DEMO4: STORM MANAGEMENT

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EWEA 2011 BRUSSELS
EUROPE'S PREMIER WIND ENERGY EVENT
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Demo 4 STORM MANAGEMENT (Leader: Energinet)

Main objective

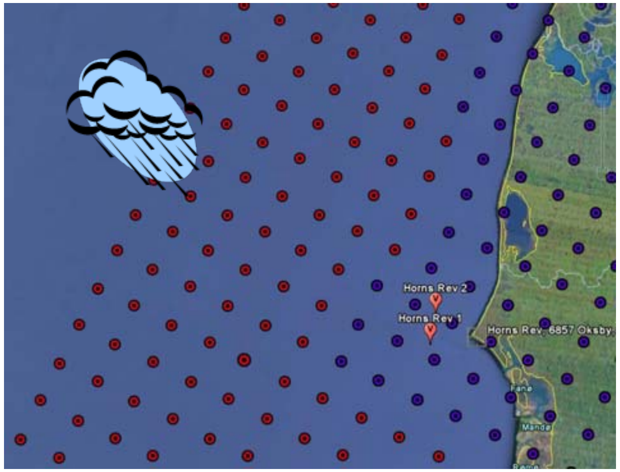
- Demonstrate shut down of wind farms under stormy conditions without jeopardizing safety of the system

Approach

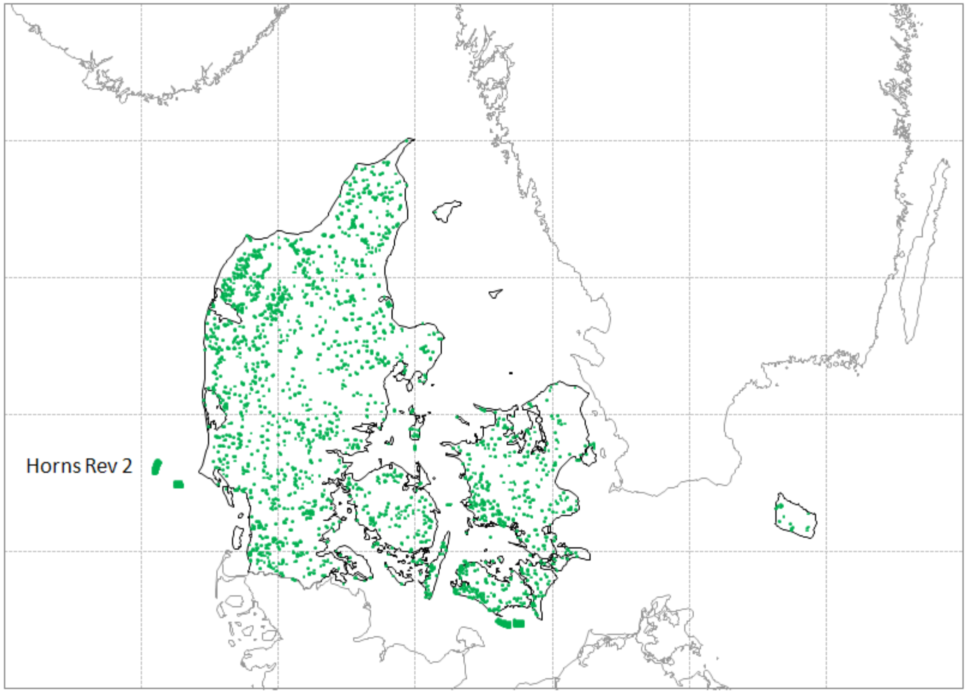
- Horns Rev 2 (200MW)
- Flexible turbine control
- Storm front forecasts
- Investigate cost of changed production associated with the planned down regulation
- Coordinate wind farm control with HVDC interconnector control and with hydro power plant operation

Wind power

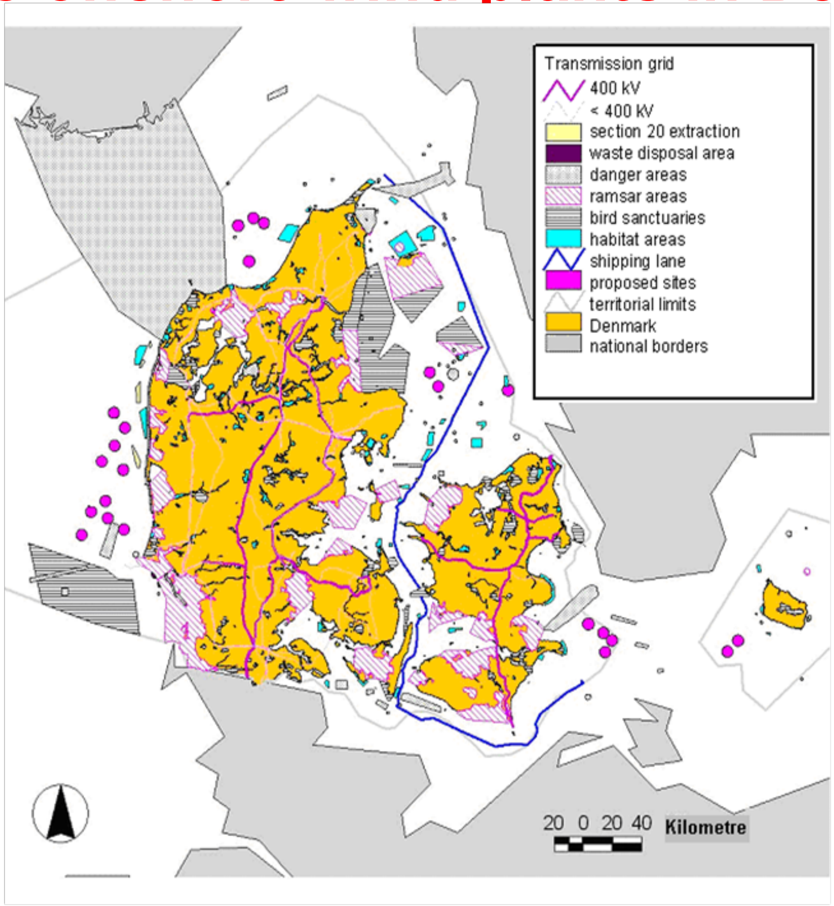
Hydro power



Present wind turbines in Denmark



Possible offshore wind plants in Denmark (23 x 200 MW)



Strategies

- Two possible strategies:
  - Manual control
  - Automatic control

- Manual control involves:
  - Wind speed forecasting
  - Wind power forecasting
  - System imbalance forecasting
  - Regulating power

- Automatic control involves:
  - New controller in the turbines
  - Automatic imbalance control

