SEVENTH FRAMEWORK PROGRAMME

EUROPEAN COMMISION

Twenties
Transmitting wind

RED ELÉCTRICA DE ESPAÑA

TWENTIES PROJECT
Some preliminary results: summary
August 2012

Twenties
Transmitting wind

Demo 1

SYSERWIND DEMOSTRATION
Enhanced System Services From Wind

Roberto Veguillas, IBERDROLA Renovables

IBERDROLA

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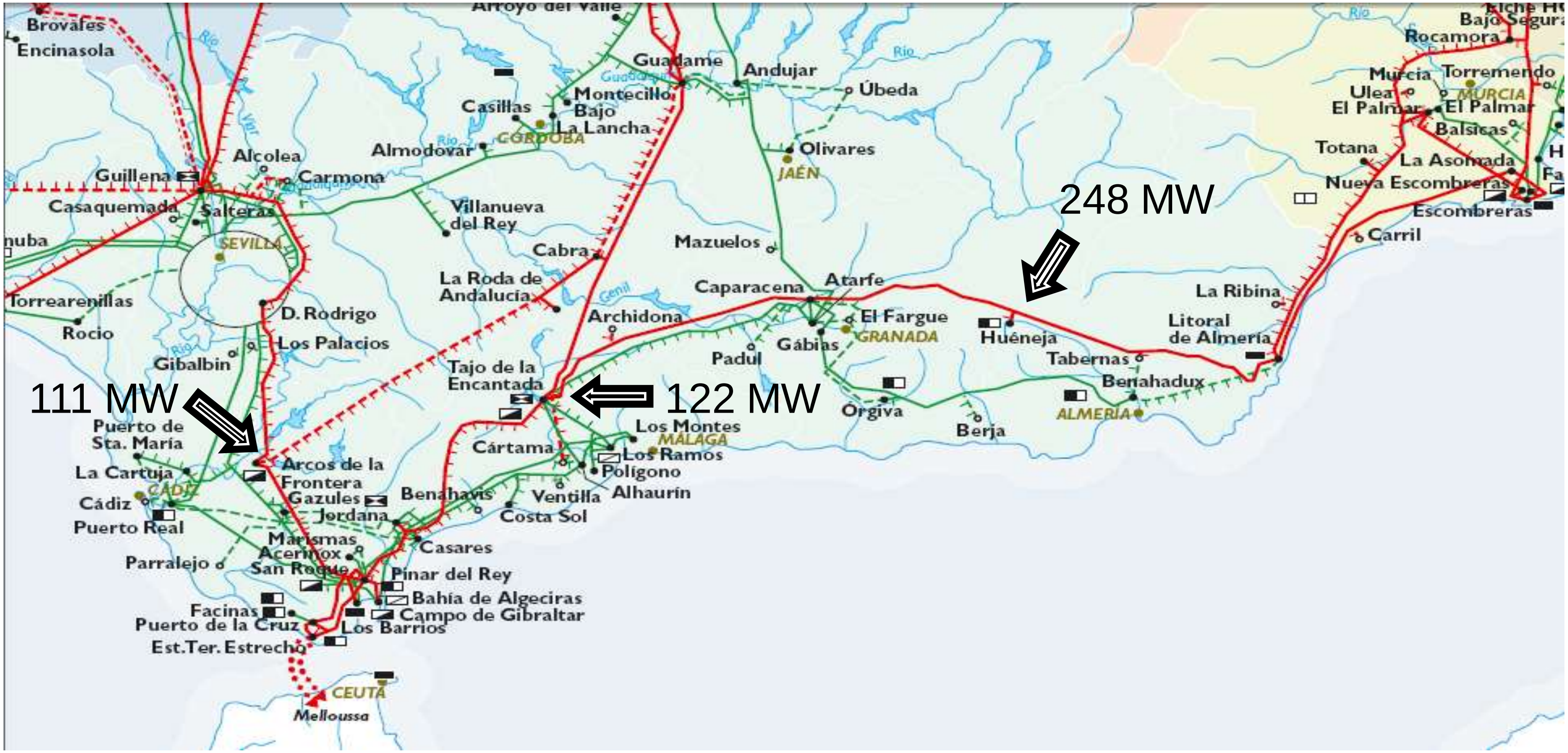
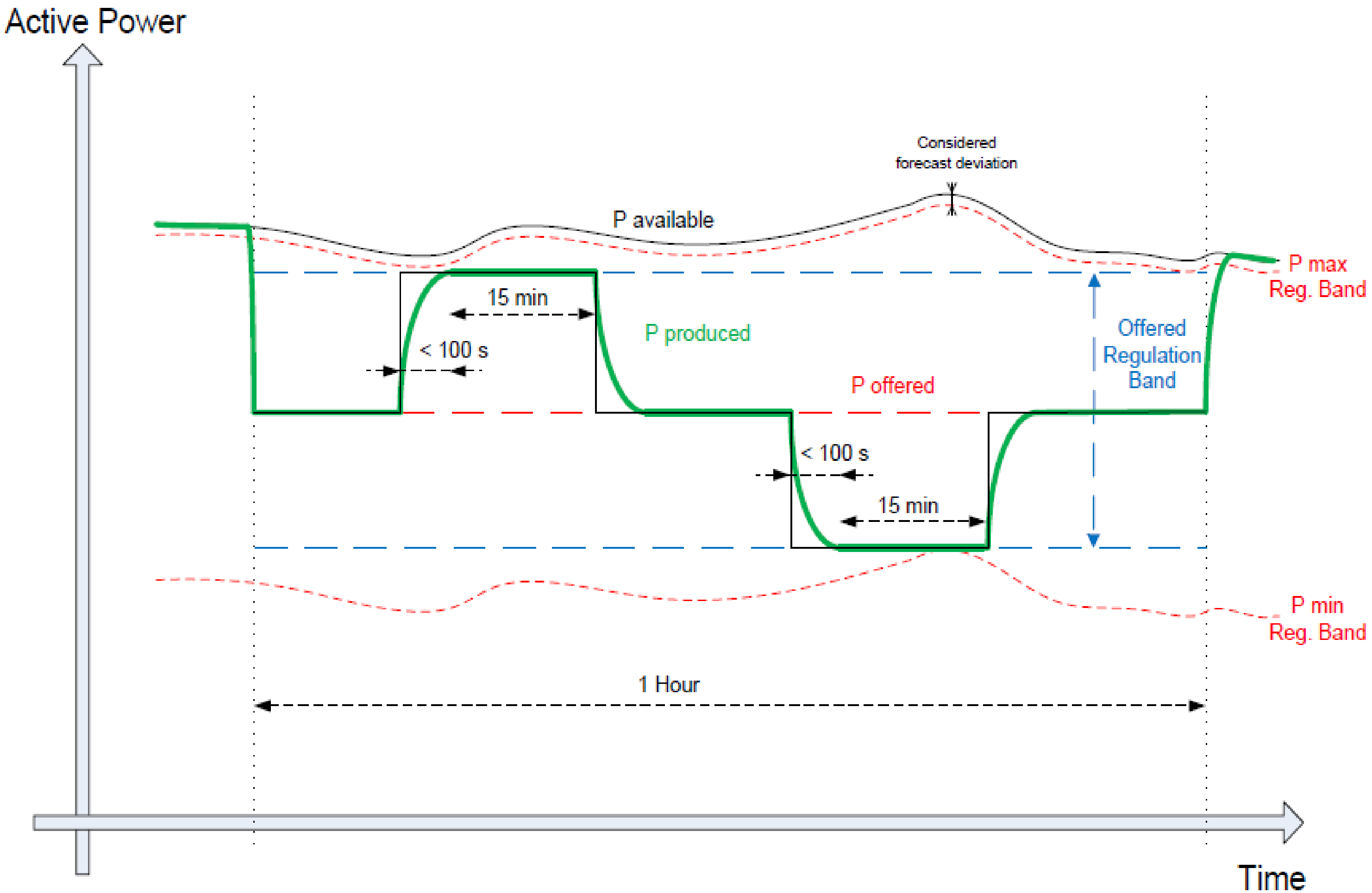
DEMO 1 SYSERWIND (Leader: IBR)



Active Power Control – Test Procedure



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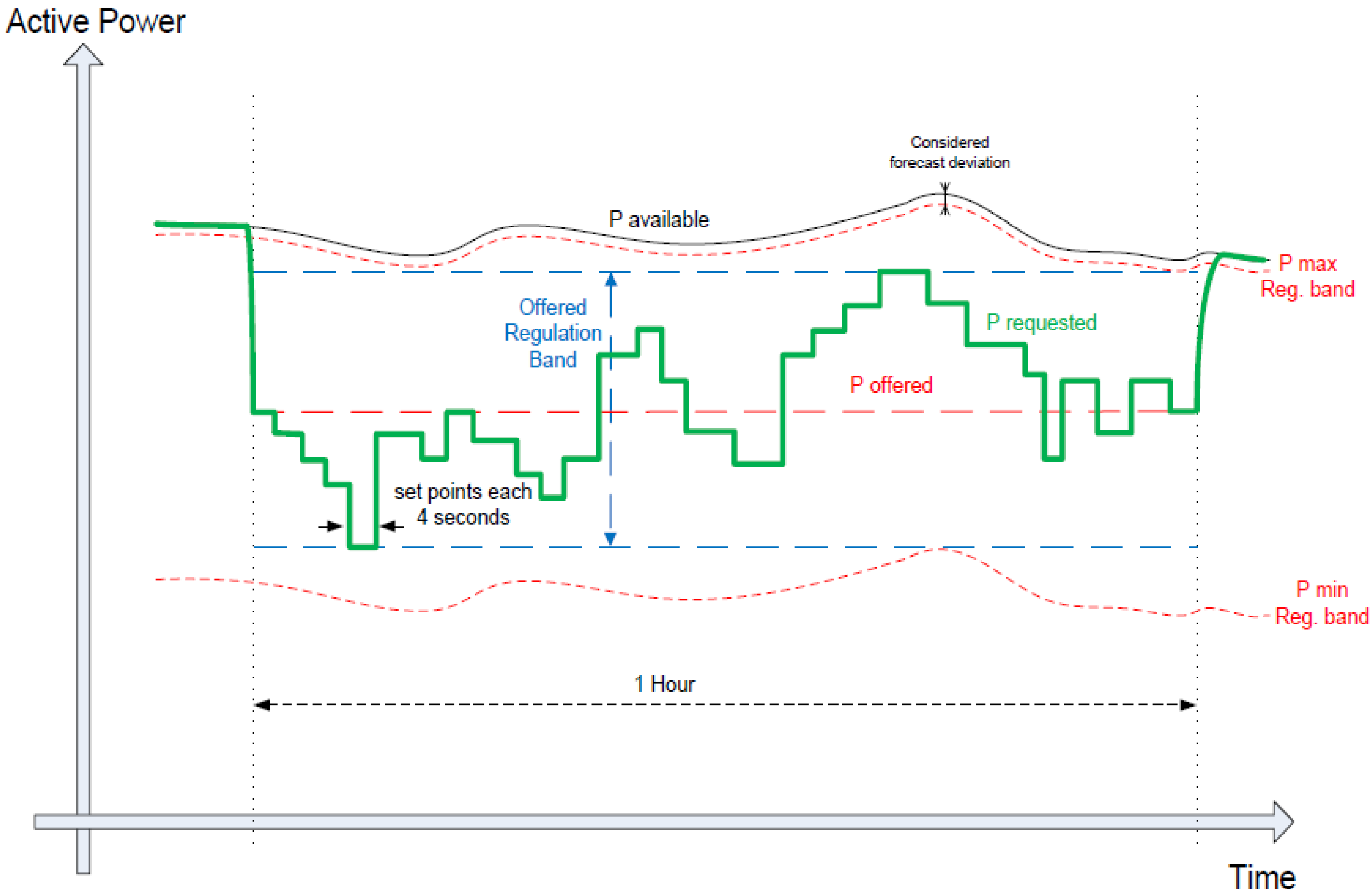
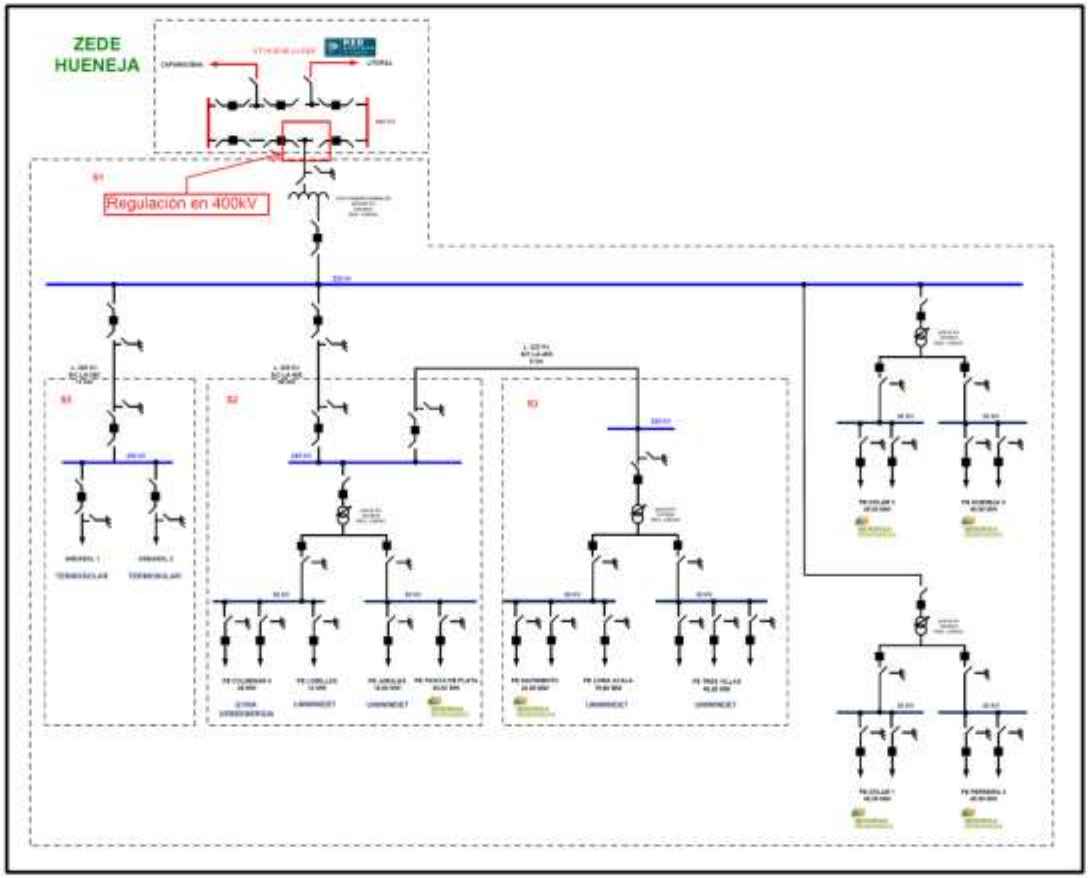
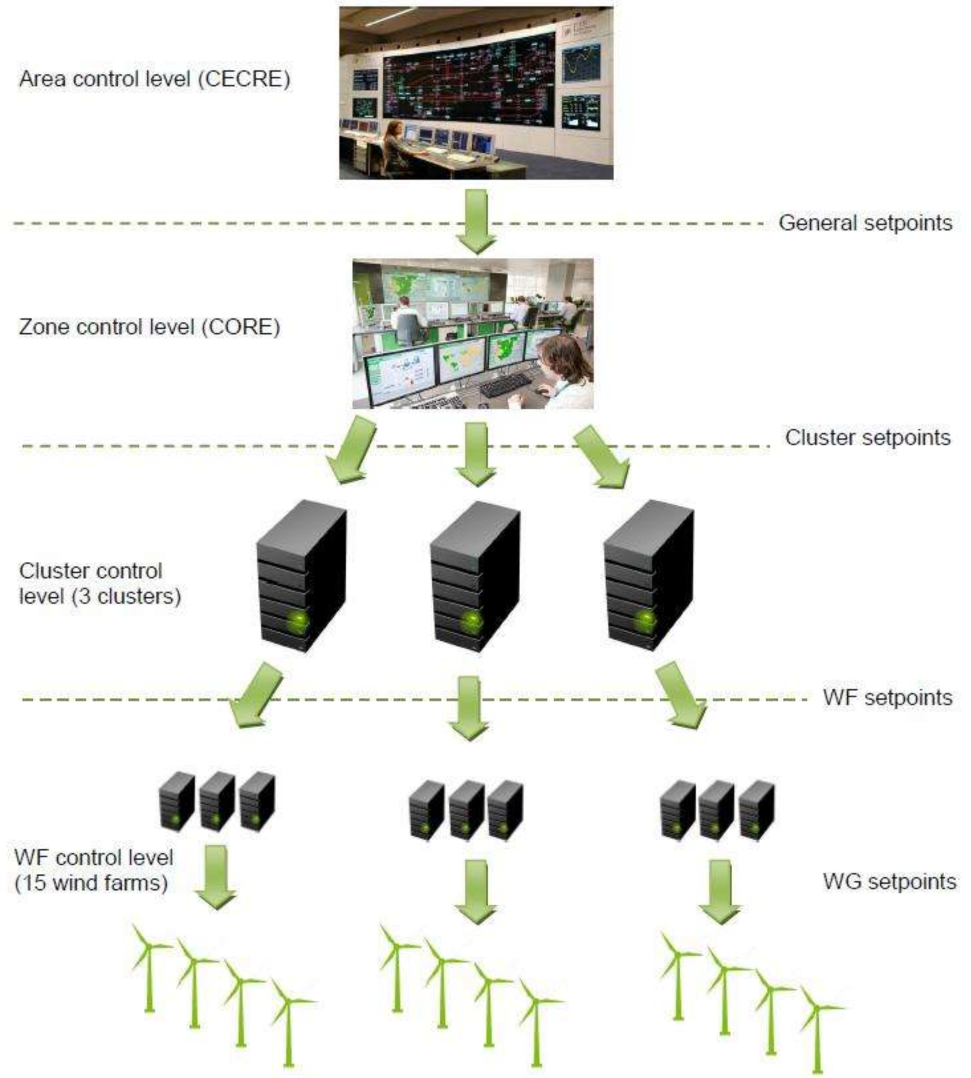


Progress of works: voltage control test

Preliminary voltage tests in Huéneja cluster.

