Dr. Cherry Yuen, ABB Switzerland Ltd, 3-5 Nov 2011, Irvine, CA

Energy Management & Control for the Evolving Smart Grid EU-USFOE-Symposium

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  - Energy Storage
  - Demand Response
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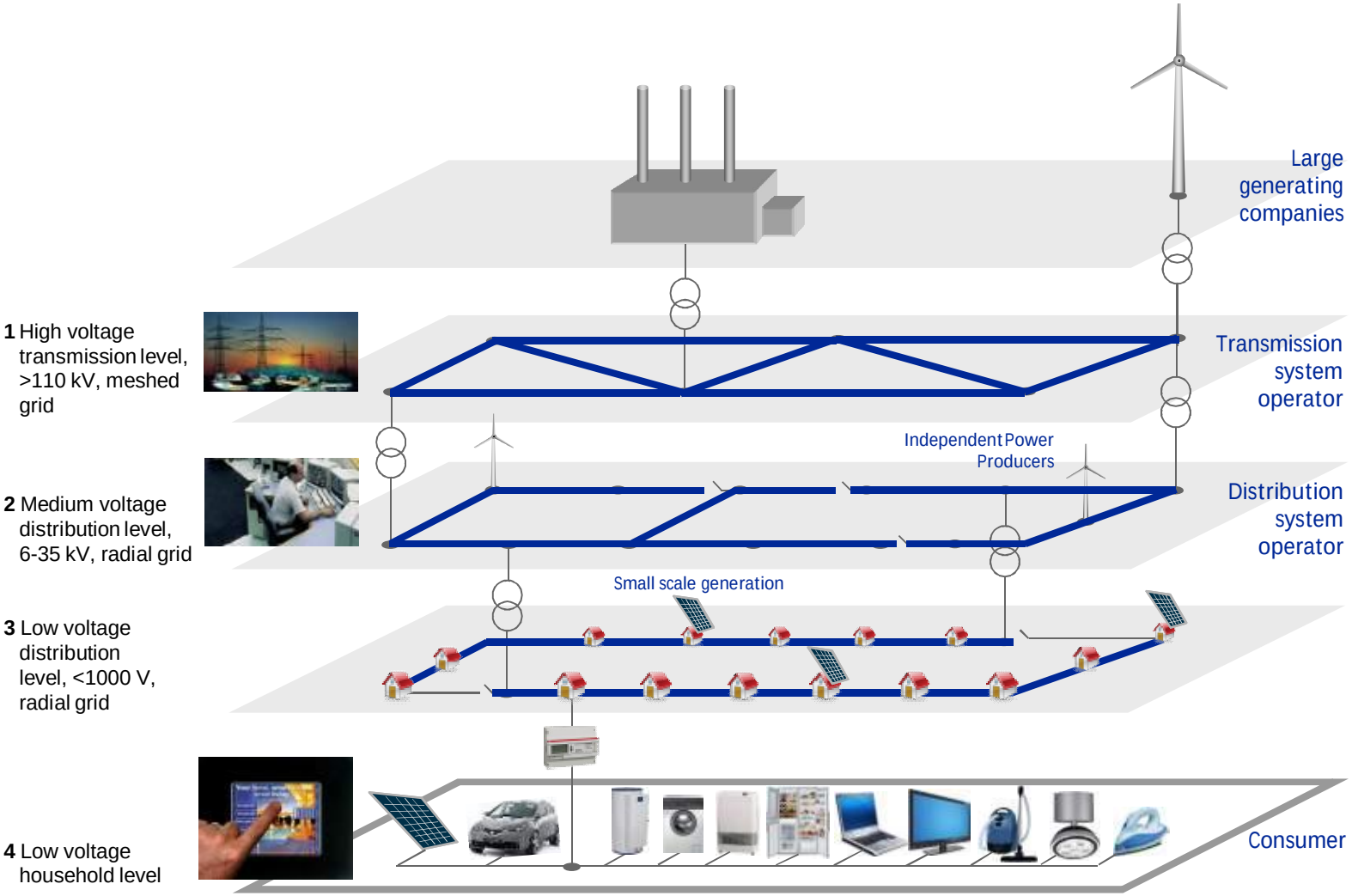
Introduction

Hierarchy of Electric Power System
HV Transmission to LV Distribution



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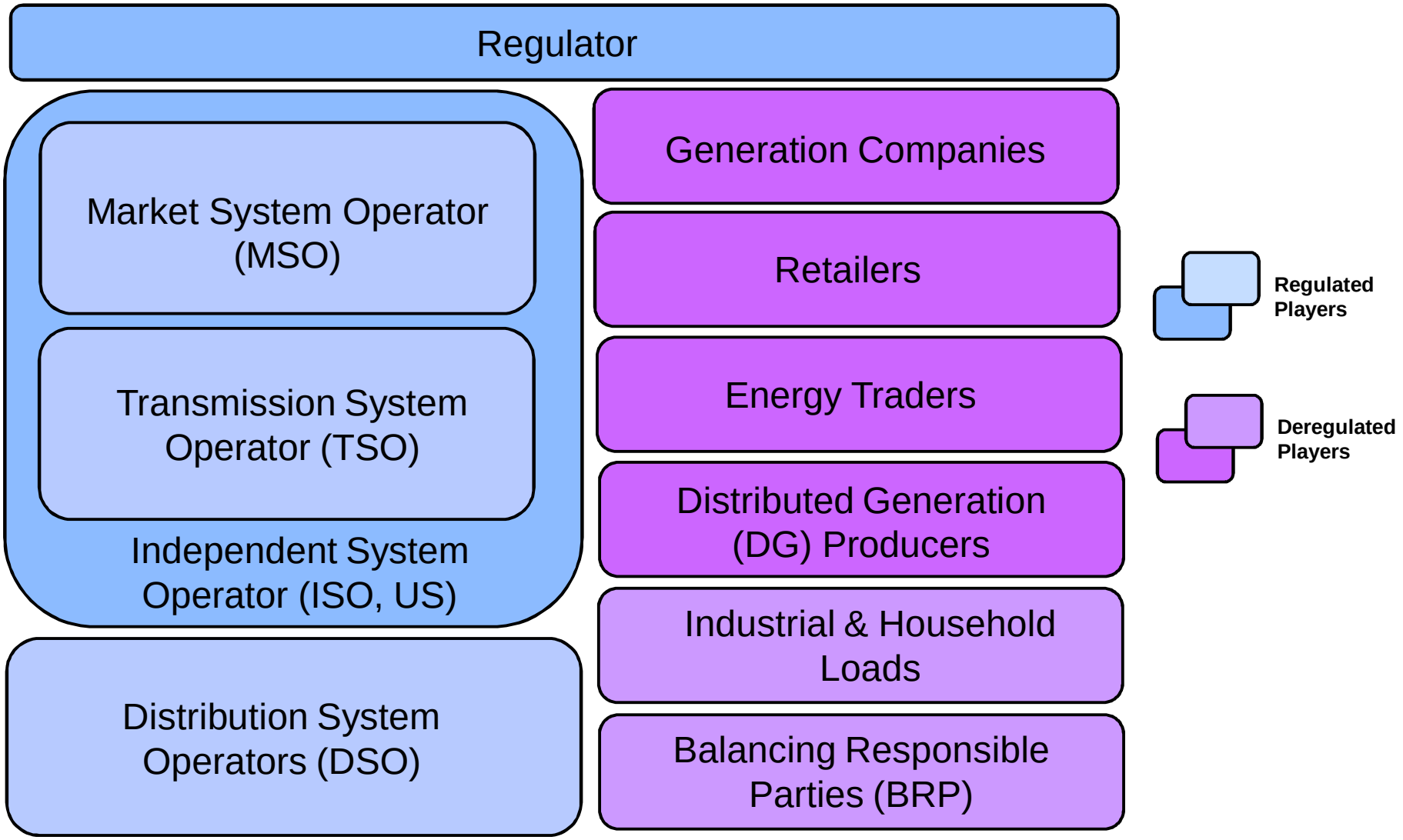
Landscape of Players & Actors
Deregulation Vs Re-regulation