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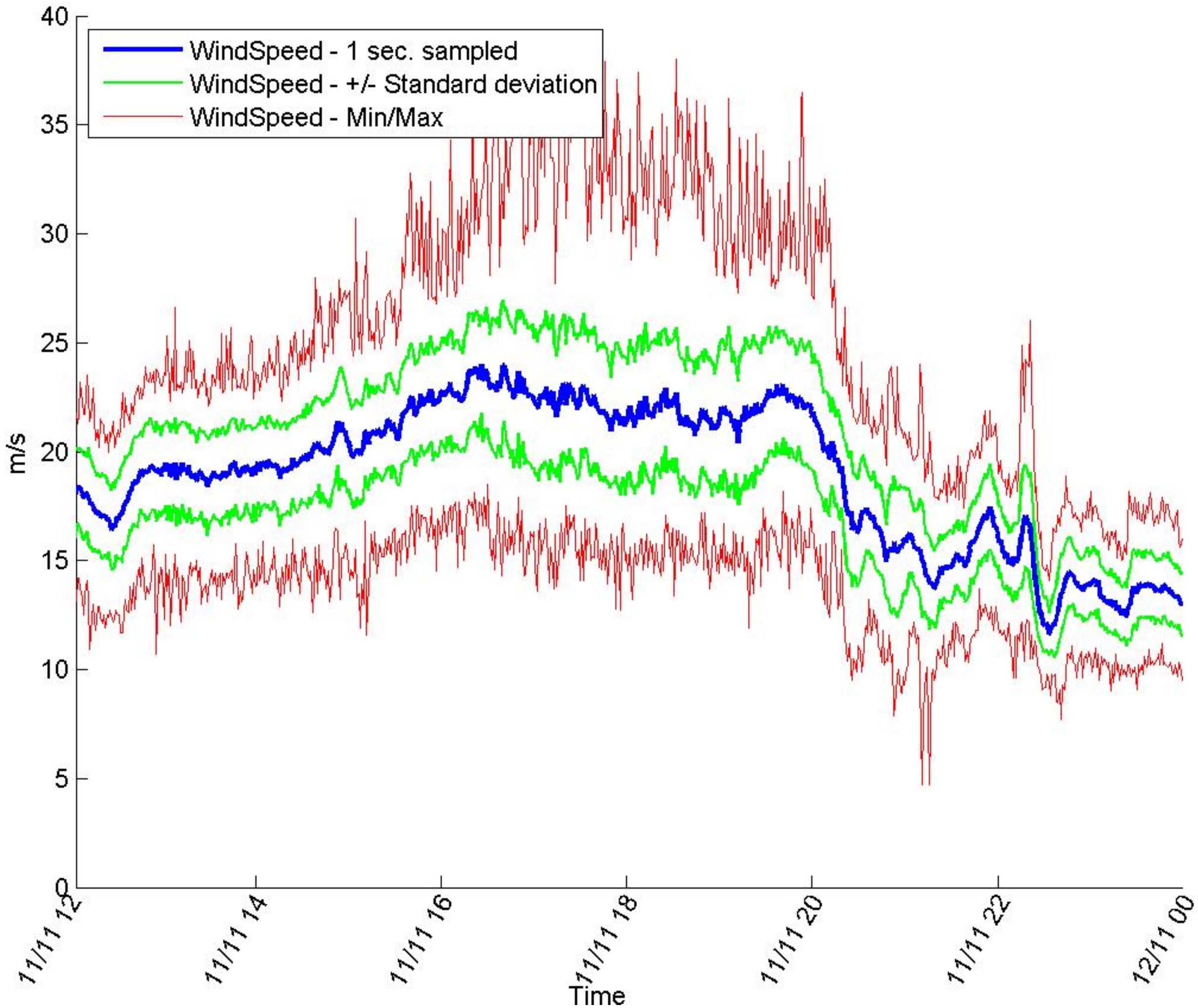
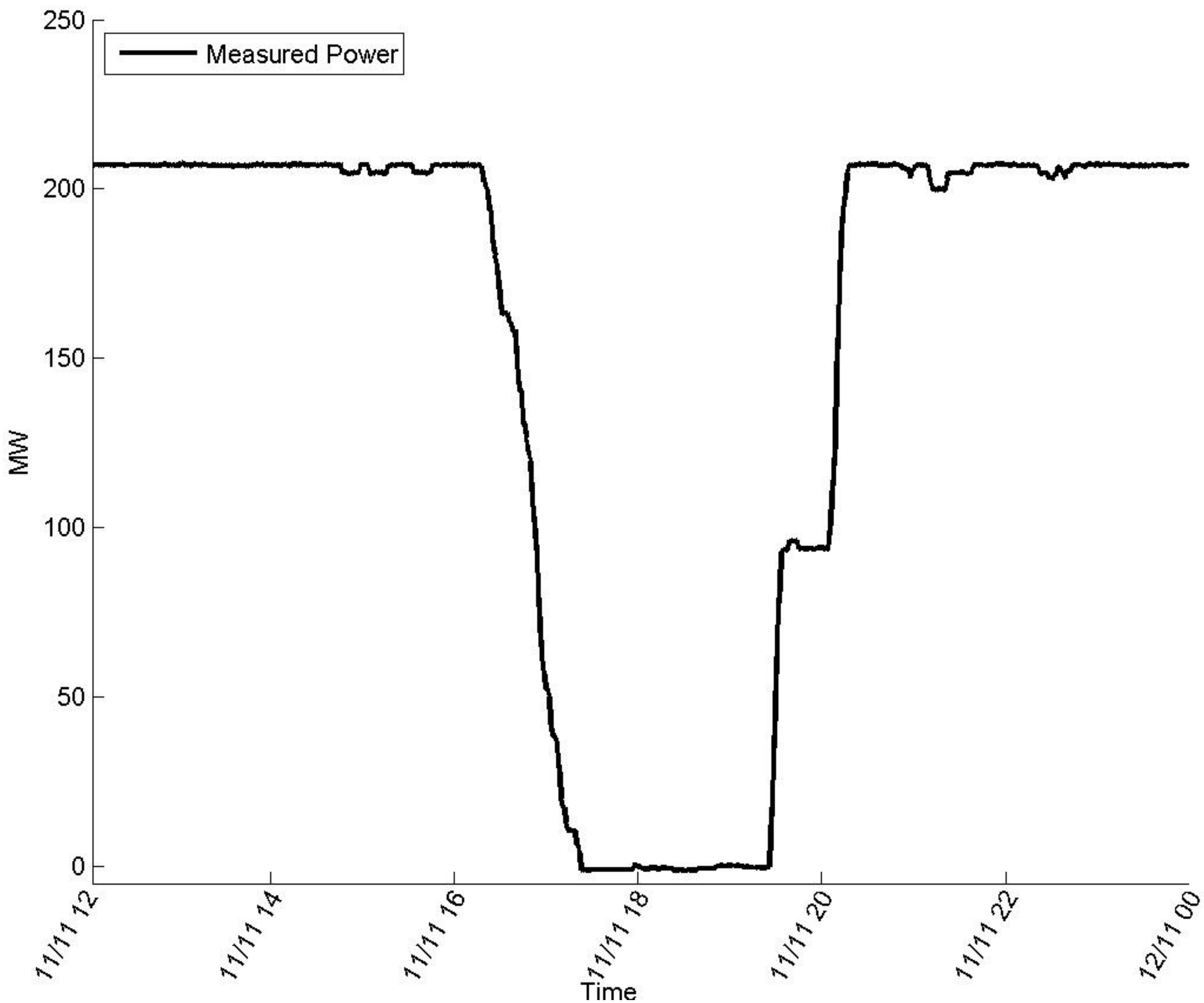
Wind speed – statistics of 91 wind turbines