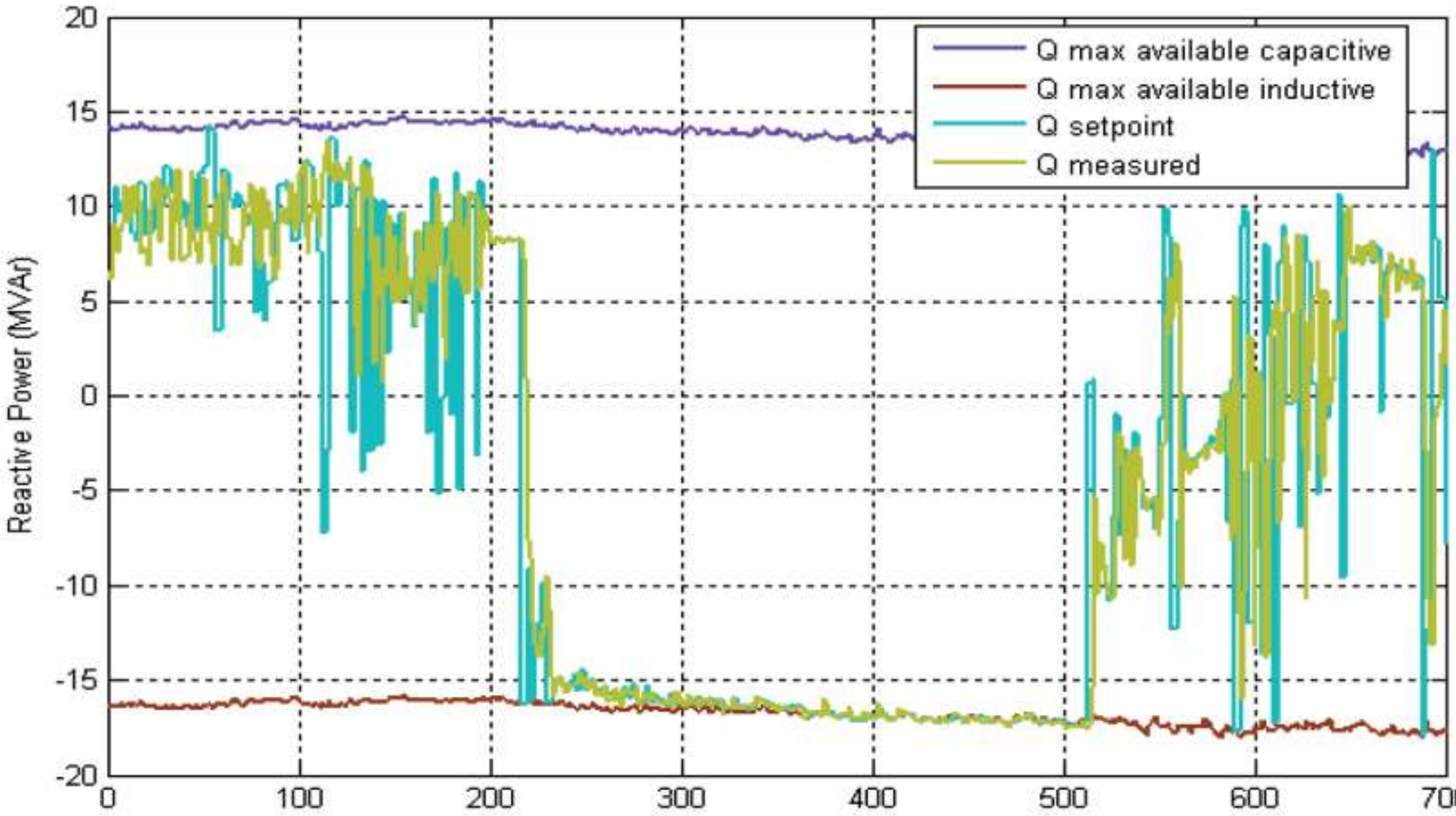


Implementation Architecture



Progress of works: voltage control test

Reactive power availability test in a single WF



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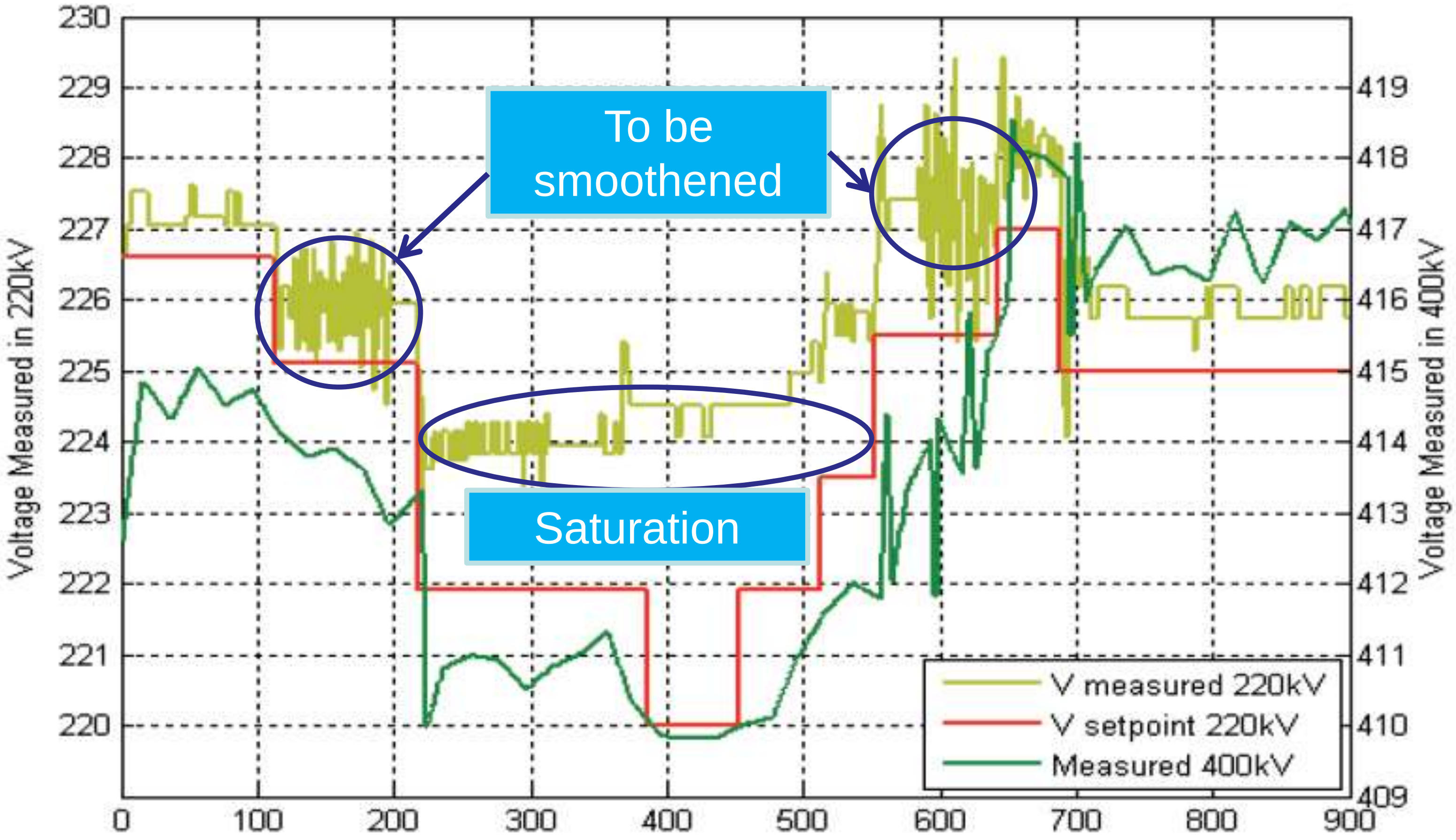

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Demo 2

Introducing Virtual Power Plants as ancillary services providers

Anders Birke, DONG Energy

DONG energy

RED ELÉCTRICA DE ESPAÑA

Fraunhofer IWES

ENERGINET/DK

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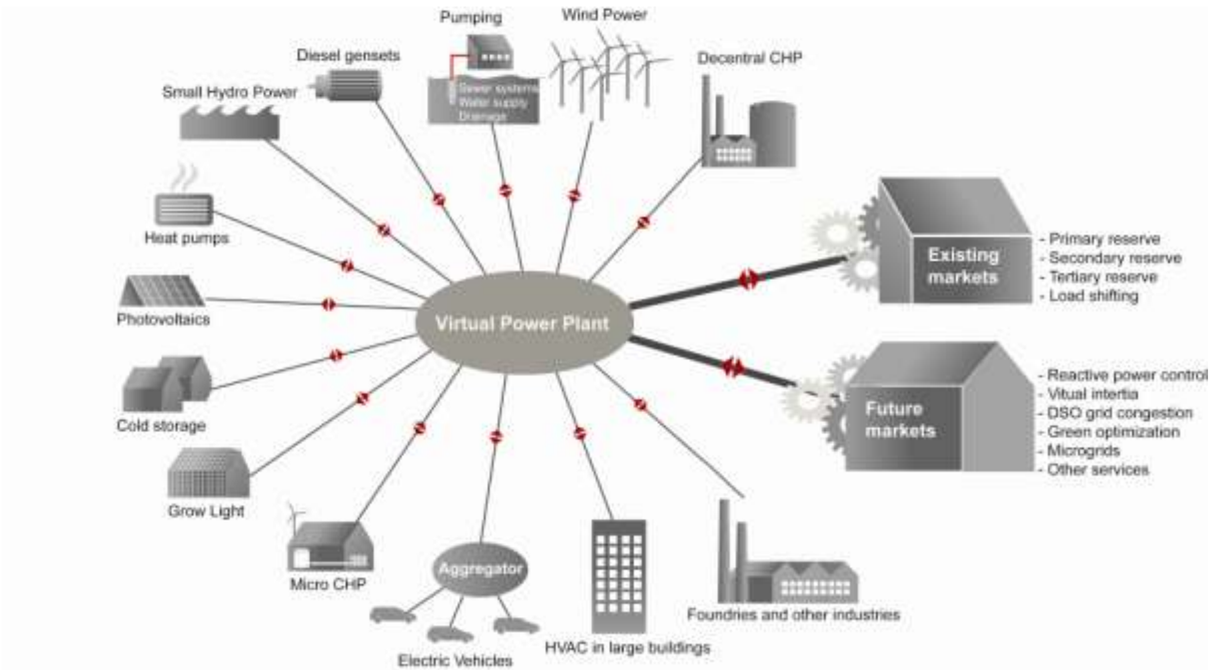
DEMO 2 DERINT (Leader: DONG)

Virtual Power Plants is a new source of flexibility to the power system

Virtual Power Plants will create services out of controlling distributed energy resources



Power Hub is almost just another power plant

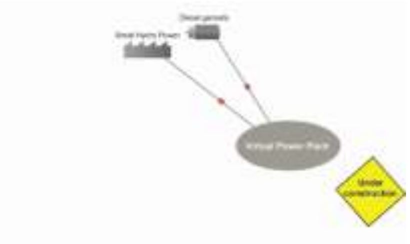
Power Hub delivers services to several markets just like traditional power plants and with the same reliability

Each distributed energy resource (DER) serves multiple purposes in the VPP, and can produce several service dependent of type of DER

Power Hub controls the DERs under full respect for the DERs primary purpose

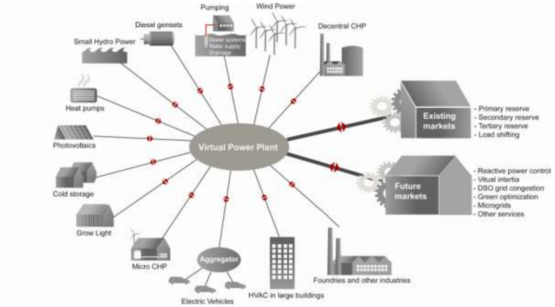
The Virtual Power Plant is extended during the project

Year 1



Year 2

Year 3



Building the VPP

In the first year of the project focus was on building the VPP:

- Building the conceptual solution, including the IT solution
- Attracting and installing control of the DERs
- Running the daily operation, selling and producing services by optimizing the DERs

Extended functionality and size

Just before the beginning of the second year, the VPP started selling its services to the market. The second year's objectives was to continue the development of the VPP, by adding more functionality to the VPP and increase the size of the VPP. The VPP is now able to interface to many different types of DERs, by using a generic driver, and the VPP is active in more markets.

Innovative diversified offerings

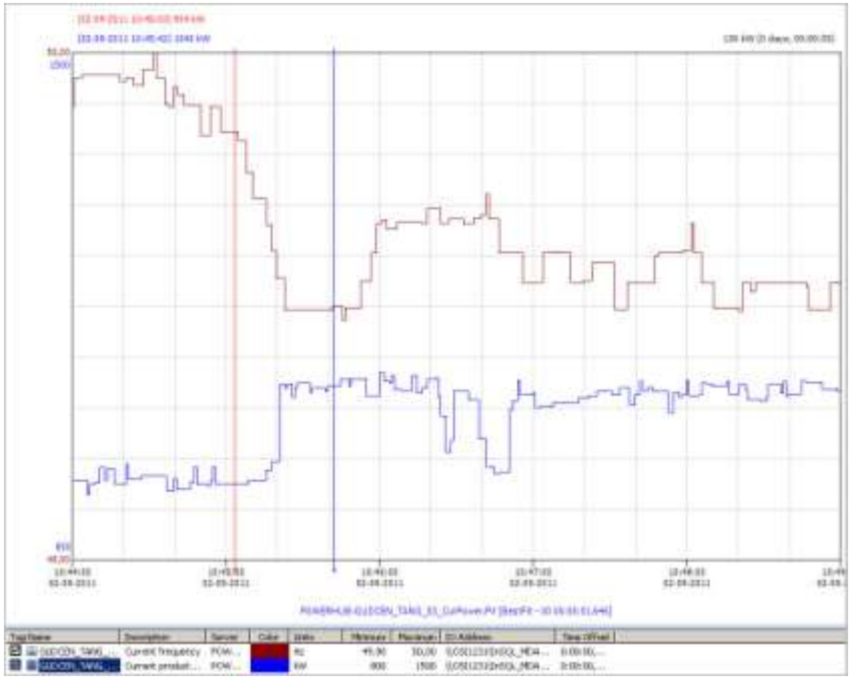
The third year's focus will be on demonstrating the full potential of the VPP technology, demonstrating new and innovative VPP services:

- Delivering virtual inertia at the Faroe Islands in order to reduce the number of black outs.
- Delivering local reactive power control.

In addition to this more DERs will be added, both on the consump-tion and production side, including integration of wind power into the portfolio.

Power Hub is productive and it works

When the frequency in Europe dropped 2. Sept. 2011 Power Hub helped restoring the frequency



The VPP responds better to grid incidents than Dong Energy Power's portfolio

Demo 3

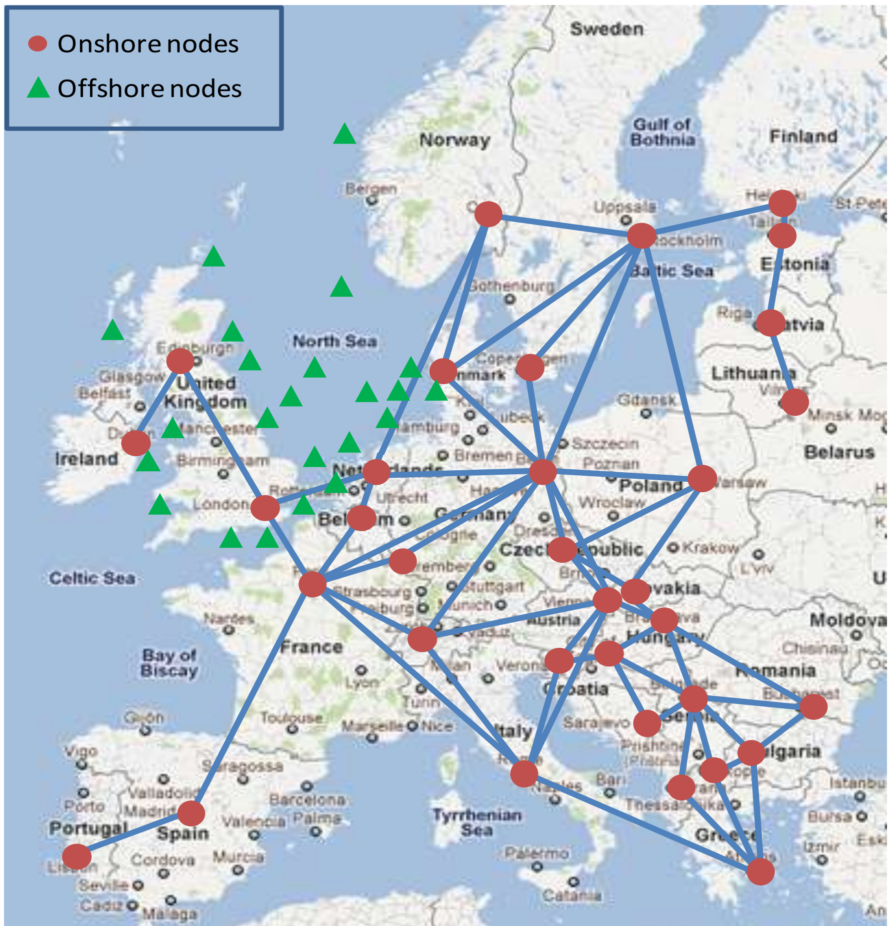
Drivers of Investment in offshore network capacity

4. June 2012

Twenties General Assembly 2012

DEMO 3 DC GRID (Leader: RTE)

European transfer model: how much offshore grid?



- ❑Build a model of the whole of Europe
  - ✓ Centre national generation portfolios and loads on single nodes
- ❑Show international interconnections
- ❑Add putative offshore wind sites
- ❑Carry out hour-by-hour Europe-wide dispatch based on
  - ✓ nodal loads
  - ✓ available generation
  - ✓ assumed ‘merit order’
  - ✓ heuristic model of hydro
- ❑Compare different network cases

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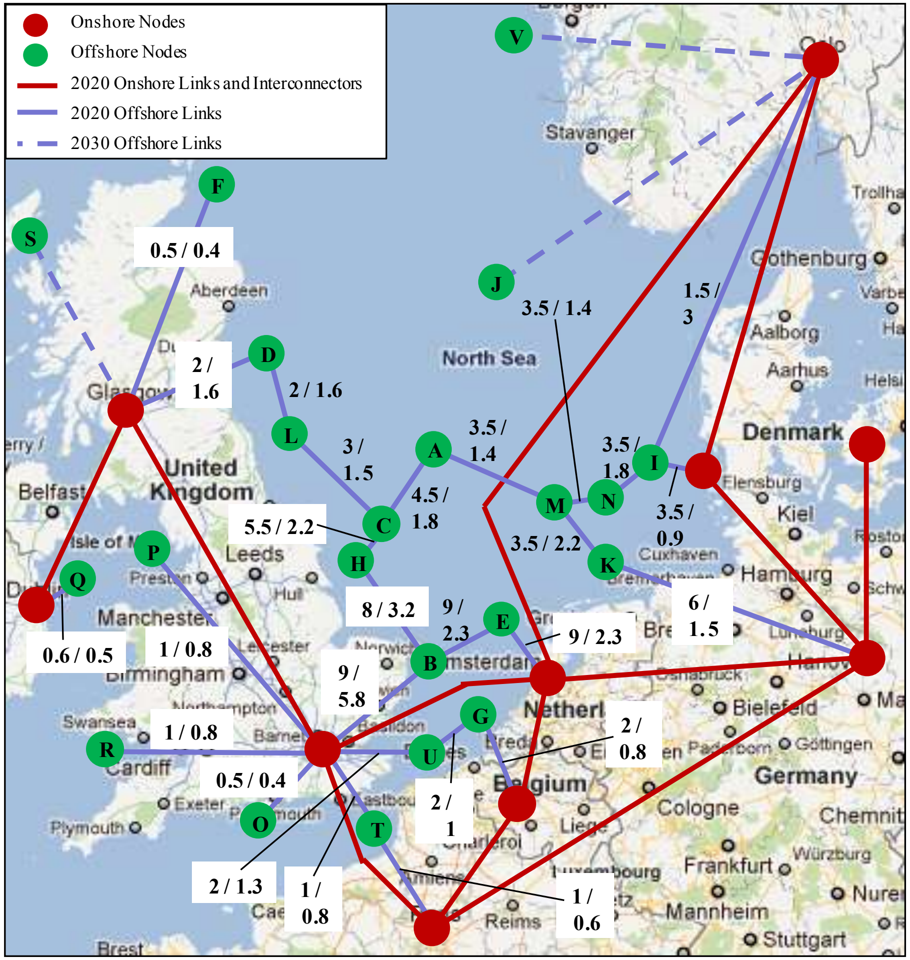
European transfer model with radial connections or an H-grid?



