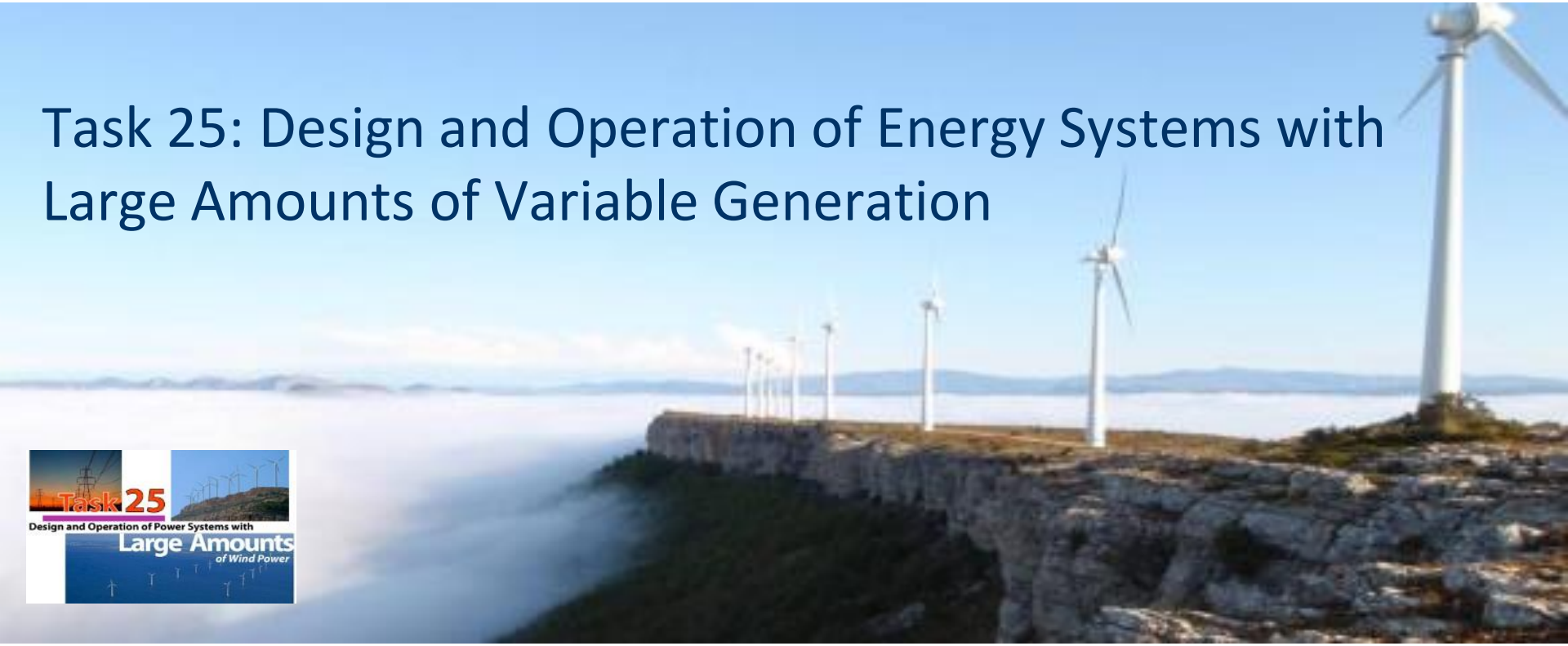
Grid integration of Variable Generation – best practices from international experience



Task 25: Design and Operation of Energy Systems with Large Amounts of Variable Generation

Hannele Holttinen, Operating Agent Task25

Partner, Recognis

WIW19, Dublin, Oct 16th, 2019

iea wind

IEA Wind Task 25 – Best practice of VG integration

- Started in 2006, now 17 countries + WindEurope participate to provide an international forum for exchange of knowledge
- State-of-the-art: review and analyze the results so far (Jan 2019)
- Formulate guidelines- Recommended Practices for Wind/PV Integration Studies (RP Ed.2 July 2018)
- Fact sheets and integration study time series (wind, solar, load…)

https://community.ieawind.org/task25

Contents

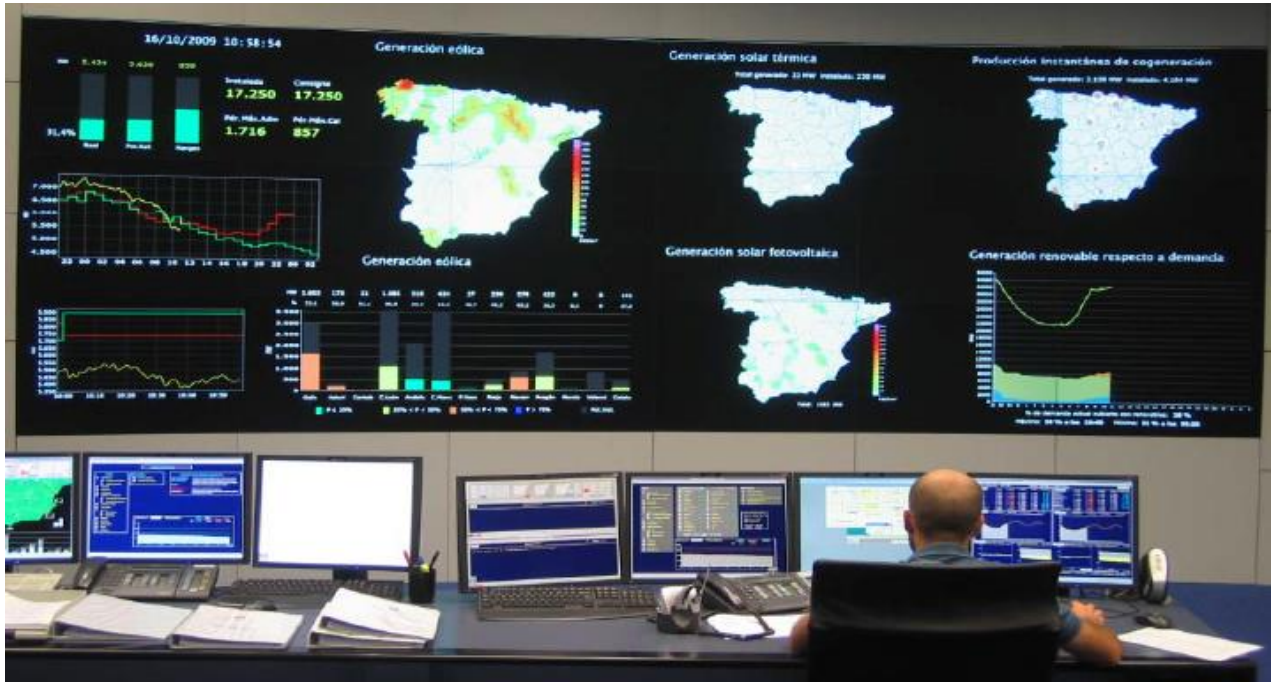
Lessons learned from challenges of wind and solar