Landscape of Players & Actors
Focus on Network Operations

Transmission System Operator (TSO)

Distribution System Operators (DSO)

- What they do?
- How they do it?
- How they interact with others?

in both current and futuristic scenarios

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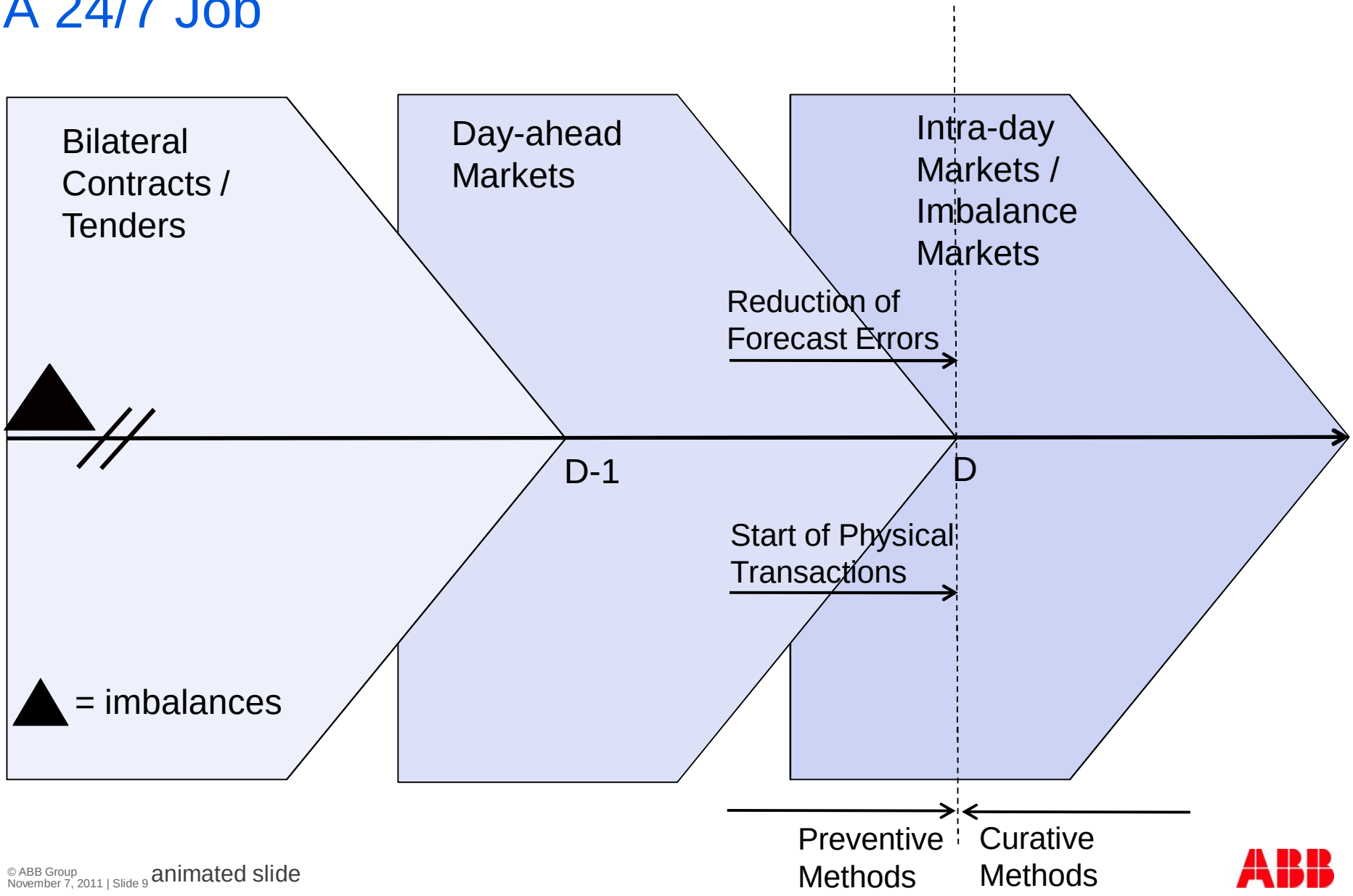
Network Operation Nowadays

Network Operation
Transmission & Distribution

- Transmission
  - Centralized approach (EMS)
  - Meshed topology for additional reliability
  - Objectives:
    - Security of supply: voltage, angle, frequency stabilities
  - Failures can lead to blackout

- Distribution
  - Centralized (DMS) & decentralized (Substation or further down the hierarchy) approaches
  - Mostly radial topology for costs reduction
  - Objectives:
    - Reliability (SAIDI, CALDI, etc.)
    - Power quality
  - Failures lead to local outages

