Twenties
Transmitting wind

SEVENTH FRAMEWORK PROGRAMME

EUROPEAN COMMISION

RED ELÉCTRICA DE ESPAÑA

TWENTIES PROJECT

EWEA 2011 Brussels
15 March 2011

EWEA 2011 BRUSSELS
EUROPE'S PREMIER WIND ENERGY EVENT

Concept-Idea

The TWENTIES project aims at:

*"**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 in its **energy mix by 2020** and beyond while **keeping its present level of reliability performance.**"*

To this extent it will be focused in removing several barriers which prevent:

- **pan European electric system** from welcoming more **renewable generated electricity.**
- **renewable-generated electricity** from contributing more efficiently **to the single European electric market.**

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Project objectives

Task force 1: What are the valuable contributions that intermittent generation and flexible load can bring to system services?

Task force 2: What should the network operators implement to allow for off-shore wind development?

Task force 3: How to give more flexibility to the transmission grid?

→ 6 high level demonstration objectives

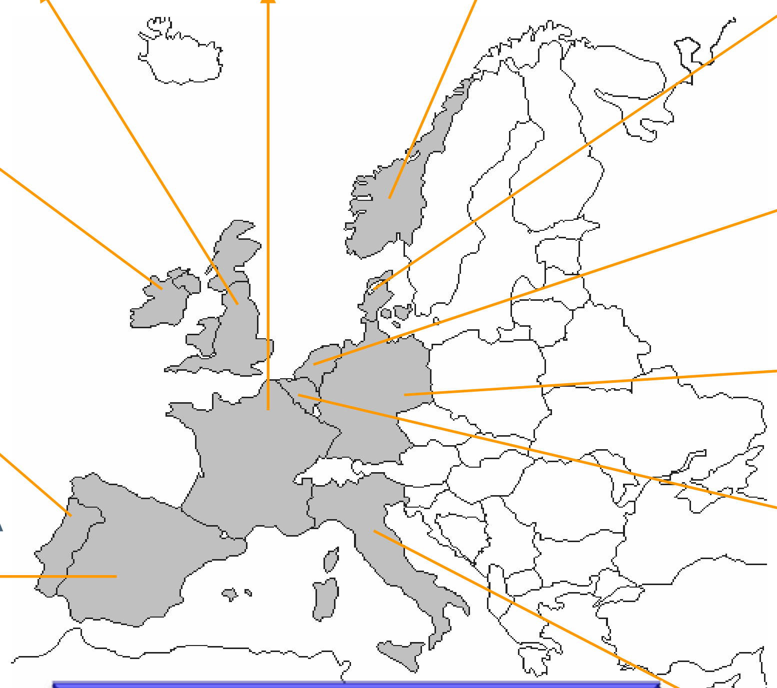
Overall: How scalable and replicable are the results within the entire pan-European electricity system?

→ 2 replication objectives

→ 1 dissemination objective

Consortium and budget

- ✓ 10 European Member States
- ✓ 1 Associated Country



United Kingdom (2)
AREVA T&D
UNIVERSITY OF STRATHCLYDE

France (2)
RTE
EDF

Norway
SINTEF

Denmark (3)
DONG ENERGY
ENERGINET
RISO DTU

Ireland
UCD

Portugal
INESC-PORTO

The Netherlands
TENNET

Germany (3)
Fraunhofer IWES
50 Hz
SIEMENS Wind Power

Spain (5)
RED ELECTRICA DE ESPAÑA
IBERDROLA RENOVABLES
ITT COMILLAS
GAMESA
ABB S.A

Belgium (6)
ELIA System Operator
EWEA
CORESO
UNIVERSITY LIEGE
UNIVERSITY LEUVEN-ELECTA
UNIVERSITE LIBRE BRUXELLES

Italy
ERSE

Total budget: 56,8 M€
EU contribution: 31,8 M€

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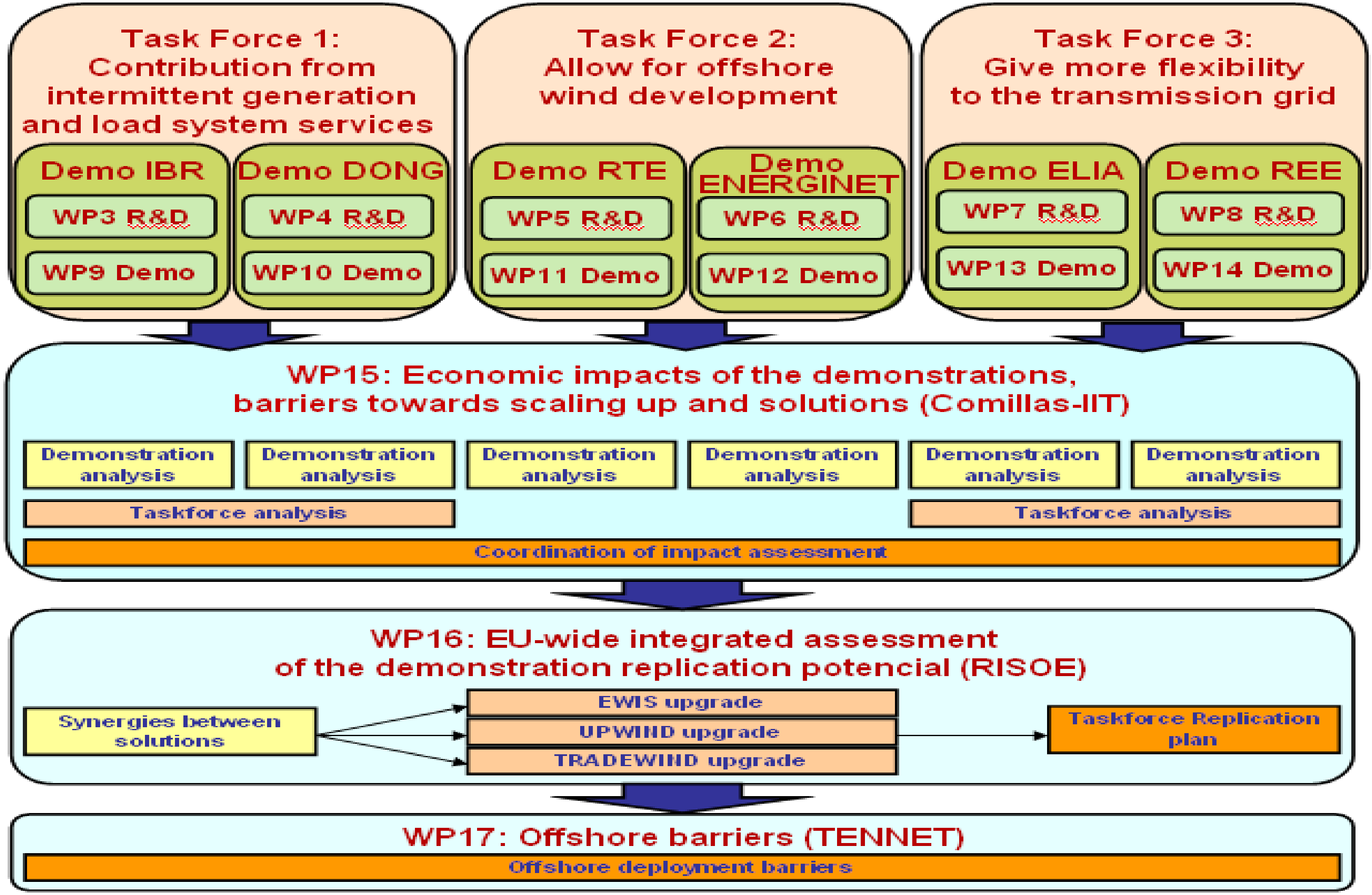
Work Plan: Workpackages Structure and Interaction



Replication work packages: barriers and up scaling

WP 15: Economic impacts of the demonstrations, barriers towards scaling up and solutions (Leader: IIT)

- Assess the local **economic and/or technological impact** of each demo.
- Identify the **barriers to scale-up** the outcomes at a member-state or regional level, and propose **solutions** to overcome these barriers.

WP 16: EU wide integrating assessment of demonstration replication potential (Leader: RISOE)

- Assess **portability** of voltage control, frequency control and VPP model **to other countries and regions**.
- Evaluate North European 2020 **offshore wind power variability**, **hydro potential and barriers** and **grid restriction** studies.
- Pan European economic impact study.

WP 17: EU Offshore barriers (Leader: TENNET)

- Address the issues of **smart licensing of submarine interconnectors** with and without wind parks in the North Sea and Baltic Sea.
- Identify **common licensing barriers** and propose regulatory measures.

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DEMO1: SYSERWIND DEMOSTRATION

Enhanced System Services From Wind

Roberto Veguillas, Iberdrola Renovables

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SYSERWIND Demo Description

Main objective: **On-site test** of new wind farms **active and reactive power control services** to the system, based on **new operation strategies at EMS level** using improved systems, devices and tools, but **keeping the current hardware** at wind farm level.

Main tests:

1. **Active power regulation:** with the objective to perform **secondary frequency control**, several wind farms will be aggregated to provide secondary frequency regulation**.**
2. **Reactive power regulation:** with the objective to **stabilize voltage in a region or zone** of the TSO network, several wind farms will be aggregated to provide a voltage regulation.

Expected impact: Preserving the **stability and security of the energy transmission system**, a higher controllability of the wind energy would be achieved, and the current barriers that impede a **further development of wind power** connected to the grid would be lowered.

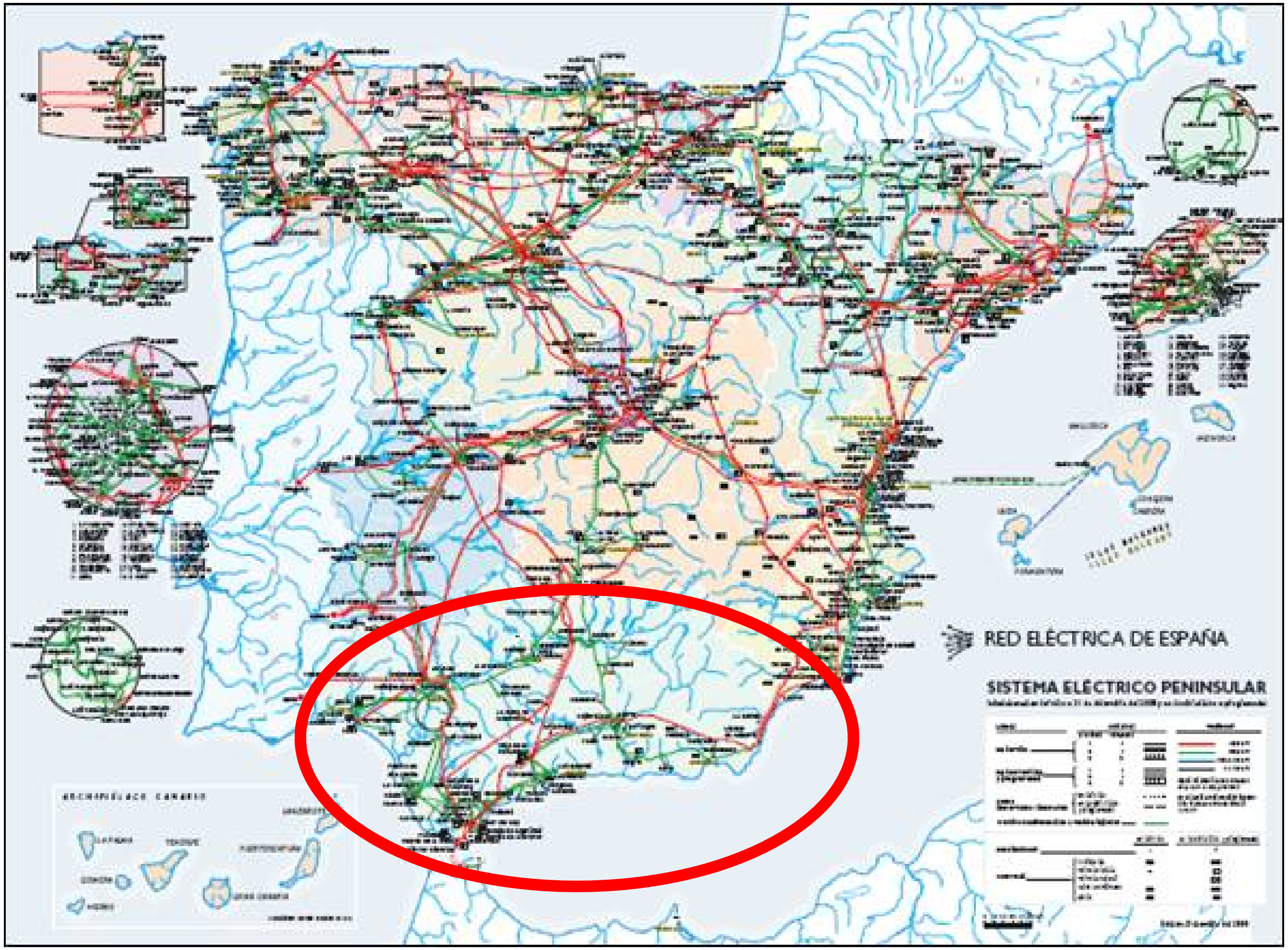
Partners:

SYSERWIND Demo Description

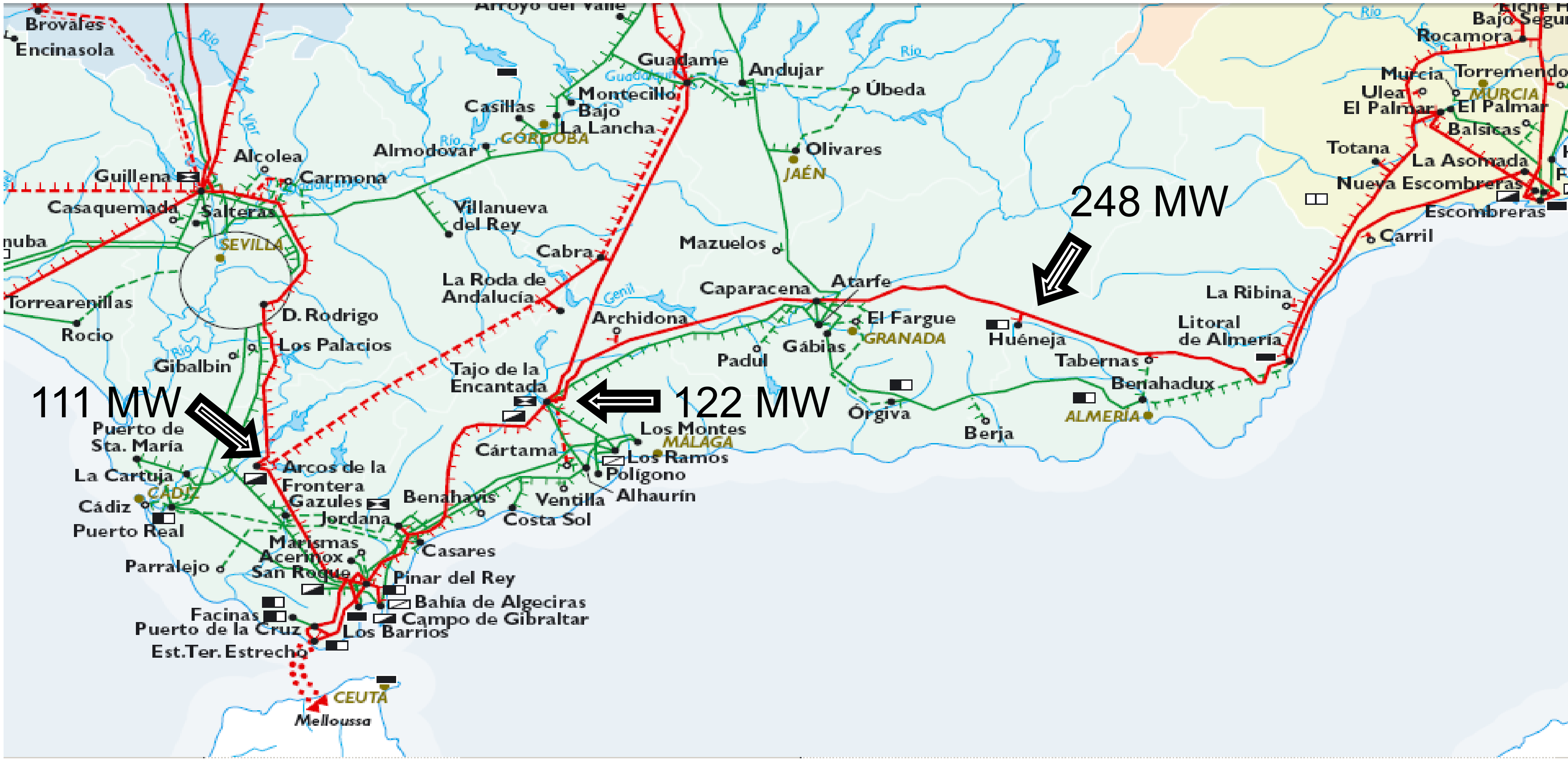
- **Active Power Control:**
  - The active power produced by 3 clusters will be **aggregated and curtailed**.
  - An active power **regulation band** will be created.
  - An AGC control will be checked, to **maintain, increase and decrease the power** at TSO's request, according the Spanish Secondary Frequency Control rules.

- **Reactive Power Control:**
  - Cluster reactive power test, to check the accuracy of the **available reactive power**.
  - Cluster voltage control test, to check the accuracy of the **cluster voltage control**.
  - Wide-area voltage control (EMS level), the cluster capabilities will be included within the voltage control tool of the TSO in order to **control the voltage profile in a wide area of the grid** considering the three cluster's capabilities together.

SYSERWIND Demo Description



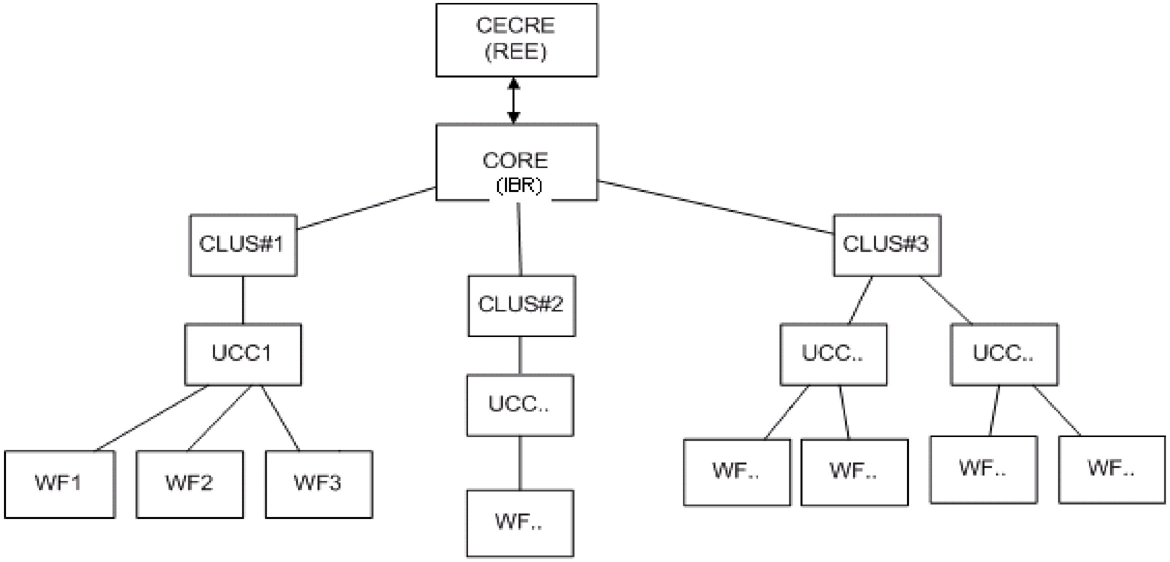
SYSERWIND Demo Description



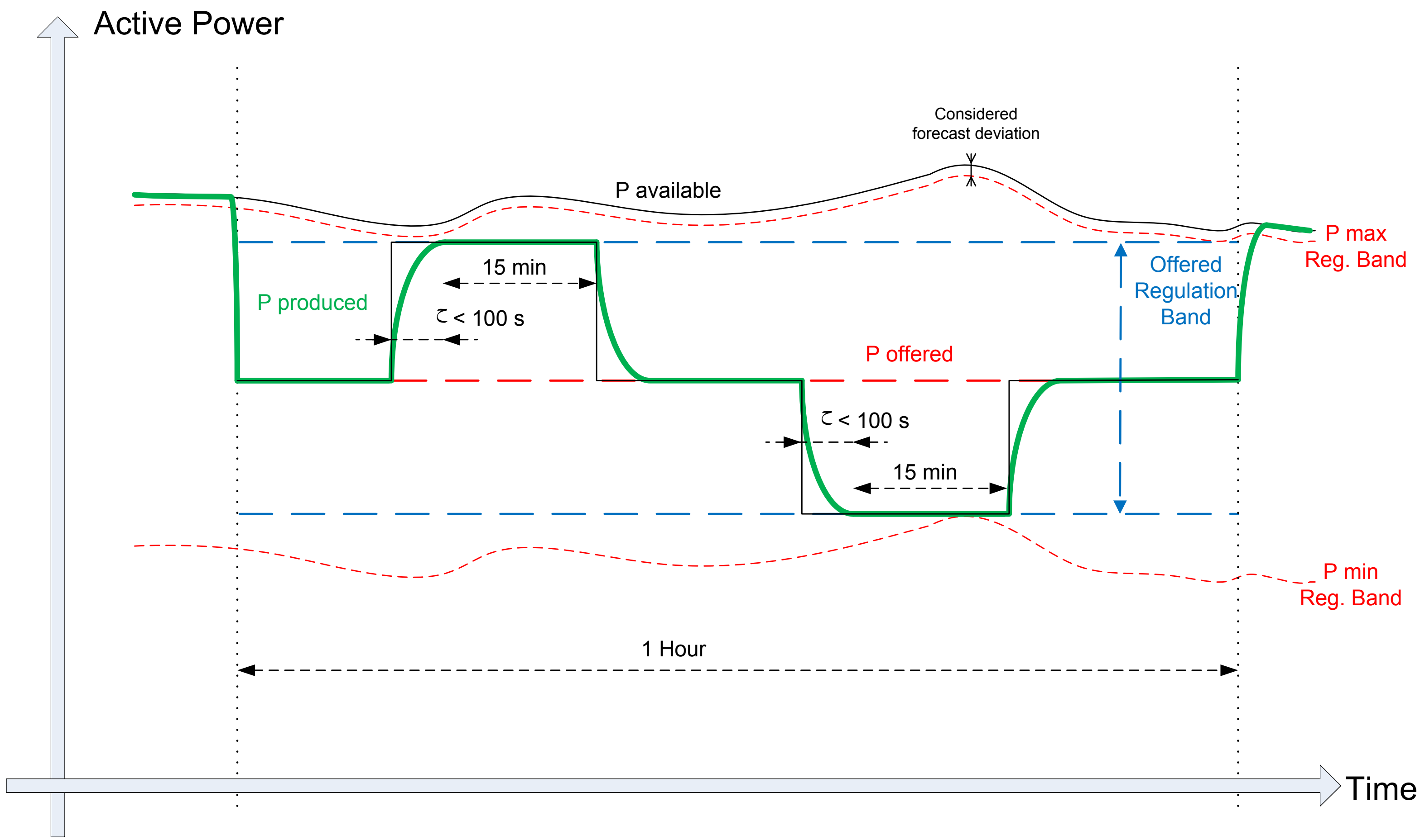
Demo Implementation Architecture

The project global architecture will be defined considering **four control levels**:

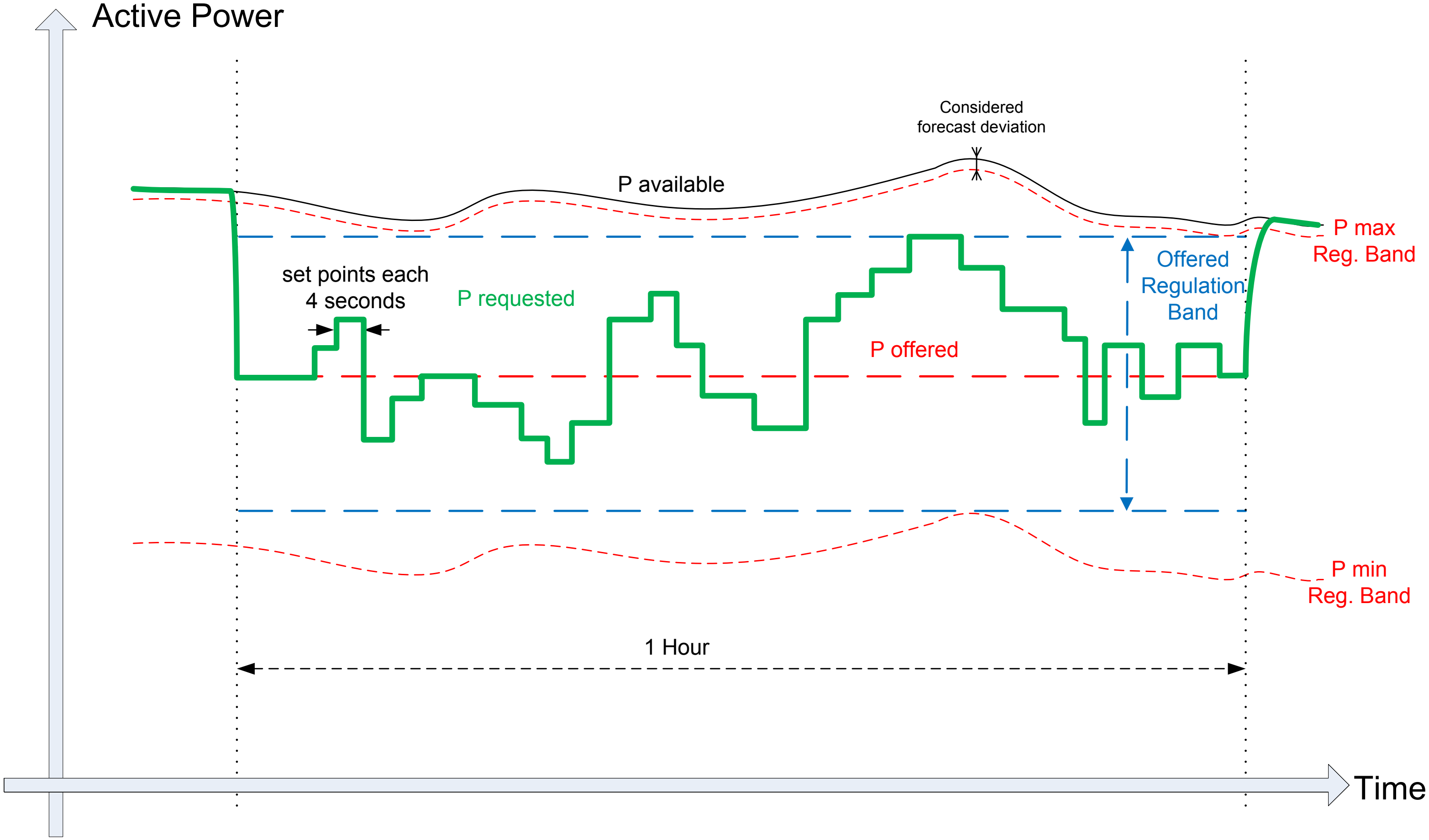
1. **Wide-area level control** (REE Control Centre, CECRE).
2. **Clusters level control** (IBR Control Centre, CORE).
3. **Wind farms cluster level control** (Communications and Control Unit, UCC).
4. **Wind farm level control** (Wind farms Control Systems, GAMESA SCADA).



Active Power Control – Test Procedure



Active Power Control – Test Procedure

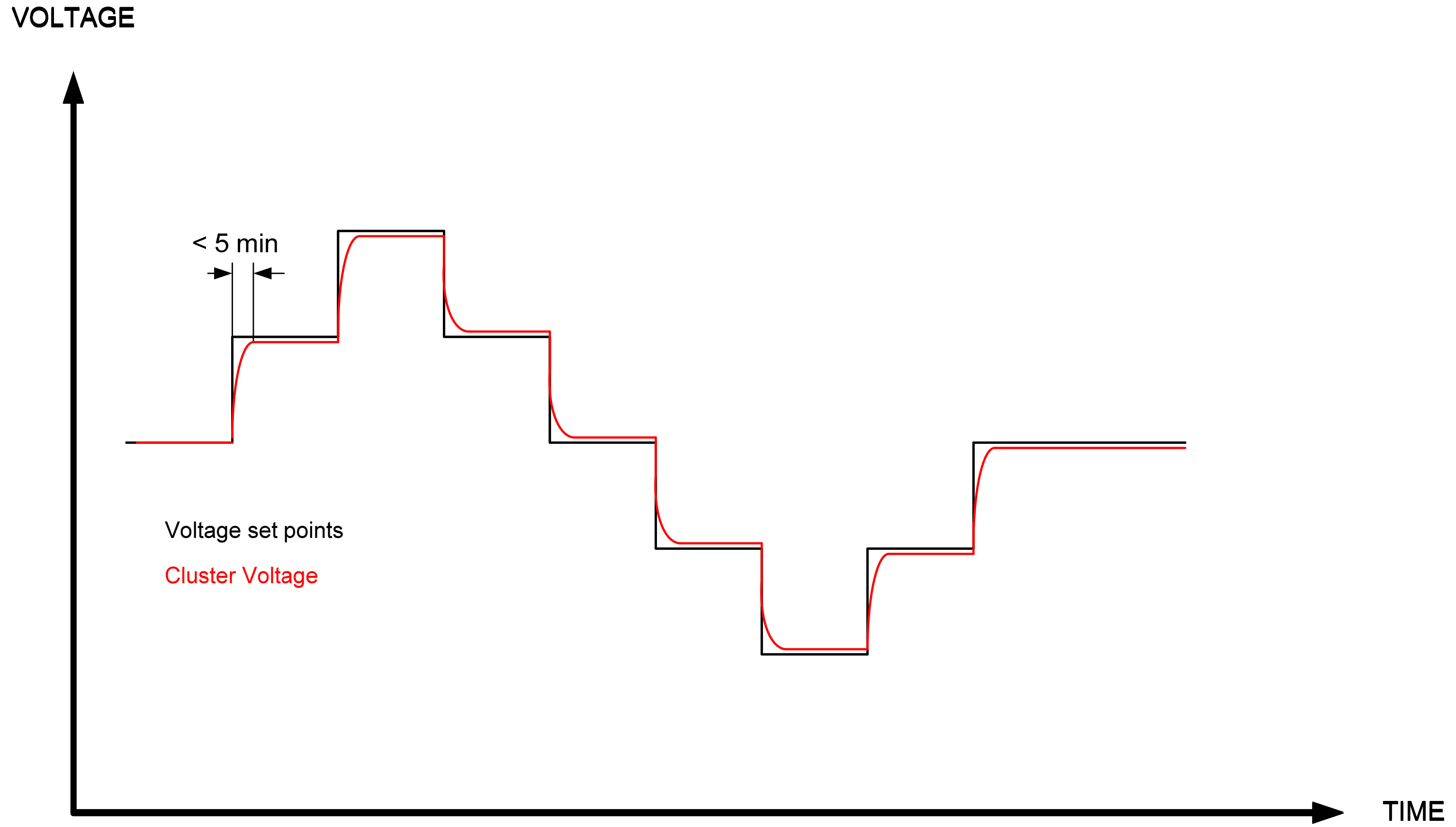


Reactive Power Control – Cluster Test Procedure (Q)

Test of the reactive power compensation capabilities of the whole cluster at different production scenarios:

	Production	Voltage in cluster	Set point
1)	Low	Mid-range	Capacitive
2)	Low	Mid-range	Inductive
3)	Low	Low	Capacitive max. saturation
4)	Low	High	Inductive max. saturation
5)	Mid-range	Mid-range	Capacitive
6)	Mid-range	Mid-range	Inductive
7)	Mid-range	Low	Capacitive max. saturation
8)	Mid-range	High	Inductive max. saturation
9)	High	Mid-range	Capacitive
10)	High	Mid-range	Inductive
11)	High	Low	Capacitive max. saturation
12)	High	High	Inductive max. saturation

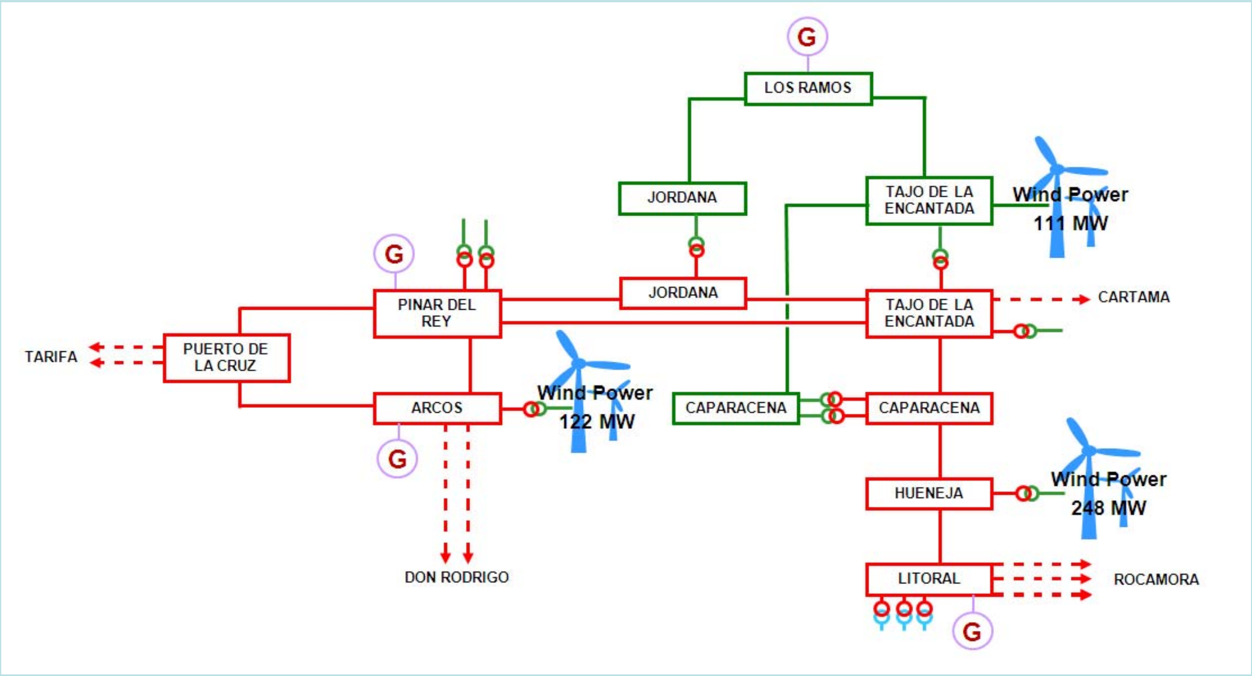
Reactive Power Control
Cluster Test Procedure (V)