- For first 5-10% share of electricity consupmtion
- For a considerable 15-30% share
- and for very high shares >50% of VG

Task 25
Design and Operation of Power Systems with Large Amounts of Wind Power

Experience from Wind and Solar Integration: first 5-10% share

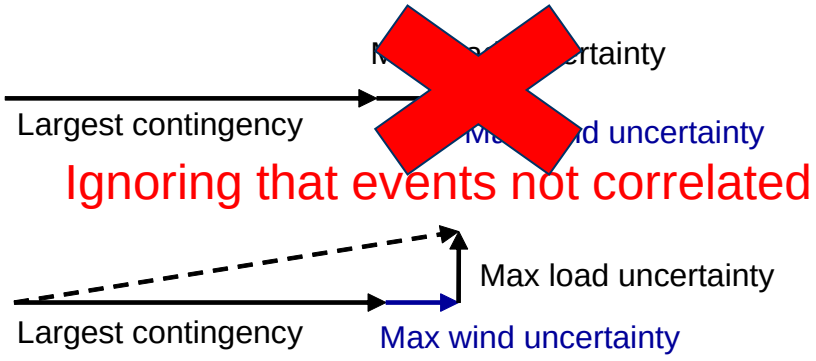
- Updated information from on-line production and forecasts.
- Possibility to curtail in critical situations.
- Grid connection codes

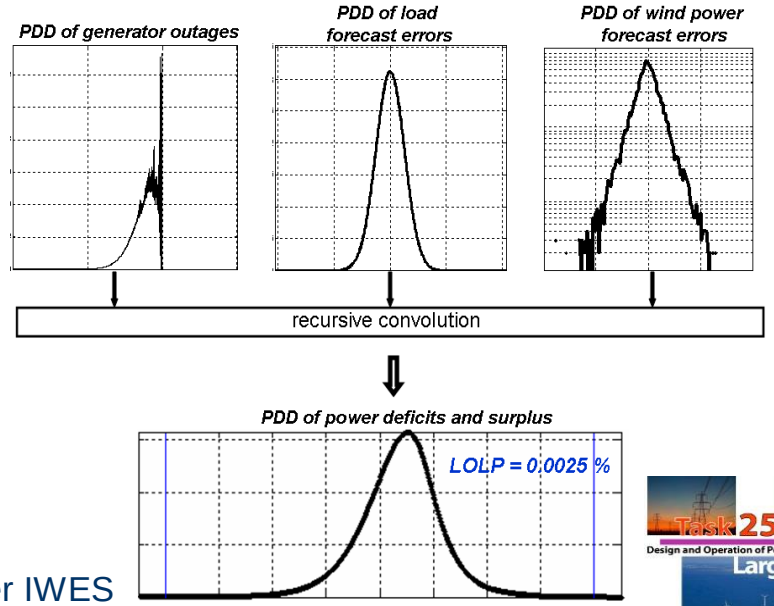


Task 25
Design and Operation of Power Systems with Large Amounts of Wind Power

Using short term forecasting

- Wind and solar taken in the day-ahead unit commitment and dispatch, with smoothing impact
  - Energy traded at markets with forecasting
- Flexibility during operating hour – allocating reserves
  - forecast errors determine the need for operating reserve – combining uncertainty from load, wind, solar and generation

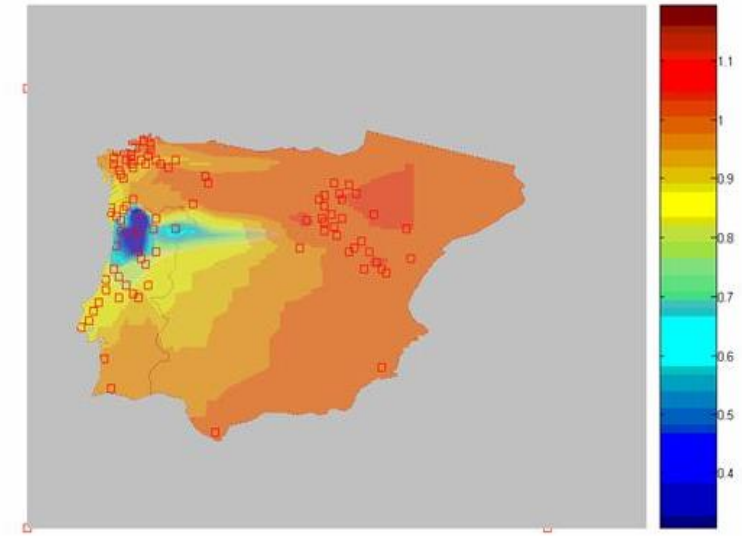




Source: Fraunhofer IWES

Experience with grid codes

- Requiring fault-ride-through, and setting frequency/voltage limits when trip-off
  - Low voltages due to short-circuits may lead to the disconnection of large shares of generation -modern turbines comply with this
  - Australia case, for weak systems need to require many consecutive faults
  - Germany, California case solar: setting of inverters to trip off at high frequency may also create an issue of losing too much generation instantly



Ride through fault capabilities attenuate the problem.