- Postulate a 2020 generation 'background'
- Assume new offshore wind (quite far from shore) clustered around hubs
- Compare transfers between areas and total power dispatches with those in different structures
  1. simple wind farm hub connections to shore
  2. simple WF connections plus additional interconnectors
  3. 'H grid'

The need for DC breakers

- ❑ **Without DC breakers**
  - ✓ **fault any on the DC grid would need to be cleared from the AC side of all terminal**
  - ✓ **Lots of power lost**
- ❑ **With DC fault location and DC breakers, only the faulted branch would be lost**
  - ✓ **Other branches can still transfer power**
- ❑ **What performance is required of a DC breaker?**
  - ✓ **and what is the likely cost?**

Annual energy production in 2020

All TWh except CO_2 in millions of tonnes	Base	Radial	Radial + IC3	H-grid 1
Connection of new offshore wind generation	None	Radial	Radial	Within H grid
New offshore NTC	None	None	3GW point-to-point	H high
Nuclear	870.9	868.0	876.0	875.3
Hydro	670.2	670.2	670.4	673.9
Lignite	316.0	313.6	317.3	314.7
Coal	724.4	688.9	700.6	697.7
Gas	377.0	346.8	325.8	326.1
Other dispatchable fossil fuelled generation	21.7	21.5	15.7	18.9
Wind generation	341.1	412.2	416.0	414.9
Total renewable generation	1132.3	1203.4	1207.4	1209.8
Net pumped storage production	-10.5	-10.5	-9.2	-9.5
Unsupplied energy	2.3	2.3	0.6	1.0
Net spilled energy	11.2	14.1	12.5	11.4
CO_2 emissions	1190.8	1143.2	1145.1	1142.2

Cost analysis

Incremental offshore capacity in addition to the radial links lowers operational costs

DC breakers add significantly to the cost of the H-Grid

Including a cost for unsupplied energy has a major impact

€m	Radial	Radial + IC1	Radial + IC3	H-Grid 1	H-Grid 2
Capital Cost Differential excl. Breakers	0	290	757	831	281
Capital Cost Differential Incl. Base Case Breakers	0	290	757	1981	1073
Operational Cost Differential (excl. unsupplied energy cost)	0	-700	-1235	-1128	-535
Operational Cost Differential (incl. unsupplied energy cost)	0	-35700	-43735	-33628	-40535
Net Benefit (Cost) Breakers and Excl. Unsupplied Energy Cost	0	-410	-478	-297	-254
Net Benefit (Cost) Breakers and Excl. Unsupplied Energy Cost	0	-410	-478	837	522
Net Benefit (Cost) Breakers and Incl. Unsupplied Energy Cost	0	-35410	-42978	-31663	-39478

A net benefit accrues to the H-Grid when either DC breaker costs are excluded or unsupplied energy costs are included (or both)

Preliminary findings

- The benefits of increasing offshore network capacity to wind energy production and use are clear but what form that network capacity should take is uncertain
- The cost of DC breakers will be a critical factor
- Understanding the variability of flows across a meshed offshore network is critical to optimisation
- Creating the business case for offshore grids is challenging
- Development of offshore wind generation and offshore network capacity must be accompanied by measures to price carbon at an appropriate level
- DC Grid Control & Operation; Multi-terminal HVDC Grids; DC-breaker prototype: challenges and advances

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Twenties Demo 4
STORM MANAGEMENT

Nina Detlefsen, Energinet.dk (demo leader)

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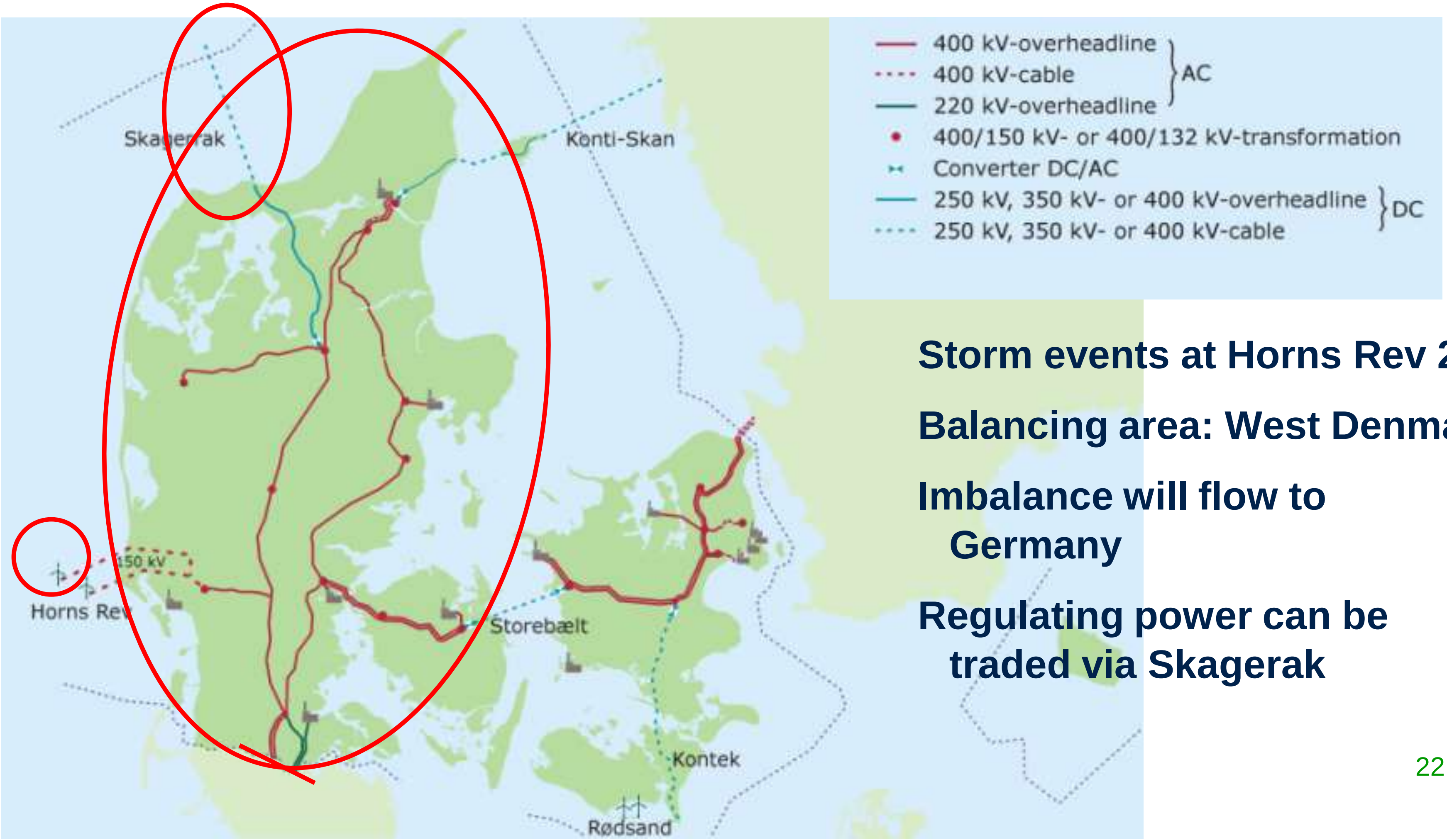
DEMO 4 STORM MANAGEMENT (LEADER: ENERGINET)

Demo 4 - focus area



Storm events at Horns Rev 2

Balancing area: West Denmark

Imbalance will flow to Germany

Regulating power can be traded via Skagerak

Future offshore projects in Denmark

Total 4.6 GW

Status for Demonstration 4

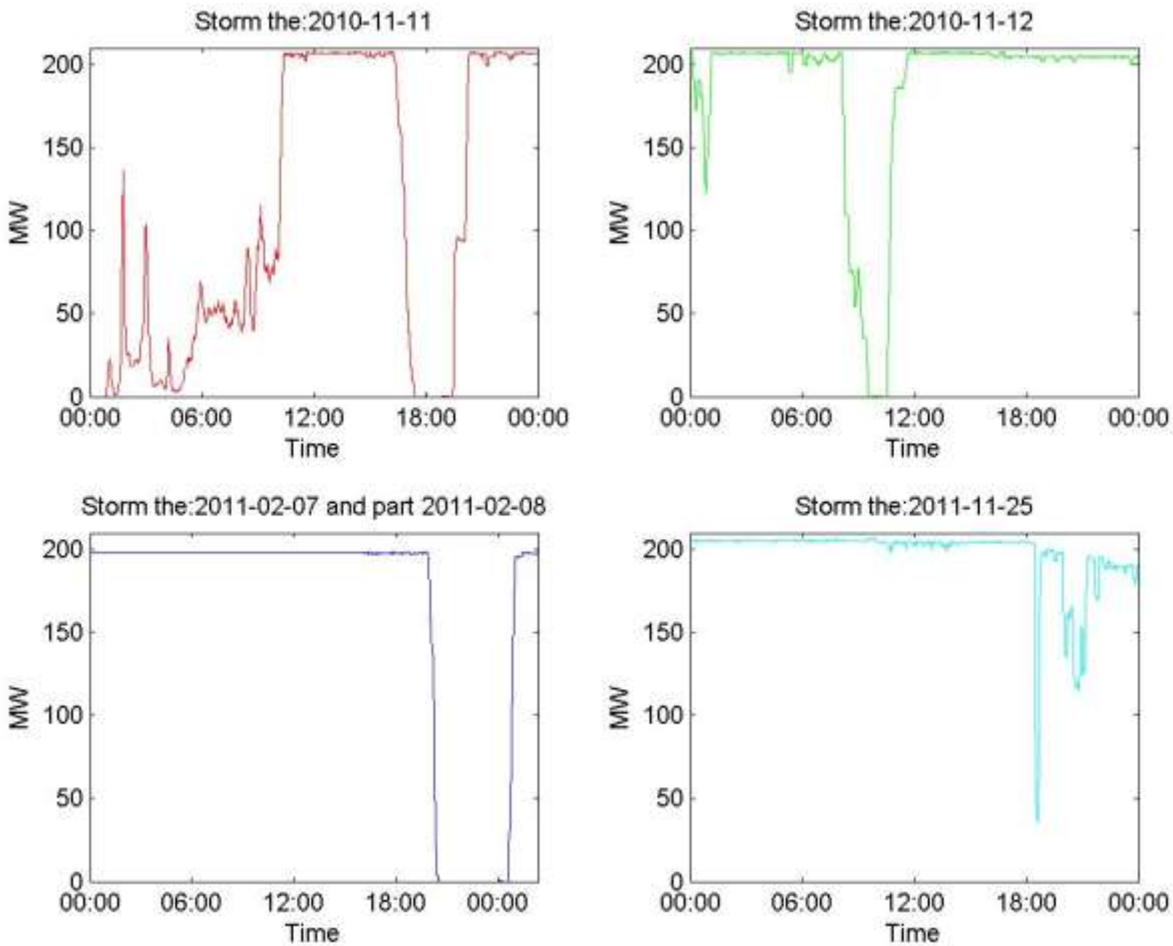
❑Scope

- ✓ **Demonstrating how**
  - .. a wind farm can be regulated according to the TSO or producer prior to the storm
  - .. energy deficit will develop in time
  - .. the energy deficit is balanced by balancing power as part of the system balance
  - .. the system imbalance might be handled by hydro power from Norway

❑Status

- ✓ **New turbine controller has been developed**
- ✓ **Controller is implemented in one turbine at HR2**
- ✓ **Controller is expected to be installed in all turbines by August 1st, 2012**
- ✓ **Collection of data is established**
- ✓ **Animation/presentation of results are discussed**

Storm – no one are alike!



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Twenties Demo 5
NETFLEX (Elia)

Demo Leader: *Christophe Druet (Elia)*
Contact: *Christophe Druet (Elia), Jacques Warichet (Elia),Jean-Jacques Lambin (Elia), and Olivier Bronckart (Coreso)*

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DEMO 5 NETFLEX (Leader: ELIA)

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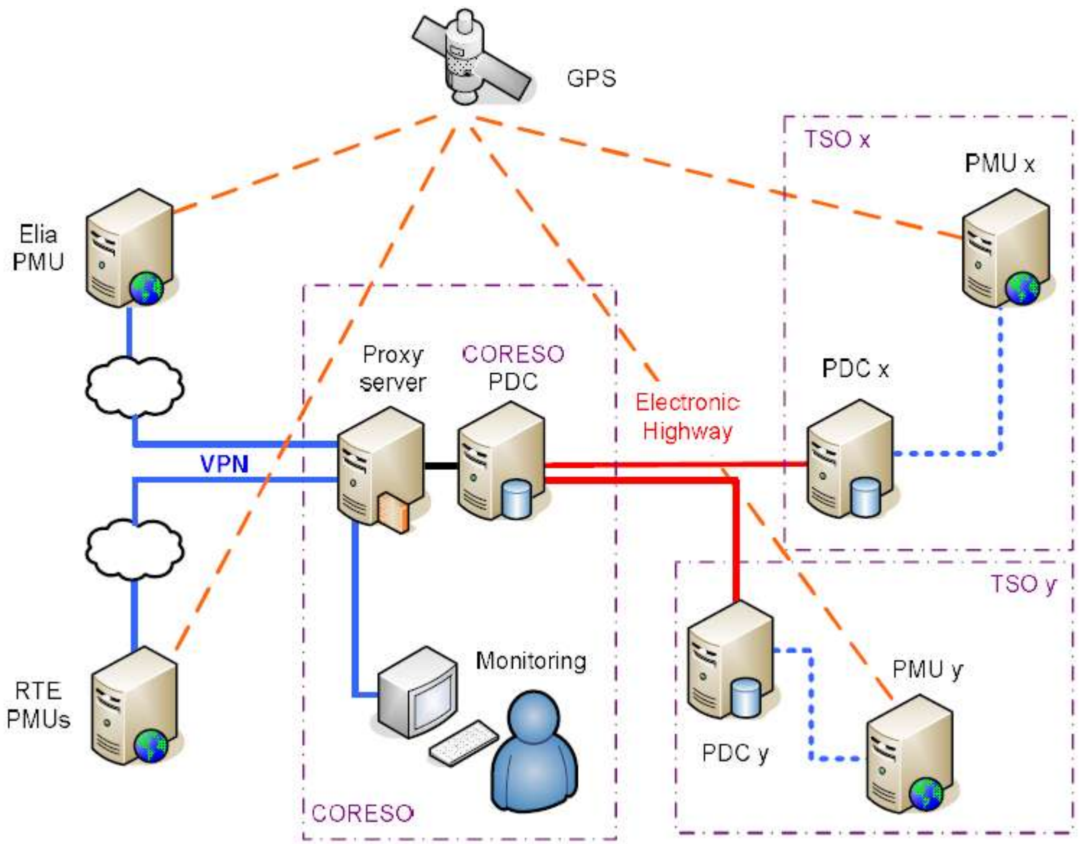
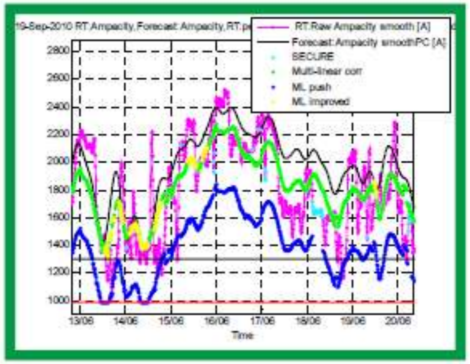


elia Rte Réseau de transport d'électricité AREVA coreso ULg LEUVEN ULB

Developments

Results

- **Forecasting using Dynamic Line Rating (DLR)**
  - Forecasting Model seem able to deliver additional firm capacities for the intraday market
  - Days with large variations in wind speed and incl. wind < 1m/s must be further investigated (this is where accuracy matters most)
- **Wide Area Measurement System (WAMS)**
  - Damping factor is monitored in real time for a few months
  - Coverage area is enlarging as PMUs from far away are connected
- **Smart Power Flow Control (Smart-PFC)**
  - Current results show that the observability of the whole area matters a lot
  - Active participation of all TSOs is needed to identify the relevant critical branches in the area



On going steps

- **Dynamic Line Rating (DLR)**
  - Forecasting Model for the day-ahead market
- **Wide Area Measurement System (WAMS)**
  - Derive Good Operating Practices (GOP) by linking damping factors with higher-level variables (e.g. flows)
- **Smart Power Flow Control (Smart-PFC)**
  - Investigate the objective function
  - Demonstrate the effect of coordinated tap changing

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Demo 6

FLEXGRID:

- Real time thermal rating project
- Increasing the wind penetration level in the EU Grid by means of power flow control

