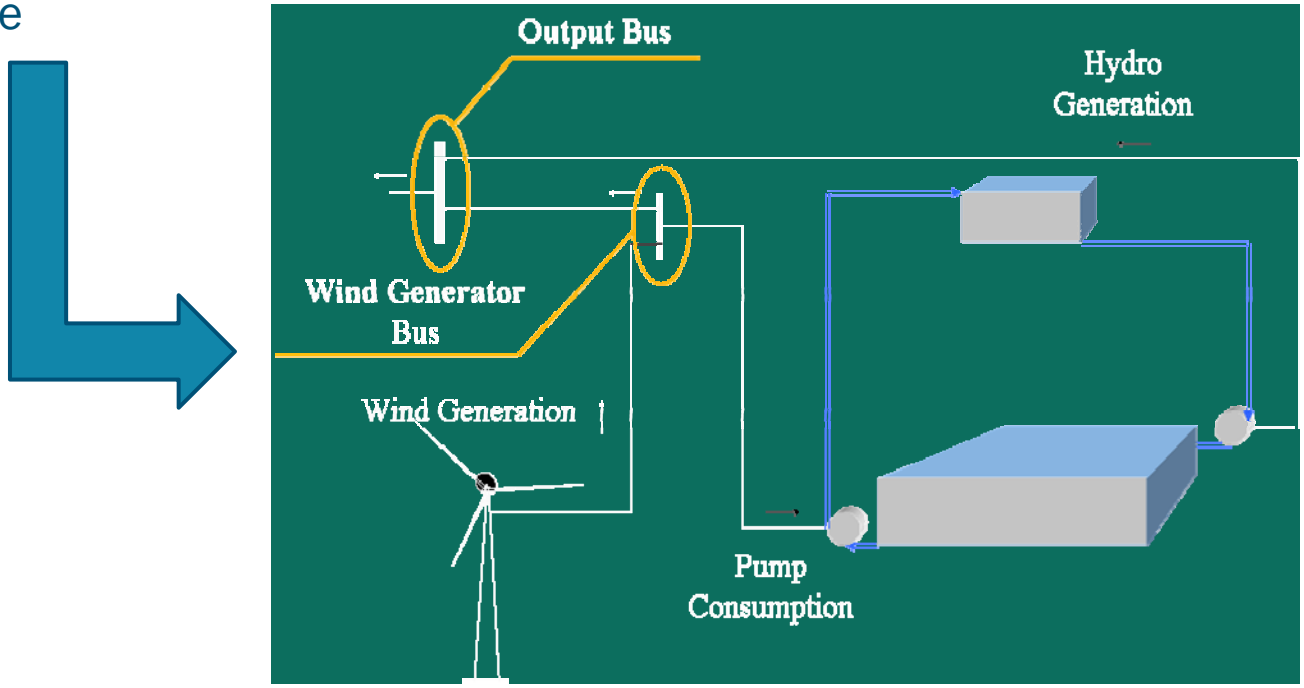
Wind Generation of 14th February 2007
Source: REN (Portuguese TSO); http://ww.ren.pt



Prospective generation allocation in a winter windy wet day (2011)