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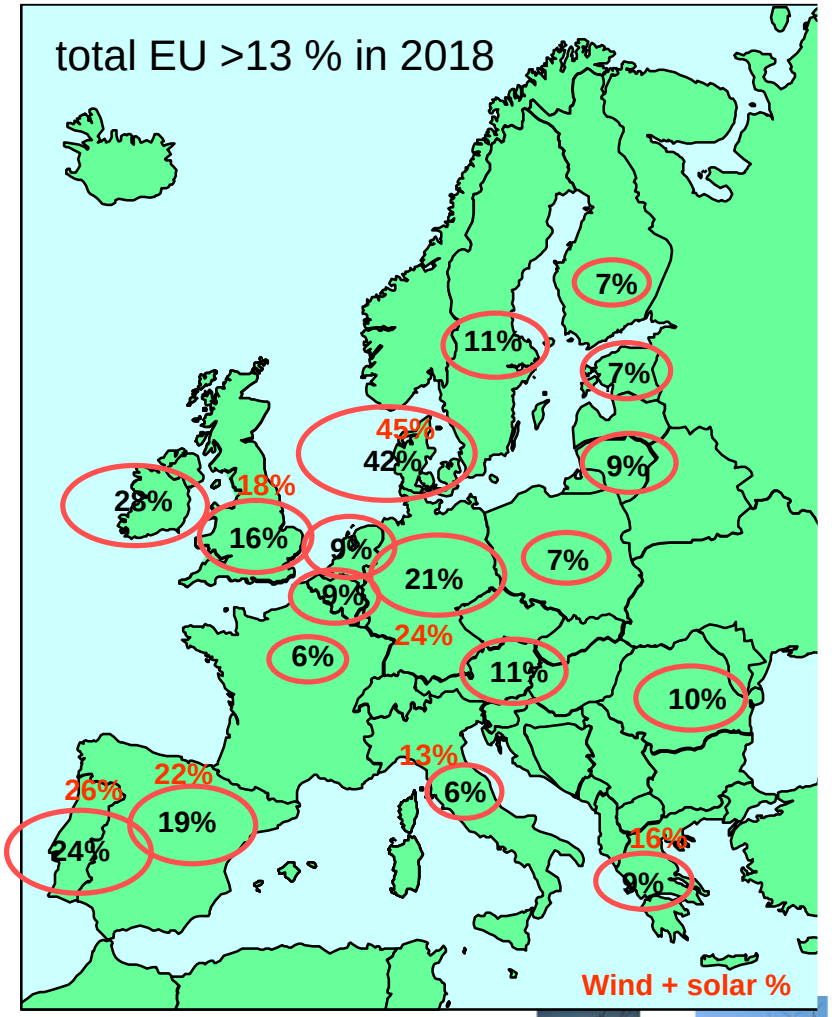
Task 25 Design and Operation of Power Systems with Large Amounts of Wind Power

Experience from Wind and Solar Integration – next phase

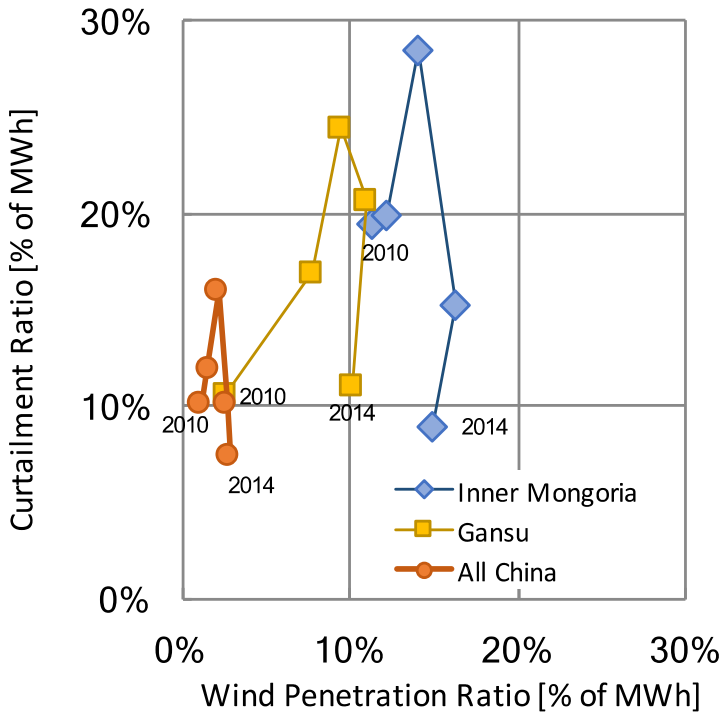
- Sharing balancing
- Enabling also wind and solar in grid support
- Generation – and demand - flexibility and adequacy
- Transmission a key enabler, with regional planning efforts
  - Local markets, PV and storages emerging as another solution
- Countries' flexibility differ
  - Interconnections, hydro flexibility, operational practices

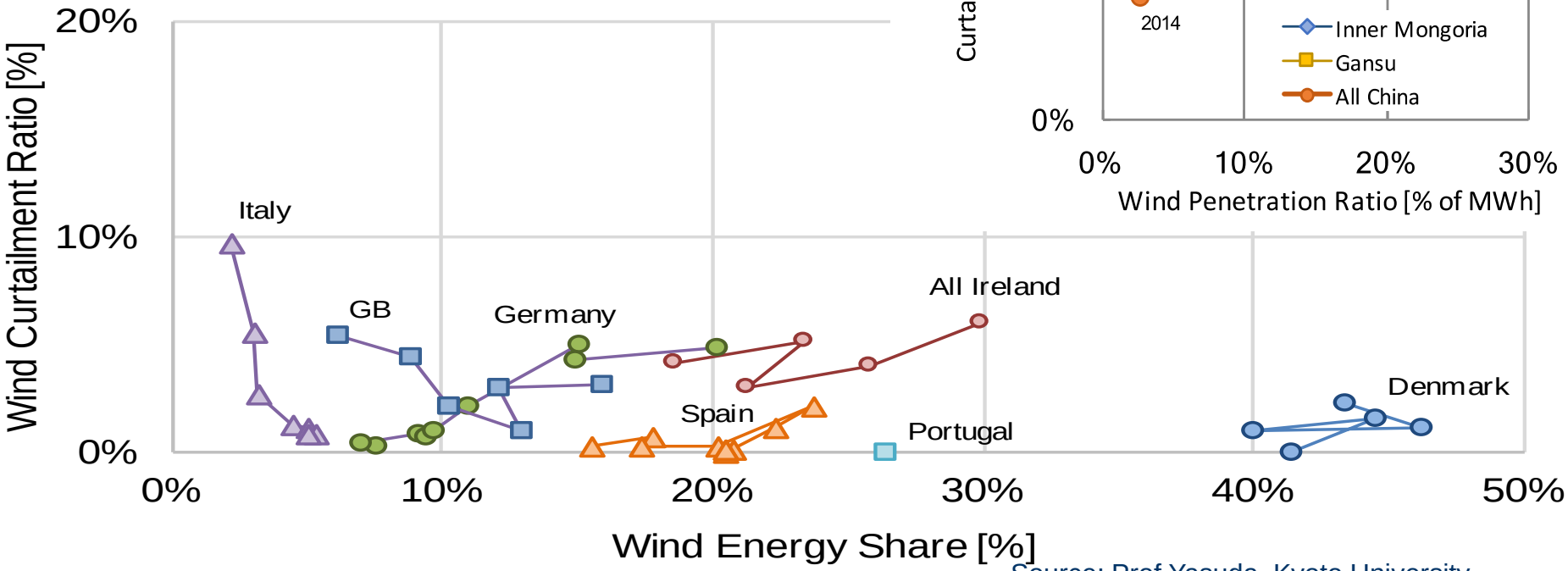


Task 25
Design and Operation of Power Systems with Large Amounts of Wind Power

Curtailments are a signal of lack of flexibility

- Delays of transmission: Italy and Texas – diminished after grid build out. Germany, still an issue
- Inflexibilities of coal power plants and tariffs: China
- Limiting max share of asynchronous generation: Ireland