Balance of Supply and Demand
A 24/7 Job



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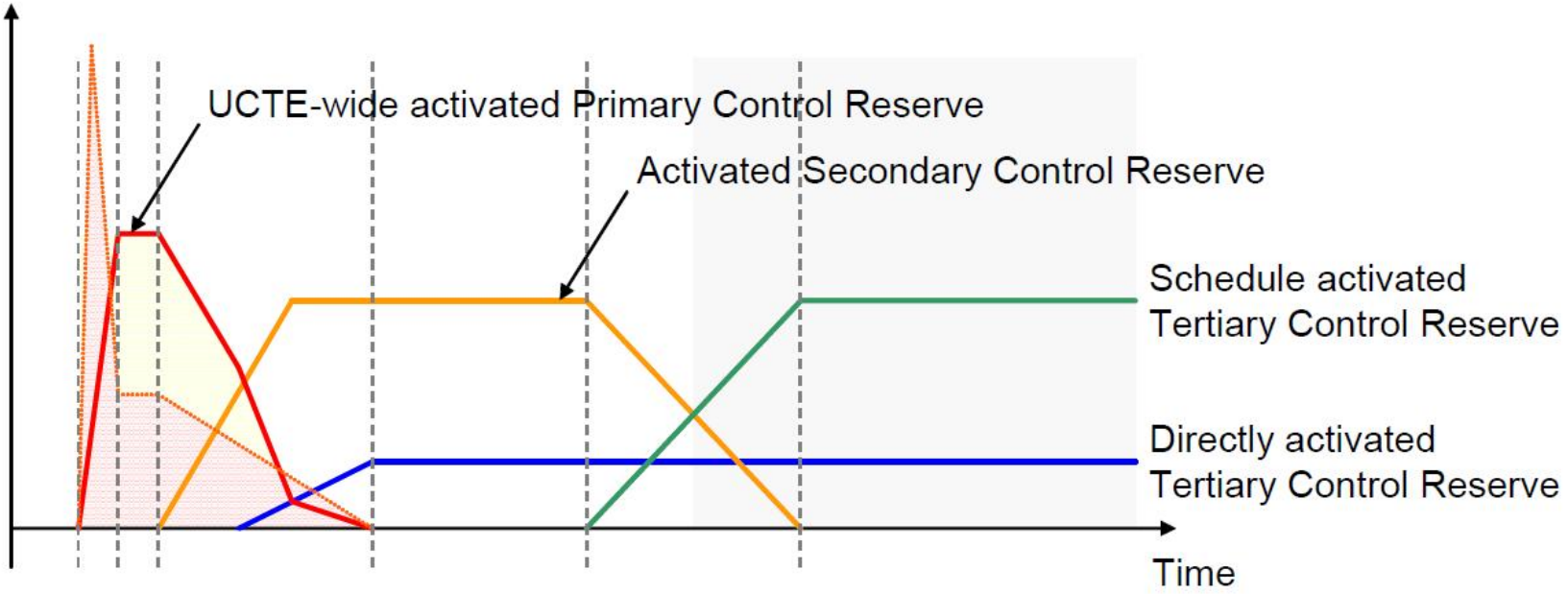
Frequency Reserves
How TSOs keep real-time balance of supply & demand



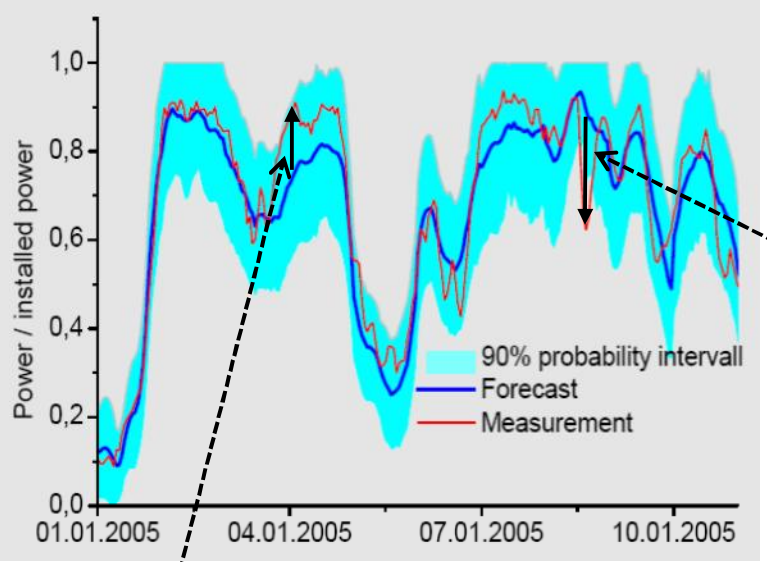
Principle frequency deviation and subsequent activation of reserves

Source: entso-e Operation Handbook

entso-e: European Network of Transmission System Operators for Electricity (former UCTE)

Challenges from Renewables

Challenges from Wind Energy # 1
Unpredictability

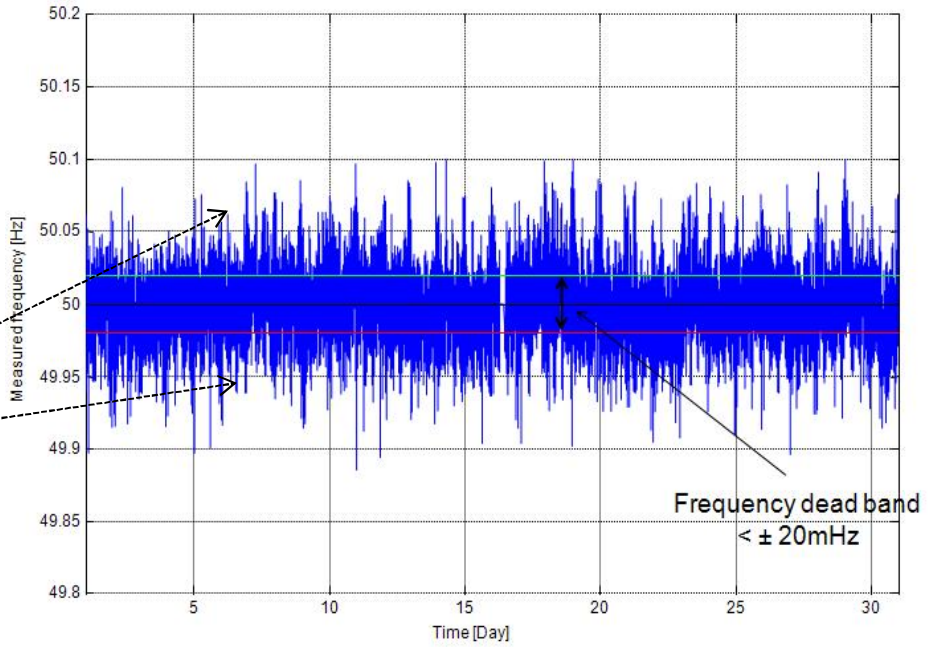


Source: Fraunhofer (Former ISET)

Without wind spilling or –ve reserves:
$+\Delta P \Rightarrow +\Delta f$

In the “business-as-usual” case we would see much more such deviations in both directions

Without +ve reserves:
$-\Delta P \Rightarrow -\Delta f$



Frequency excursion of the UCTE system April 2005
Source: SwissGrid (Former ETRANS)