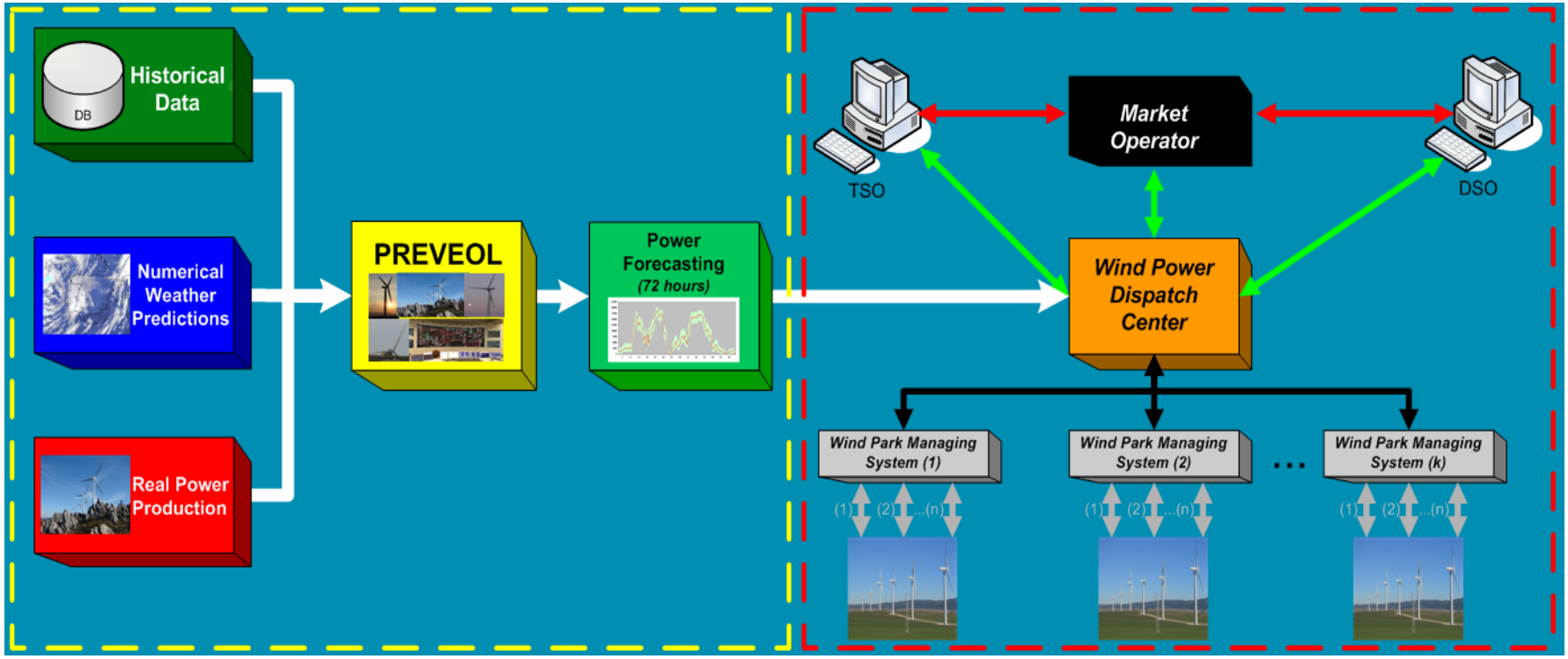
Storage as Way to Help Managing the System

- Storage technologies:
  - Short term storage: flywheels, super-capacitors, SMES devices
  - Medium term storage (to keep energy balance, help in frequency control, costumer peak shaving): Compressed air, flow batteries, hydro pumping storage
  - Long term storage (transferring energy from one period to another): hydro pumping storage