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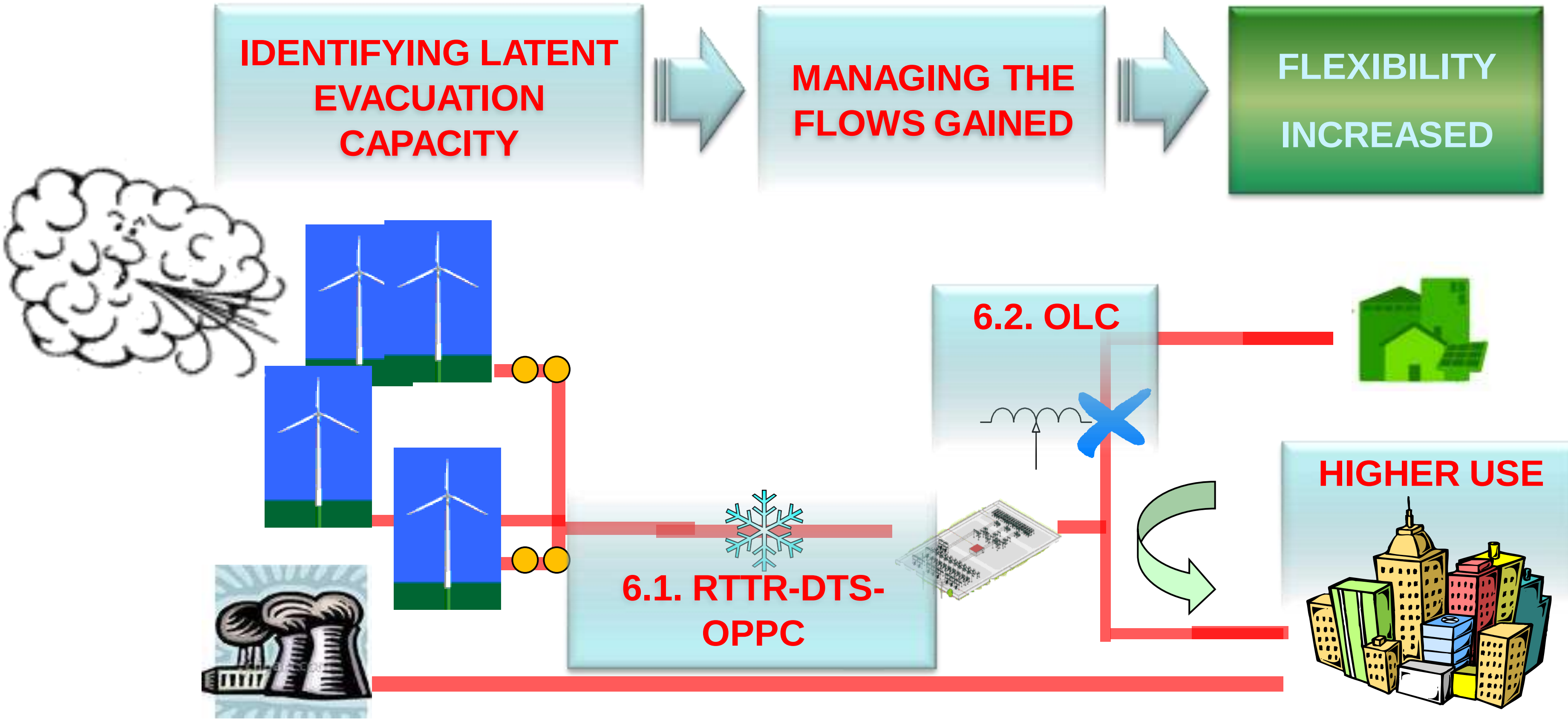
DEMO 6 FLEXGRID (Leader: REE)

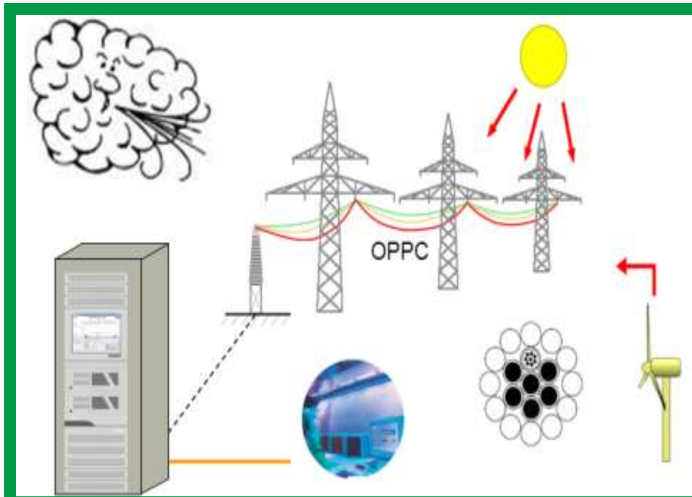


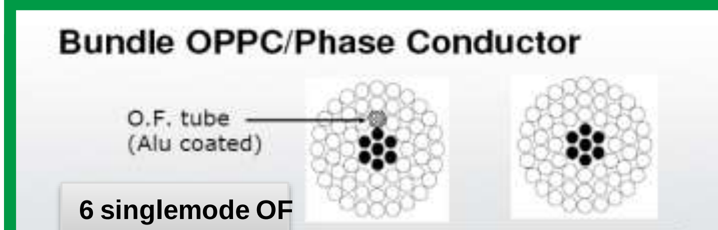
Fully integration of Renevawel energies / Better exploitation of the existing facilities

DEMO 6.1 Real time thermal Rating Project

Previous Steps

- **Task 8.1.1: Definition of Monitoring system requirements. <u>Completed</u>**
  - Benchmarking of several commercial devices.
  - Selection of technology provider:
    - *Distributed temperature sensing (Raman Effect)*
    - *Temperature accuracy:1-3ºC*
    - *Typical resolution:10 m*
    - *Weather stations*
- Specification and design of RTTR system
- OPPC acceptance Tests and manufacturing.





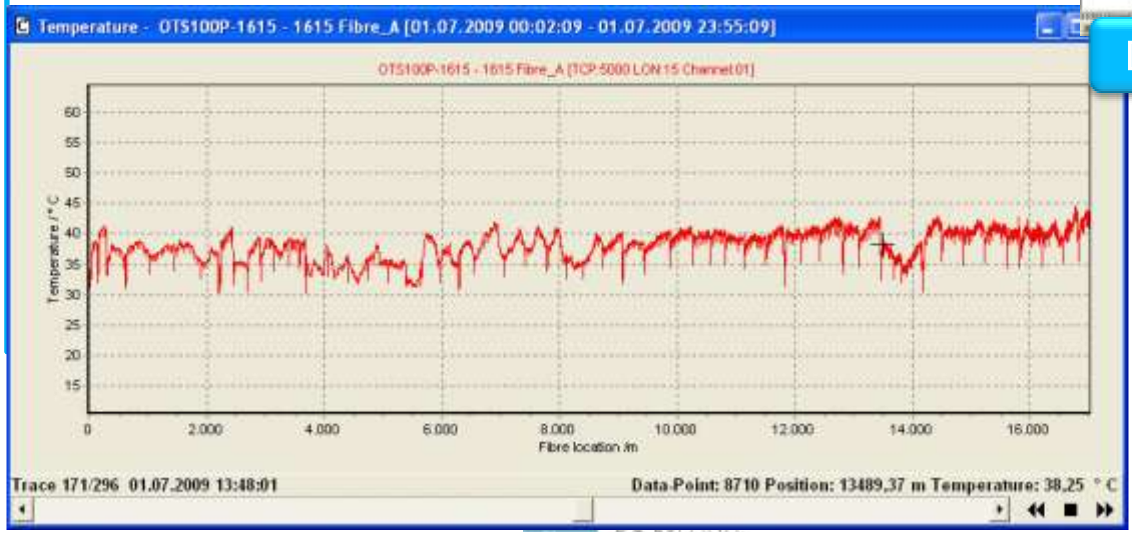
	OPPC	Phase Conductor
Diameter [mm]	27,8	27,7
Weight [kg/km]	1471	1466
Calcul. Ampathity	892	897
No. Of Fibres	10 Low Loss	

DEMO 6.1 Real time thermal Rating Project

Previous Steps

- **Task 8.1.1: Definition of Monitoring system requirements.**

- Validation of accuracy of monitoring system
- Comparison: temperature measured vs. values obtained from current algorithms (IEEE 728 std) using measured ambient conditions.
- CTAR: Dynamic rating profile updated every 10 min.



Data

- Temperature profile and hot spots
- Average temperature in every section and standard deviation
- Weather conditions profile:

SIEMENS

DEMO 6.1 Real time thermal Rating Project

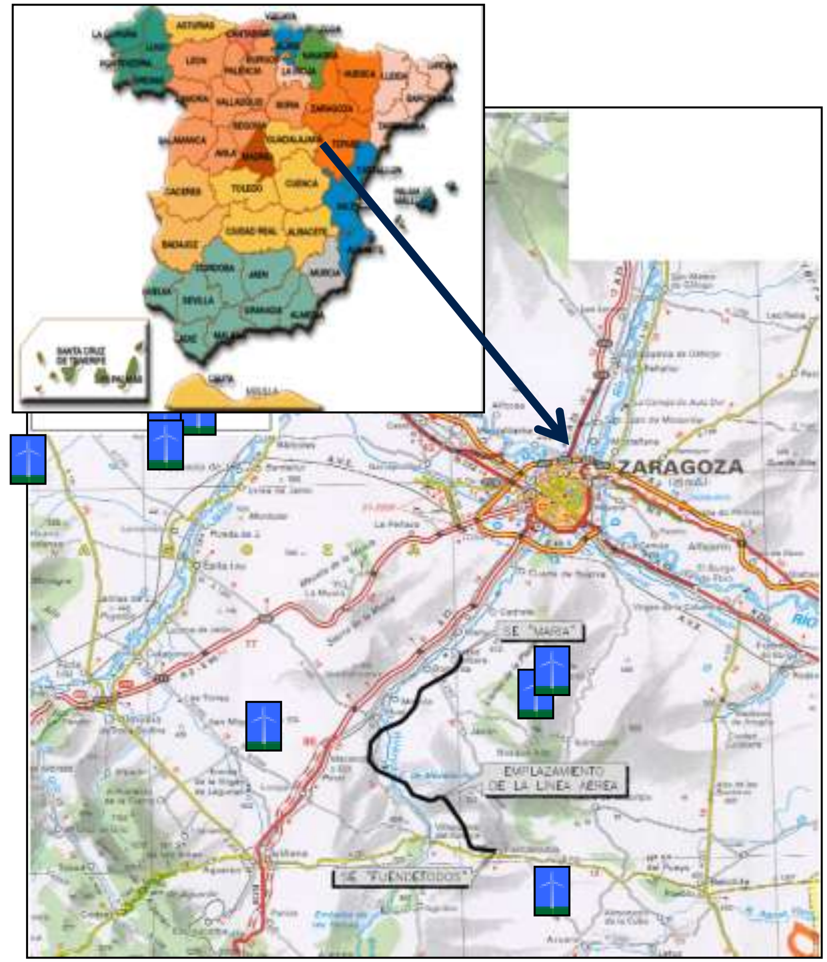
Previous Steps

- **Task 8.1.2: Selection of location of RTTR device. <u>Completed</u>**

- Placed at north-east of Spain
- New line 220 kV "María-Fuendetodos": 30 km length
- 11 straight joints

- Total installed wind power: 1730 MW.

- **Task 14.1: Construction of 220 kV "María-Fuendetodos" line:**
  - 13th of June: OPPC stringing
  - Tower construction and civil works (foundations) on time.
  - Commissioning in November of 2012



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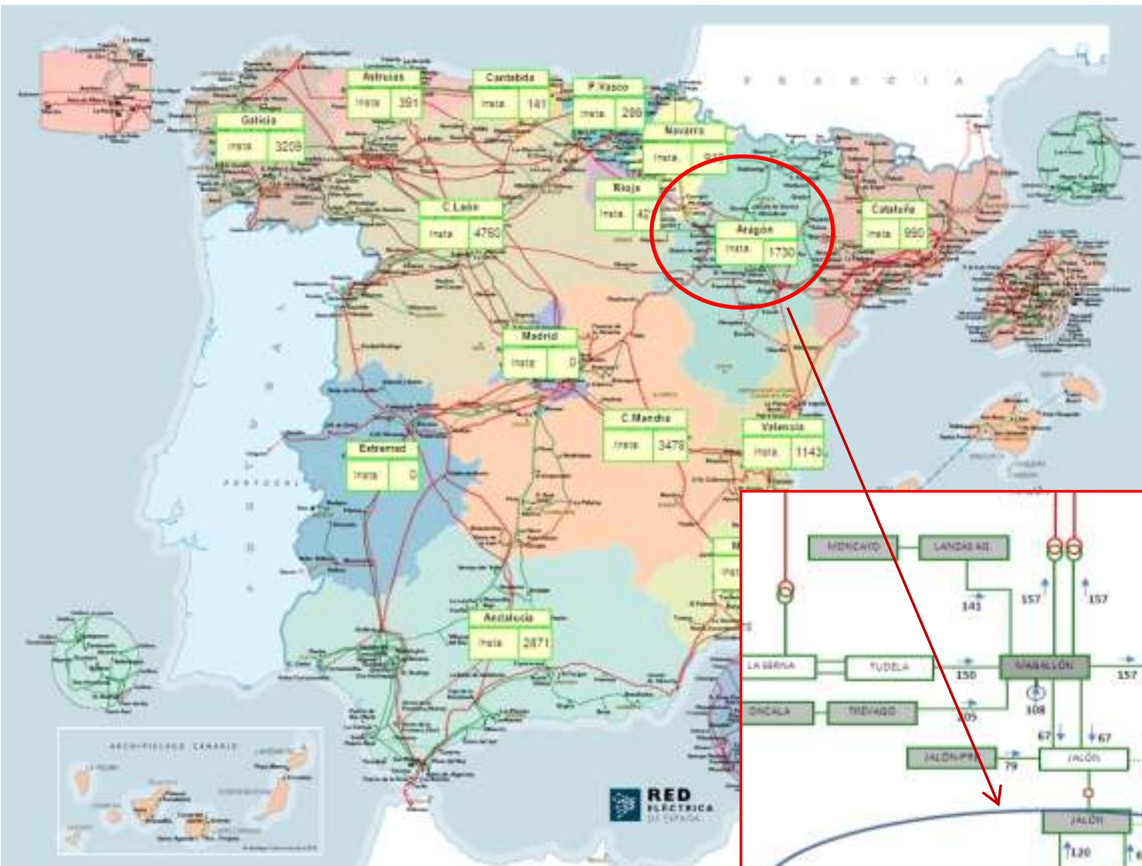
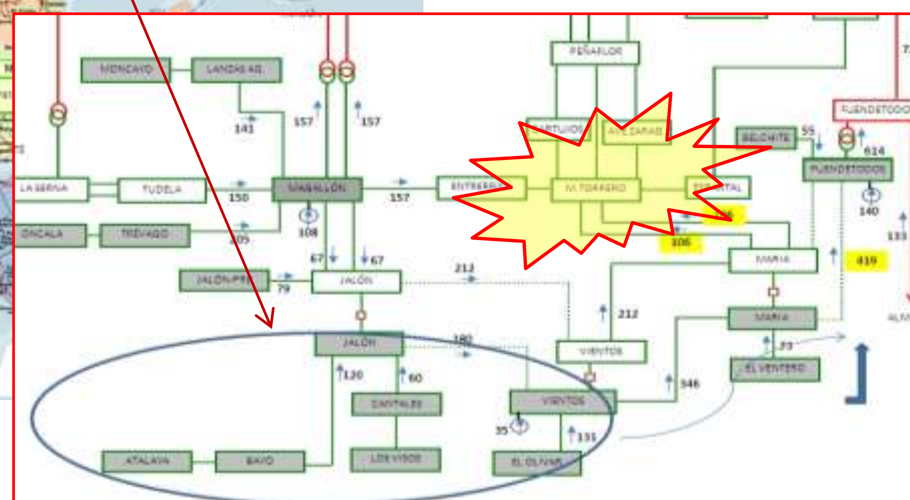
DEMO 6.1 Real time thermal Rating Project





Previous Steps

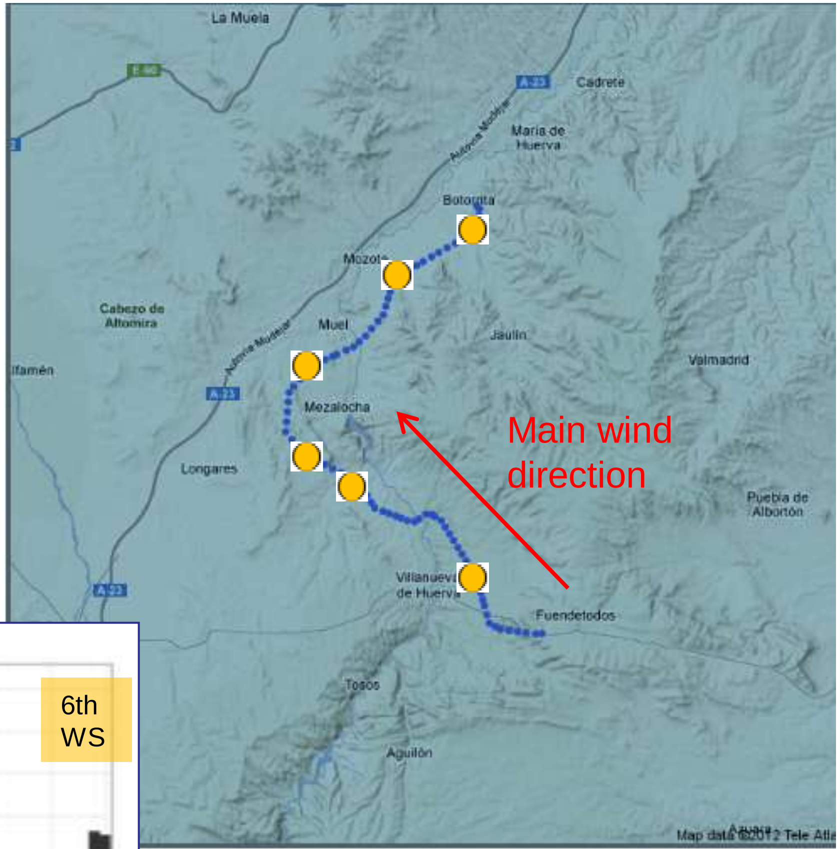
- **Task 8.1.3: Analysis on wind power generation disaggregation. Completed**
    - **27% total installed wind power** in Aragón.
    - **≥ 50% of CTAC (current static seasonal ratio).**

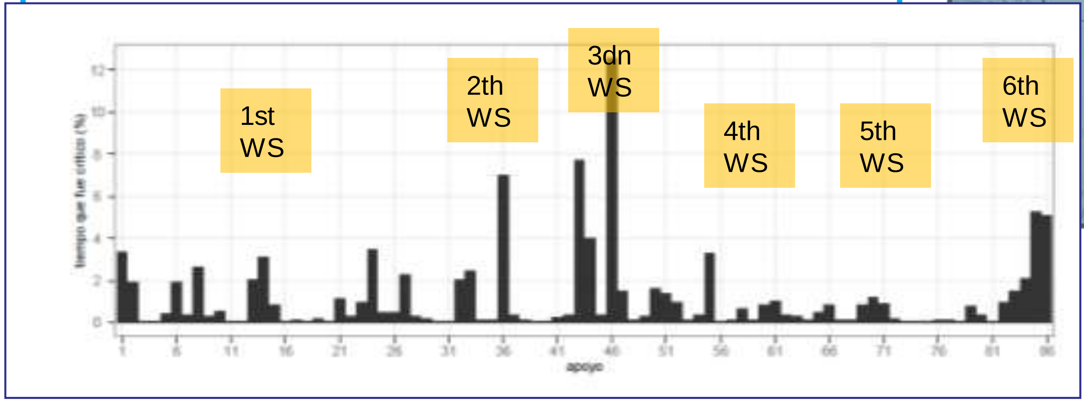
DEMO 6.1 Real time thermal Rating Project

Previous Steps

- **Task 8.1.3: Selection of weather stations location. Completed**

- Solar radiation[W/m2], wind velocity [m/s], wind direction [deg.], Tamb.
- Detailed topography of the line
- Meteorological forecast: 5 years (2007-2012). *State Agency of Meteorology.*
- Ruggedness of the land: European environmental agency.