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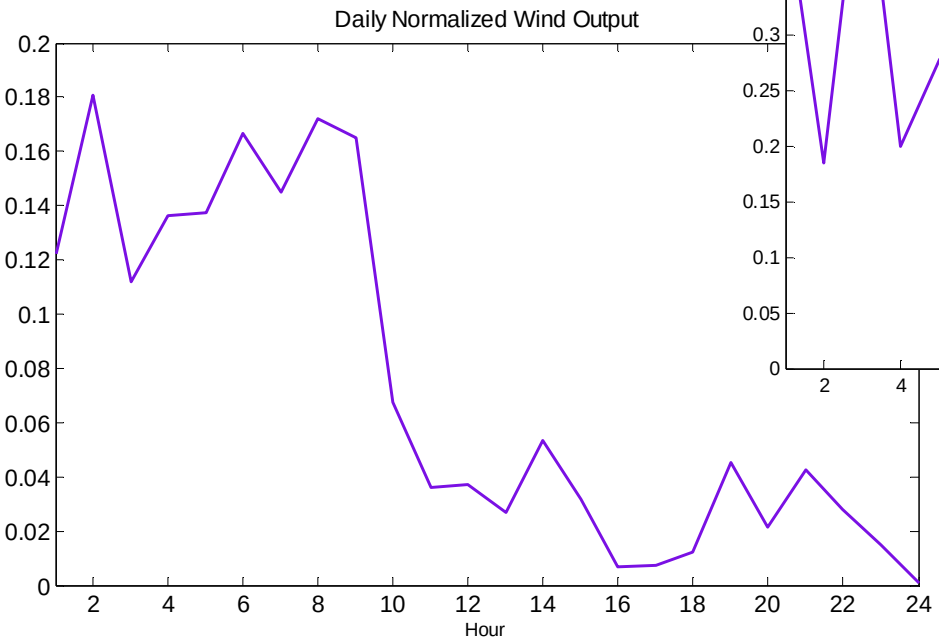
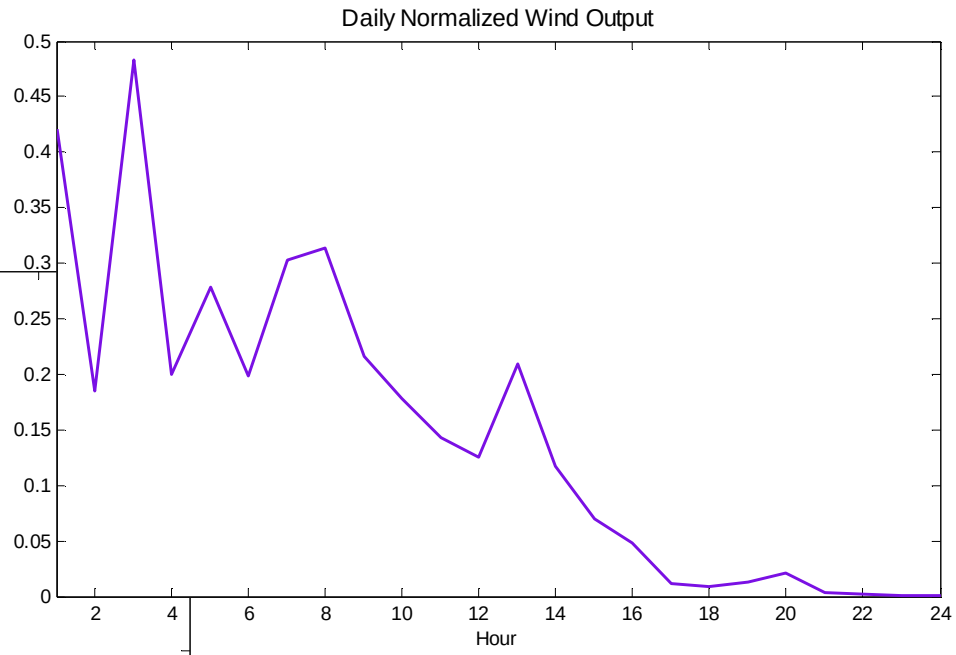
Challenges from Wind Energy # 2
Intermittency



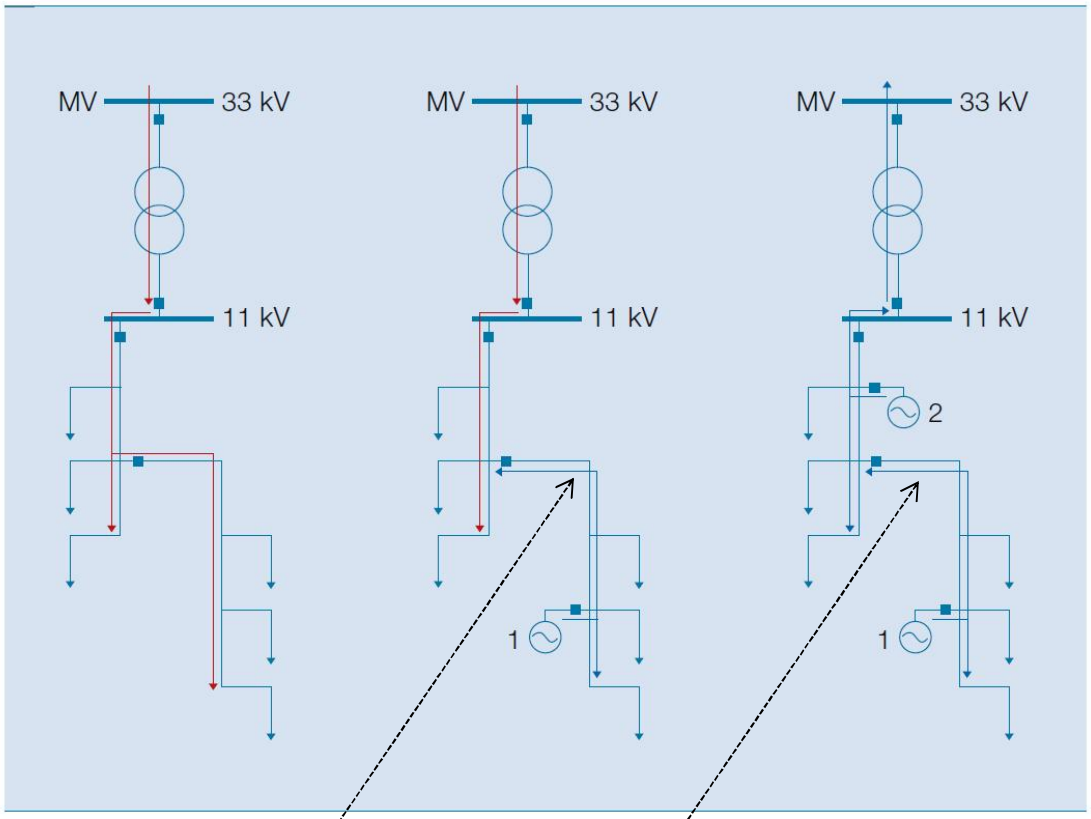


In the “business-as-usual” case wind production could become bigger than total demand
=> Zero or negative prices in some markets