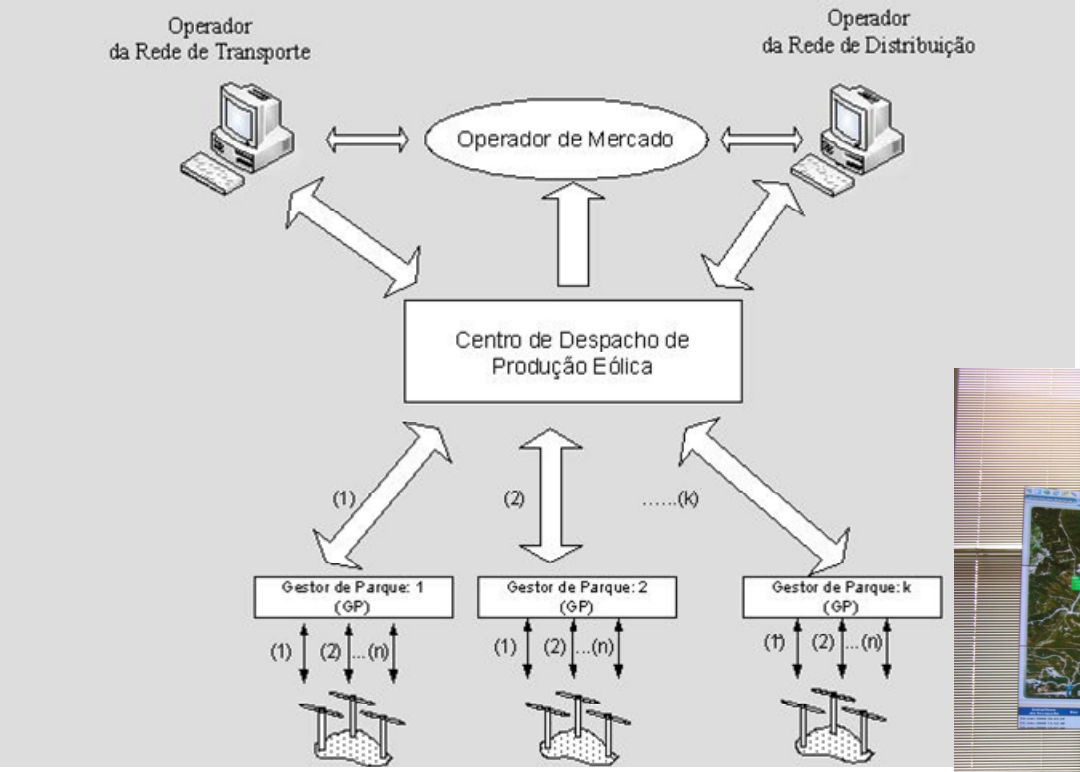


The need for wind power forecasting tools

- Operational framework



New Management and Control Structures: Dispatch Centers as VPP

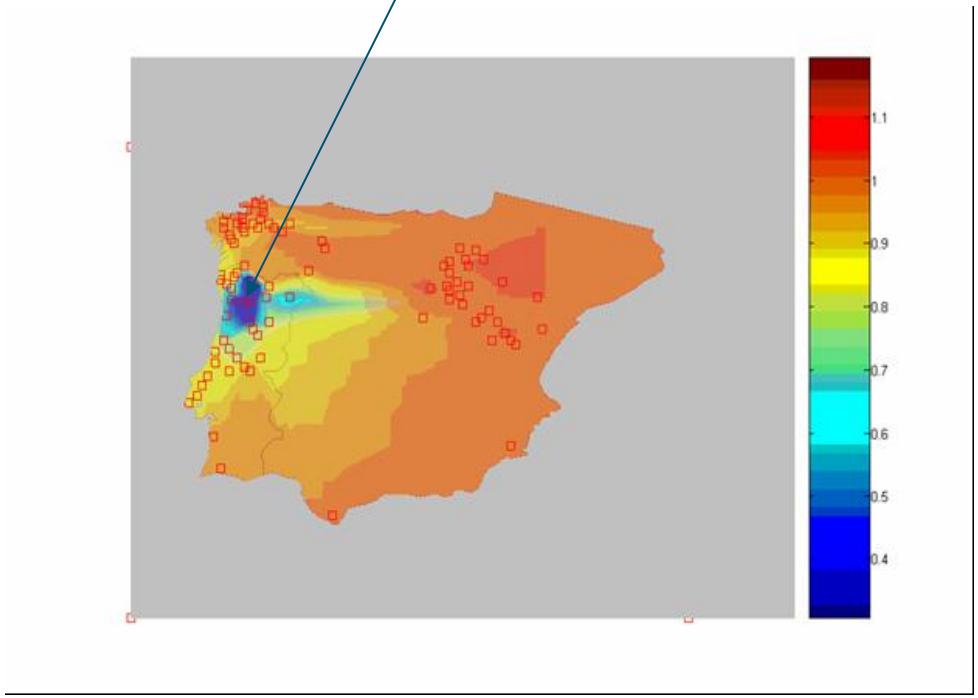


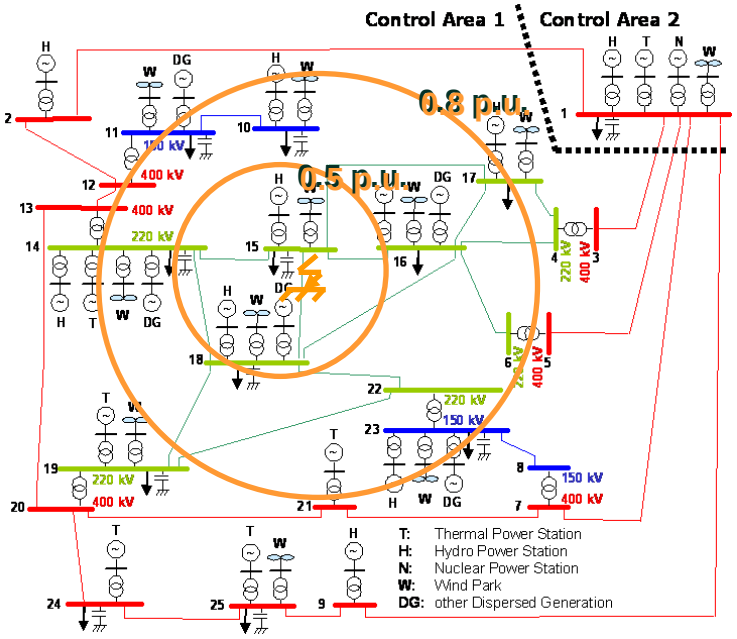
Solution already adopted for Portugal: Wind Generation Tender