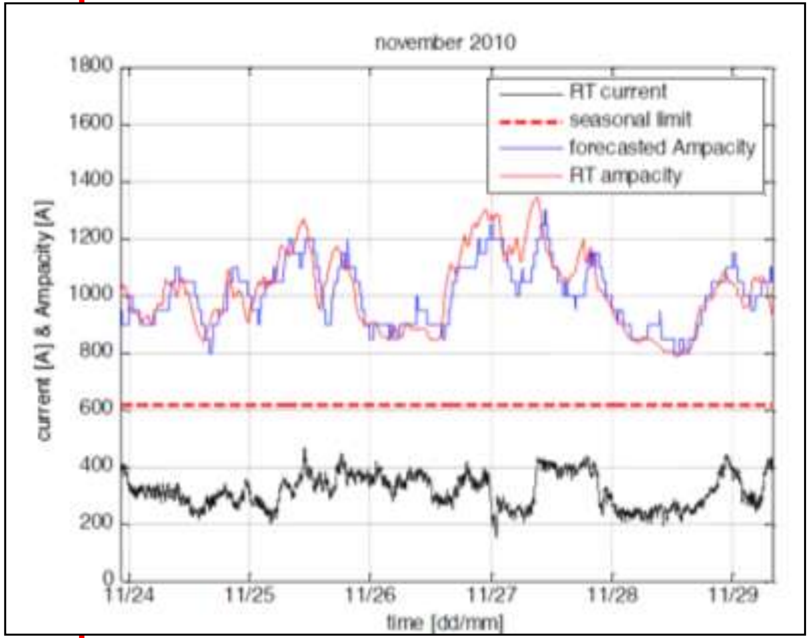


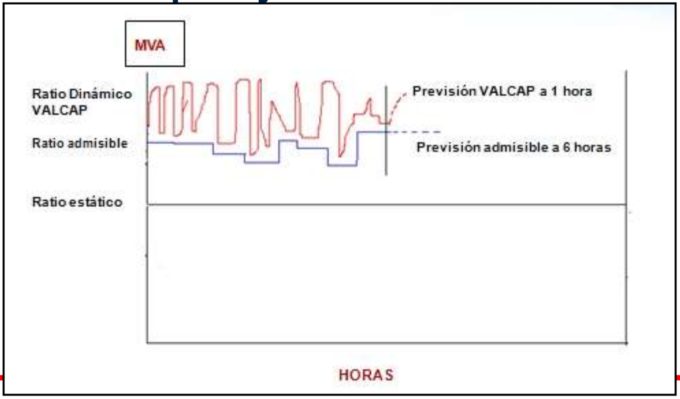


DEMO 6.1 Real time thermal Rating Project

On going steps

- **Task 8.1.3: Computation of measurements on monitored lines.**
  - Development of Models to Calculate the Transmission Capacity:
    - **1. CTAR:** Dynamic Ratio based on DTS (IEEE-728).
    - **2. CTAO:** Operating Transmission Capacity
    - **3. PCTAO:** Prediction Operating Transmission Capacity Curve (1-4 hours)
- **Task 8.1.4: Correlation analysis between the thermal behavior of the line and nearby wind production capacity**



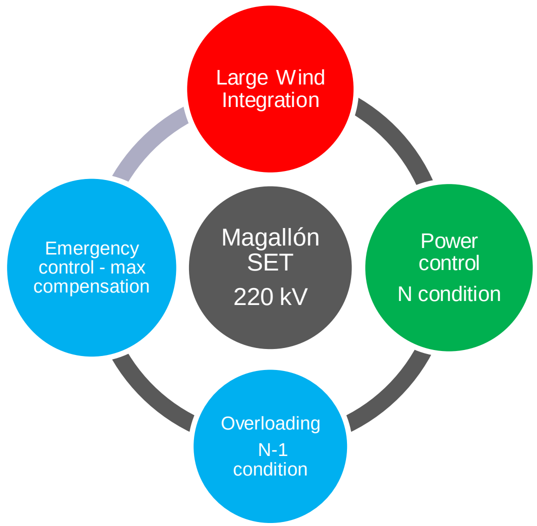


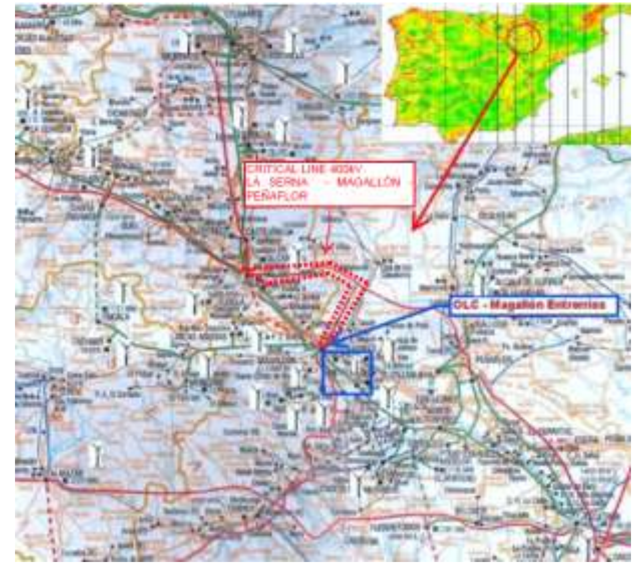
Main objective

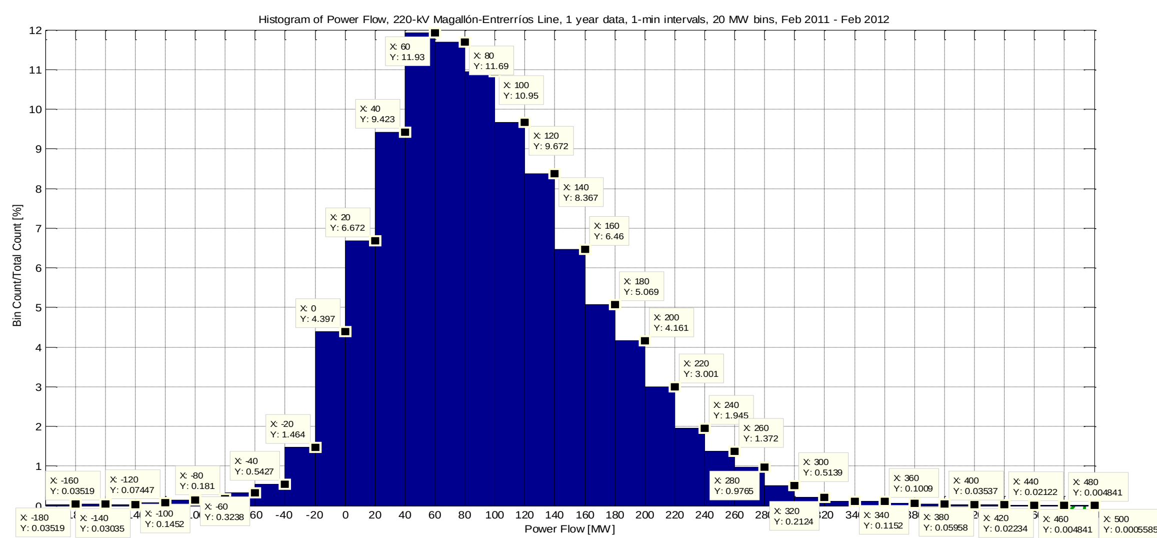
- To **increase the level of renewable penetration** in transmission grid by
  - extending operational limits
  - maintaining safety criteria (N/N-1 conditions)

Approach

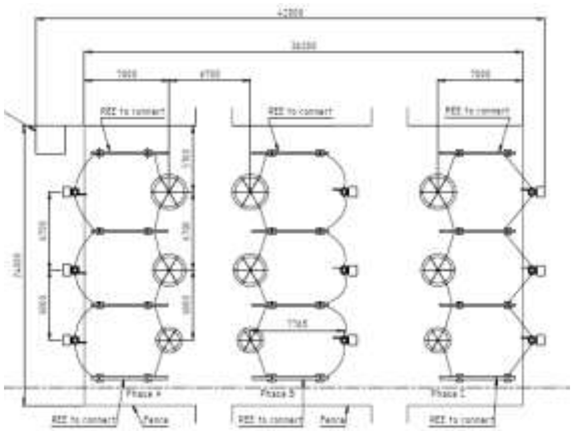
- To define an innovative solution, the **Overload Line Controller (OLC)** able to limit the renewable energy curtailment by **redirecting power flows**
- The OLC is based on **mechanically switched series reactors, managed by a high-end control system (Mach2)**:
  - Change the impedance of the line modifies the load flow
  - Step-wise control increases grid flexibility and security

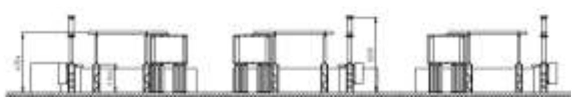


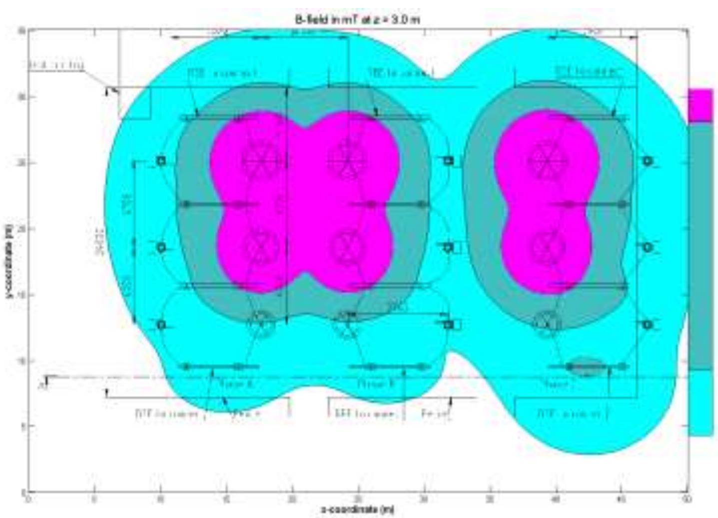




Mechanical Design



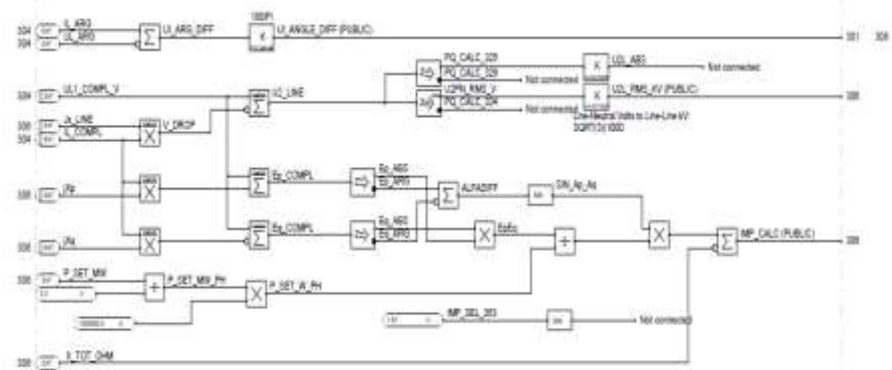


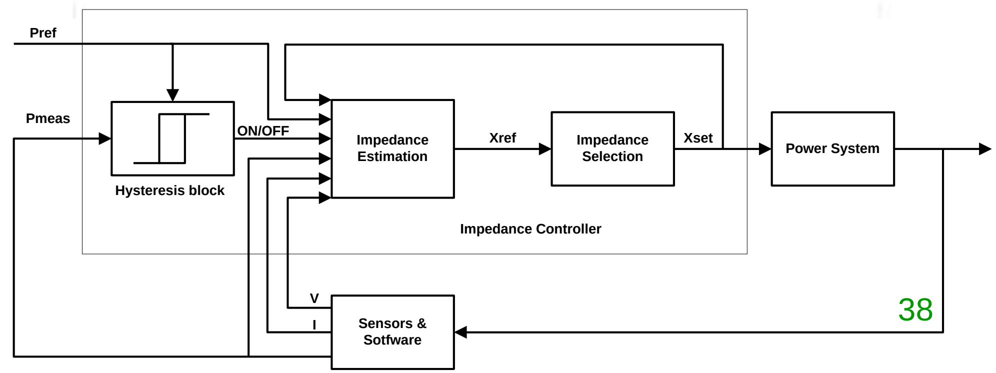


Mach2 Control System

Main Features

- Different control modes available locally and remotely
- Fast and reliable calculation of the compensation level needed given the operating conditions
- Avoid a large number of switching actions, thus increasing the OLC lifetime





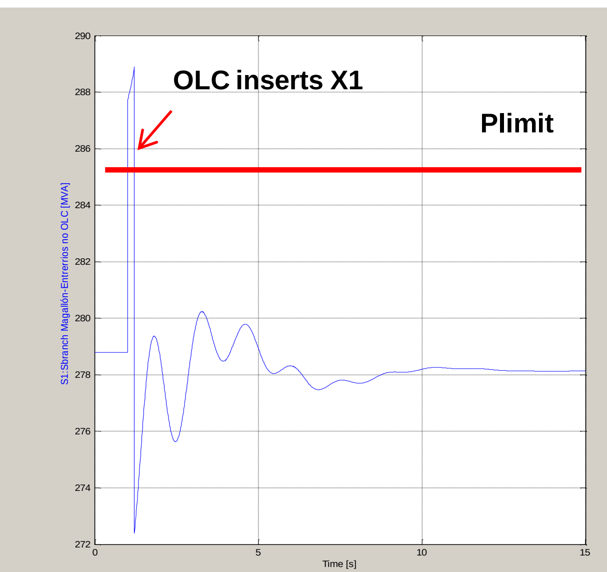
Power Flow Control Modes

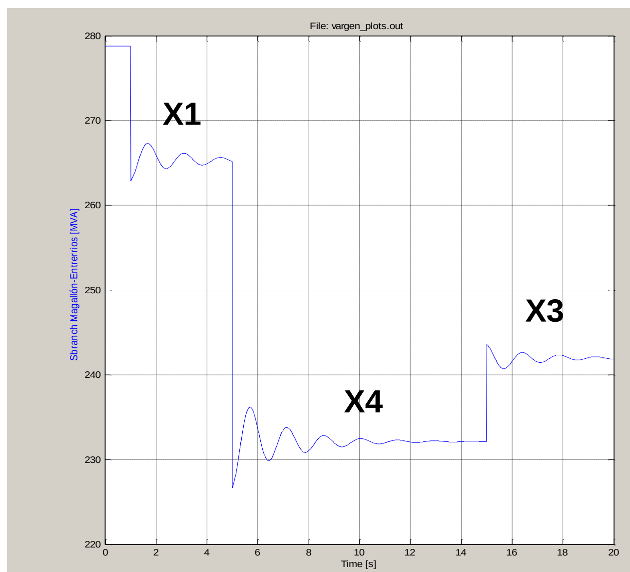
Grid Operator ModeSelection

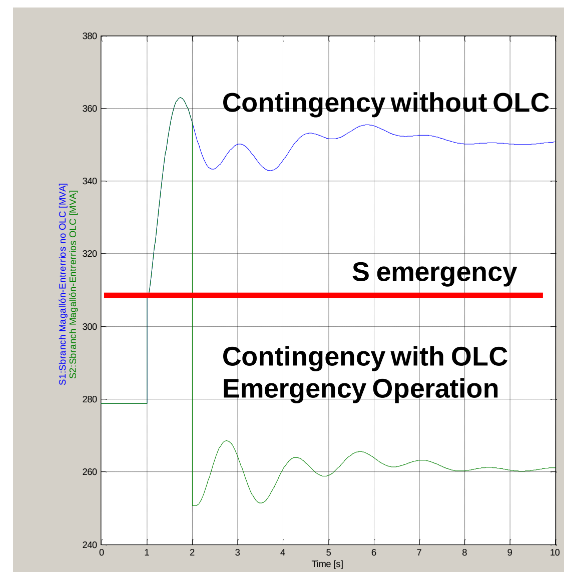
- **P regulation Closed Loop**
  - Operator sets Preg
  - Pline ≈ Preg
- **Plimit Closed Loop**
  - Operator sets Plimit
  - Pline < Plimit
- **Zmode Open Loop**
  - Operator selects Zvalue
  - Zline1 =Zvalue+ Zline
- **Zmax Open Loop**
  - Operator selects maximum compensation

Emergency Mode (Back-up)

- Operator sets S emergency: seasonal ratio / defined value
- If **Sline> Semergency → Zmax**
- Time response < 3sec







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WP 15

Javier García González, IIT-Comillas

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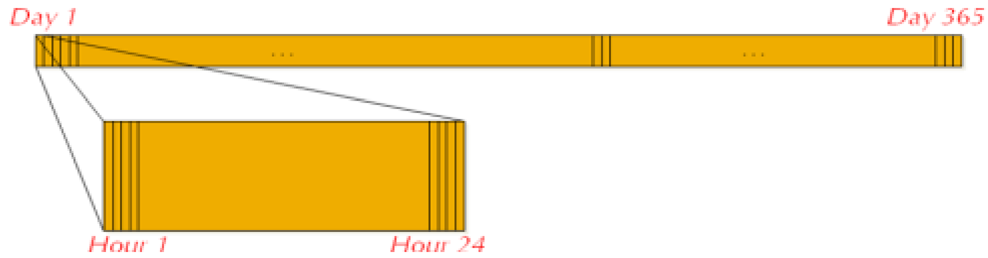
- ❑ Economic assessment of the provision of active power control by wind generation (demo # 1 in Spain)

- ❑ Economic assessment of the provision of voltage control by wind generation (demo # 1 in Spain)