- Low capacity factor ~ 40% for offshore wind
- Very often producing during night time: low demand!!!

animated slide

Challenges from Distributed Generation
Change of Flow Pattern



Flow from DG is going upstream in LV network

Flow from DG is going upstream in MV network

In the “business-as-usual” case this would lead to higher losses and voltage excursion at specific locations of the network

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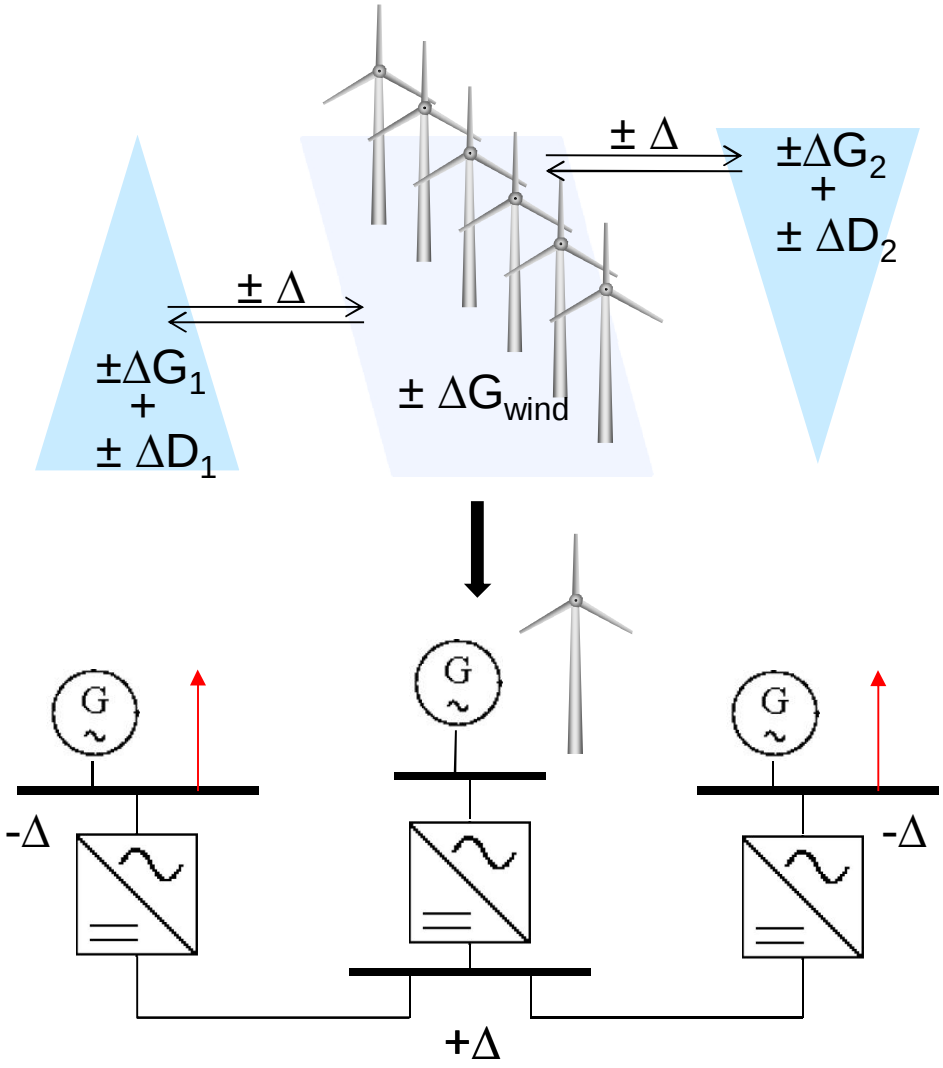
Possible Remedies

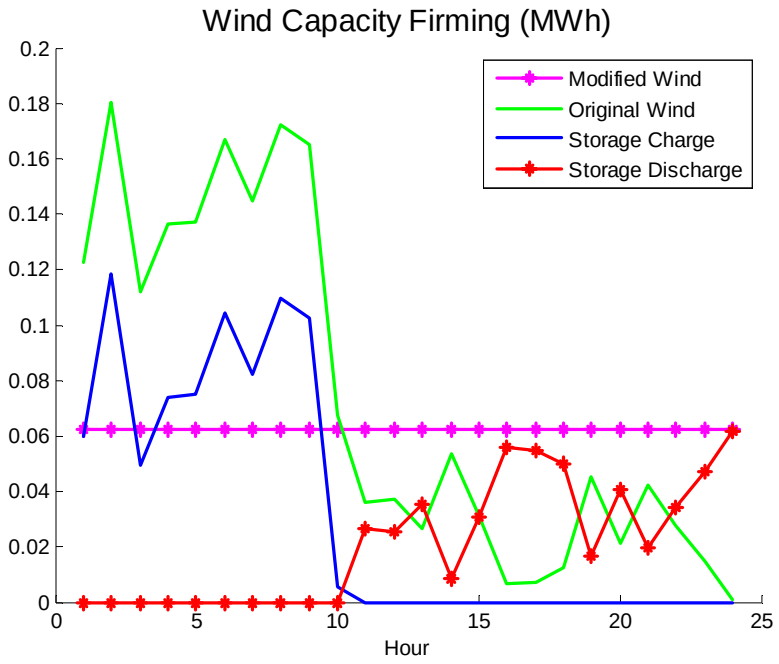
Power Balancing using HVDC Grids
Imbalance Netting