Additional Control Capabilities: Fault Ride-through capability

Low voltages due to short-circuits may lead to the disconnection of large shares of wind power production:

Fault Ride- through capabilities will attenuate the problem





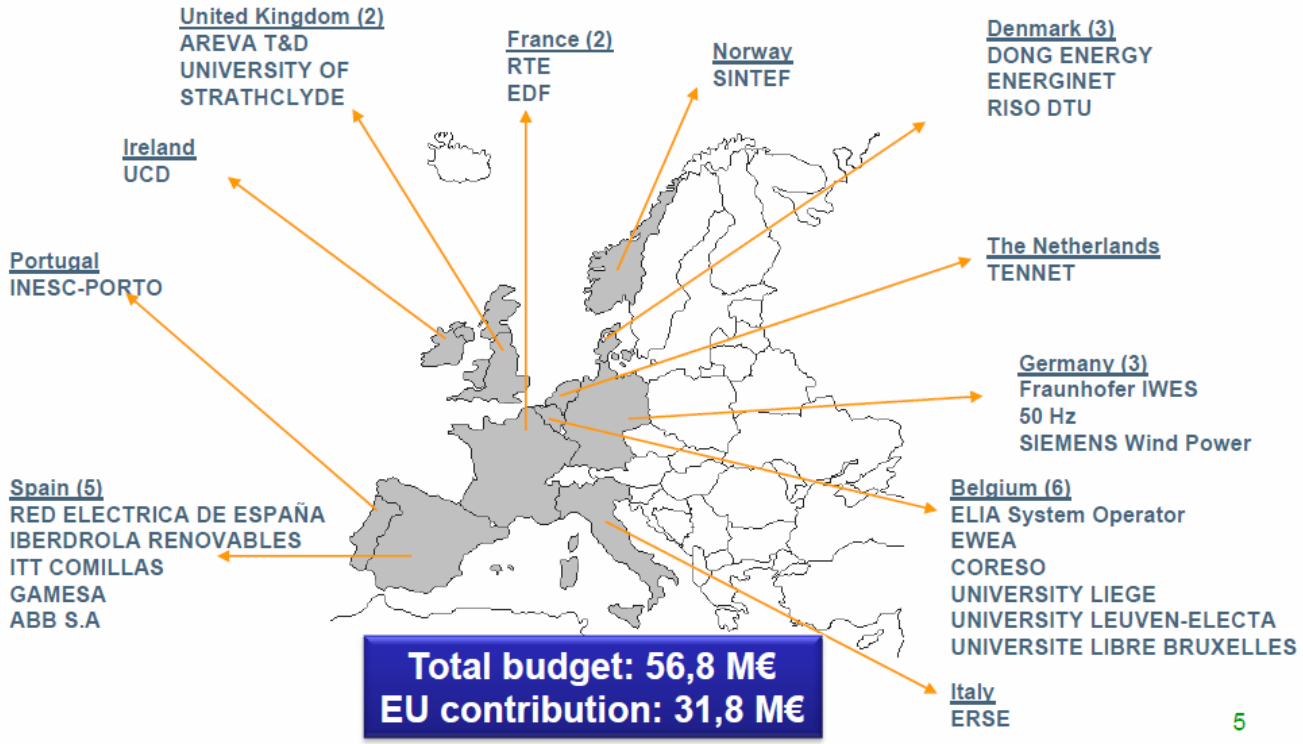
Solution already adopted for Portugal: Wind Generation Tender

Twenties Project: Objectives

- Demonstrating by early 2014 through real life large scale demonstrations, the benefits and impacts of several critical technologies required to improve the pan-European transmission network, thus giving Europe a capability of responding to the increasing share of renewable energy mix by 2020 and beyond, while keeping its present level of reliability and performance.