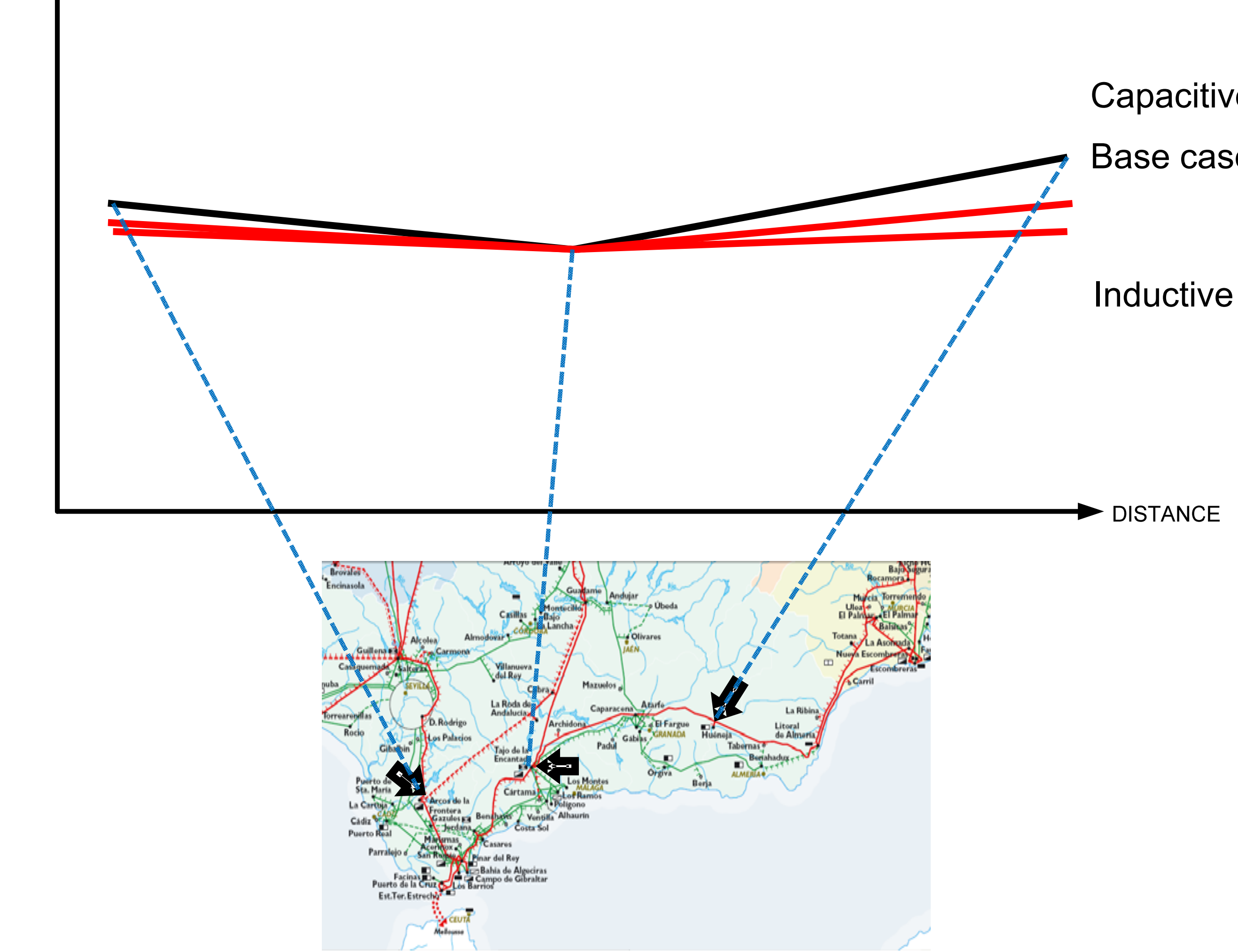
Reactive Power Control – Wide-Area Test Procedure

Test of the voltage profile control of a wide-area of the grid:

- Capacitive voltage profile
- Inductive voltage profile



Reactive Power Control Wide-Area Test Procedure



CONCLUSIONS

- **Active Power Test:** Through the new active power control services tested, a **lower system power reserve** due to wind energy penetration might be needed, and a **new approach to wind energy market integration** could be addressed.
- **Reactive Power Test:** Through the new reactive power control services tested, the wind energy could participate in the **grid voltage control** in a similar way as the conventional power plants, fully integrated in the EMS system of the TSO. Therefore, it will **lower the power losses and the voltage control complexity** for the TSO.

THE NEW WIND ENERGY SYSTEM SERVICES COULD BE MORE SIMILAR TO THE CONVENTIONAL POWER PLANTS

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DEMO2: DERINT

Klaus Bagessen Hilger, DONG Energy

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DEMO 2 DERINT

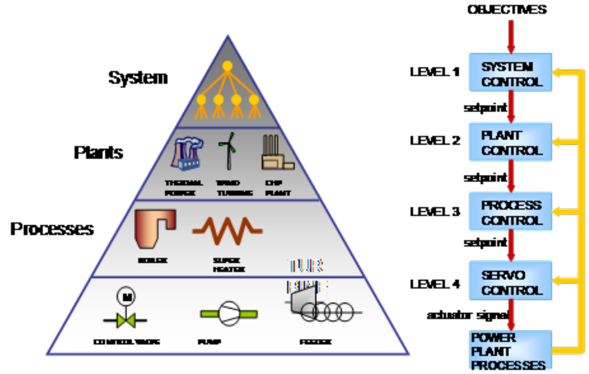
Main objective

- Improve wind integration based on **intelligent energy management of central CHPs, off-shore wind, and local generation and load units in the distribution grid**

Approach

- Mobilization of the **entire value chain** across central and local units
- Focus is on shorter time scale with the goal to **balance wind better** i.e. for a longer time and more cost efficiently
- **Market** shaping, **regulatory** recommendations and **scale up** rules
- 3 year iterative roll-out, growing in scale and complexity

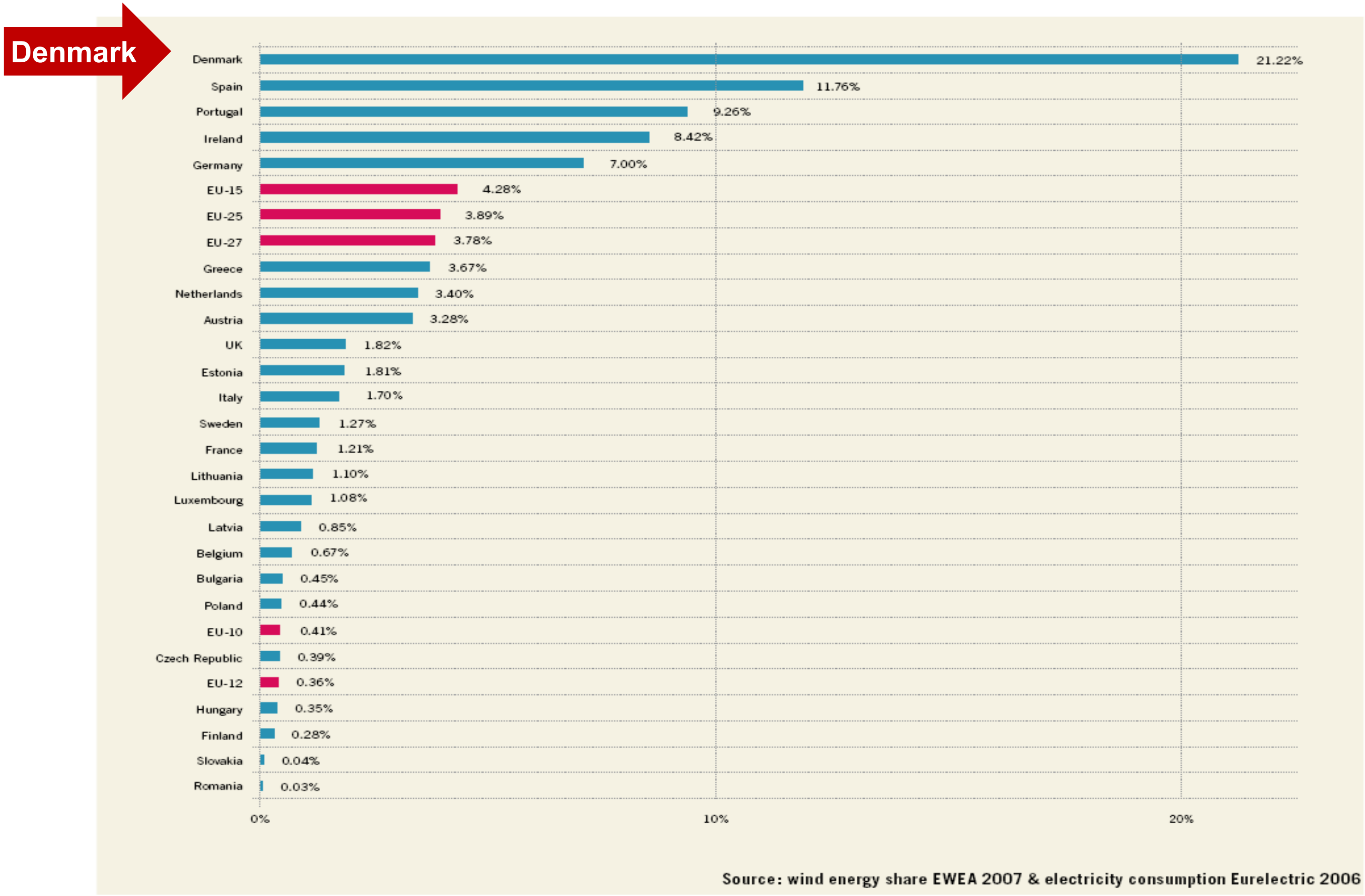
Portfolio optimization of market positions across energy and as markets



Integrating the VPP with central power control

DONG energy · ENERGINET/DK · RED ELÉCTRICA DE ESPAÑA · Fraunhofer IWES

Demonstration in Denmark – drivers for a VPP solution



Wind share of EU electricity demand by end of 2007

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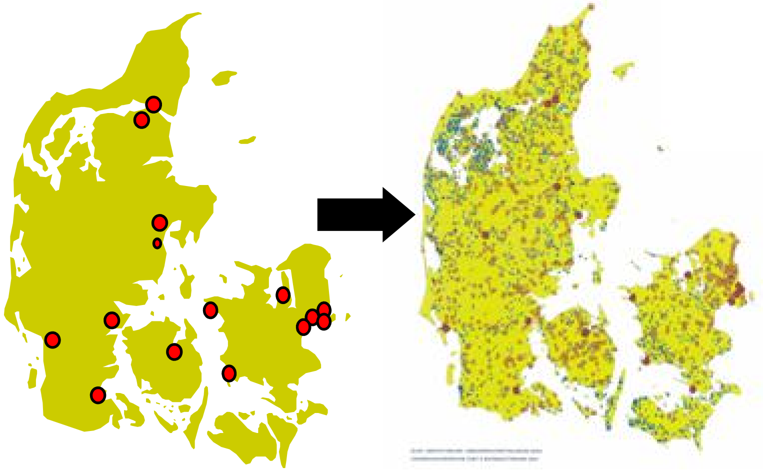
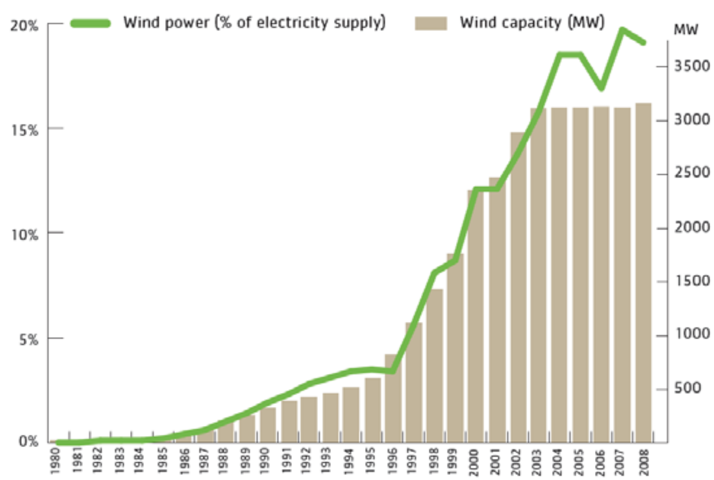
Demonstration in Denmark – drivers for a VPP solution