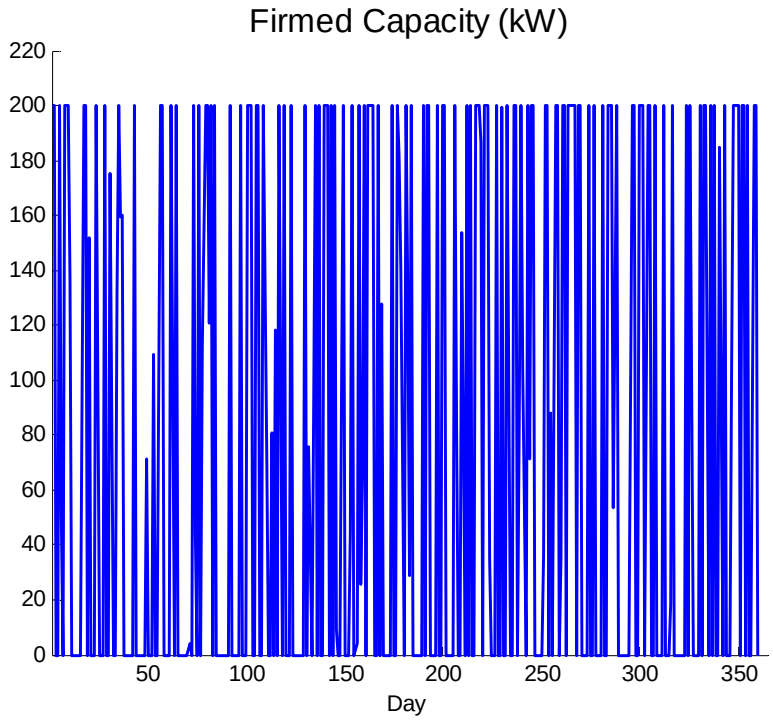
- Imbalances resulting from forecast errors can be exchanged between the different nodes with a MT-VSC-HVDC setup
- One possible scenario:
  - Actual wind output is higher than forecast => surplus
  - Other areas can have deficits at the same time
  - MT-HVDC can be used for real-time power balancing (see animation)
- System imbalances can be reduced:
  - Enhanced system security
  - Reduced use of other reserves
- Better benefits with higher number of nodes => HVDC Grid

animated slide

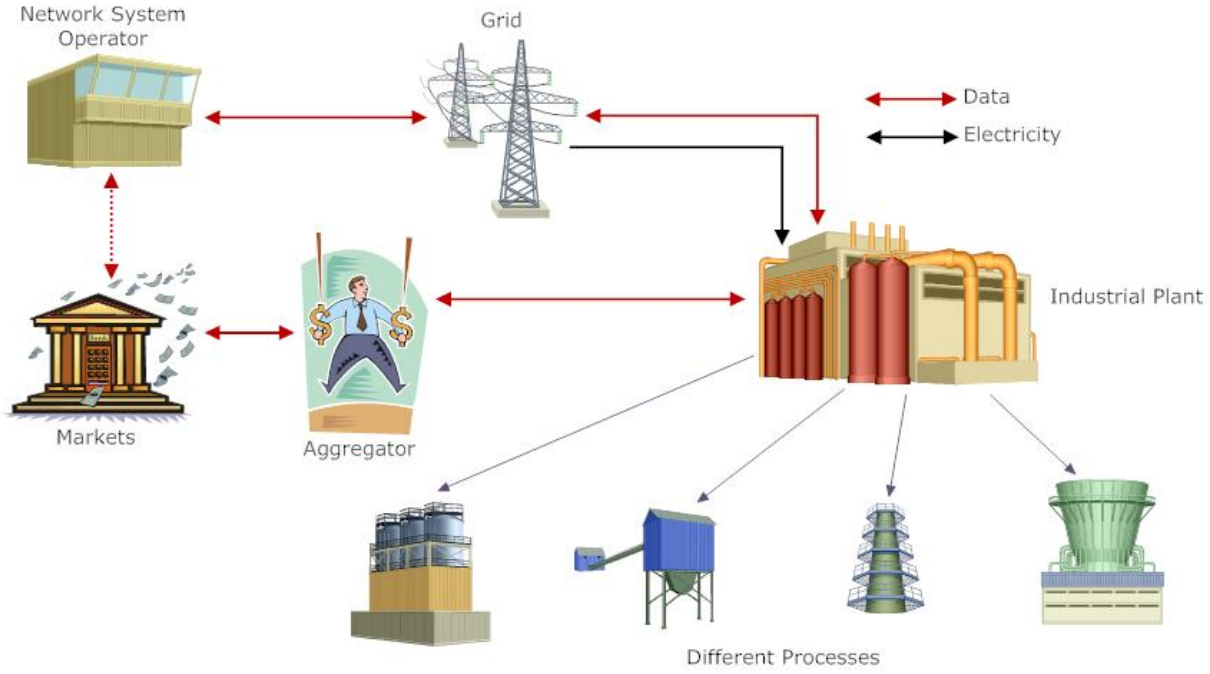
Wind Integration using Energy Storage
Capacity Firming

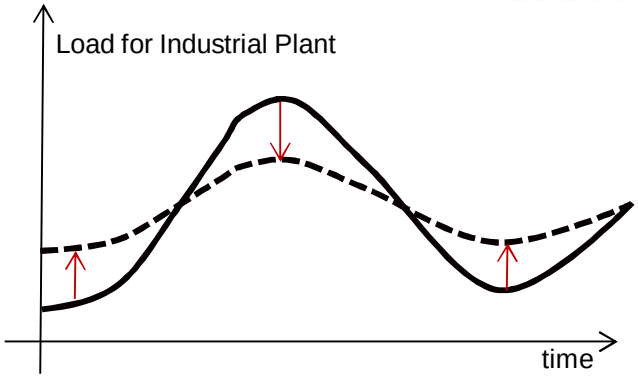


One possible application of energy storage for wind energy integration is to firm the daily output capacity of the wind facility. This is equivalent to maximizing its daily minimum power output. This can reduce intermittency of wind energy and render the wind farm more like a traditional dispatchable generation plant.