Consortium and budget

✓ 10 European Member States
✓ 1 Associated Country



Twenties Project: Objectives

DEMO 3 DC GRID (Leader: RTE)

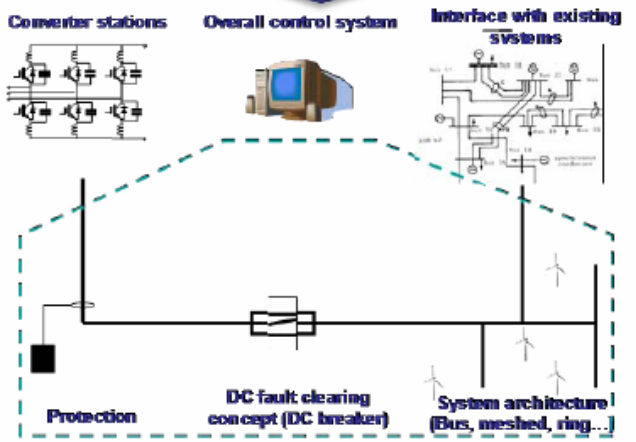
Main objective

- Assess main drivers for the development of off-shore HVDC networks

Approach

- Optimal planning and operation of AC/DC interconnected power systems
- Local control of HVDC networks
- Operation under normal and emergency conditions
- Design and quantify experimental DC networks (N-1, faults)
- Design and test control functions, protection systems…
- Benchmark several network topologies

Knowledge and components for connecting offshore resources: multi-terminal DC networks and interaction with on-shore AC system



www.twenties-project.eu

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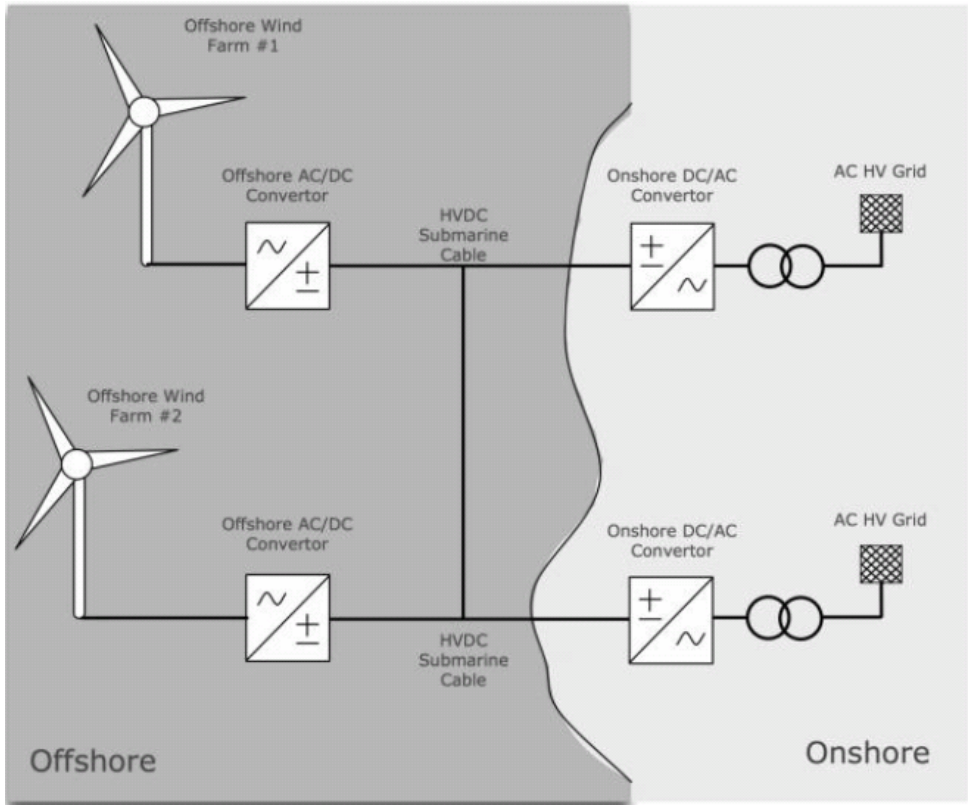
Twenties Project: Conceptual definition of the HVDC VPP