From primary to local generation



Danish wind power – capacity and supply

The Danish Electricity System – Development and Policy

Long-term vision: Fossil-fuel independence

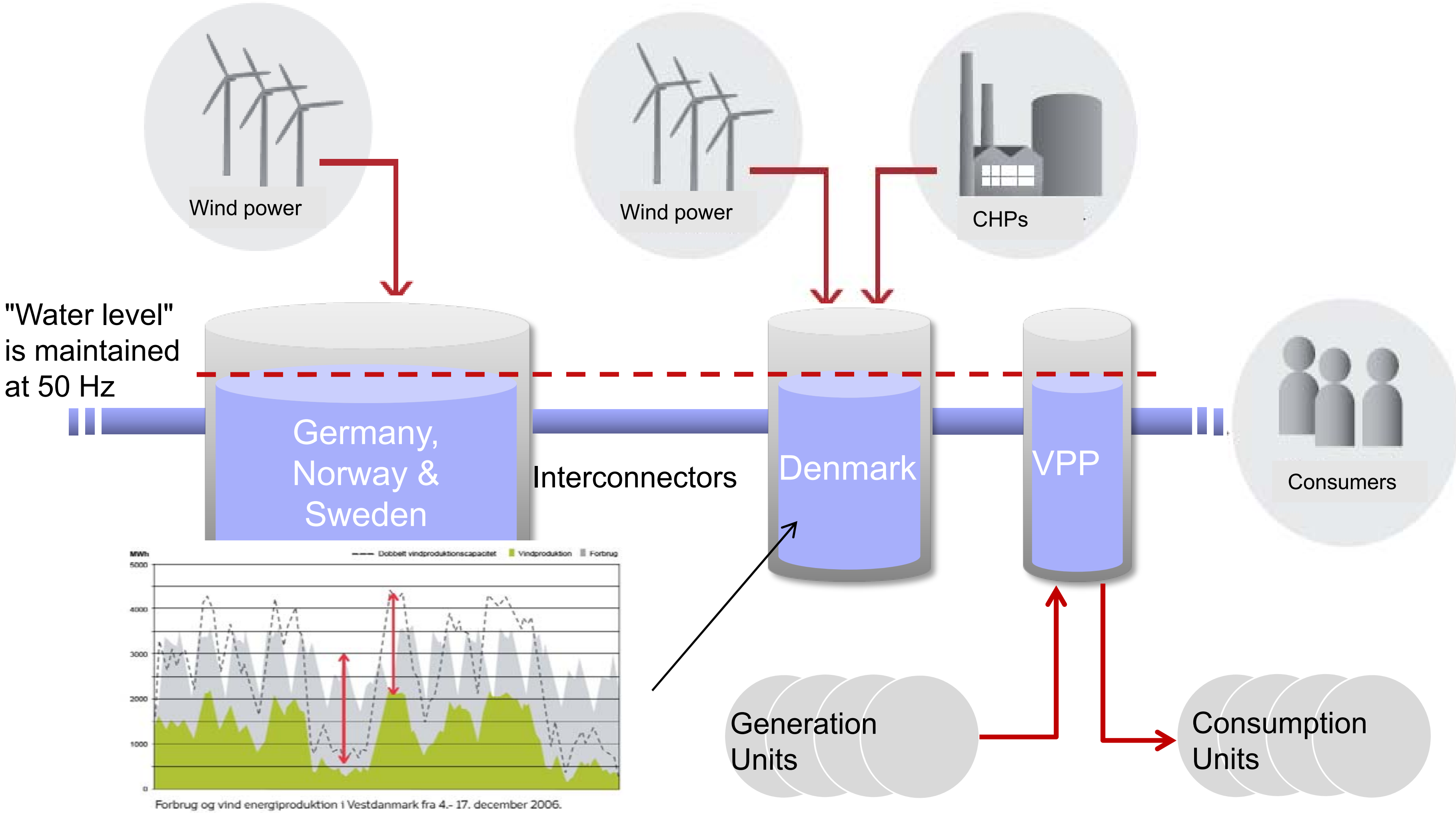
A visionary Danish Energy Policy 2025 (2007)
Possible doubling of wind-power from 3 GW to 6 GW
~ 50% coverage!

Energy agreement 2008-2011 (2008)
Up to 2012: 1.300 MW of new wind-power capacity
~ +40%!

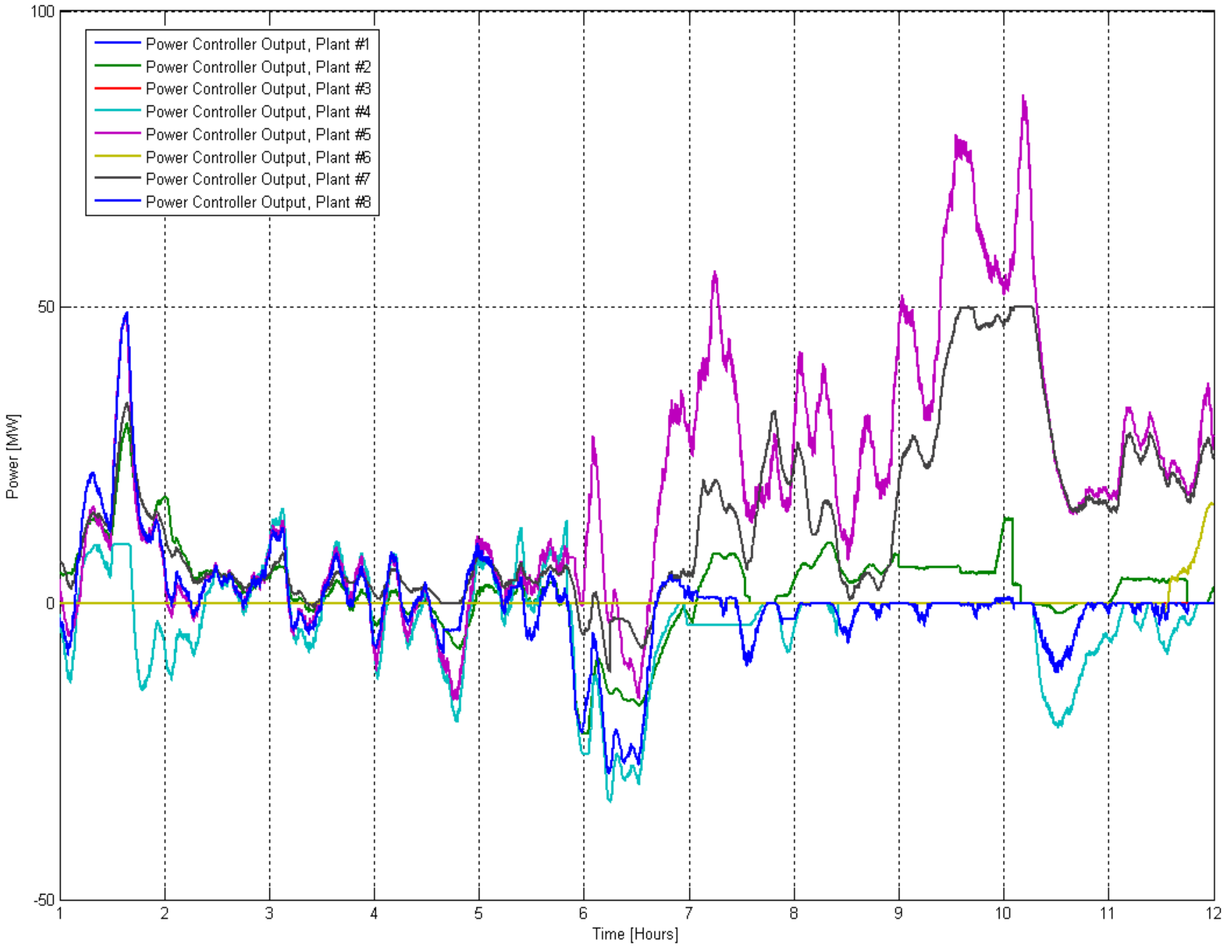
EU 20-20-20 target – 30% renewables
In 2020, the power system may have to handle 50% wind-power

Managing Wind Power in Denmark today – and tomorrow

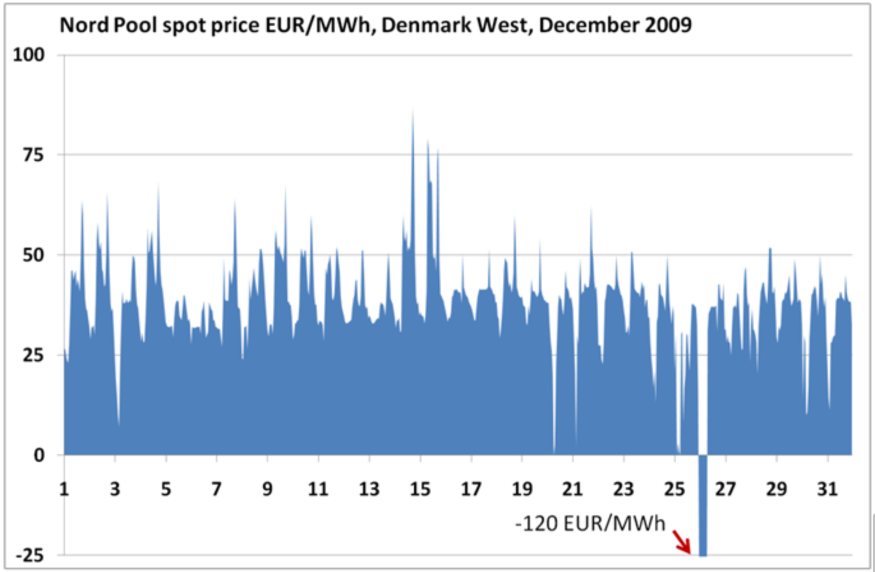
– System safetv. market integration and portfolio synergies



CHP Plant optimization for managing the power balance



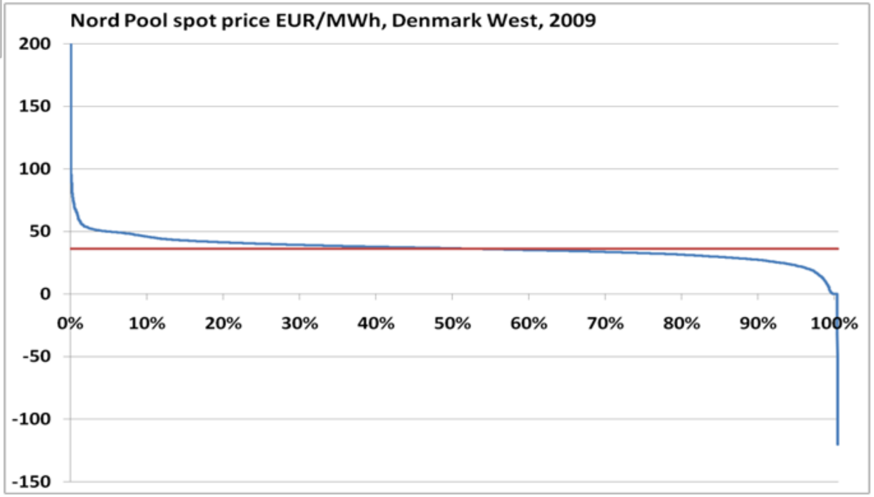
A limit has been meet and the markets are showing negative prices