Source: Prof Yasuda, Kyoto University

Trade with neighbouring areas will help balancing more than VG adds

- Sharing balancing task with neighbouring system operators in Germany has resulted in reduction of use of frequency control, while wind and solar have increased
- Denmark integration of close to 50% wind share is based on using Nordic hydro power system flexibility

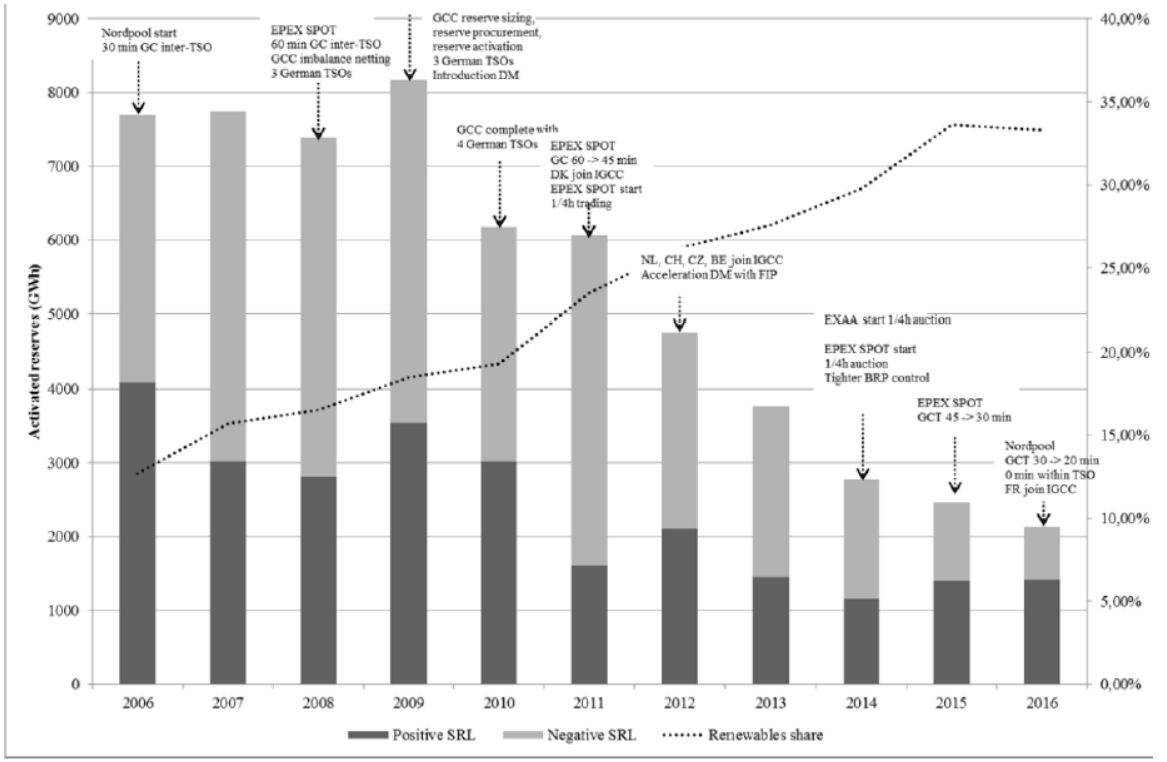


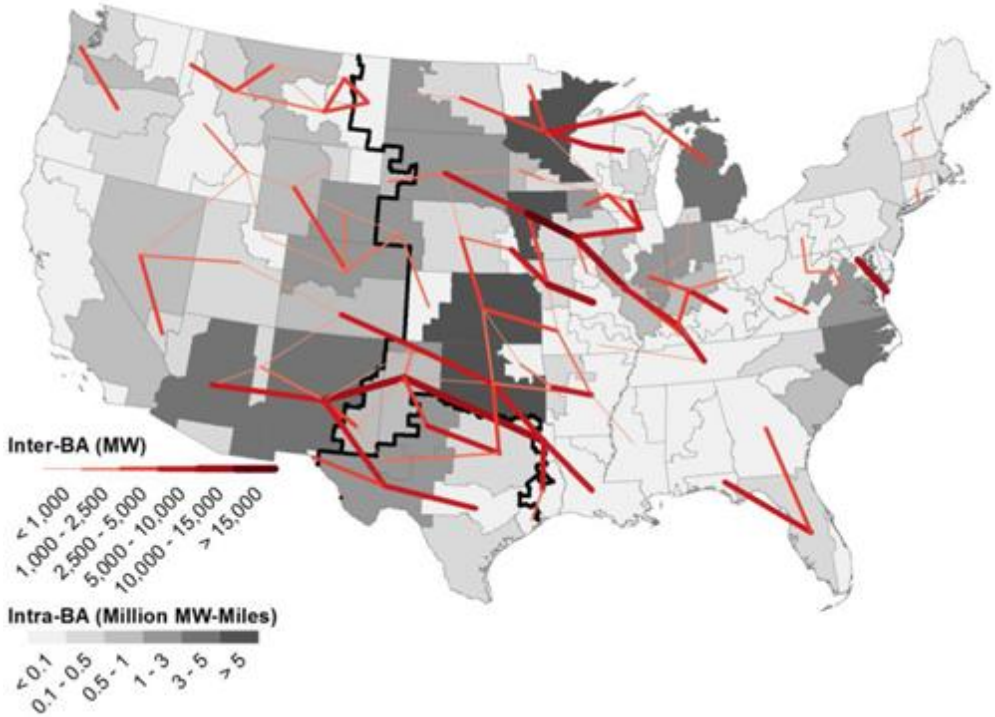
Figure 13: Total activated German Secondary Reserves (or aFRR) per year marked with events considered in this paper.