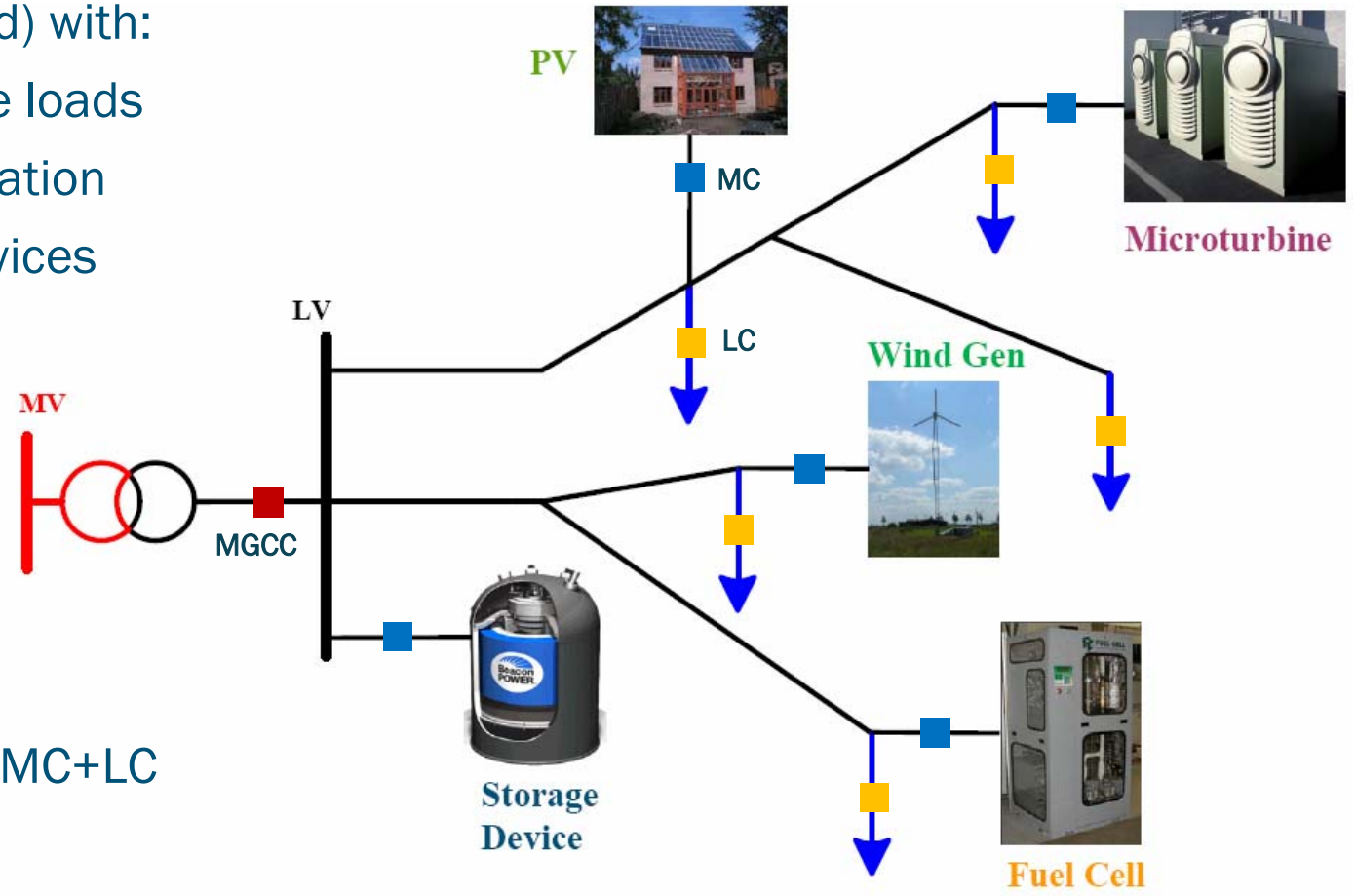
Main functionalities:

- Operating wind generators, the offshore DC grid and the corresponding connection points (AC/DC and DC/AC converters);
- Providing system ancillary services to the onshore AC system
  - Frequency control: emulating inertia, primary and secondary frequency control
  - Voltage and reactive power support, including FRT capability;
  - Small signal stability related services.