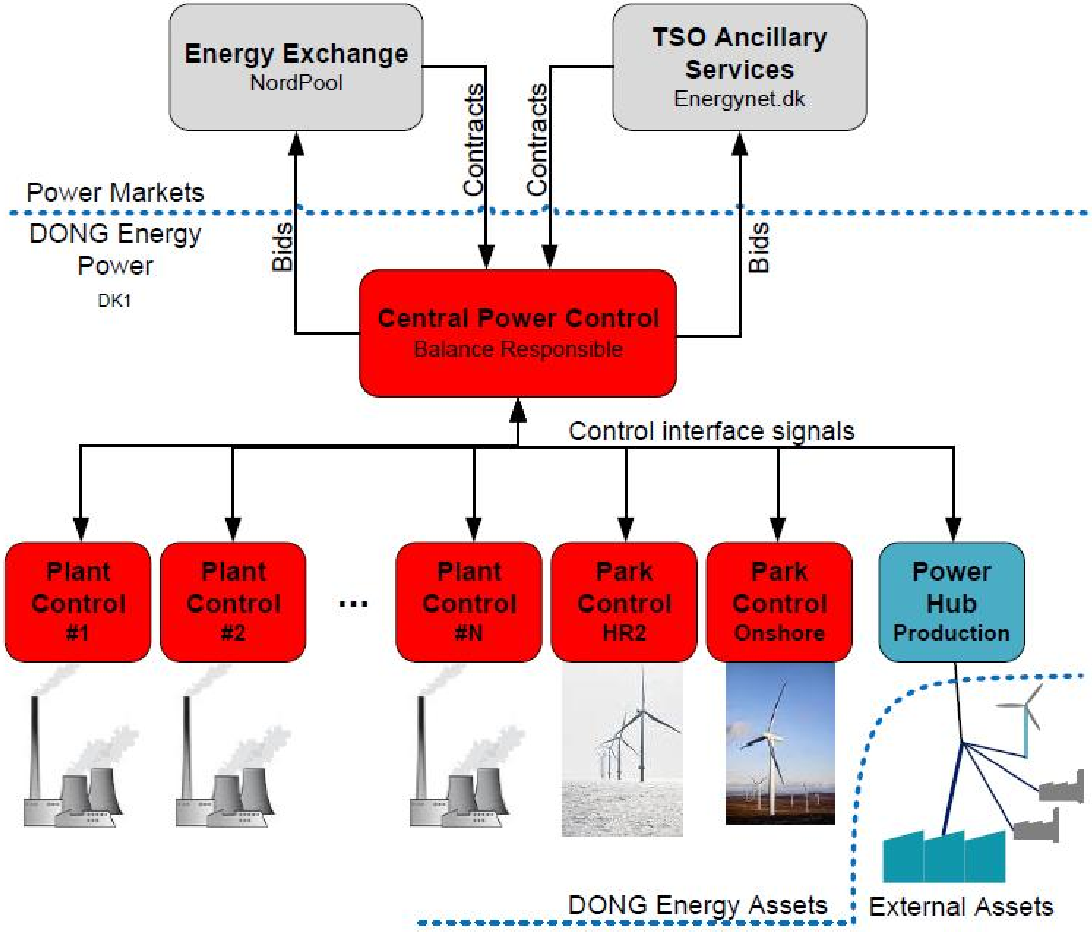
- In December 2009, negative electricity prices were introduced
- December alone had 9 hours with negative prices

Price duration curve for 2009

- Price peak at 200 EUR/MWh
- 56 hours with zero or negative prices

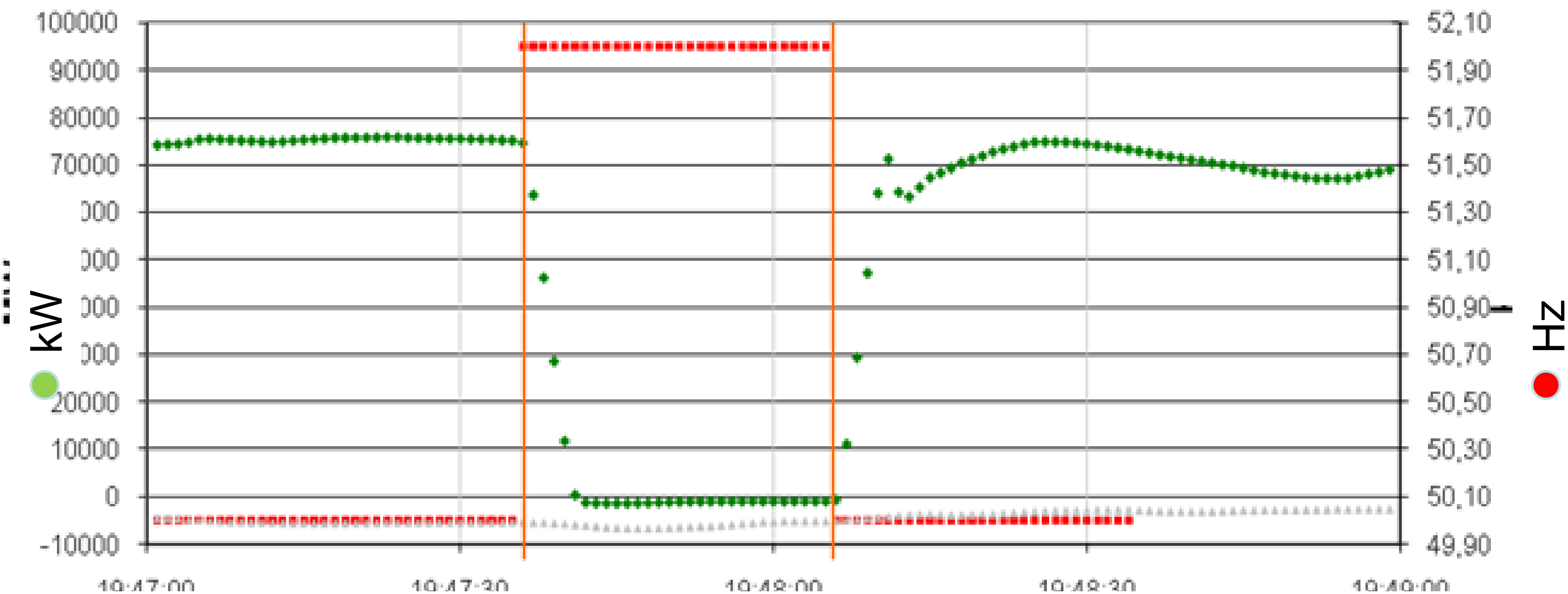


Demonstration:
DONG Energy and the existing Danish market setup

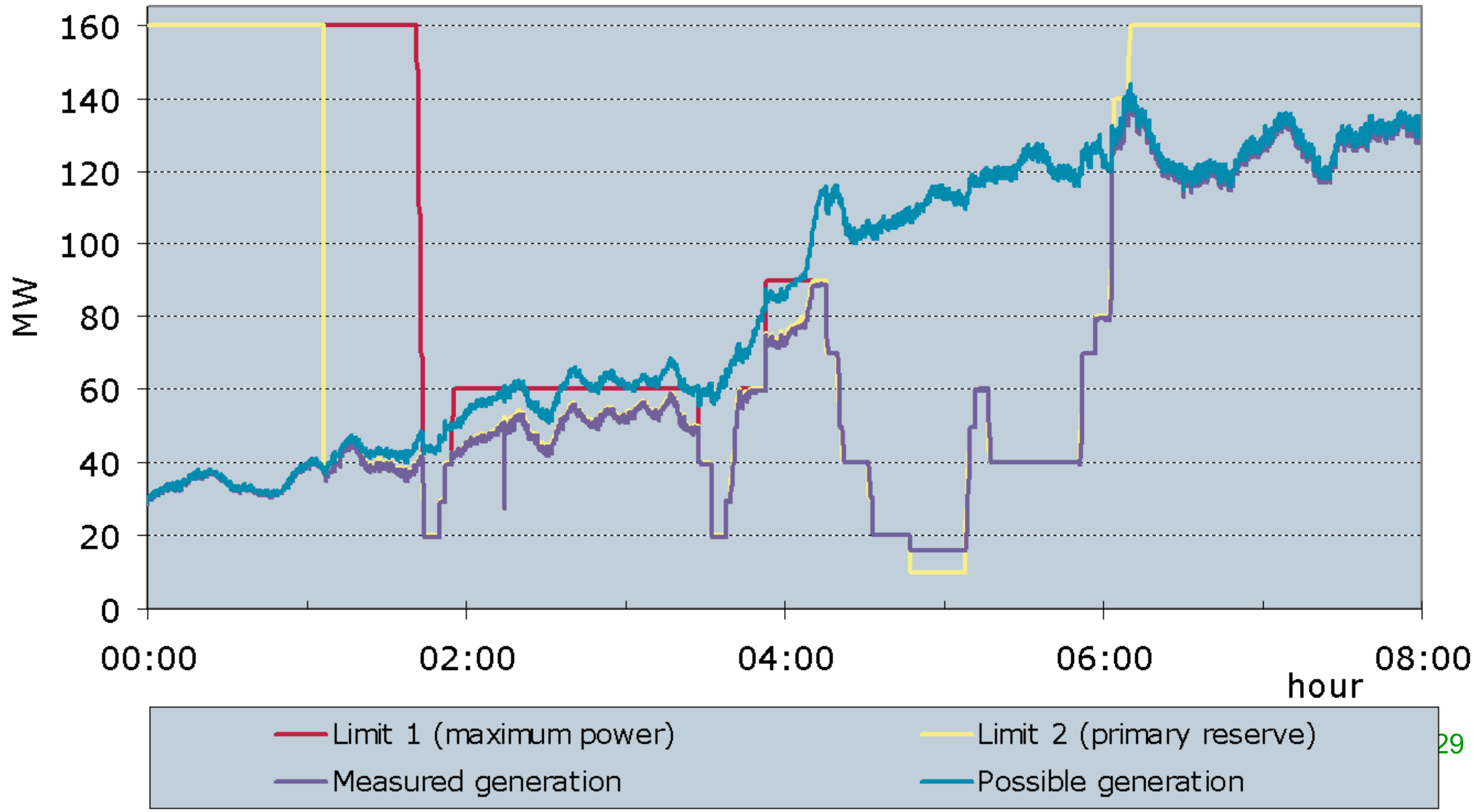


Windfarms have extreme regulating capabilities and rapid responce proven at Burbo Banks

Burbo Banks Wind Farm
Frequency Injection NG-BC3v1 LFSM



Integration of offshore wind into the central portfolio control – optimization across energy markets and ancillary services



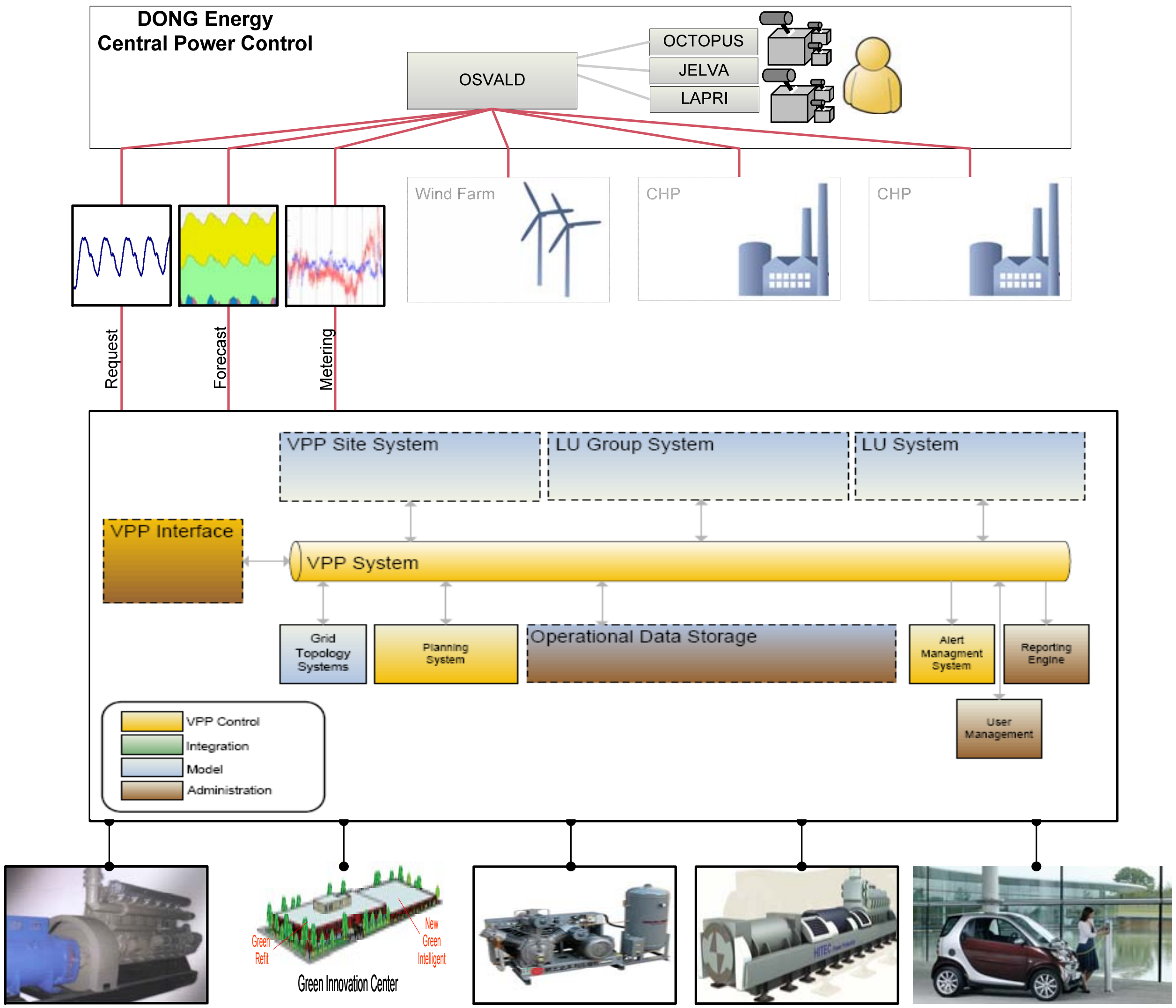
Demonstration: Integrating the VPP with central power control