DG Integration using Demand Response
Load Shifting





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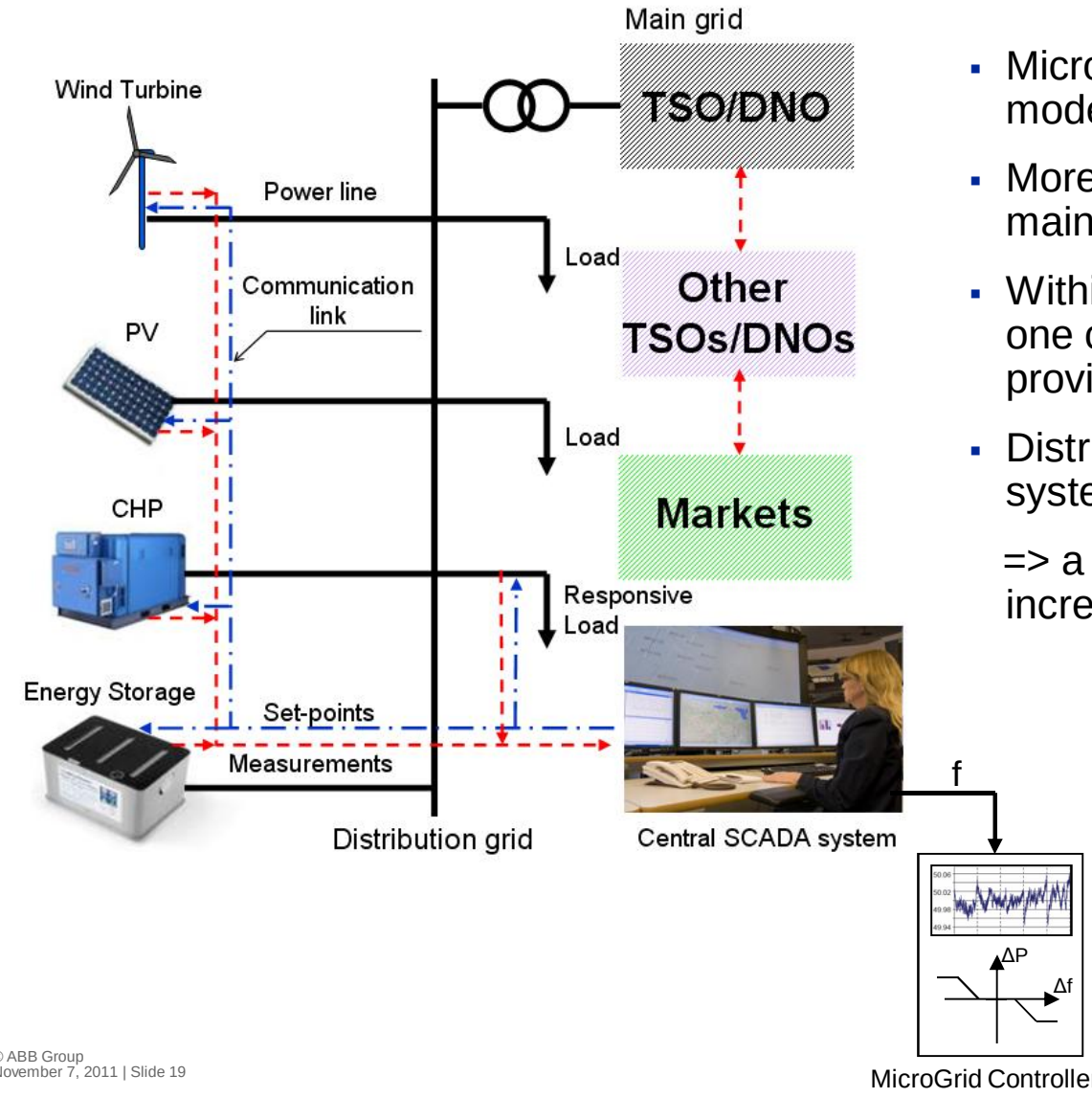
- With industrial DSM (Demand Side Management) one can shift the peak load to low demand period(s) for “peak shaving” or to adjust the load curve to fit the output of DG
- This can be motivated either by financial or technical objectives
- In a regulated regime or vertically integrated environment the network operator will manage the demand response directly
- In a deregulated regime the industrial plant operator can participate into the markets either directly or through a demand response aggregator (see animation)

System Services Provision from MicroGrids
Frequency Reserves



- MicroGrids can operate in islanded mode in case of faults in the main grid
- More often they are connected to the main grid
- Within the same MicroGrid controller one can implement the functionality to provide frequency reserves
- Distribution grids start to provide system services for the TSO

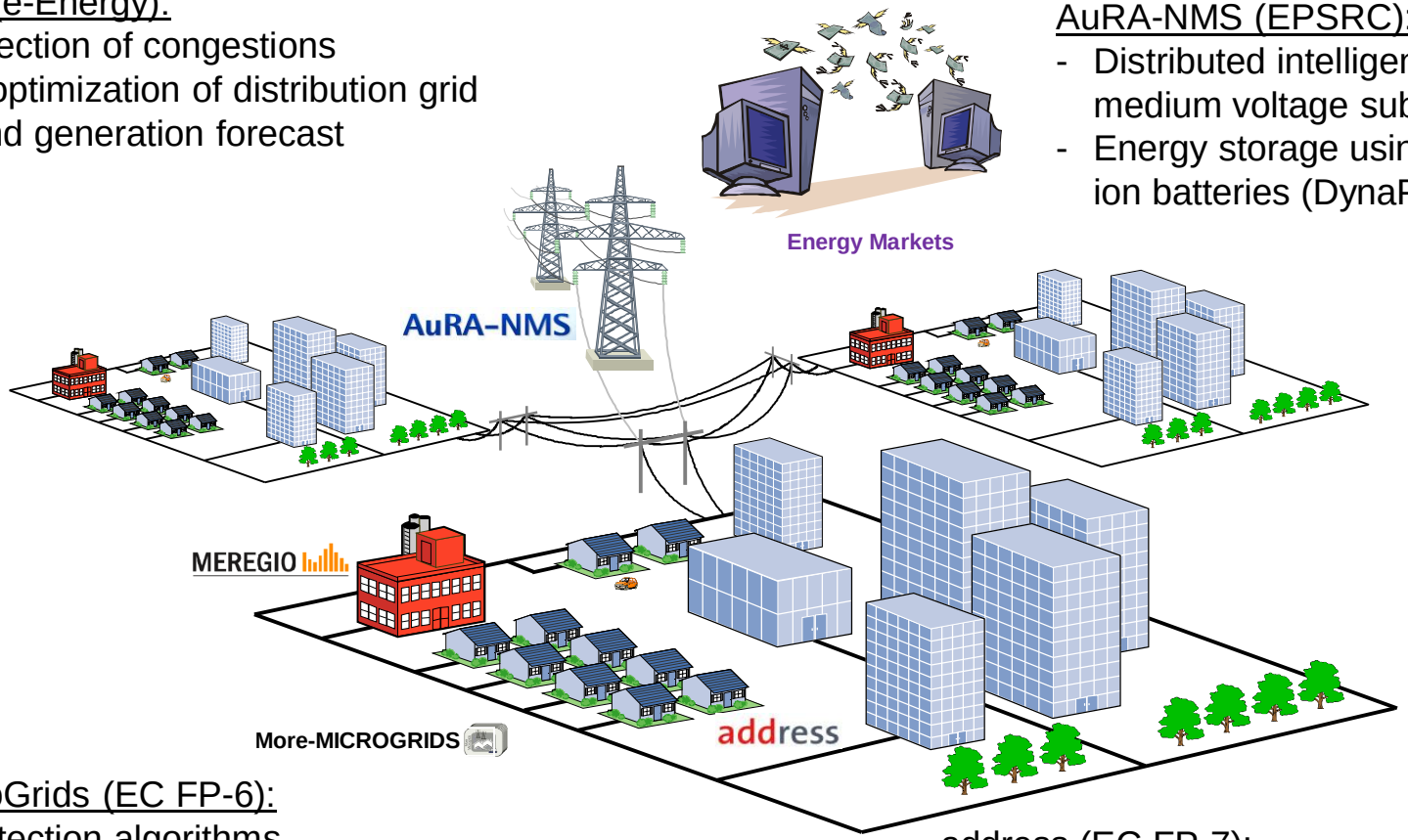
  => a natural tendency because of the increase of distributed generation