Rena Kuwahata, Peter Merk, WIW17

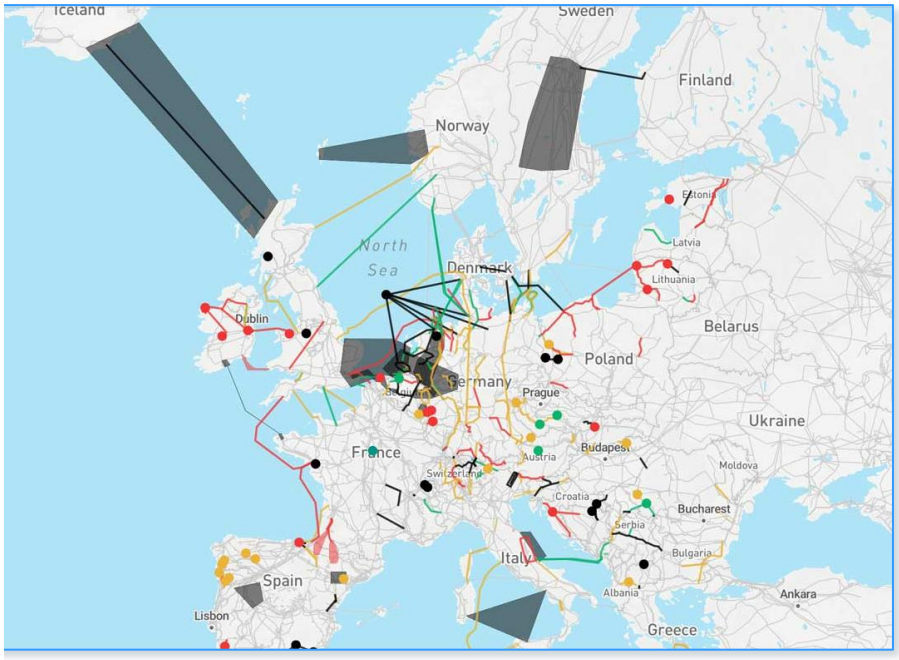
Task 25
Design and Operation of Power Systems with Large Amounts of Wind Power

Long term planning for grid – enabling sharing balancing

- Transmission planning – towards regional planning



Source NREL NATIONAL RENEWABLE ENERGY LABORATORY
http://www.nrel.gov/analysis/re_futures/



Source TYNDP (ENTSO-E, 2018)

Task 25
Design and Operation of Power Systems with Large Amounts of Wind Power

Using flexibility of thermal plants. Case Denmark.

- Changing the tariffs of smaller CHP plants to operate according to market prices
- Retrofitting the larger thermal plants

HIGH FLEXIBILITY OF POWER PLANTS

Operational range:
10–100%

Regulating rate:
3-4% per minute

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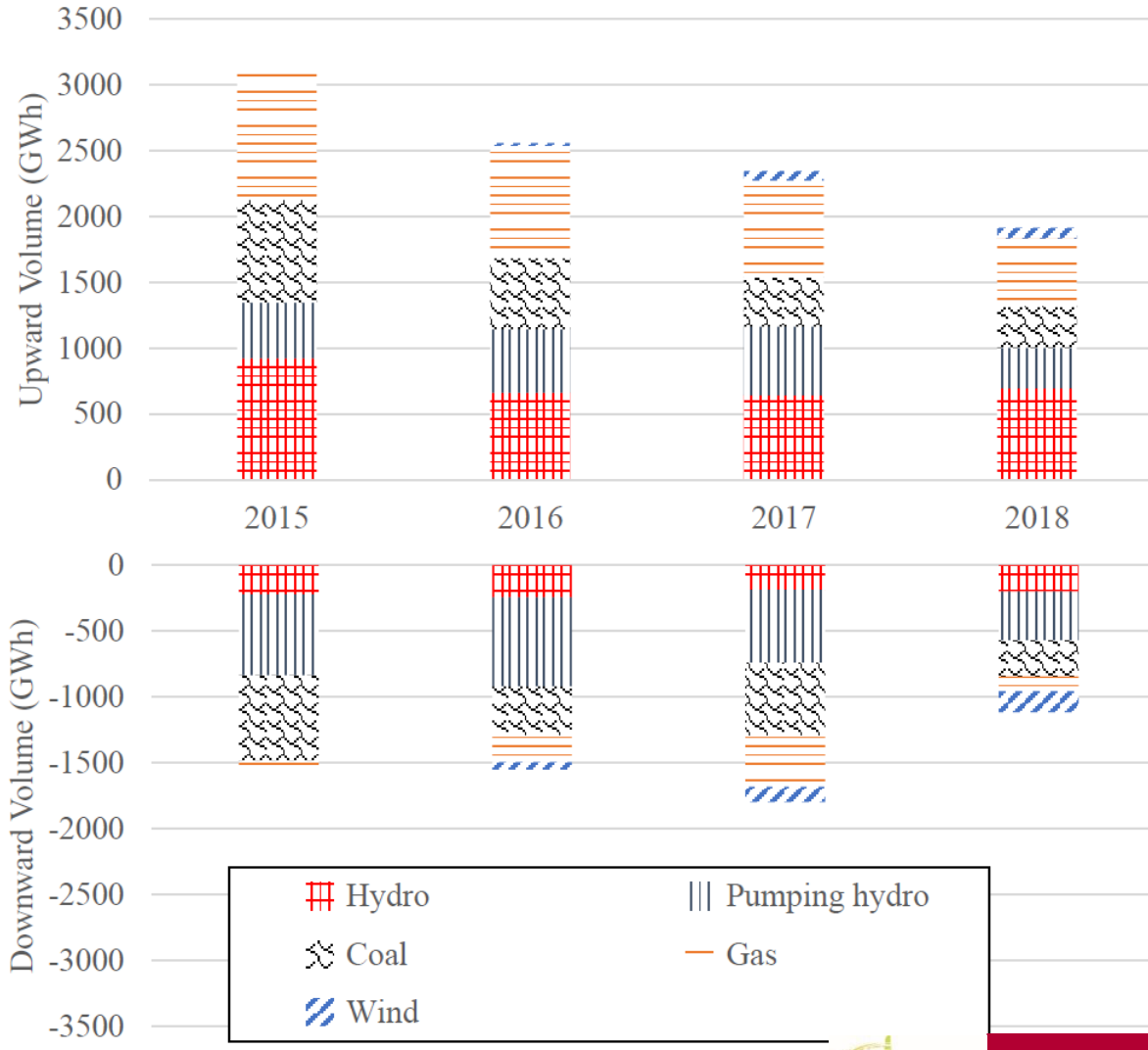
Using system services from wind and solar