DONG Energy
Central Power Control

Central Power Plants &
Wind Farms

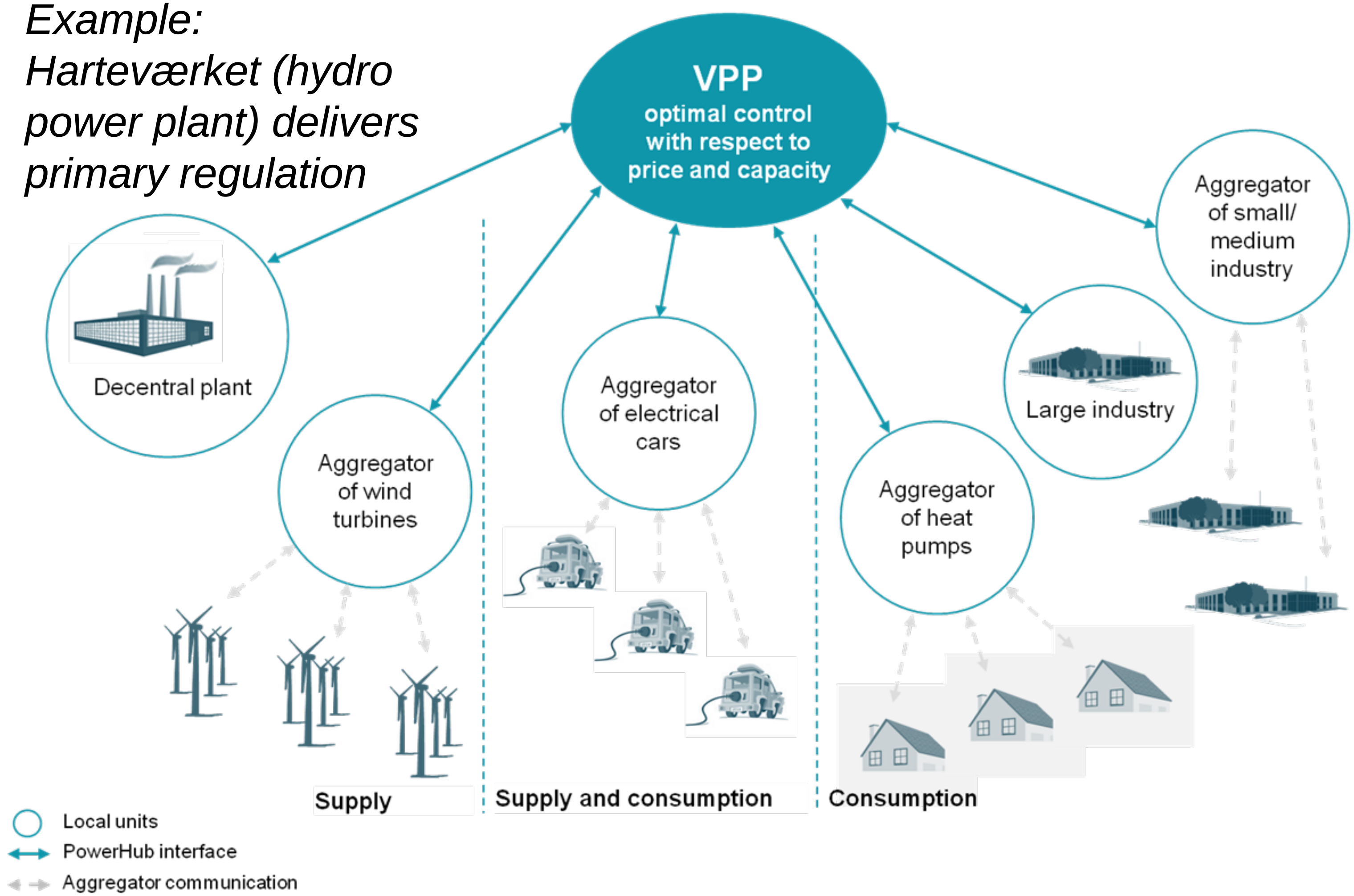
Integration platform

VPP Generation
and Consumption Units



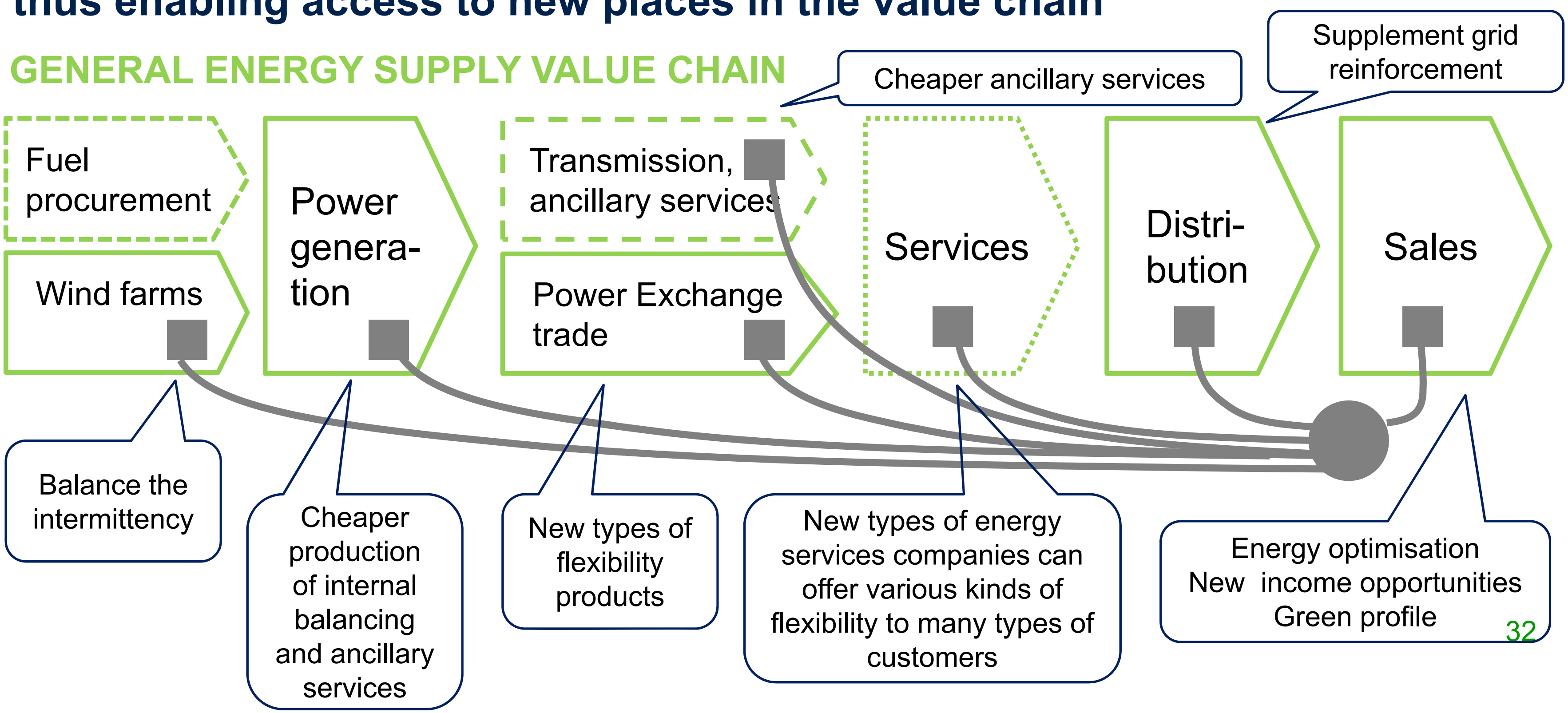
Actual demonstration - The VPP intelligently controls several points of supply and/or consumption

Example:
Harteværket (hydro power plant) delivers primary regulation



VPP is a "Hub" for energy services and can provide benefits for the whole energy value chain

- **In the geographies where DONG Energy is a full-value-chain energy company, a VPP can enable cross-value chain synergies**
- **In other markets, a VPP can provide market opportunities towards partners thus enabling access to new places in the value chain**

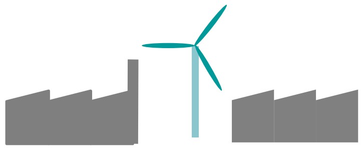


Demonstration and industrialisation of the Power Hub in the Twenties EU project together with TSOs

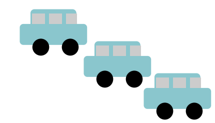
2009: Pilot → **2010**: Phase 1 → **2011-12**: Phase 2 → Further development

Starting from

- **B2B business models**
- **Large local units (LUs)**
- **Short-term energy control**
- **Existing power market terms and ancillary services**
- **Denmark**
- **DONG Energy specific solution**



Towards



- **B2C business models**
- Small-scale LUs
- LU owner needs
- Energy control along longer time spans
- Grid optimisation services
- Development of new power market terms and ancillary services
- EU and international solution
- General solution and possibly a standard product

DEMO3: Economic and technical feasibility of HVDC off-shore grids

Samuel Nguefeu - RTE

Aim of DEMO3 - R&D demo + development

- Propose a methodological approach to design an HVDC off-shore grid
- Identify the technical barriers to be overcome
- Propose a prototype for a DC breaking function with laboratory tests
- Elaborate a realistic road-map and time-schedule for future off-shore wind power connection to the mainland grid

Off-shore wind in Europe over next 20 years

How much ?

- 2 GW in 2009 (PTPC)
- 40 GW in 2020 – 150 GW in 2030 (EWEA)
- Ambitious 2020 objectives:
  - UK > 33 GW – DE > 20 GW – FR > 6 GW

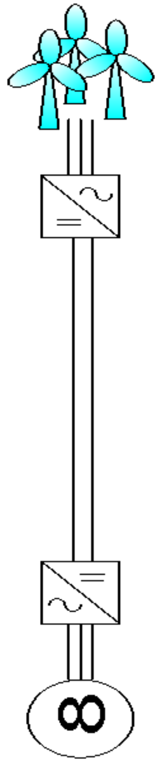
Where ?

- North Sea, Baltic Sea, British Isles
- Atlantic shore ?
- Mediterranean shore ?