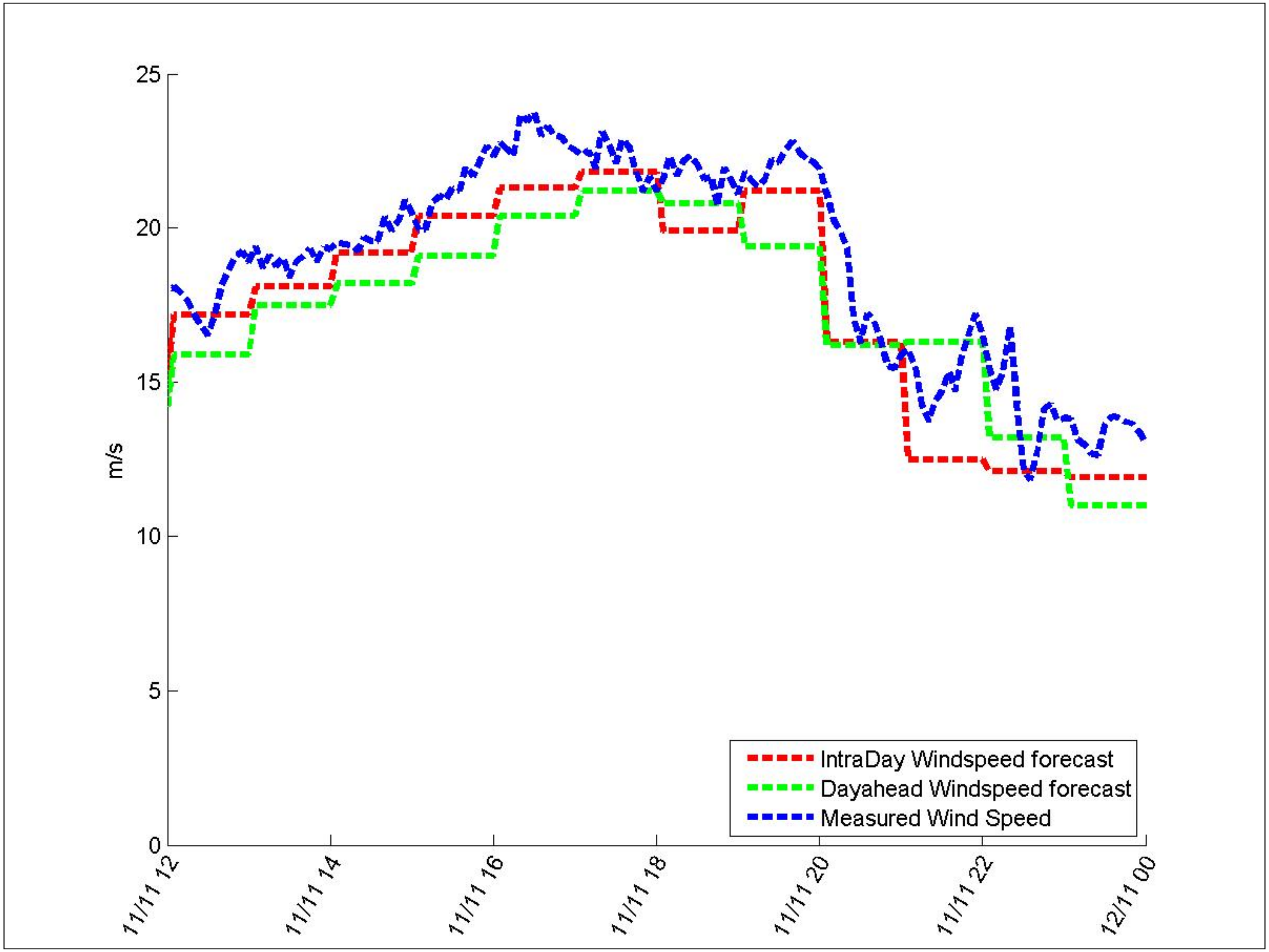


Wind power



Measured Power
250
200
150
100
50
0
MW
11/11 12
11/11 14
11/11 16
11/11 18
11/11 20
11/11 22
12/11 00
Time

Wind speed forecast



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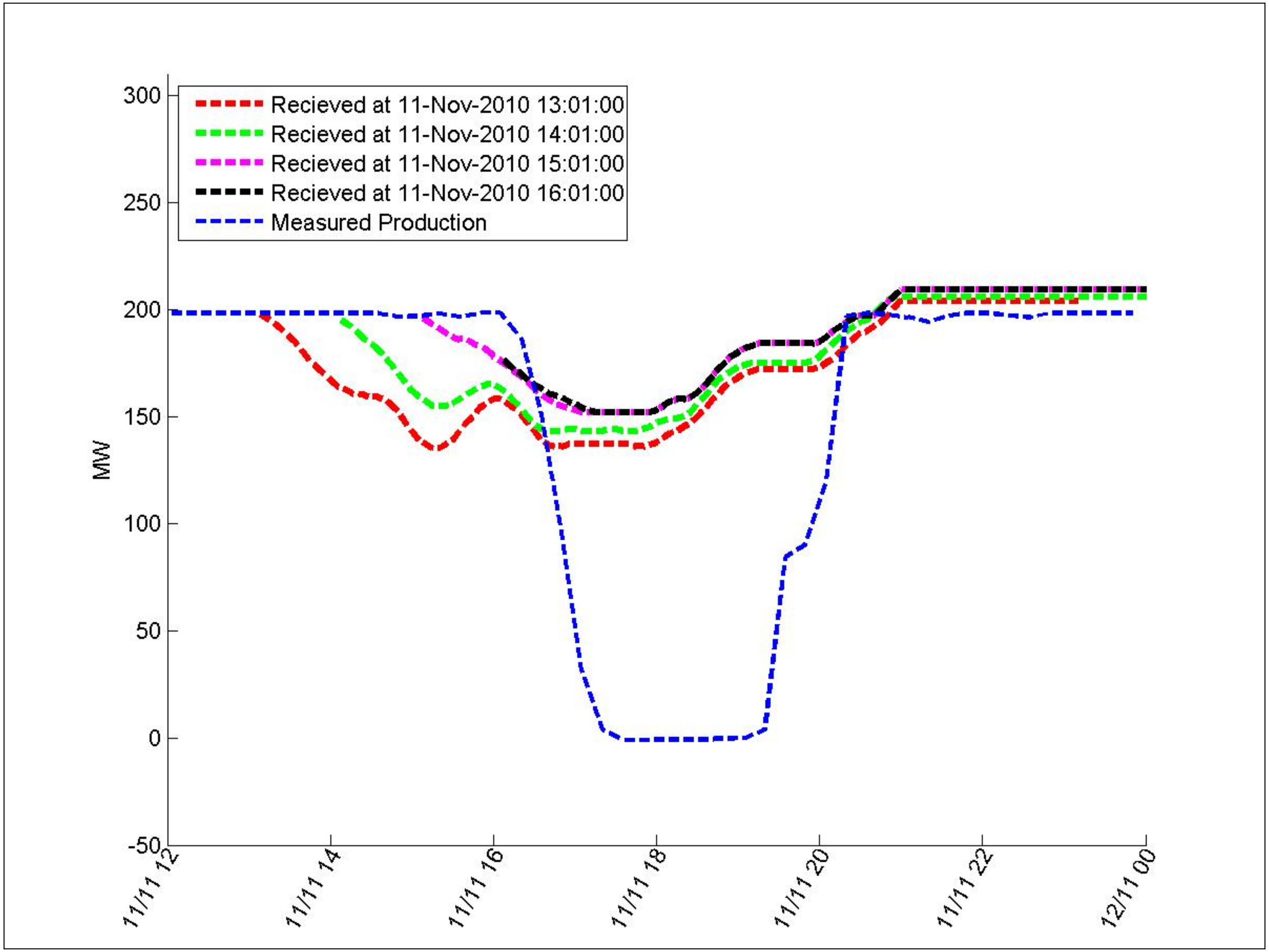
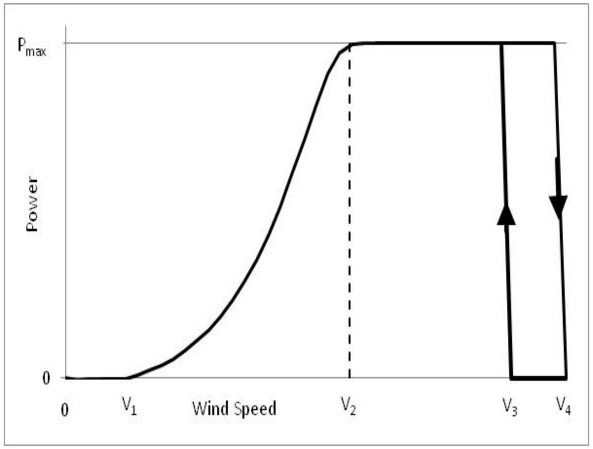
Wind power forecast



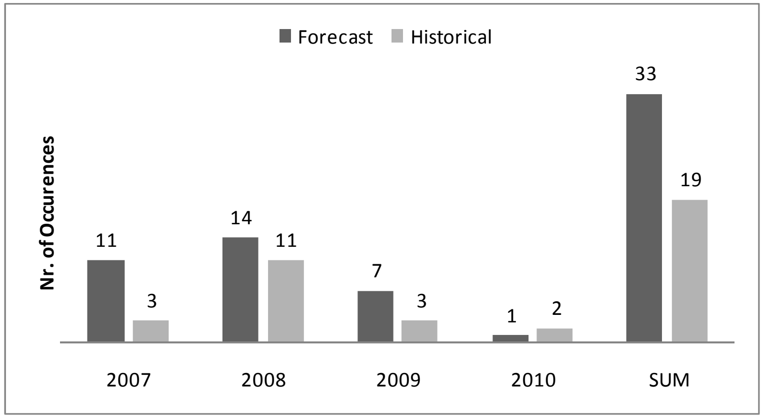
Definition of Extreme Wind Period (EWP)