Experience of frequency response:

- Very fast (inertial) in Quebec – helps in N-1 event
- Secondary in Colorado – when curtailed
- Tertiary in Spain: compliance tests and used by the market

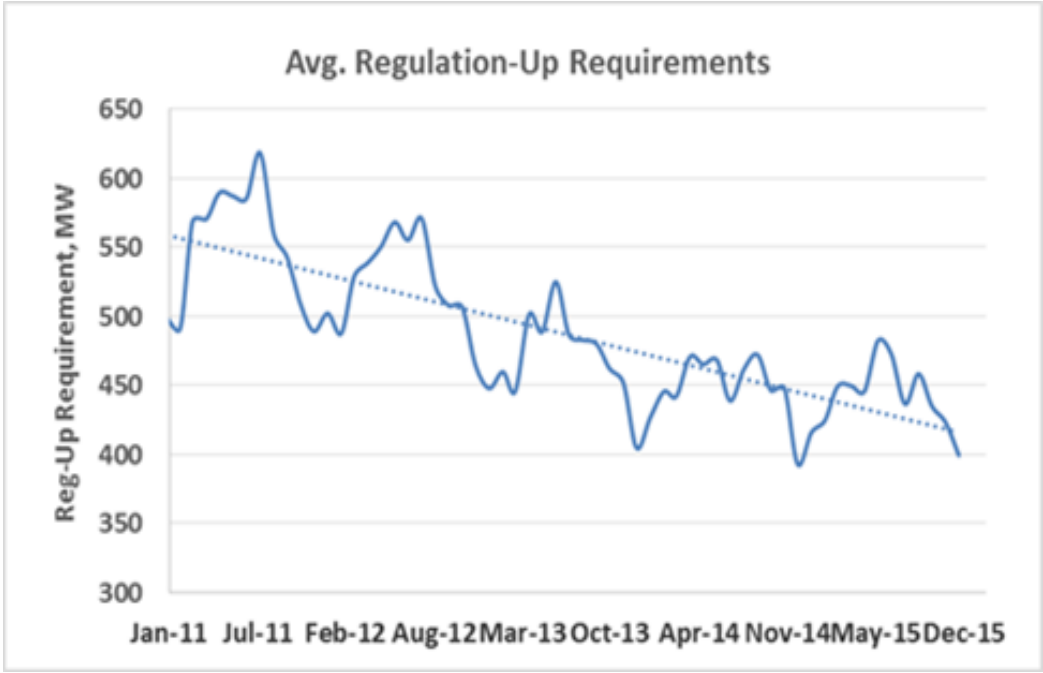


Spain tertiary reserves

Experience: Wind power frequency response is fast and high quality

- Texas: fast response of WPPs reduce the overall need for automatically activated frequency support services

- California: responses from PV better than conventional generators



Source: Julia Matevosjana, ERCOT

https://www.caiso.com/Documents/UsingRenewablesTo OperateLow-CarbonGrid.pdf

Task 25
Design and Operation of Power Systems with Large Amounts of Wind Power

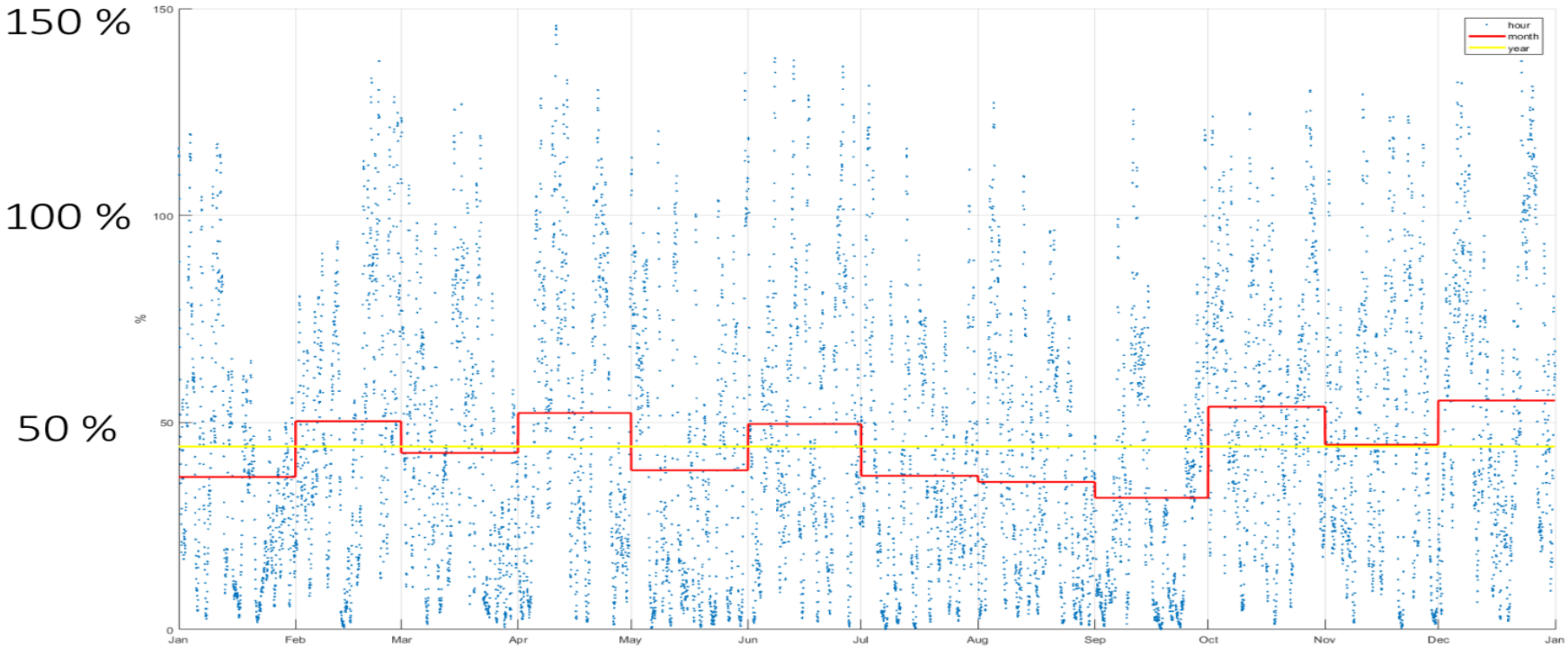
Operational practices to enable wind and solar in balancing and system support