New Solutions: MicroGrid - A Flexible Cell of Electric Power Systems

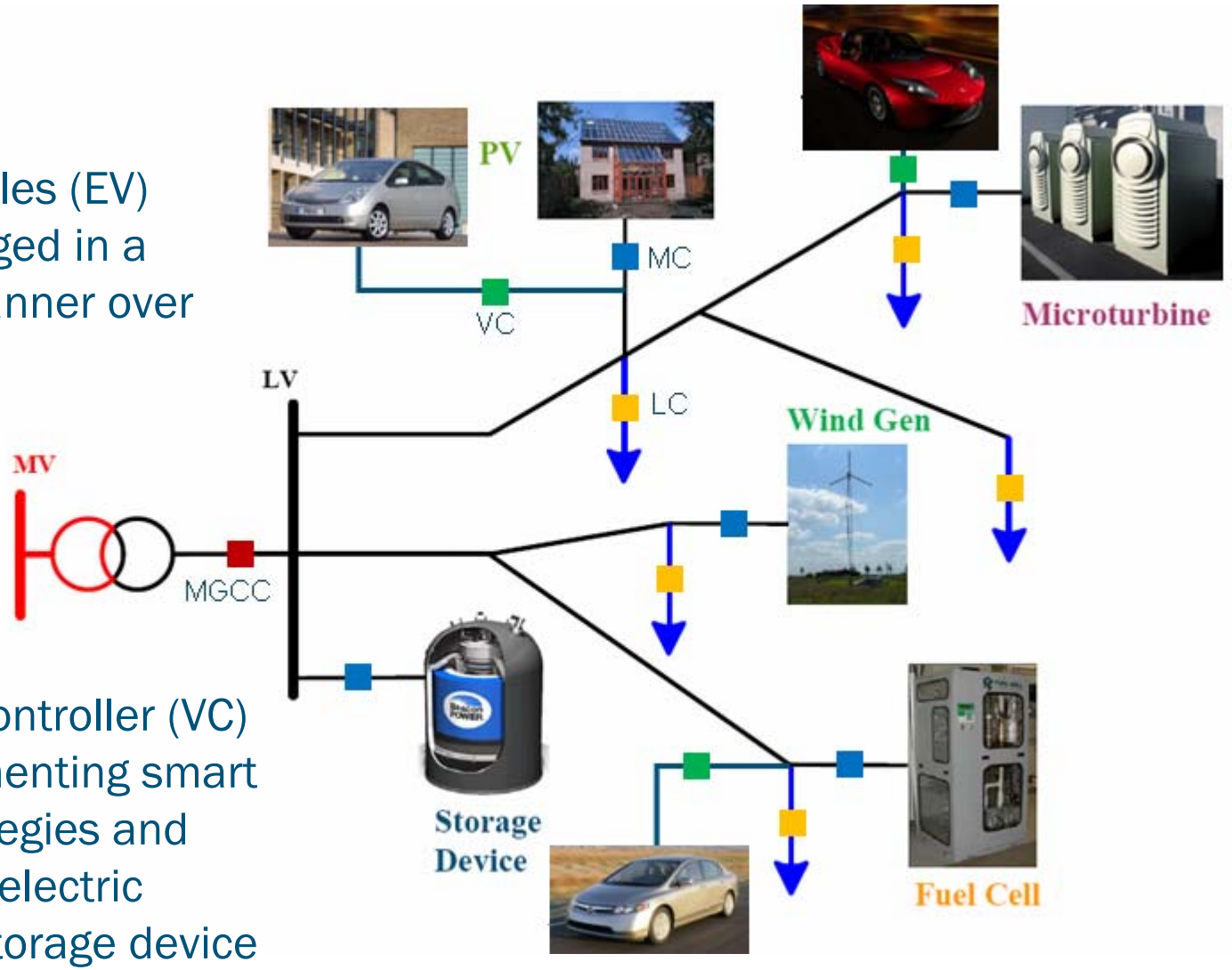
- The LV grid of the future (microgrid) with:
  - Controllable loads
  - Microgeneration
  - Storage devices



- Energy box=MC+LC

The MG concept to support the integration of electric vehicles

- Electric Vehicles (EV) are now plugged in a dispersed manner over the LV grid
- The Vehicle Controller (VC) allows implementing smart charging strategies and regarding the electric vehicle as a storage device



The Vision for the Future Power Systems

Source: "Smart Grids – Vision and Strategy for Europe's Electricity Networks of the Future"

Final Remarks

- The integration, in an efficient way, of large shares of renewable energy sources requires a set of new technical solutions and operational rules, where Information and Communication Technologies will play a key role
  - A wise level of central management and decision regarding network reinforcements and operation planning is needed
  - Cooperation among TSO, DSO and wind park developers is required
  - Definition of new technical requirements for robust and safe system operation
- Society benefits (less tangible benefits related to energy policy):
  - Diversification of primary energy sources / reduction on energy external dependence
  - Reduction of CO_2 emissions
  - Potential economic benefits (new economic activities, increase in job creation, improvements in social cohesion and environmental sustainability)


Thank you!