Perfect information case



- **ROM model**
- **2020 Results:**
  - **$OPEX_A - OPEX_B$ = 52.88 M€ (↓ 0.76%).**
    - Thermal output is reduced by 0.27%
  - **WIND OUTPUT increases, WIND SPILLAGE decreases**

$$WindGeneration + Spillage + WindUpReserve = \mathrm{WF}$$

Wind Output Comparison	No Reserves	Reserves	Difference
Wind Output / WF	95.94 %	96.44%	-0.5%
Wind Spillage / WF	4.06%	2.44%	1.62%
Wind Up Reserve / WF	0	1.11%	

$$HydroUpRes + ThermalUpRes + WindUpReserve + DeficitUp = \mathrm{UP\_REQUIREMENT}$$

Wind Output Comparison	No Reserves	Reserves	Difference
HydroUpRes/ UP_REQ	60.16 %	60.16%	0 %
ThermalUpRes/ UP_REQ	39.74%	37.78%	1.96%
WindUpRes/ UP_REQ	0%	1.96%	-1.96%
DeficitUp/UP_REQ	0.09%	0.09%	0%

$$HydroDwRes + ThermalDwRes + WindDwReserve + DeficitDw = \mathrm{DW\_REQUIREMENT}$$

Wind Output Comparison	No Reserves	Reserves	Difference
HydroDwRes/ DW_REQ	76.80 %	69.61%	7.19%
ThermalDwRes/ DW_REQ	23.14%	20.84%	2.30%
WindDwRes/ DW_REQ	0	9.53%	-9.53%
DeficitDw/DW_REQ	0.05%	0.005%	0.045%

Perfect information case

OUTPUT	No Reserves [GWh]	Reserves [GWh]	Diference [GWh]	percentage %
THERMAL	142036	141656	380	0,27
NUCLEAR	58587	58587	0	0,00
CARBON	27862	27796	66	0,24
CCGT	55550	55254	297	0,53
GAS	36	19	17	46,58
HYDRO	27676	27676	0	0,00
WINDOUTPUT	71949	72329	-380	-0,53
ENS	0	0	0	0,00
Other RES	89339	89339	0	0,00
(DEMAND)	331000	331000	0	0,00

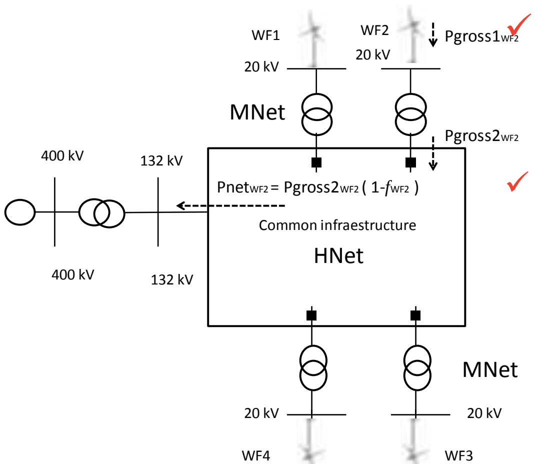
- Economic assessment of the provision of active power control by wind generation (demo # 1 in Spain)

- Economic assessment of the provision of voltage control by wind generation (demo # 1 in Spain)

Voltage control-Losses: Conclusions

- **Quantify the reduction or increase of the power losses within the distribution network**

  - The increase of the losses profile in HNet and in MNet depends on the characteristics of the network evaluated

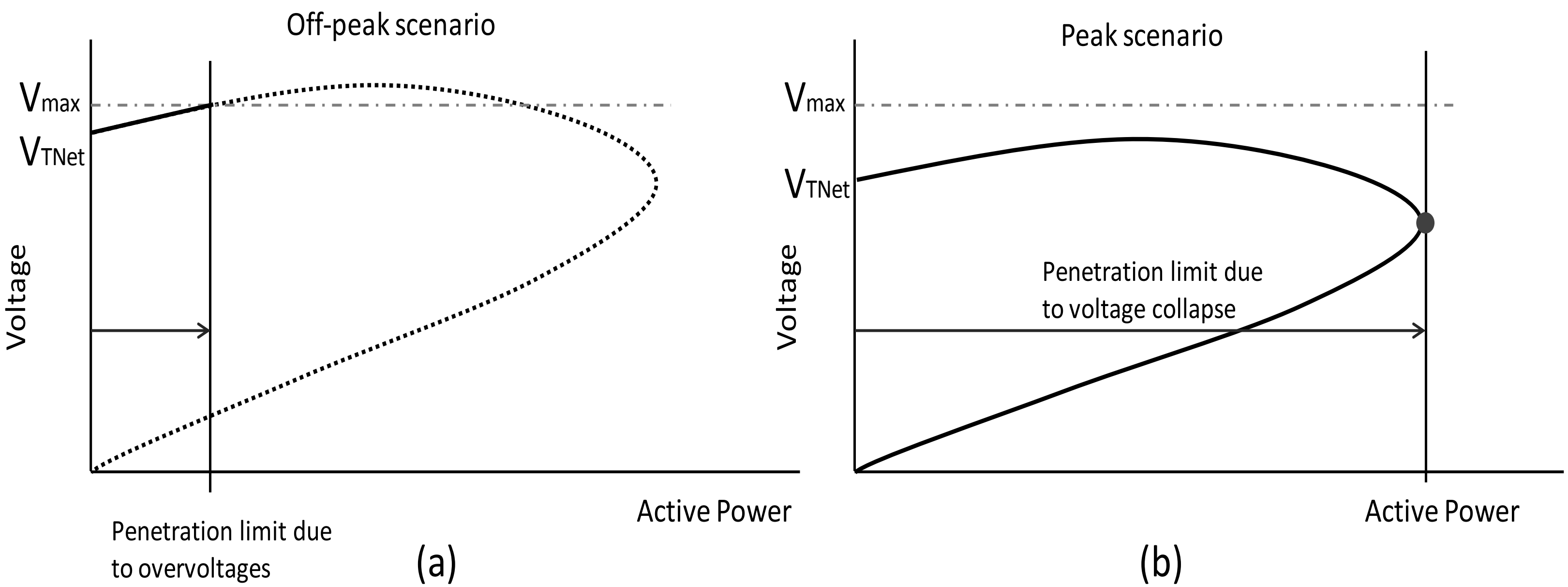


  - ✓ In a distribution network with a significant common infrastructure (HNet) the optimal operation corresponds to wind farms generating reactive power
  - ✓ In distribution networks with a small common infrastructure the optimal operation of the wind farms is that they consume the reactive power generated in their own infrastructure

  - For common distribution networks that allocate wind farms, the loss reduction is **not very significant**.

Voltage collapse curves

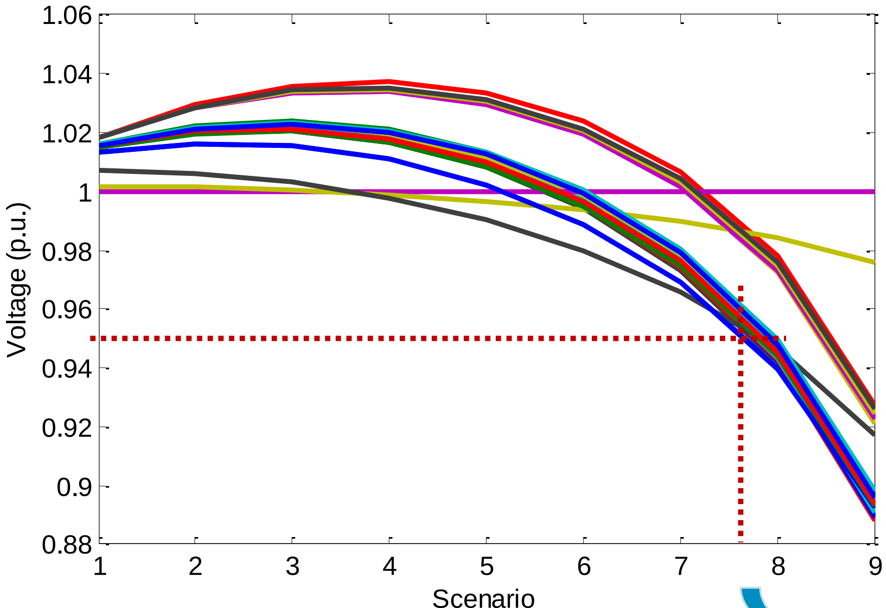
Wind power penetration limits



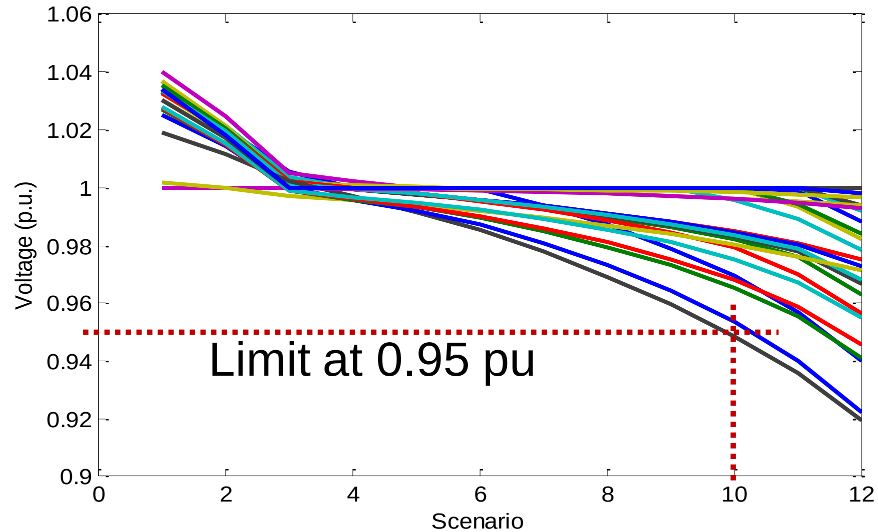
Comparison of the voltage collapse curve

Fuentes del Alcarria $V_{TN} = 1.00$

Without voltage control



With voltage control



Wind Penetration increment
Improves up to 33%

- Economic impact assessment of network flexibility tested in CWE by Elia (demo # 5)

- Economic impact assessment of network flexibility in Spain by REE (demo # 6)

EDF participation in WP15

Main objective

- **Find Economic impact of demo 5**
- **Transit capability of existing transmission network will be enhanced**:
  - The result may be an **increase in the NTC** between neighboring countries
  - The aim of the study is the assessment of the economical balance of this changes (impact on market prices) at a cross-border scale including Benelux, France and Germany

Approach

- **Cost-benefits assessment (CBA)**
- Benefits in terms of « Total Welfare » provided by the DLR vs costs to implement it
- *Only cross-border effects assessed (no internal reinforcements benefits evaluated, only trade effects)*

Cost-benefits assessment (CBA) by EDF

- **Done in a wide European perimeter**
  - Commercial links connect the different zones, with monthly NTC as the maximal power that can be transmitted
- **The demo will provide a function linking NTC and wind**
- **EDF will perform a comparison between 2 cases:**
  - Business-as-usual case without DLR implementation by 2020
  - DLR case: DLR devices are supposed to be widely deployed on French and Belgian networks by 2020

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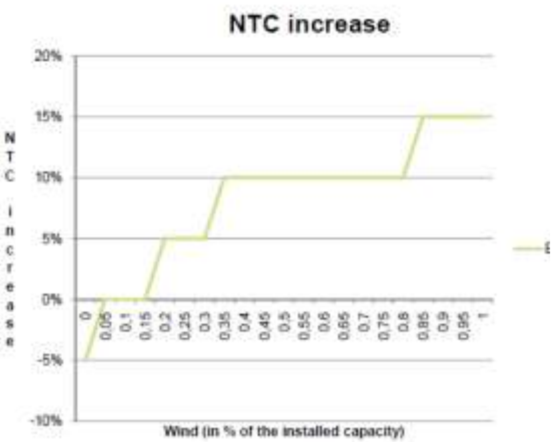
EDF's market model & Elia inputs

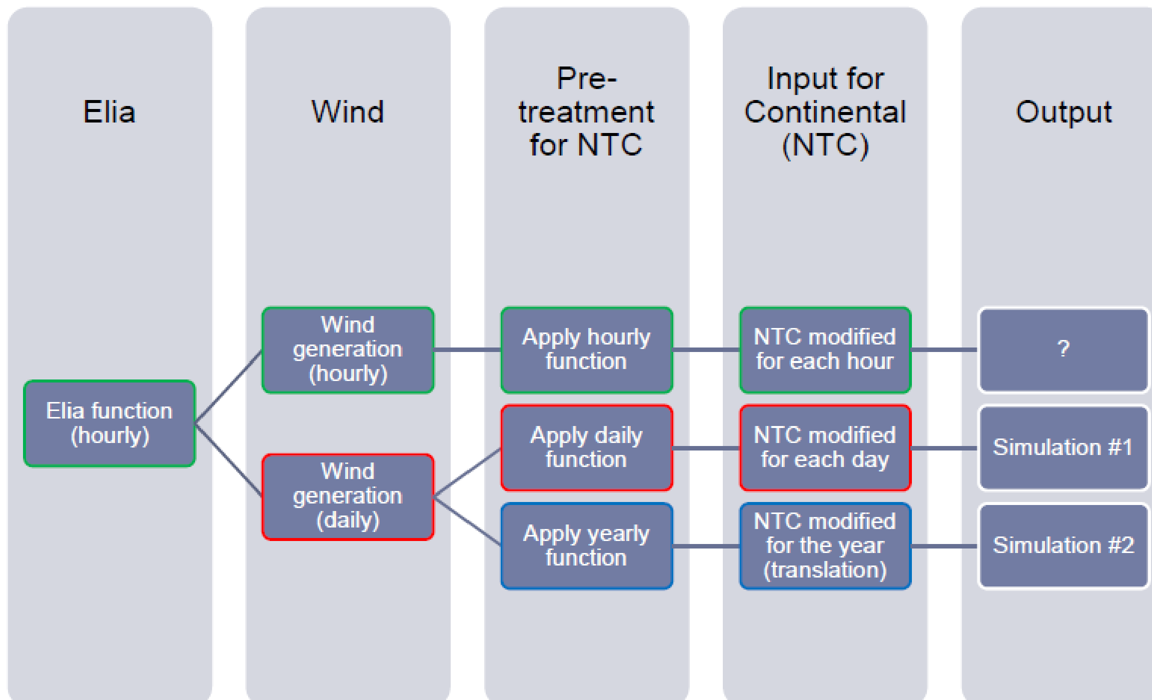
- 81 scenarios corresponding to real experienced weather conditions: various demands, intermittent renewable generation, generation availabilities (contingencies), water inflows > compute monthly value of water

NUMBER OF DIFFERENT TIME SERIES AND RELATED GRANULARITY FOR EACH DATA TYPE USED IN THIS STUDY

Data type	Granularity used in this study	Number of different time series over the 81 scenarios
Fuel costs	monthly	1
Water inflows	daily	27
Pumping reference	daily	1
Generation maintenance	daily	1
Generation forced outage	daily	81
Run-of-river and wind	hourly	27
Cogeneration and biomass	weekly	1
Exchanges with countries outside the perimeter of study	weekly	1
Demand	hourly	27
Net transfer capacities (NTC)	monthly	1

DLR impacts this input





Open question: level of granularity of the NTC profiles

- Economic impact assessment of network flexibility tested in CWE by Elia (demo # 5)

- Economic impact assessment of network flexibility in Spain by REE (demo # 6)

20 20 20 Twenties Transmitting wind

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REE expertise

Wind curtailment characterization

Critical lines' loading 2011→ Overloads

❑When?

- N, N-1 and N-2 (maintenance)
- Demand: peak/valley; summer/winter
- Conventional generation
- Hydro generation (dry/wet)
- Power flows from other areas affecting line loading

❑How often? Number of hours

❑ How much? Energy, power

➢Wind curtailment profile in 2011

Analysis with PSS/E

Wind curtailment computation

Loading analysis for 2011, 2013 and 2020

❑Simulate possible system states (boundary conditions) under which wind may be curtailed

❑For each case, compute the amount of wind curtailment (local wind power that cannot be evacuated due to line overloading)

❑ How wind curtailment is reduced when line capacity limits are increased due to:

- FACTS (line reactance sensitivities)
- RTTR (line capacity sensitivities)

* Wind curtailment profiles changed by FACTS and RTTR

Wind curtailment profiles for 2013 and 2020

❑When?

- Boundary conditions identified by REE
- New conditions depending on the evolution of wind capacity and network extensions within the period 2011-2020 (PSS/E)

❑How often?

- Based on the number of hours of wind curtailment in 2011
- More/less hours depending on the evolution of wind capacity and network extensions within the period 2011-2020 (PSS/E)

❑How much?