Pilot Projects

Example Pilot Projects – Distribution Networks Involving ABB Corporate Research

MeRegio (e-Energy):
- The detection of congestions
- Usage optimization of distribution grid
- Load and generation forecast

AuRA-NMS (EPSRC):
- Distributed intelligence in medium voltage substations
- Energy storage using Lithium-ion batteries (DynaPeaQ®)

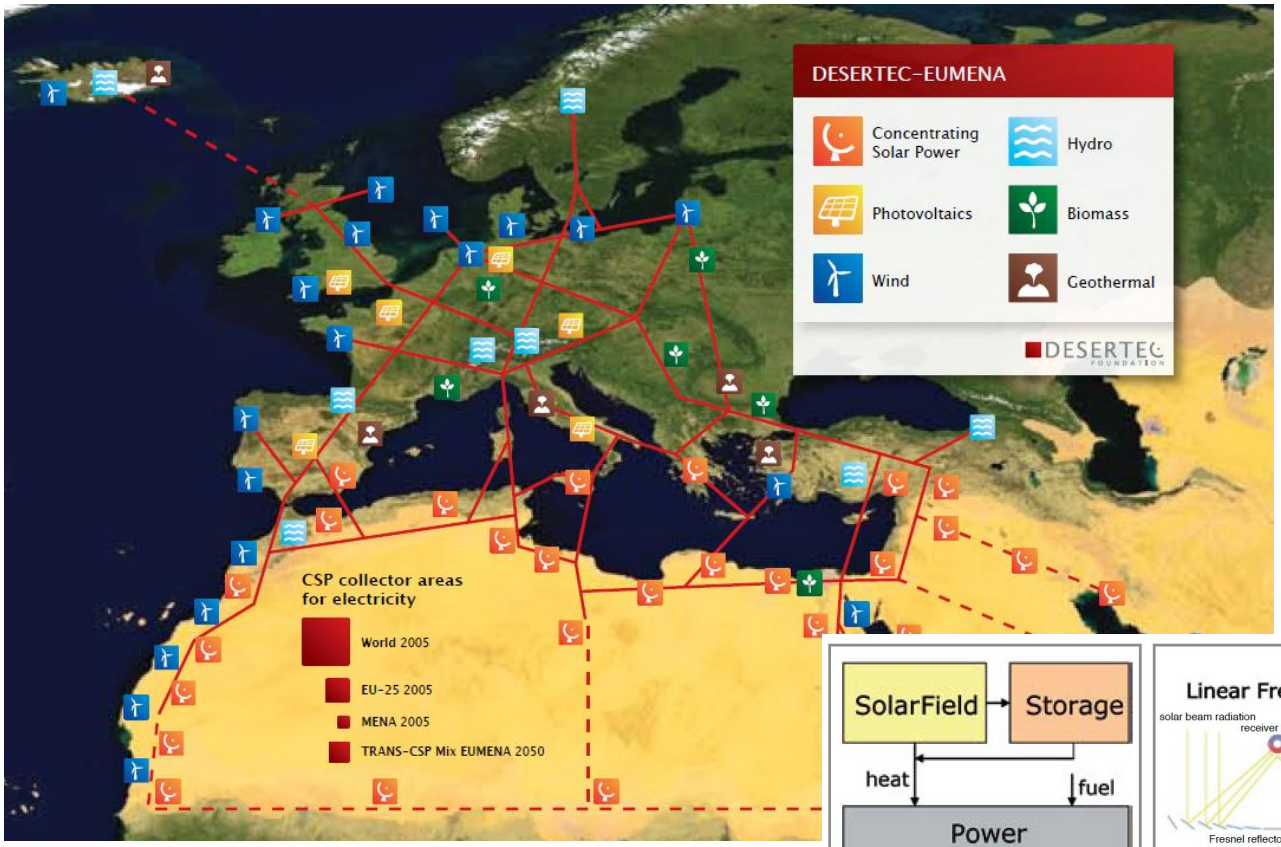


Source: ABB review 1/10 – Smart Teamwork

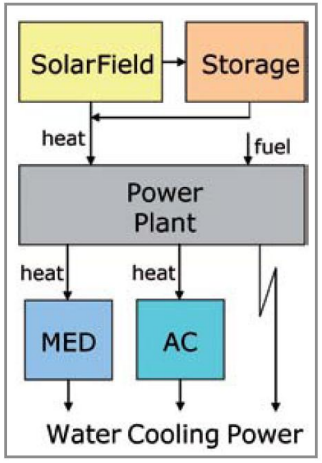
More MicroGrids (EC FP-6):
- New protection algorithms and relay coordination for islanded mode
- Provision of frequency reserves from MicroGrids

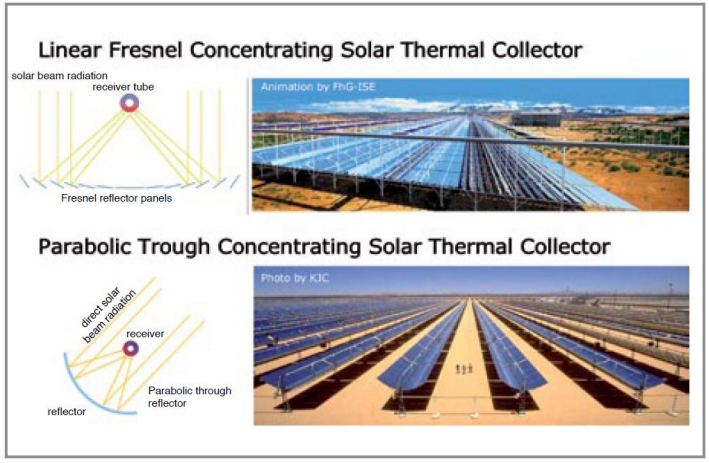
address (EC FP-7):
- The concept and information modeling for communication between different actors (IEC 61970)
- Network operation algorithms with active demand

Transmission Networks
EU Supergrid - Desertec



- A vision to help alleviate the world energy crisis
- Connect wind energy in the north and solar energy (CSP-Concentrated Solar Plant) in the south (MENA) for different load centers in central EU
- An “Electricity Highway” or “Supergrid” using a HVDC backbone is proposed





Source (both diagrams): Desertec Foundation
Clean Power from Deserts (WhiteBook)

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