- Markets one option where good experience in EU and US
  - generally about timing of dispatch decisions and possibility to take smaller balancing bids
  - no fixed tariffs to enable flexing down to give room to VG
- Enabling VG to offer flexibility, with extra gains from support services

Task 25
Design and Operation of Power Systems with Large Amounts of Wind Power

Very high shares of 50% and beyond

- Instant 100% of VRE operation already well before 50 % yearly share



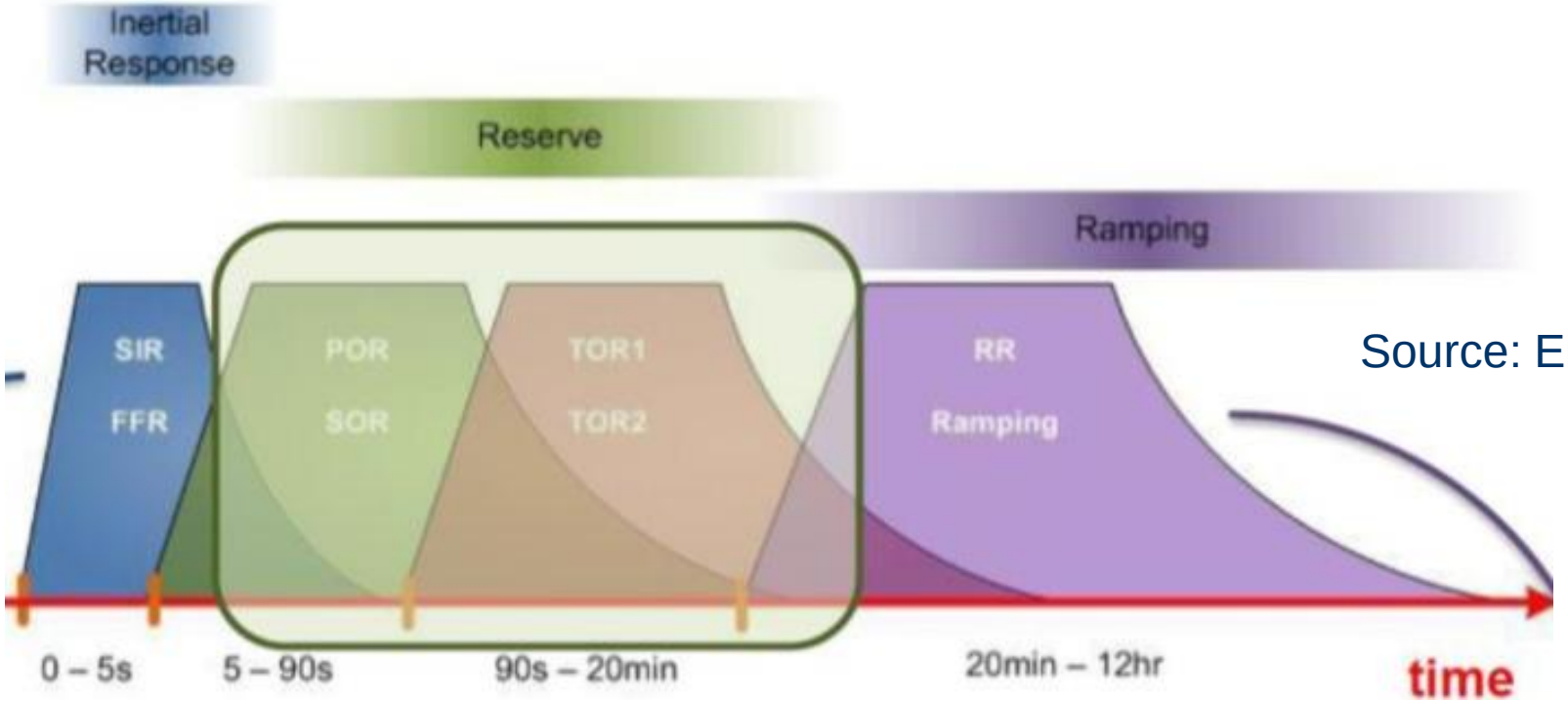
ENERGINET

Example DK 2017 43 % on average

Task 25
Design and Operation of Power Systems with Large Amounts of Wind Power

Experience Ireland: a range of system services

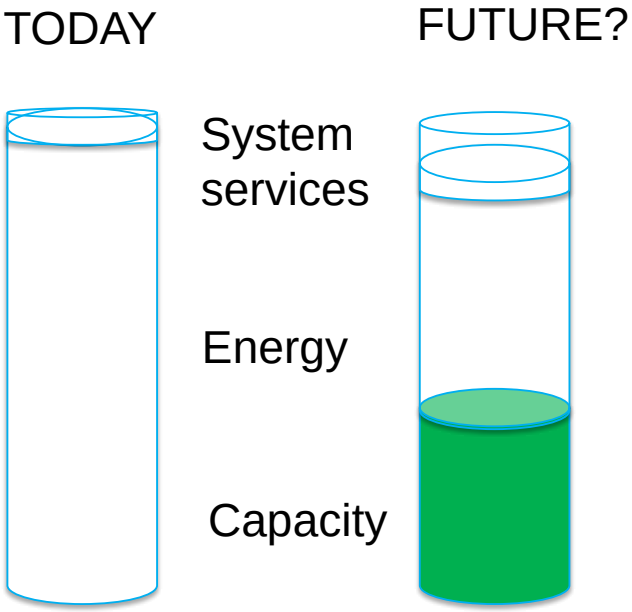
- Adding faster response, and slower ramping services
- Enabling high VG – low inertia – protection settings
- Situational awareness tools WAMS