- Computed with PSS/E for each situation leading to wind curtailment

❑After the characterization of wind spillages: system economic assessment with ROM

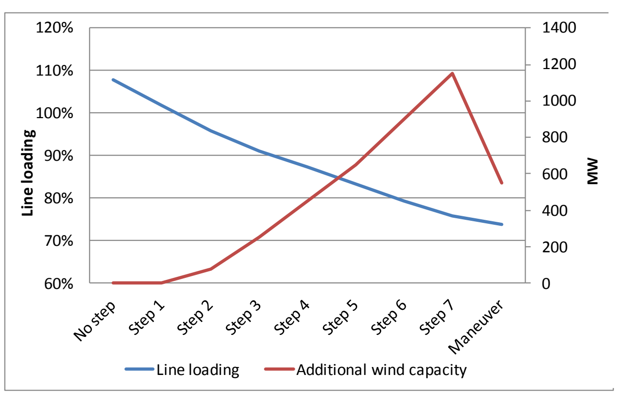
Preliminary analyses for 2011

- FACTS: “Installed” in the 220kV Magallón-Entrerríos line

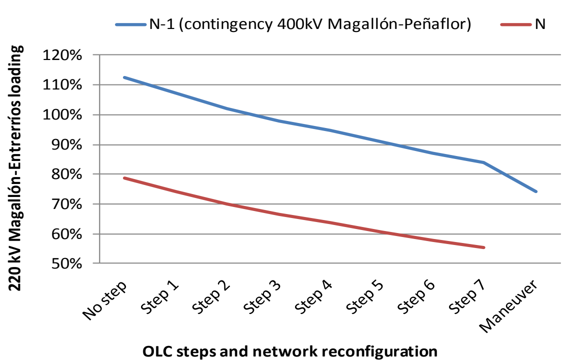
- Data:

  - ✓ 220kV Magallón-Entrerríos line flows in 2011
  - ✓ Maneuvers in the 220kV Magallón substation to avoid line overloading in 2010
  - ✓ PSS/E files of 2011
  - ✓ OLC steps

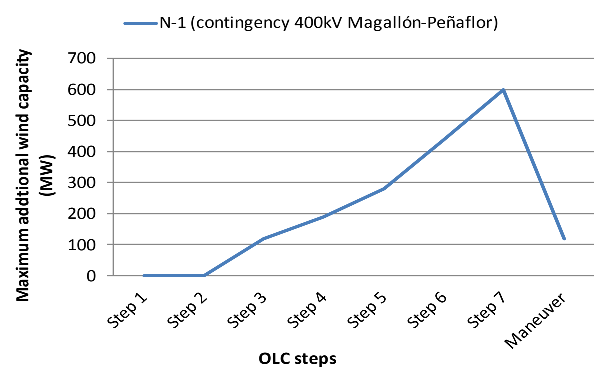
overload



(n-1)



Additional wind



Twenties
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WP 16

Poul Sørensen, DTU Wind Energy

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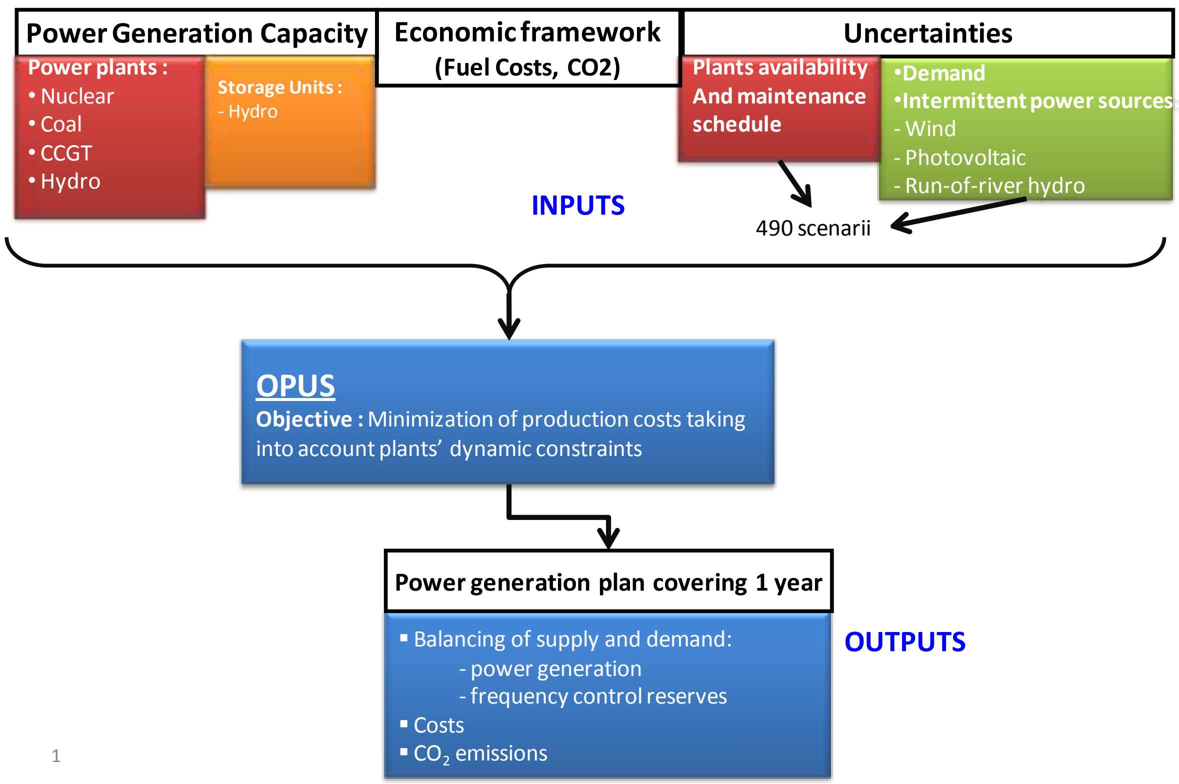
WP16: EU wide assessment of demonstration replication potential

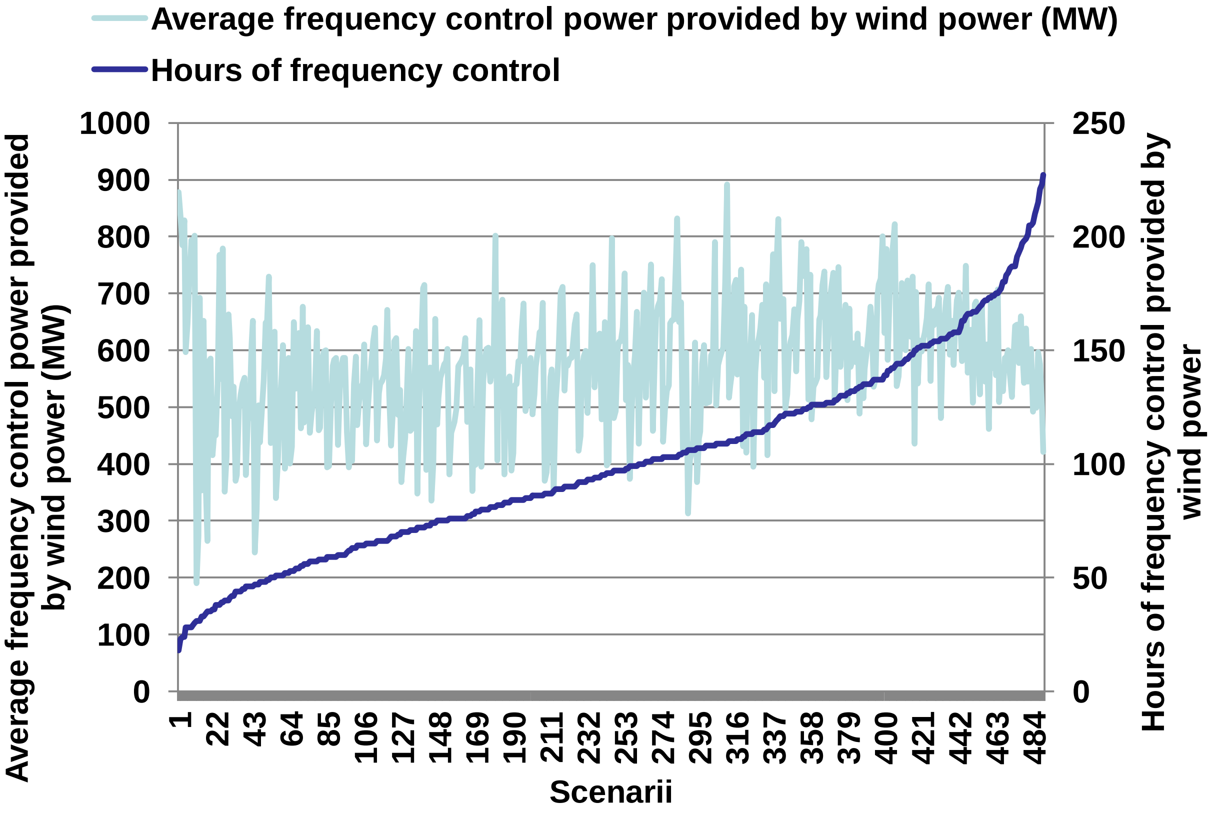
- **Presentation of selected results**
  - **Task force 1:**
    - Frequency control from wind turbines in France (EDF)
    - Ancillary services from wind turbines in Germany (IWES Fh)
    - Economic impact of VPPs in Germany / Spain (IWES, DTU, DONG Energy - Comillas)
  - **Task force 2:**
    - Offshore wind power scenarios (DTU)
    - Hydro potential and grid constraints North (SINTEF)
    - Economic impact assessment (DTU, Energinet.dk)
  - **Task force 3:**
    - Questionaire to ENTSO-E (REE, Elia - Comillas)

Upscaling of demo 1 to France

Unit commitment model : OPUS



First results : Power of frequency control provided by wind power

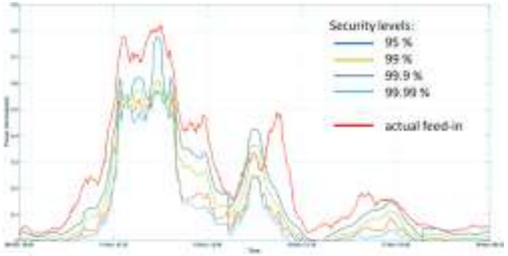


Task force 1 in Germany

Ancillary Services from Wind Turbines

Economic Impact of Control Reserve Provision

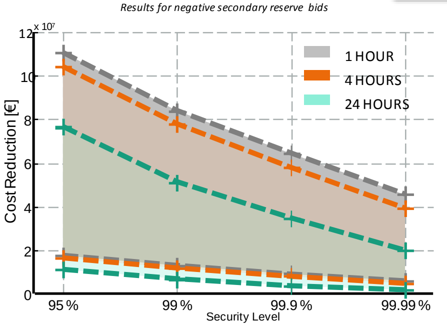
Probabilistic forecast



Offer control reserve

Bid on german control reserve markets (day-ahead)

Economic Impact

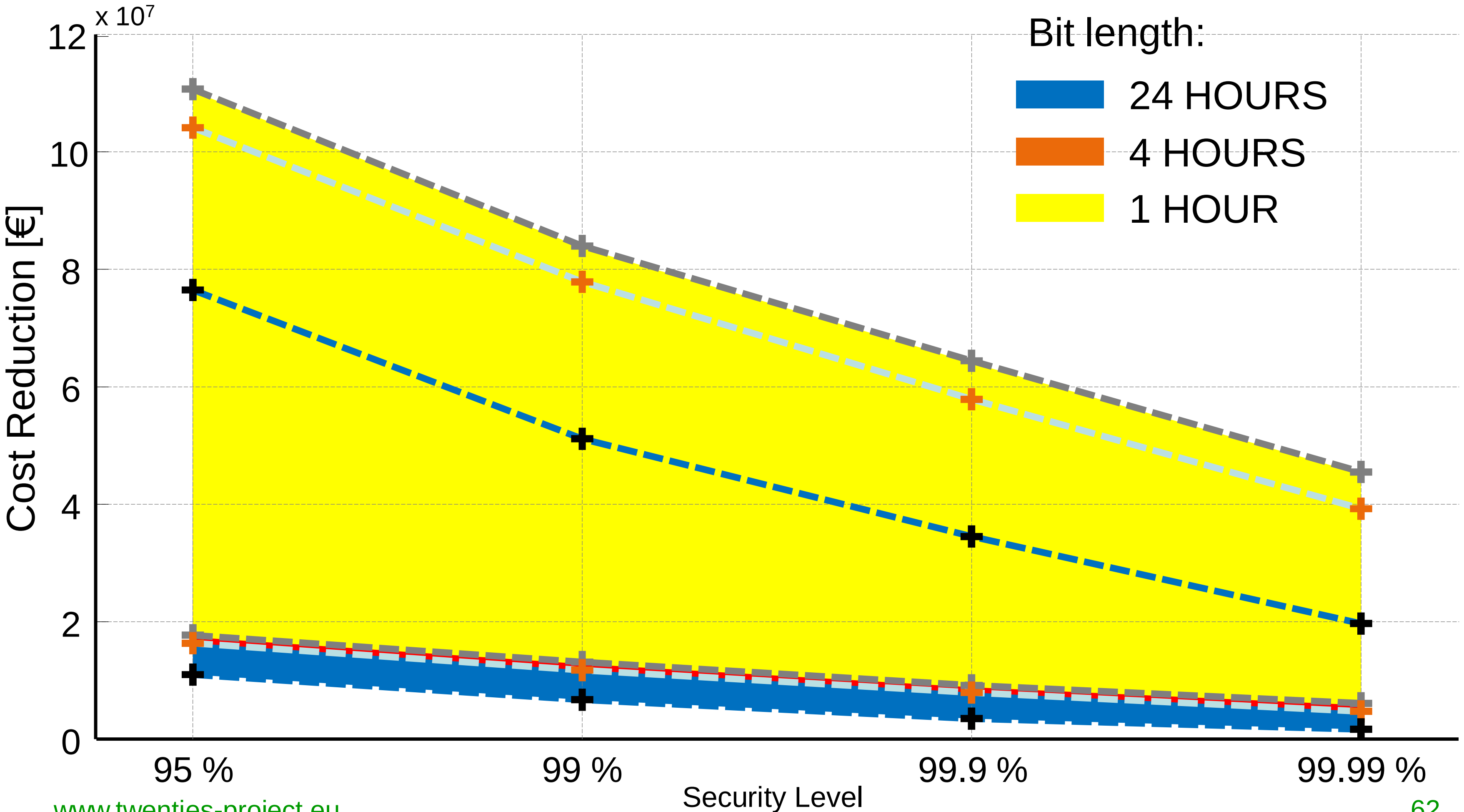


Cost reductions at 99.99 % confidence interval of the offer

- Maximum on secondary reserve markets: 24 % (≈45 Mio. €)
- Maximum on minute reserve markets: 21 %

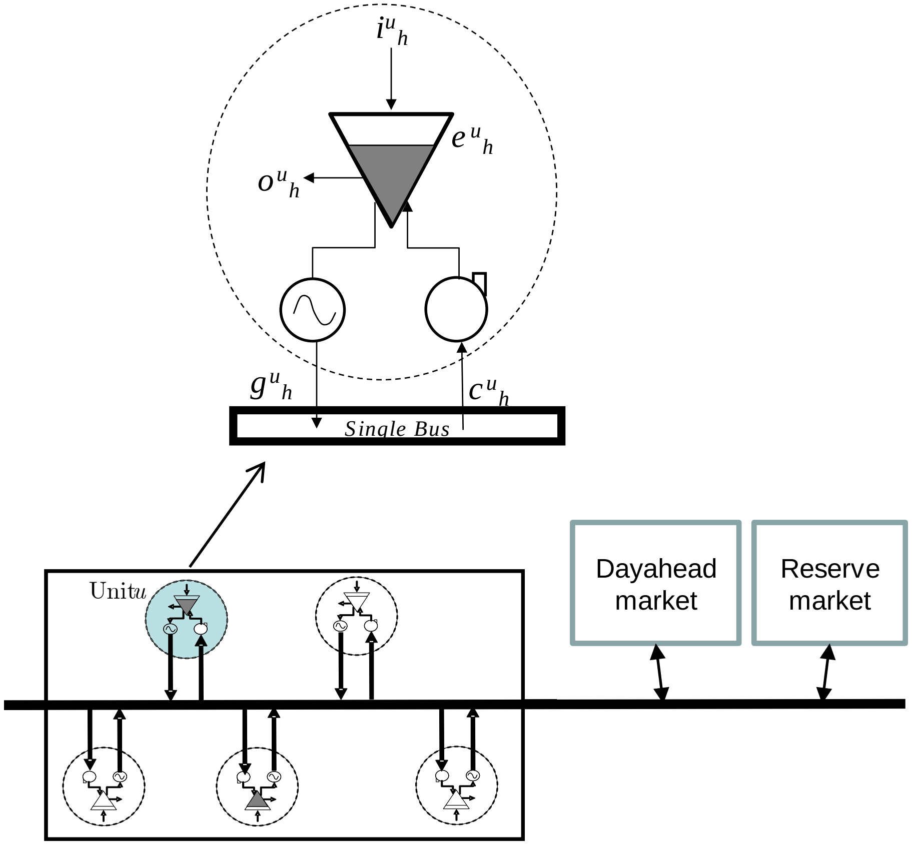
1

Results for negative secondary reserve bids

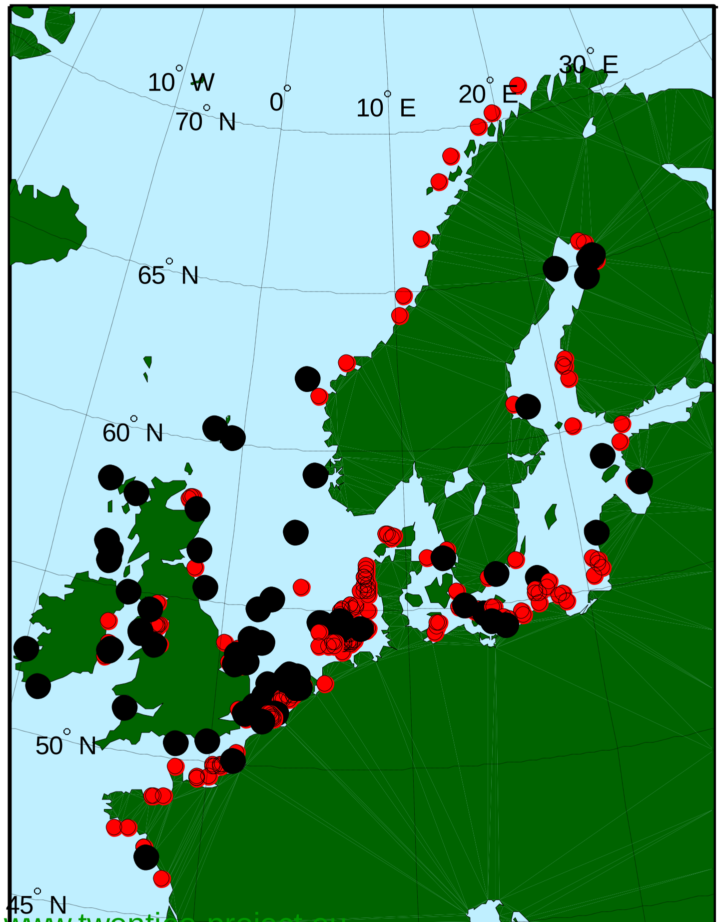


Economic impact of VPPs in Germany / Spain

- **Comillas model of VPP**
- **Impact assessment in Germany using Wilmar**
- **Impact assessment in Spain using ROM**