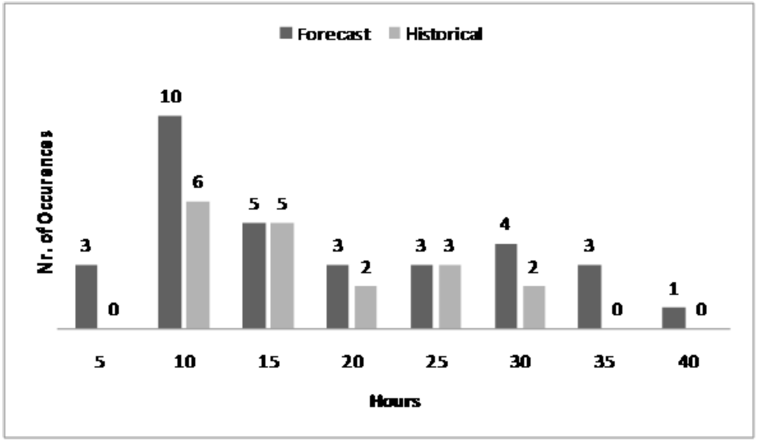
- **Wind speeds:**
  - **v_1: cut-in wind speed**
  - **v_2: rated wind speed**
  - **v_4: cut-out wind speed**
  - **v_3: high wind reconnection wind speed**
- **EWP for single turbine**
  - **Starts when $v > v_4$** (typically 25 m/s)
  - **Ends when $v < v_3$** (typically 20 m/s)
- **EWP for wind power plant (wind farm)**
  - **Starts when half of wind turbines are cut-out** (typically at wind farm average 22.5 m/s)
  - **Stops when half of wind turbines are re-connected** (typically at wind farm average 18 m/s)



Statistics of Extreme Wind Periods (EWPs)

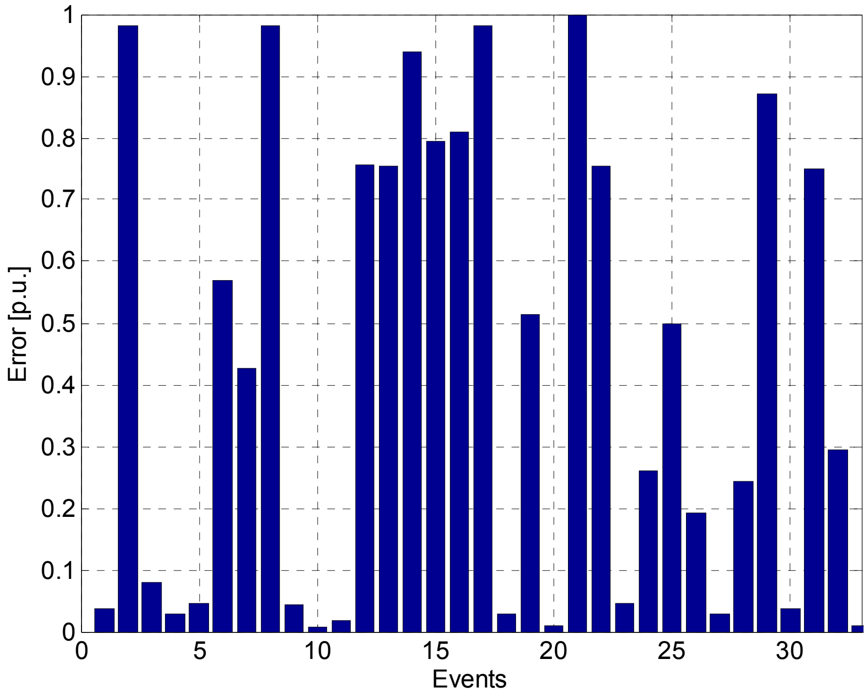
- Ideally, purpose is to compare actual and forecasted wind speeds
- Difficult to provide sufficiently long period of data
- Forecasts are from Energinet.dk
- Historical data would ideally be measurements, but are re-analysis performed with Weather Research and Forecasting (WRF)-model
- Grahps show 100m height (10m data much better agreement, but less relevant)





KPI: worst case forecast error

- **Maximum absolute power prediction error for each Extreme Wind Period (EWP)**



Conclusions

- New turbine controller will be developed
- Improved actions based on wind power forecasts will be developed
- Potential of Norwegian Hydro
- Impact from storm in Danish (UCTE) and Nordic system
- Correlation of storms in the regions will be assessed

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DEMO5: NETFLEX

NETWORK ENHANCE FLEXIBILITY

Jacques Warichet, ELIA

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Overview

- Aims of DEMO 5
- Impact of additional wind generation
- Methods & Present State of Progress
  - Dynamic Line Rating
  - WAMS
  - Smart Power Flow Control
- Conclusion

Aims of NETFLEX (1)

- Network Enhanced Flexibility
  - Demonstration at a regional level (CWE, Central Western Europe)
    - Determine how much additional wind generation can be handled in the coming hours/day(s)
      - Increased capacity provided by DLR (Dynamic Line Ratings)
      - Improved coordination of controllable devices (PSTs & HVDCs)
    - Considering stability issues using WAMS
    - Win-win Market & TSOs

PST=Phase Shifter Transformer
HVDC=High Voltage Direct Current *connection*

Aims of NETFLEX (2)

- Network Enhanced Flexibility
  - Demonstration at a regional level
  - Collection and sharing of knowledge
    - Operation of the future transmission networks
    - How to increase the utilization of network capacity
    - How to increase the utilization of controllable devices
    - Good operating practices for network stability
    - Use-cases for advanced network management tools

PST=Phase Shifter Transformer
HVDC=High Voltage Direct Current *connection*

Additional Wind Generation

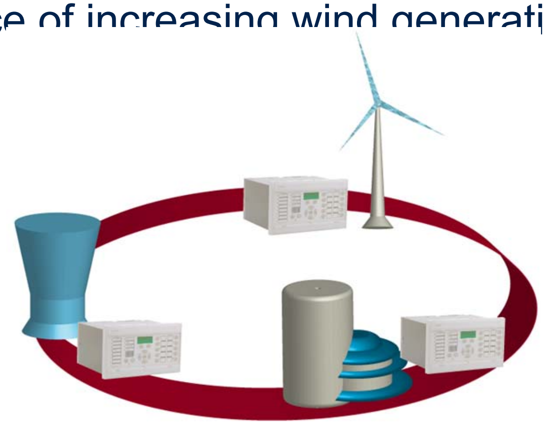
- Volatility of wind generation is the main new operational issue faced by TSOs
  - Real-time and ST-planning (determining market capacities)
  - Impact on reserves (demonstrated by demo 1)
- More flexibility demanded from the system while maintaining the same level of security
- Wind is not always bad for the grid
  - Lines are better cooled
  - Significant gain in transmission capacity

Dynamic Line Rating (DLR)

- 10 Ampacimons
  - Installed in the Elia grid
  - Monitoring of line capacities (ampacities)
- An Ampacity Forecasting Model
  - To be developed on observations and wind forecasts
  - Forecasting line capacity
    - Not only for equipped line
    - Also for others in the vicinity and further away

Wide Area Measurement System (WAMS)

- 3 Phasor Measurement Units (PMUs)
  - Under installation in France & Belgium
  - Used together with existing PMUs
  - To monitor the stability margin of the system
- Good Operating Practices
  - Using a Dynamic Model and experience feedback
  - In order to maintain system stability in the presence of increasing wind generation