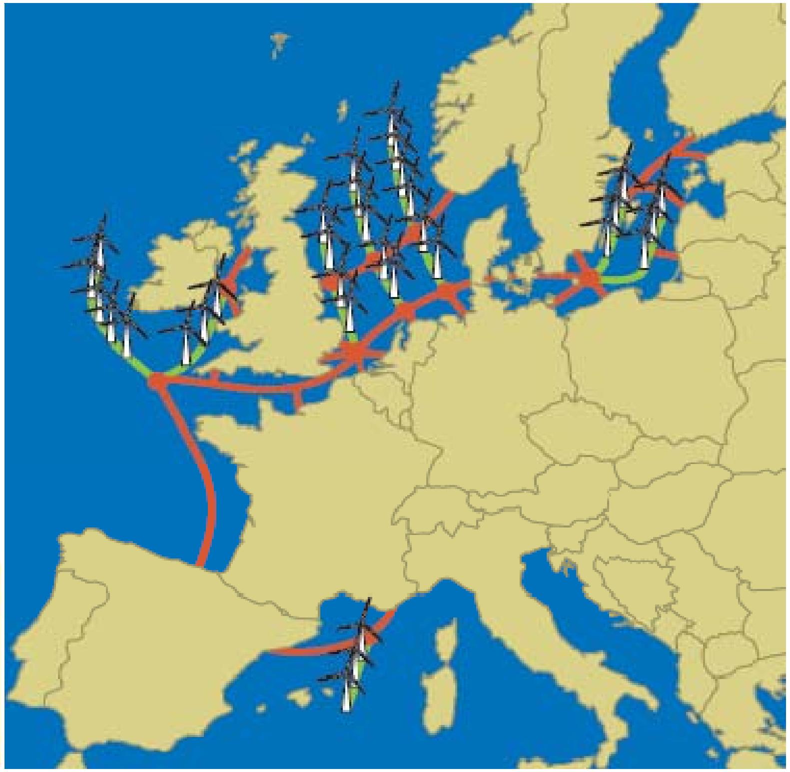
How ?

From PTPC to a HVDC grid, via MTDC

Economic and technical detailed feasibility analysis

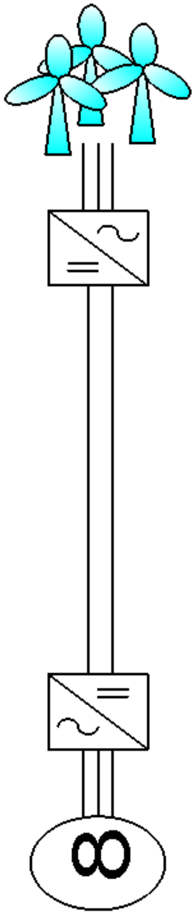


Kriegers Flak source



Airtricity source

Off-shore DC connection today



« Easy » to build – local / bilateral initiative

« Easy » fault localisation

➢ No need for a DC breaker, …..

“Only” dedicated to wind energy

➢ No additional interconnection capacity for the electricity market

No smoothing of wind intermittency

High N-1 impact , …..

➢Limited flexibility and security (both for the producer and the TSO)

➢ How many GW can safely be interconnected to the European power system with PTPC ???

Advanced functions that might be provided by an off-shore grid

Investigated in Demo3 – Probabilistic economic approach

1 - Mitigate wind intermittency for “more constant” injectors to the AC grid

- **same reserve for a wide range of wind conditions**
- **better control of operational over-costs for high levels of wind penetration**

2- Offer additional interconnection capacities to the electricity market

- **efficient use of the HVDC grid under “low wind ” or “no wind” conditions**
- **avoid or postpone the development of mainland interconnections**

3- Offer interconnection capacity for future marine energy (?)

Operational functions that might be provided by an off-shore grid

Investigated in Demo3 – "Multi-leg VPP functions"

4 - Contribute to congestion and losses management on the AC grid

- elaborate coordinated control on the injectors to the mainland grid, depending on wind conditions and AC grid operational state
- minimize operational losses

5 - Provide ancillary services to the mainland power system

- frequency regulation, voltage control
- PSS compensation for substituted conventional generation
- autonomous black start capability

6 – Partial operation of the VPP in emergency conditions

- storm, short-circuit, wind turbine tripping, ….

Protection of an off-shore grid

1 - Detection, localisation and fault clearing process

- protect the devices
- protect the stability of the whole DC / AC power system
- isolate only the faulty section
- within appropriate delay

✓ **breaking function for DC grids**

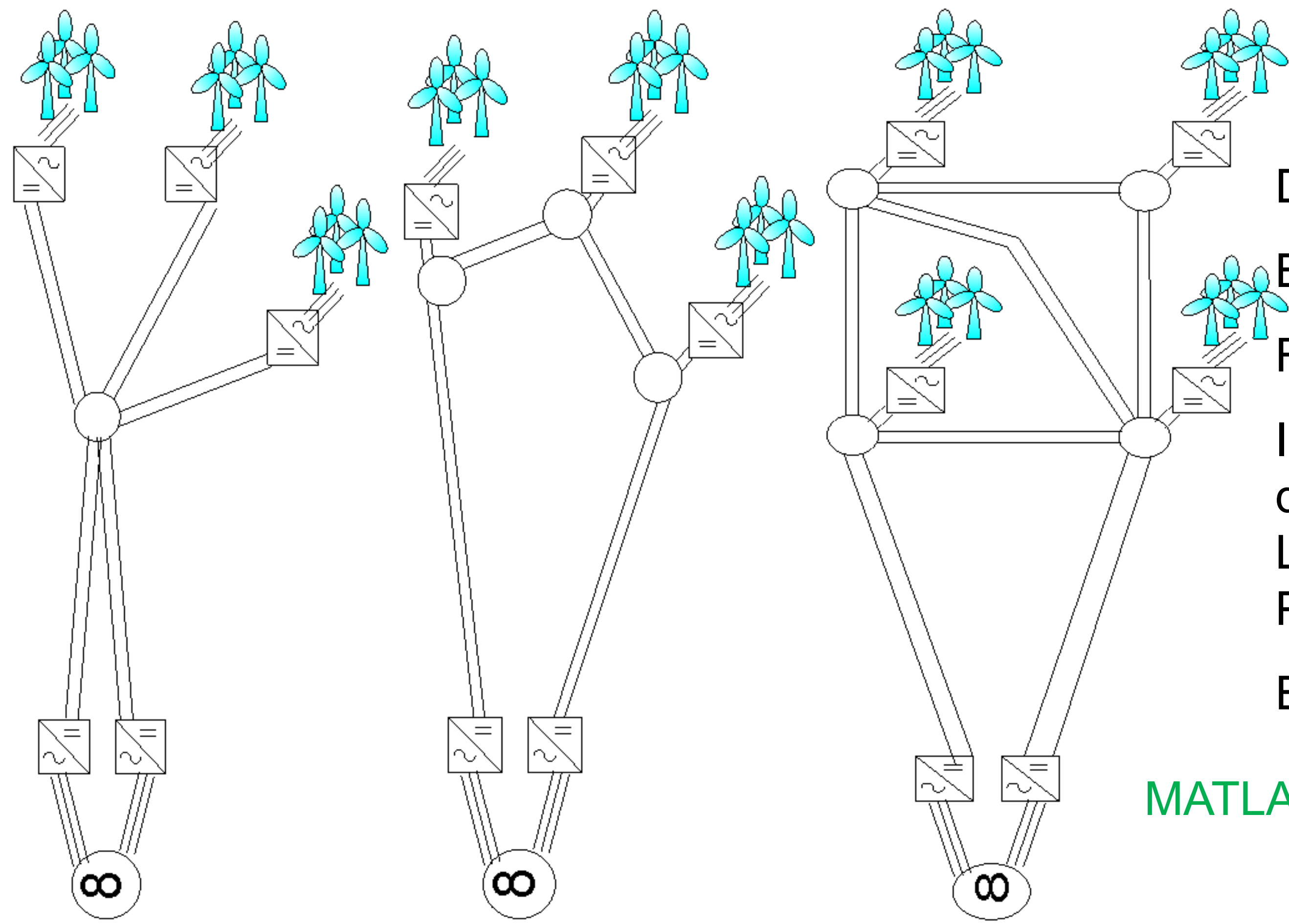
✓ **no DC grids if no appropriate DC breakers**

2 – Design a complete protection plan

Progress of work 1 - Towards a target off-shore grid

- **Are we able to design scenarios for a target off-shore network [2030-2050] at the European level ?**
  - **from local or bilateral projects to a regional / European view**
  - **taking into account:**
    - ✓ wind time series characteristics on wide marine areas over Europe
    - ✓ on shore wind developments and on-shore wind characteristics
    - ✓ storage capacities (Scandinavia, Alps)
    - ✓ conventional generation development
    - ✓ potential other renewable energy sources
    - ✓ load evolution
  - **costs and benefits assessment – RTI estimation**
  - **optimal zonal topology (-ies) for the off-shore grid**
- ❑ **Probabilistic economic approach with the tool ANTARES (RTE)**

Progress of work 2 – Technical analysis of basic topologies



DC node ?

Breaking functions ?

Robust control laws

Inter operability for different technologies LCC / VSC (Light, Plus)

Evolution capabilities

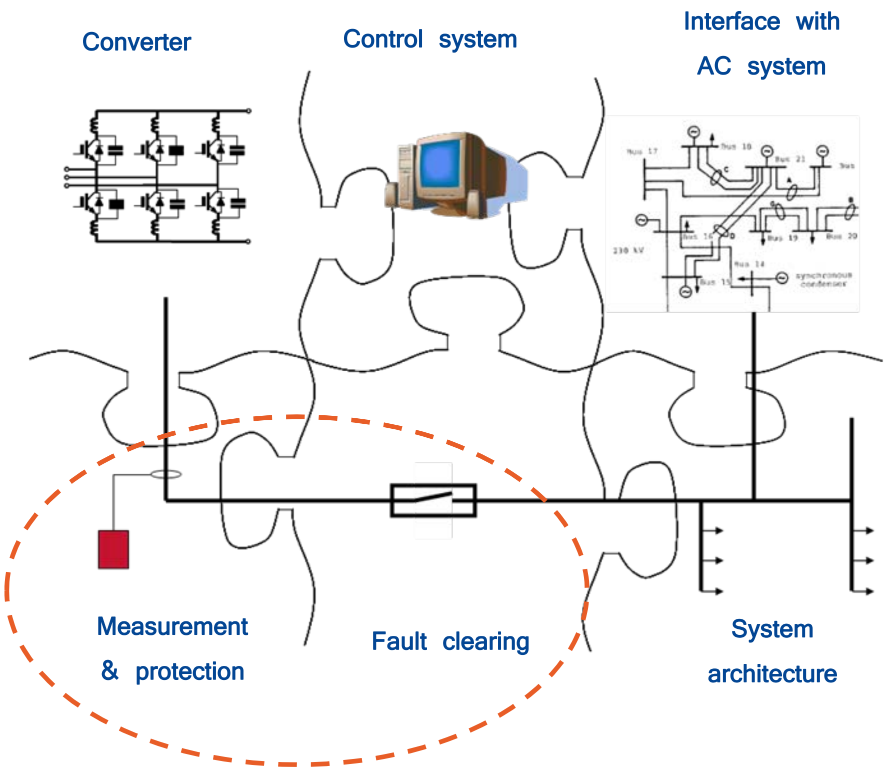
MATLAB/SIMULINK/SPS

EMPT-RV

WP11 Technical specifications towards offshore HVDC networks – DC GRID

- Demo 3 focus: DC network key technologies – Protection and fault management
- WP11 DC :
  - Fault-event characterisation
  - Development of a DC breaker prototype

Multi−terminal DC system: pieces of the puzzle



DC-breaker functions

Breaker state	Without power	With power	
		Normal condition	DC fault condition
Open state	• **Voltage withstand**		
Closing	• **Let-through current**	• **Let-through current** • **Load switching**	• **Let-through current** • **Fault switching** • **Close on fault**
Closed state	• **Low resistance, voltage withstand to ground** • **Let-through current (short time & peak current withstand)**		
Opening	**On idle line or cable: no current, no TRV → no problem**	• **Load switching**	• **Terminal fault** • **Short line fault** • **Long line, cable fault** **→** **Highest rate of rise of current, highest prospective fault current)**

Performance indicators and targets of DEMO#3

1. **Voltage withstand in open state**
   - **Target: lightning impulse withstand voltage peak > 650kV**
2. **Over-current conduction in closed state**
   - **Target: 3000Adc during 1 minute**
3. **Prevent harm on power transformers by reducing peak current**
   - **Target:** $\frac{(\text{Peak fault current without action})^2}{(\text{Peak fault current with DEMO\#3})^2} > 1.2$
4. **Current interruption duration**
   - **Target: less than 40ms (common value of AC circuit-breakers)**

Targets to be surpassed