Source: Eirgrid

Revenue sufficiency from markets– mitigating low prices

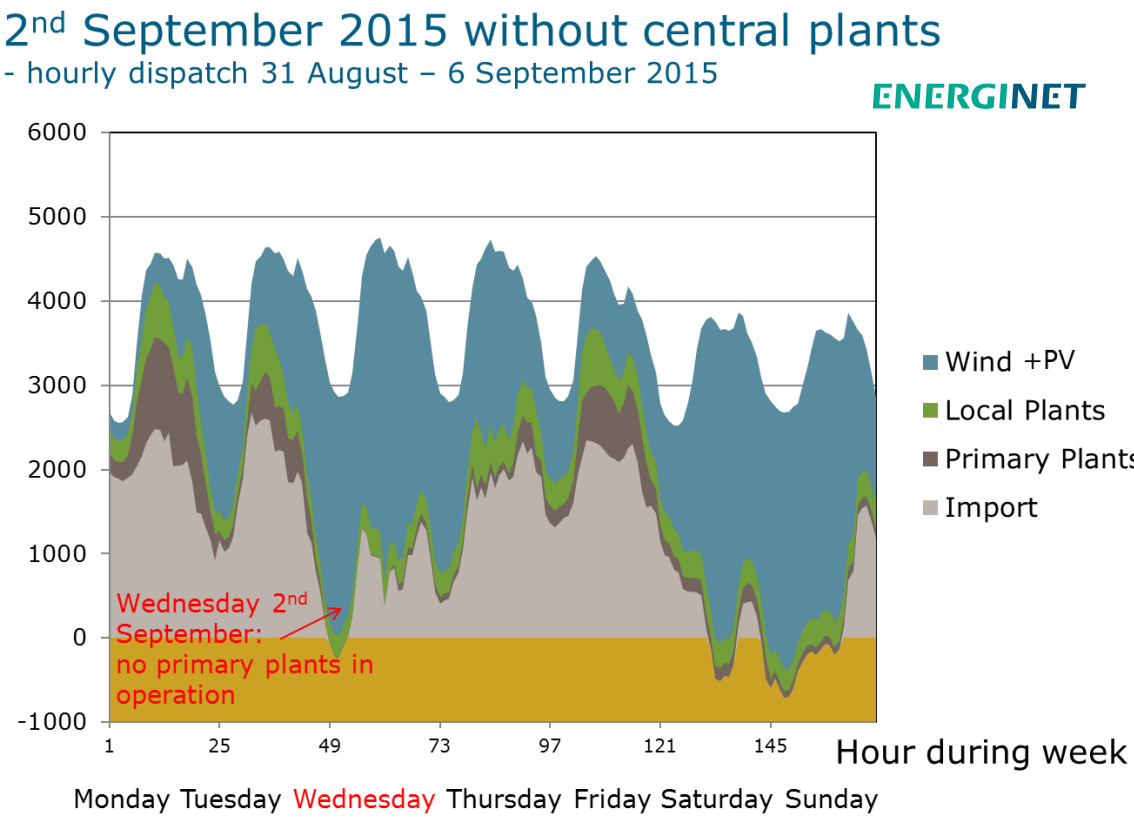
- Larger market area – keeping prices up
  - less correlated wind power production
- New loads to take cheaper electricity
- Faster markets – balancing costs down
  - Improved load/net load following dispatch
- Frequency control from wind and solar
  - where surplus energy /very low prices, wind/PV can operate part load and offer fast up- and down-regulation
  - Often this becomes cost effective at larger (>20%) shares of wind and solar



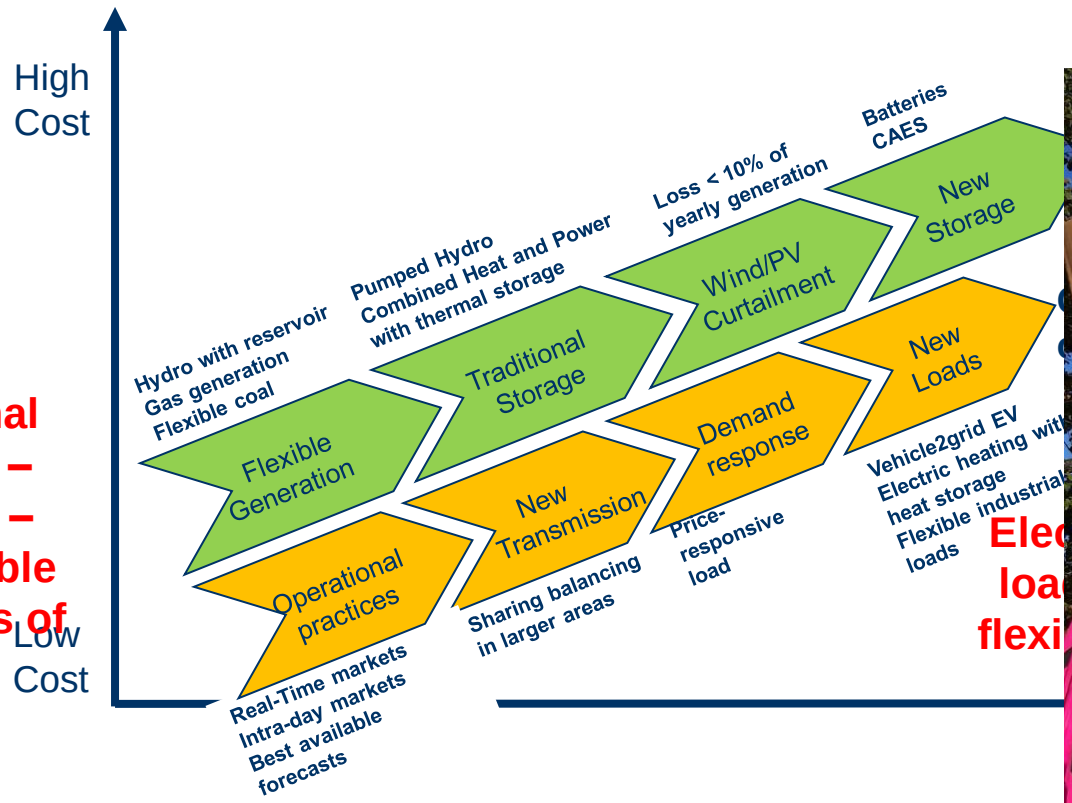
Pushing the limits: Denmark operating the system without central power plants

First time in 2015 and several times since then, all central power plants shut down. The necessary system support from:

- HVDC link: 700 MW Denmark-Norway
- synchronous compensators 4 in DK-W and 2 in DK-E
- and small scale power plants



Load transition and inverter controls -opportunities for high VG shares



Operational practices – and tools – key to enable high shares of VIBRES

VIBREs – and loads and electrical storage can provide the system support services provided by generators today

Thank You!!

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