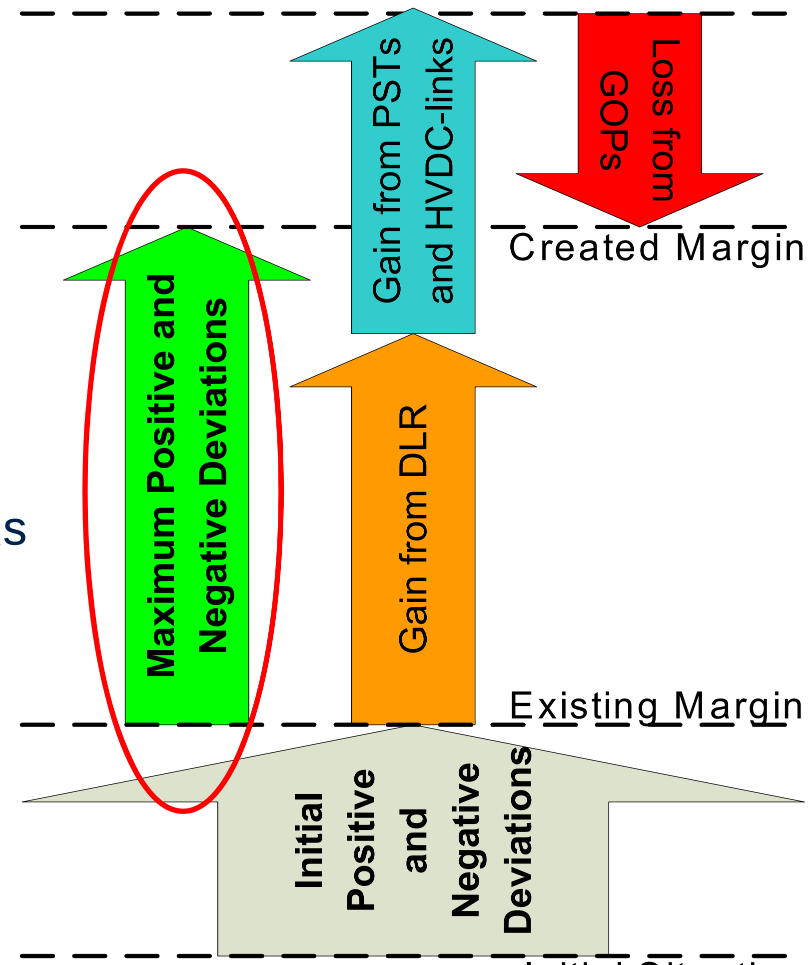


Smart Power Flow Control (Smart-PFC)

- Coordinated use of PSTs and HVDCs
  - On international basis using a Smart-PFC tool
    - Sliding-window of 24 hours (forecast)
    - Considering
      - Real-time and forecasted capacities estimated by Ampacimons
      - GOPs determined using WAMS
- Assess available margin for additional wind generation
  - For each technology
    - Gain from DLR
    - Gain from PSTs+HVDCs
    - Possible loss from GOPs

Conclusion

- Already now managing wind uncertainty
- Additional wind integration
  - Gain from DLR
  - Gain from optimising the coordination of PSTs and HVDC links over the region
  - Loss from stability constraints
  - Gain from the set of technologies
- Target: 10% more wind integration with existing grid



DEMO6: FLEXGRID

INCREASE GRID FLEXIBILITY

José Luis Mata, Red Eléctrica de España

GRIDS 2010 BERLIN
ORGANISED BY EWEA

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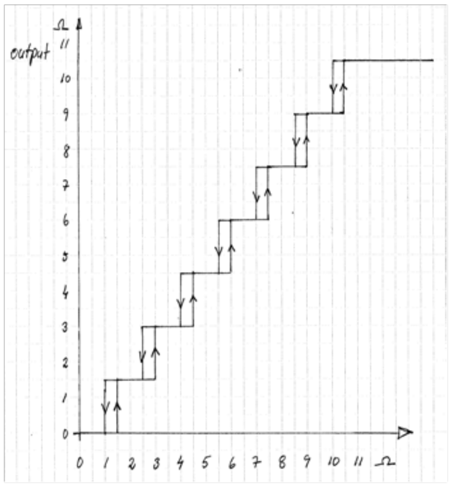
DEMO 6 FLEXGRID (Leader: REE)

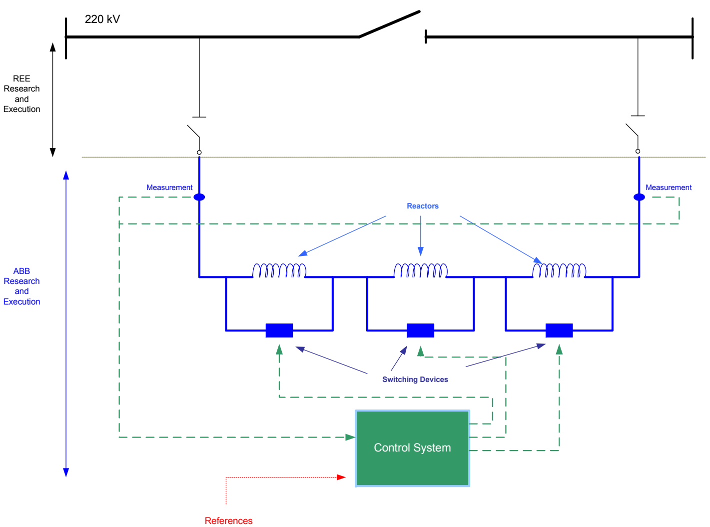
Main objective

- Demonstrating that current transmission network can meet demands of renewable energy by **extending system operational limits**, maintaining safety criteria.

Approach

- **Real-time thermal rating**
  - Benchmarking of different commercial devices
  - Analysis on wind power generation and correlation with monitored lines
- **Innovative FACTS (mobility)**
  - Selection of the location of the FACTS
  - Specification, construction and installation of the prototype.





DEMO 6: RTTR for congestion management

Objective: FLEXGRID is aimed at demonstrating that the current transmission network can meet the demands of renewable energy by extending the current system operational limits, maintaining the safety criteria.

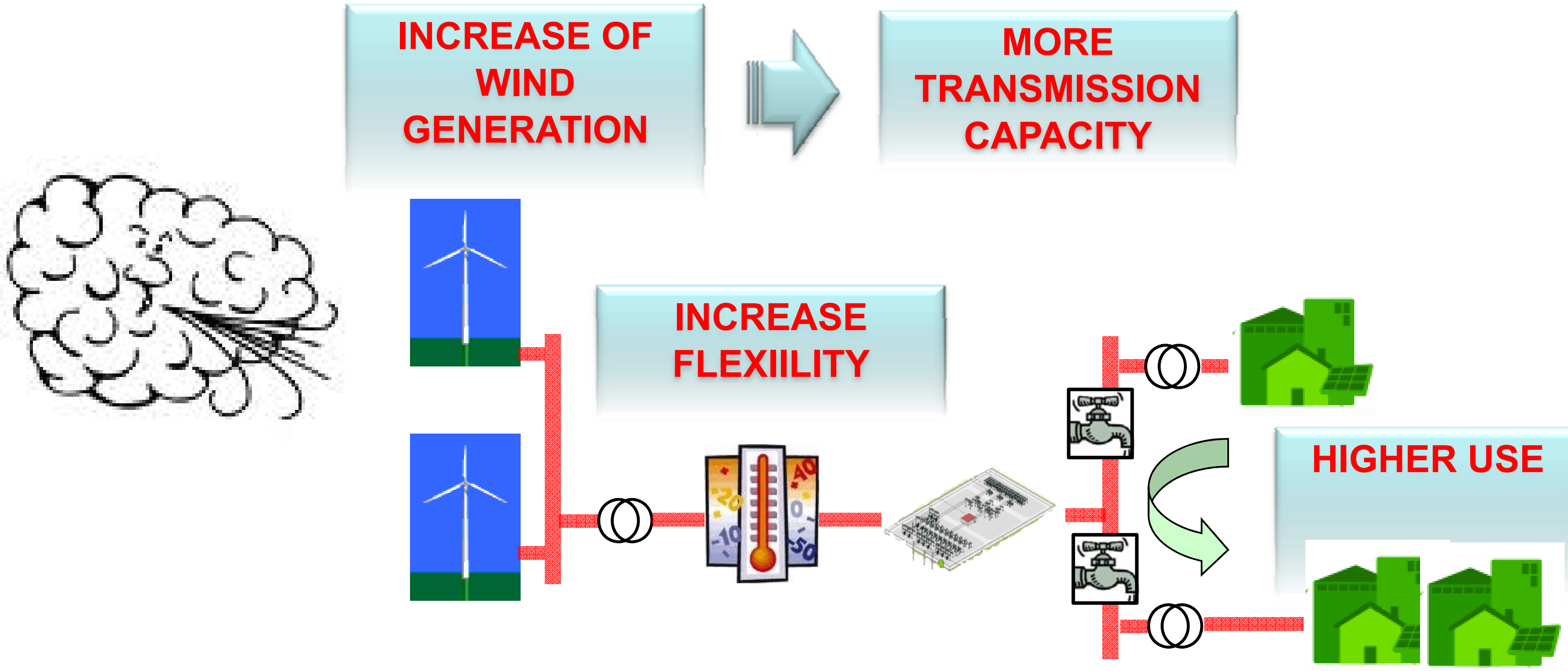
TODAY:

Static restrictions in the use of infrastructures, without taking into account favourable meteorological conditions

AFTER TWENTIES:

Knowledge and use of the actual capacity of the infrastructures according to the needs and weather conditions

DEMO 6: RTTR for congestion management



Dynamic operation for a better exploitation of the existing facilities

Technological objective

- **Real Time Thermal Rating (RTTR):**
- Increasing the operational network limits
- Developing new models and algorithms based on dynamic line rating to meet the rising demands requested by large wind energy integration
- Algorithms will be basically based on Real Time Thermal Rating in overhead lines
- Algorithms will take into account thermal rating forecast

State of the art

Previous projects realized by REE provide good results about the use of dynamic Real time thermal ratings.

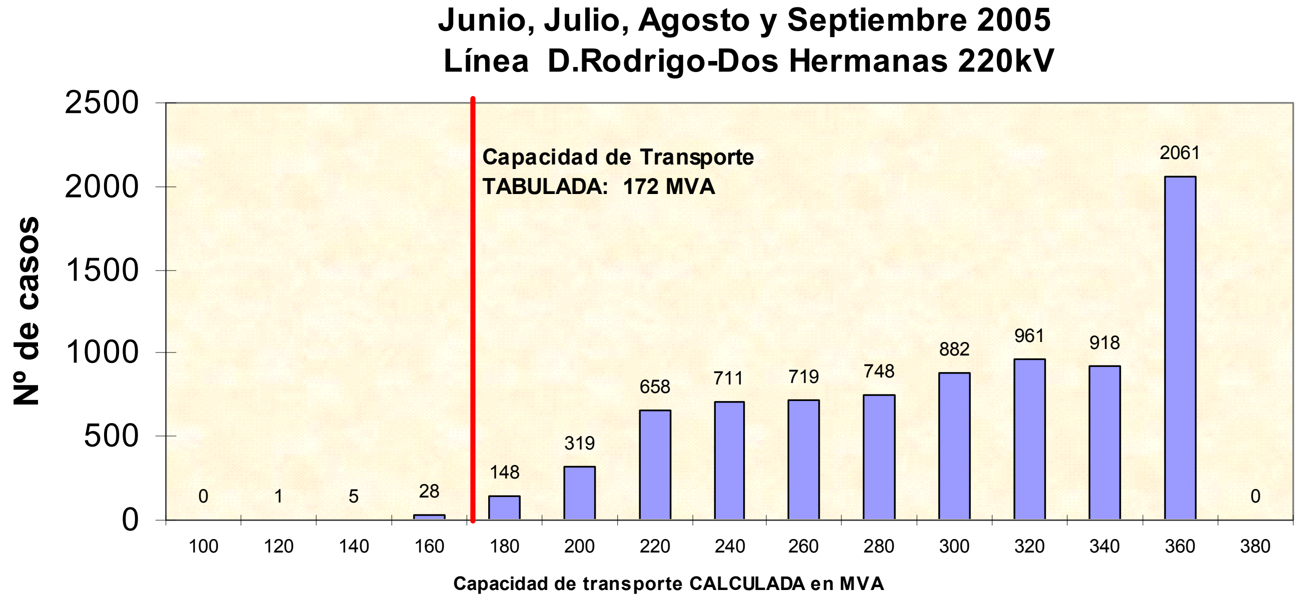
Use meteorological stations to calculate the most probable real capacity of the transmission line.

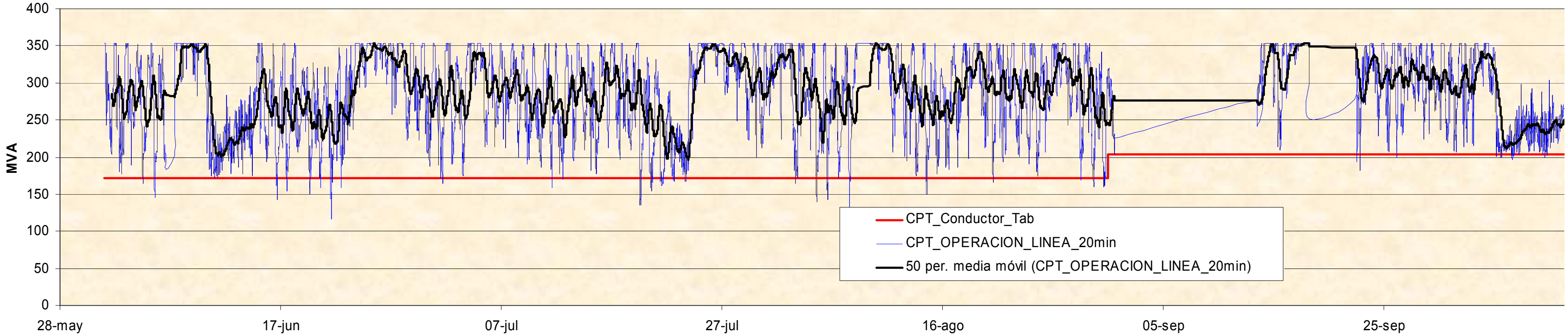
But this is not a real measure, is a estimation!

TWENTIES will provide a:

REAL MEASUREMENTS IN ENTIRE LINE

Previous experience





Technology benchmark

- SagoMeter: Camera to calculate the distance of the conductor to the soil.
- Ampacimon: Calculate of the sag using the natural frequency of the conductor.
- Meteorological Stations: Monitoring of ambient parameters to calculate the temperature of the conductor.
- SMT-Sensor Measure of Temperature: Direct measure of the conductor in one specific point. Pt-1000.
- CAT-1 Device: Measure the mechanical tense of the conductor and with this parameter calculate the sag of the conductor.
- OPPC: Optical phase conductor. Optical fiber integrated in overhead line.