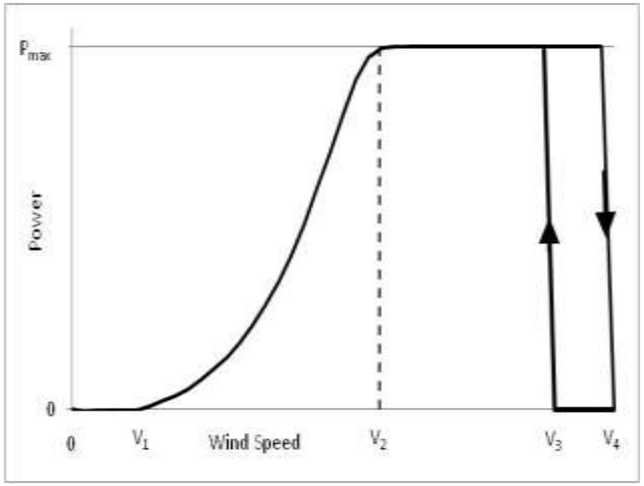


Task force 2+: Offshore wind power scenarios

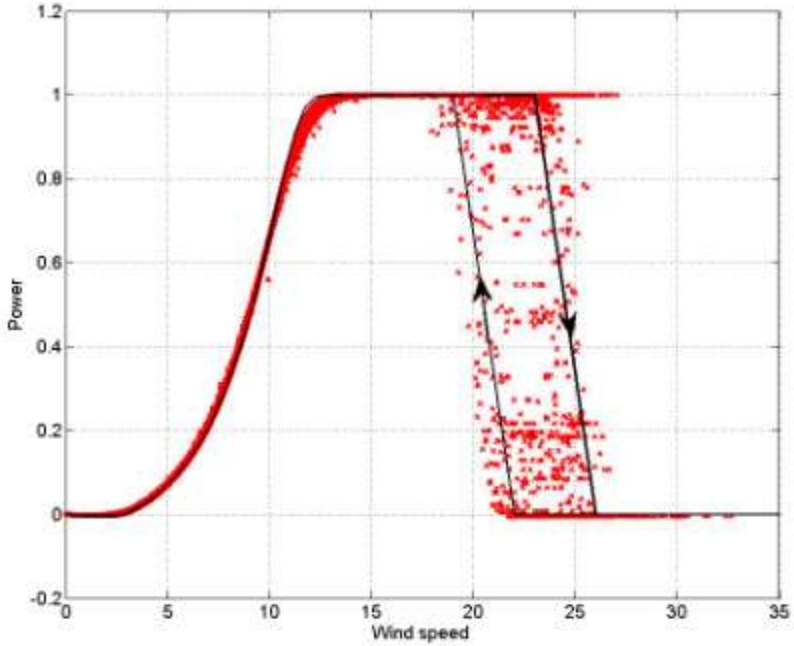


Country	MW installed end 2020		MW installed end 2030	
	Baseline	High	Baseline	High
Belgium	2,156	2,156	3,956	3,956
Denmark	2,811	3,211	4,611	5,811
Estonia	0	0	1,695	1,695
Finland	846	1,446	3,833	4,933
France	3,275	3,935	5,650	7,035
Germany	8,805	12,999	24,063	31,702
Ireland	1,155	2,119	3,480	4,219
Latvia	0	0	1,100	1,100
Lithuania	0	0	1,000	1,000
Netherlands	5,298	6,298	13,294	16,794
Norway	415	1,020	3,215	5,540
Poland	500	500	500	500
Russia	0	0	500	500
Sweden	1,699	3,129	6,865	8,215
UK	13,711	19,381	39,901	48,071
TOTAL	**40,671**	**56,194**	**113,663**	**141,071**

Aggregated wind farm model – original storm controller



wind turbine model



aggregated wind farm model

Task force 2+: Hydro Power Potential

Table 21 Incremental Hydro Potential Scenarios in 2020

Countries	Maximum increased hydro potential (GW)	Scenario 1		Scenario 2	
		Most likely	Optimistic	Most likely	Optimistic
Norway	10	5	10	5	10
Sweden	10	0	0	5	10
Finland	0	0	0	0	0

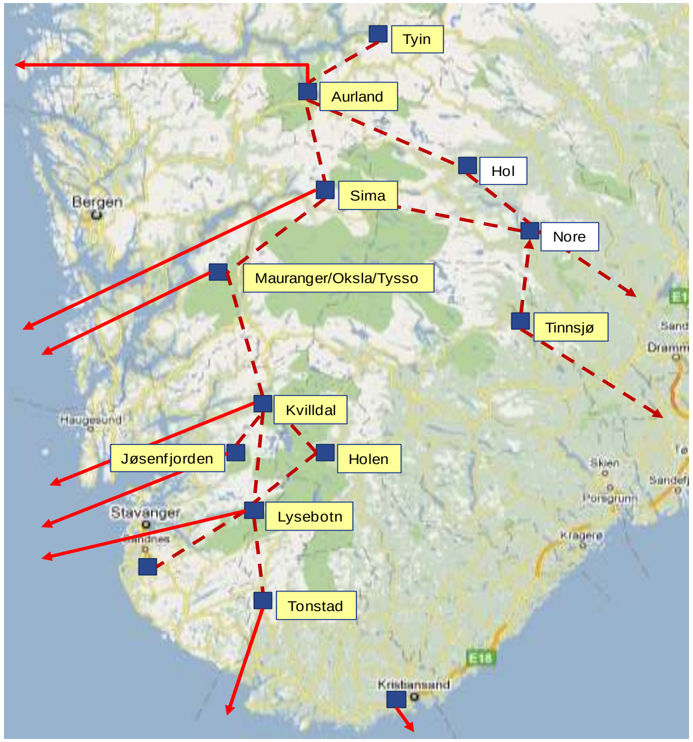
Table 22 Incremental Hydro Potential Scenarios in 2030

Countries	Maximum increased hydro potential (GW)	Scenario 1		Scenario 2	
		Most likely	Optimistic	Most likely	Optimistic
Norway	20	10	20	10	20
Sweden	20	0	0	10	20
Finland	0	0	0	0	0

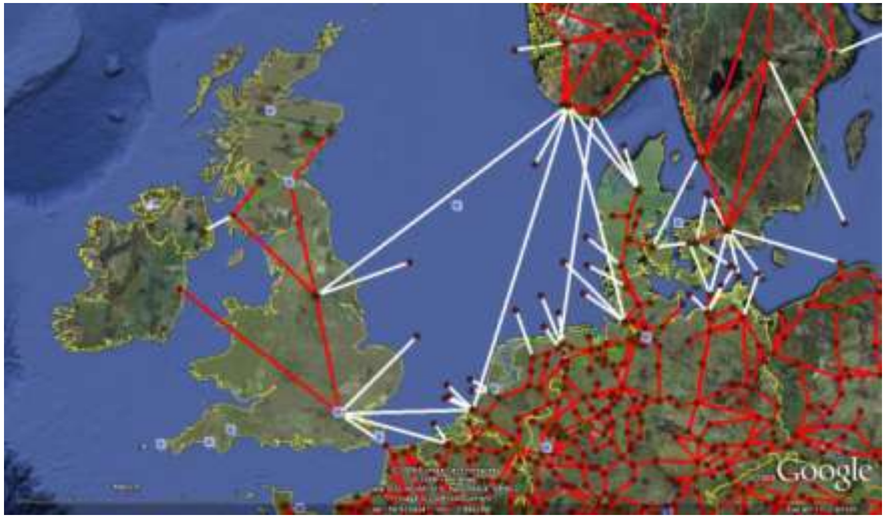
Plant	Most likely (MW)	Optimistic (MW)
Pump Storage Plant Tonstad	1400	1400
Pump Storage Plant Holen	700	1000
Pump Storage Plant Kvilldal	1400	2400
Power Plant Jøsenfjord	1400	2400
Pump Storage Plant Tinnsjø	1000	2000
Pump Storage Plant Tinnsjø	1400	2400
Power Plant Lysebotn	400	1800
Power Plant Mauranger	-	400
Power Plant Oksla	700	700
Pump Storage Plant Tysso	700	1000
Power Plant Sy-Sima	700	1000
Power Plant Aurland	700	700
Power Plant Tyin	700	1000
Amount of new power capacity	**11200**	**18200**

Grid Implications of Hydro Power Flexibility in Norway

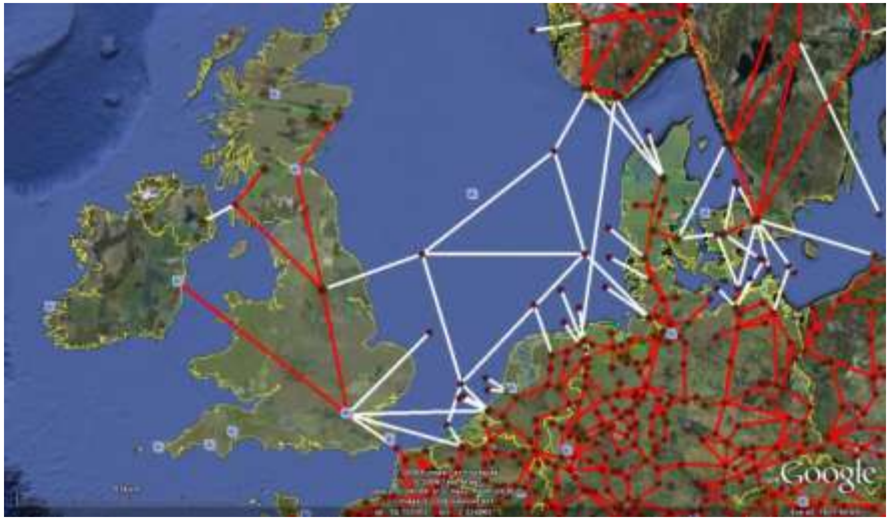
(WP16.2.3: Grid Implications)



Offshore grid topologies



radial



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Task force 2+: Economic impact assessment

- **Tasks**
  - **Compare socio-economics of North European offshore wind power with**
    - original and new wind turbine storm controls
    - 2020 and 2030 – baseline and high wind cases
    - 2020 and 2030 hydro potential
- **Tools**
  - **WILMAR for Europe – to simulate the power system commitment and dispatch with 1 h time steps**
  - **CorWind – to simulate wind power variability**
  - **+ Simba for Denmark – Energinet.dk tool simulating the operation within the hour with 5 min time steps**
- **Outputs (expected)**
  - **Energy cost / emission savings due to new storm control**
  - **Reserve requirements in Denmark with old and new controls**

Upscaling of task force 3

- Upscaling in Spain in WP15 (Comillas)
- Questionaire to ENTSO-E (REE, Elia - Comillas)
- Contact to EDF re. WP15.7 (Economic impact of demo 5 in CORESO)

Twenties
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WP 17

Optimising planning and permitting
for Offshore Interconnectors

Jos Spits.TenneT TSO

ENERGINET/DK

TenneT

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Optimising planning and permitting for Offshore Interconnectors

- ❑Recent offshore interconnector projects
- ❑Barriers for offshore interconnectors
- ❑Objectives WP17
- ❑Method WP17
- ❑Preliminary findings and conclusions WP17
- ❑Results WP17

Recent offshore interconnectors projects

North Sea and Baltic Sea

1. Shore to shore interconnectors
2. Farm to shore connectors
3. Combined solutions (e.g. COBRAcable)

WP17 -Virtual projectcase TRIFFID

- *Three-leg interconnector NL-DE-DK*
- *Wind tee-in*

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Barriers for offshore interconnectors

Risk factors for planning and permitting of interconnectors seem:

Timeline overruns…

- **No timely consent from all authorities**
- **Transnational coordination is lacking**
- **Research scope is unsettled**

Budget overruns…

- **Route length increases when detouring restricted areas**
- **Additional surveys**

Internal projectmanagement…

- **Dedicated project teams (highly complex projects)**
- **Involvement of management**

Objectives WP17

Optimising the planning and permitting for offshore interconnectors

Goal = Strengthening predictability of consenting and making processes leaner

Improving <u>efficiency</u> of projects: 20% reduction in cost and time

Interconnectors projects applying best practices will have a 20% reduction of costs and time for planning and permitting

Improving <u>effectiveness</u> of projects: 30% of permits improved

Best practices are targeting 30% of the number of permits and consents for new licensing of interconnectors.

Method WP17

Three result areas:

1. Analysis of recent European practices for spatial planning and permitting for offshore interconnectors (D.1)
2. Case study on three-legged offshore interconnector TRIFFID with possible wind tee-in (D.2)
3. Best practice recommendations for spatial planning and permitting (D.2)

Research components:

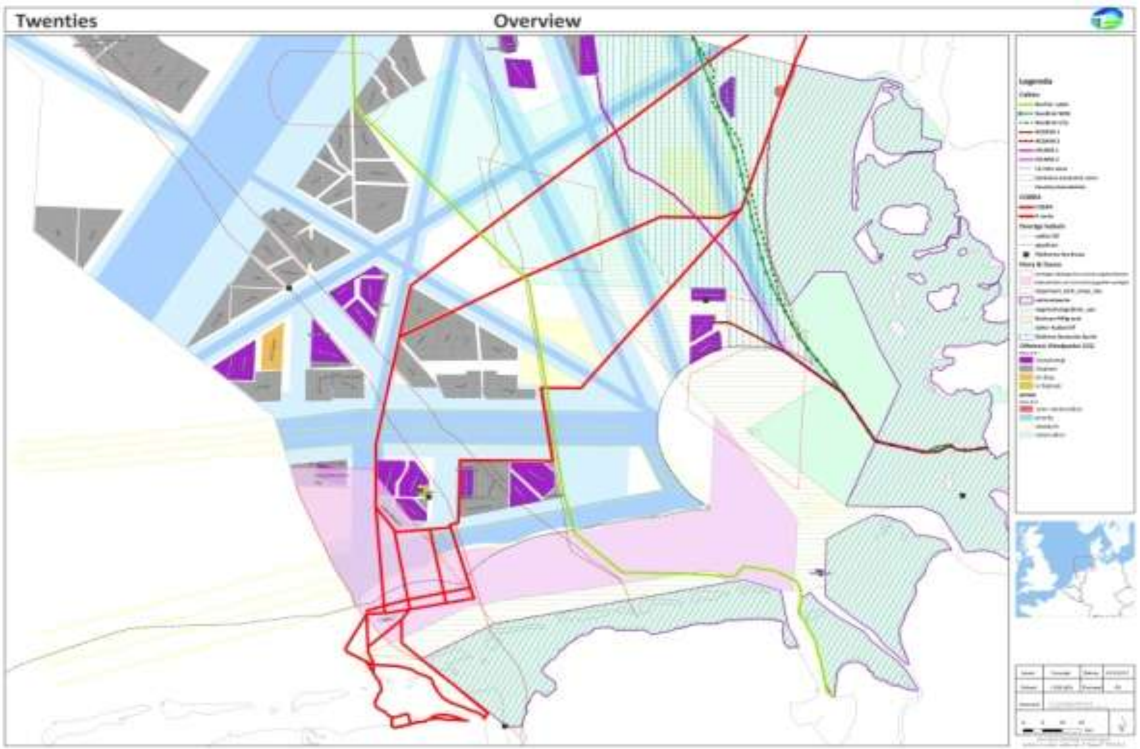
A. Public acceptance / stakeholder management

B. Test case interconnector with multiple landing points and linking up wind farms

C. Regulatory issues / market models

D. Review on European consenting studies

WP17 - Virtual projectcase TRIFFID



Simulating:

- ❑Planning and permitting
- ❑Regulation and business case
- ❑Market models and operations

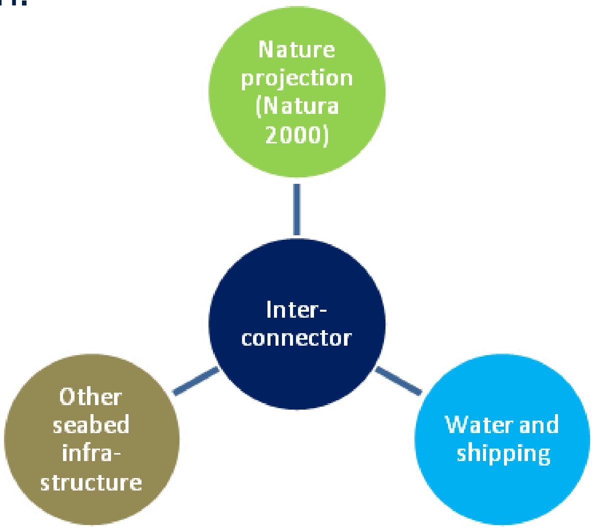
Virtual Triffid case based on COBRAcable interconnector between the Netherlands and Denmark, and Sylwin 1 connector to offshore wind farm in German waters

Preliminary findings and conclusions WP17 (1)

1. Coordinating overall cable route evaluation

Transnational cable routes are subject to partial evaluation of route sections at fairly local level.

WP17 recommends that cooperation agreements with and between national planning authorities are entered to facilitate overall and holistic evaluation of cable route design.



Mediation with competing sea users, primarily nature conservation, shipping interest and other infrastructures

Preliminary findings and conclusions WP17 (2)

2. The EIA is a transnational reference

The Environmental Impact Assessment is applied by all planning authorities and may serve as a common skeleton.

WP17 recommends that a common road map for EIA studies is applied with shared practices for scoping of studies and documentation.

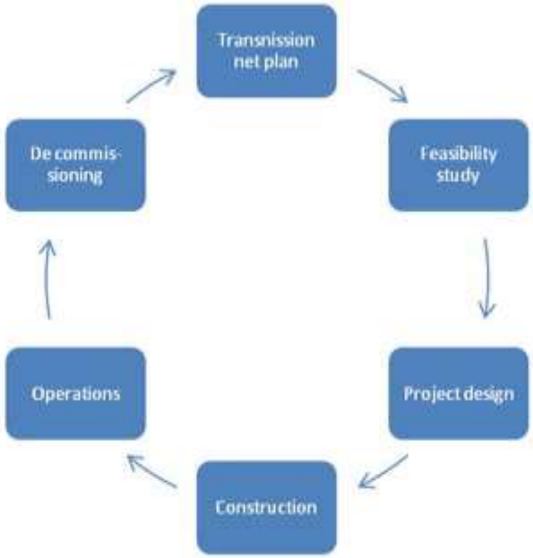
Note that impacts from cable installation and operation seem fairly limited. Up to date cable installation disturbs less than a meter band in the seabed.

Preliminary findings and conclusions WP17 (3)

3. Best available technology as reference

The cable technologies and impacts are very similar from the one project to the other. In practice there is a lot of repetitive work when preparing documentation for planning consents.

WP17 recommends that best available technologies are nominated by a transnational body.



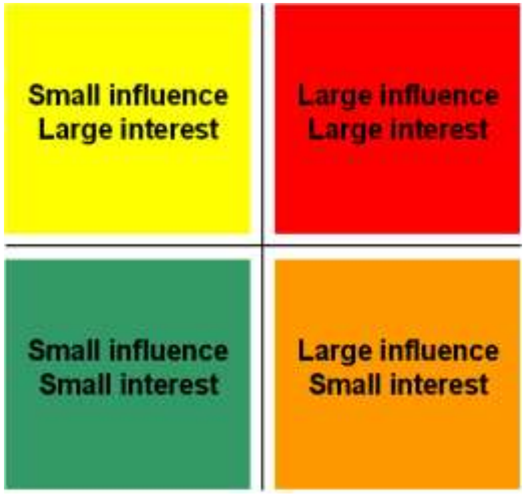
Flow chart of interconnector planning and implementation

Preliminary findings and conclusions WP17 (4)

4. Benefits of interconnectors are to be recognised against competing interests

The socio-economic justification of interconnectors is weak when balancing with Natura2000 sites, shipping and other sea uses.

WP17 recommends that interconnectors need to be recognized as vital infrastructure for renewable electricity.



Matrix of statutory and other stakeholders

Preliminary findings and conclusions WP17 (5)

5. Early screening of route design is preferable

Maritime spatial plans with corridors and gates for preferential use may partly serve as tool for cable routing.

WP17 recommends that, next to master plan for offshore grids, also tools for mediating and possibly acceptance of routes in restricted zones are necessary (co-existence with other sea uses).

Results WP17

Towards a new (regional) planning and permitting concept

- Public affairs
- Planning and permitting
- Regulatory issues

Deliverables

- Thematic guidelines / good practice cases on subsea cable development and consenting
- Test case interconnector project TRIFFID with multiple landing points and wind farm link-up as prelude for an offshore grid.

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