DTS Monitorization (Distributed Temperature Sensor)

- **The capacity of an overhead line is limited by maximum conductor temperature.**
- **Conductor temperatures above this limit will result in high line sag with danger of short-circuit and irreversible damages on overhead line.**
  - **Temperature Monitoring along an Optical fiber (Raman or Brillouin effect)**
  - **Optical fiber integrated in overhead line**

Hot spots can be detected OVER ENTIRE LINE

Optical Phase Conductor

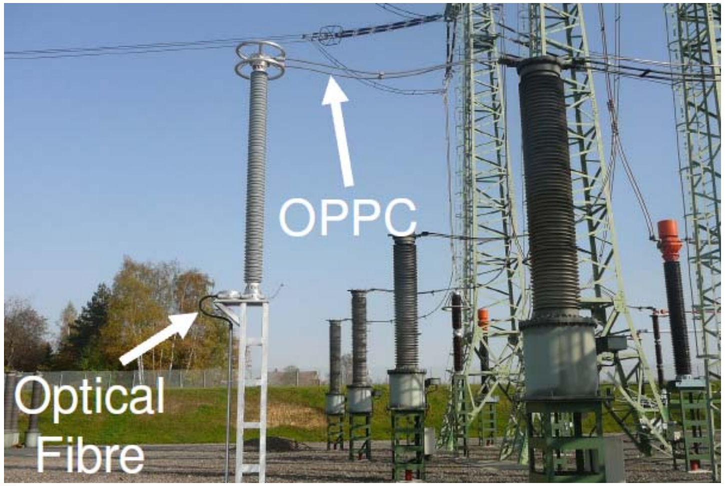
Calculation each 5 minutes.

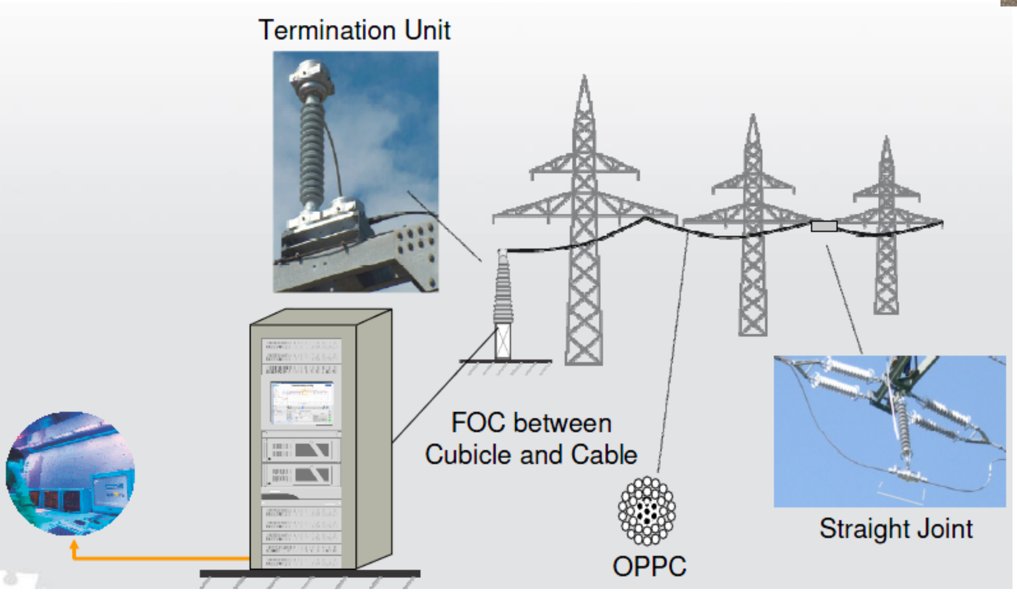
Monitorization 4 to 12 FO (optical switch)

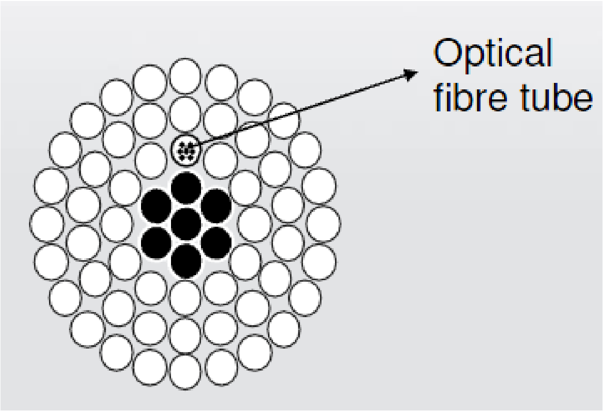
Temperature accuracy: Between 1 y 3 ºC.

Location of hot point accuracy: 10 m.

Technology maximum 100km







DEMO 6: Serial Power Flow Control device

Objective: FLEXGRID is aimed at demonstrating that the current transmission network can meet the demands of renewable energy by extending the current system operational limits, maintaining the safety criteria.

TODAY:

System behavior determined by Kirchhoff's laws

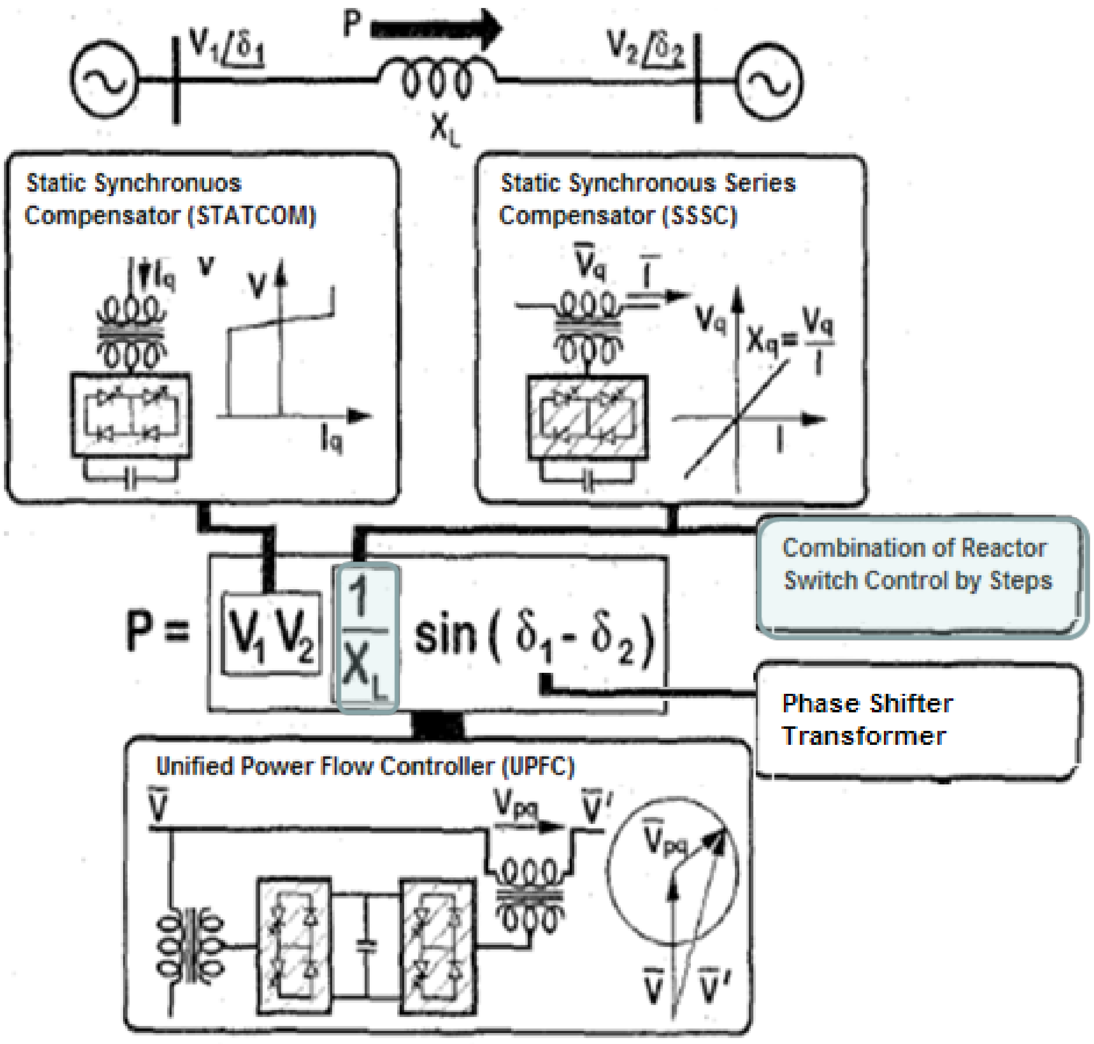
AFTER TWENTIES:

Devices with a certain capability of controlling power flows to cope with grid constrains

Technological objective

- **FACTS Devices**
- Innovative FACTS system
- Economically feasible
- Respond to the influence of the variability of the wind generation in the power flow of certain power lines
- Mobility?

FACTS


P
V1/δ1
V2/δ2
XL
Static Synchronuos Compensator (STATCOM)
Static Synchronous Series Compensator (SSSC)
Combination of Reactor Switch Control by Steps
P = V1 V2 1/XL sin (δ1 - δ2)
Phase Shifter Transformer
Unified Power Flow Controller (UPFC)

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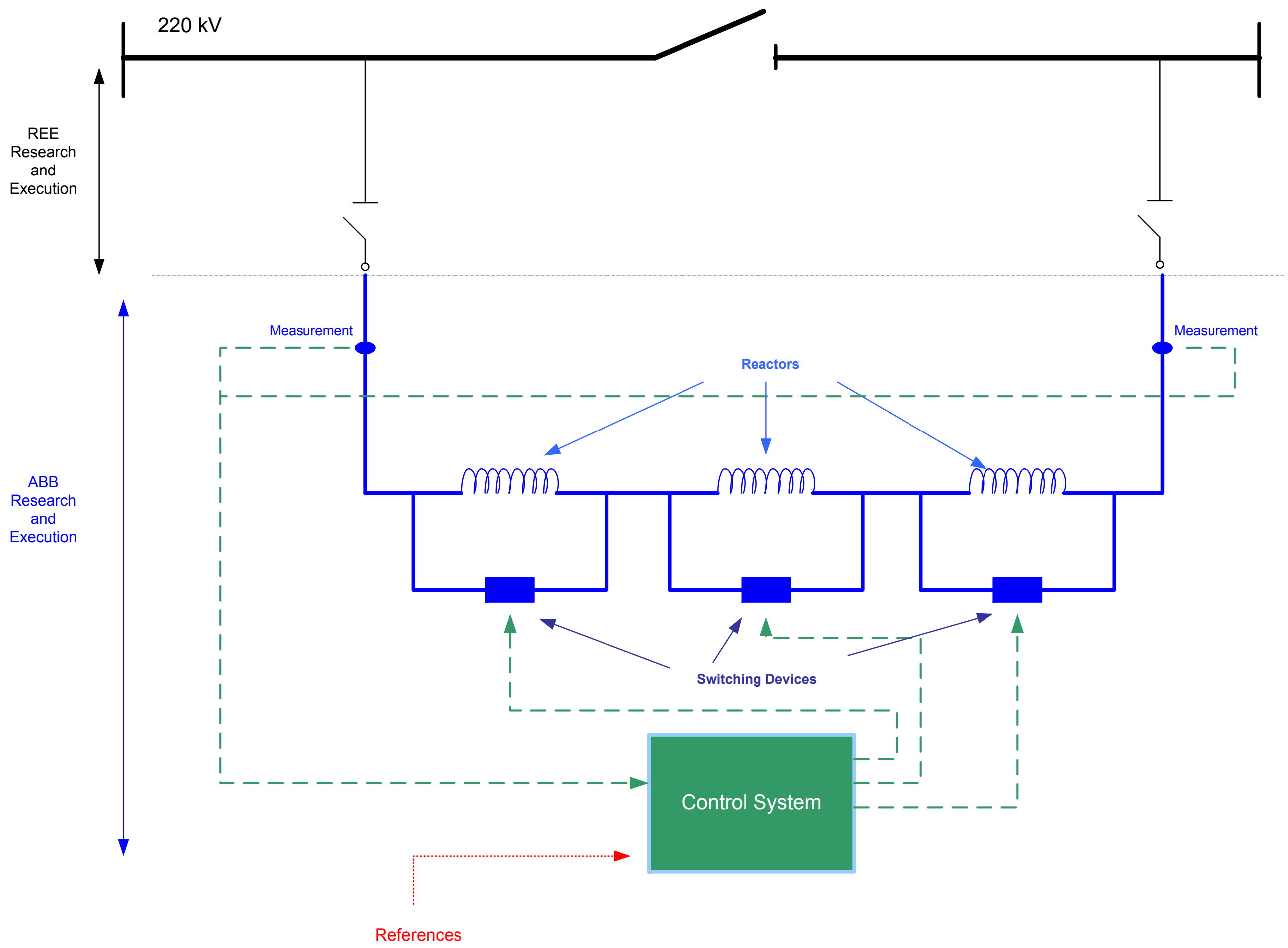
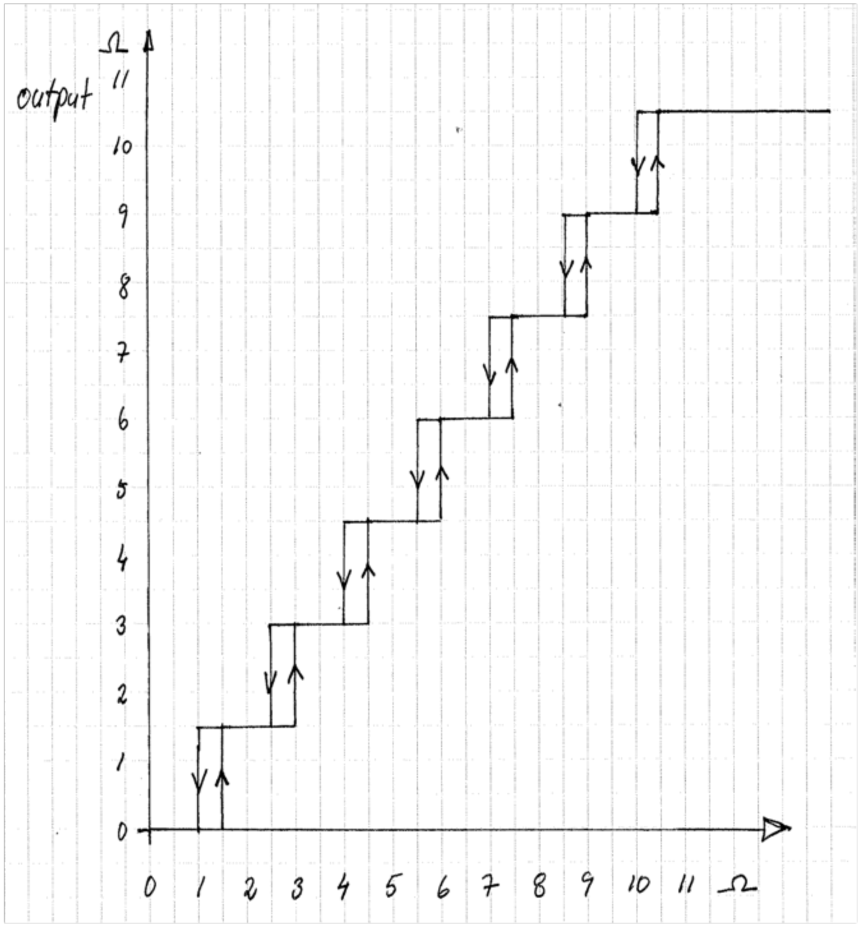
TWENTIES basic outline



Overload Power Flow controller

Main features



- **Step-Wise Switched Series Reactor FACTS: "Overload Power Flow controller".**

Steps of 2,6 / 5,2 / 10,3Ω

Impact in Grid (Ohms)
0
2,6
7,8
10,3
12,9
15,5
18,1

Overload Power Flow Controller

- Power flow control and connectivity possibilities increases the wind energy evacuation limits.
- Standardized Device suitable for Several locations.
- Compact design and flexible I&C suitable for mobility.
- Effective block on transmission assets conditions, easily scalable.
- Control functions based on specific case to case location: System Stability. Overvoltages. Short Circuit fault limiter.
- Adaptive control strategies based on Measurement/references.
- Cost effective low-end device.
- Low maintenance device.

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QUESTIONS?