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

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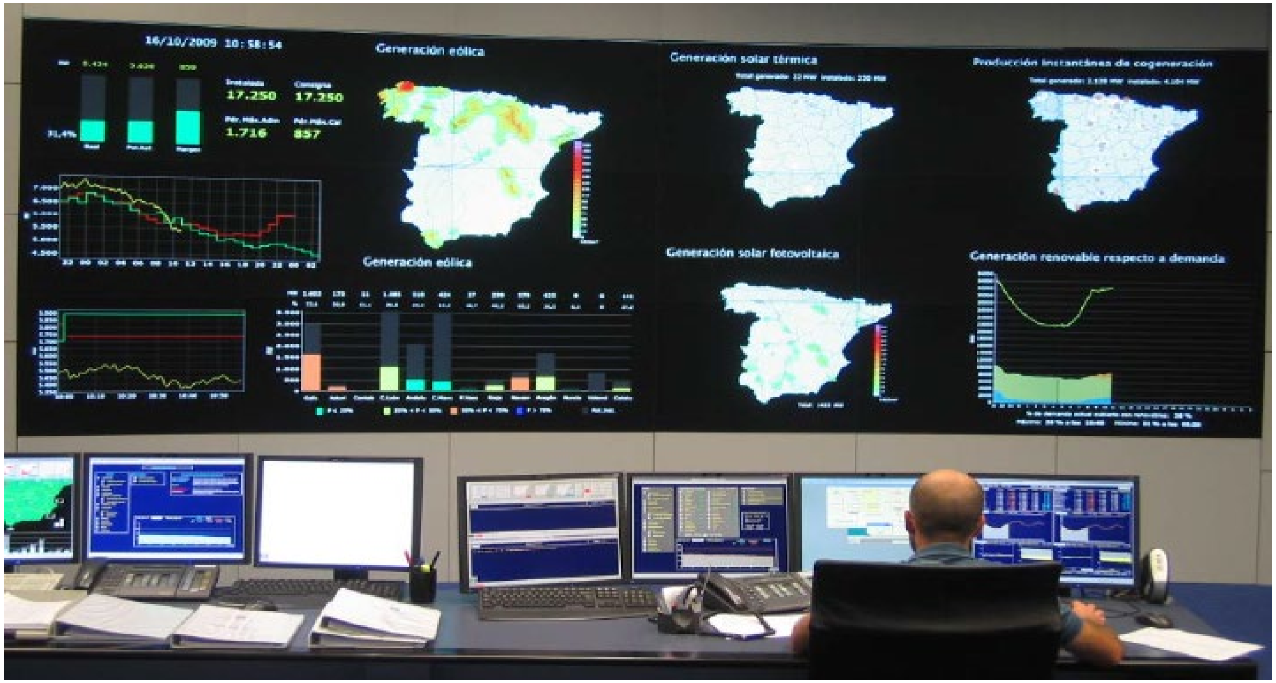
of Wind Power

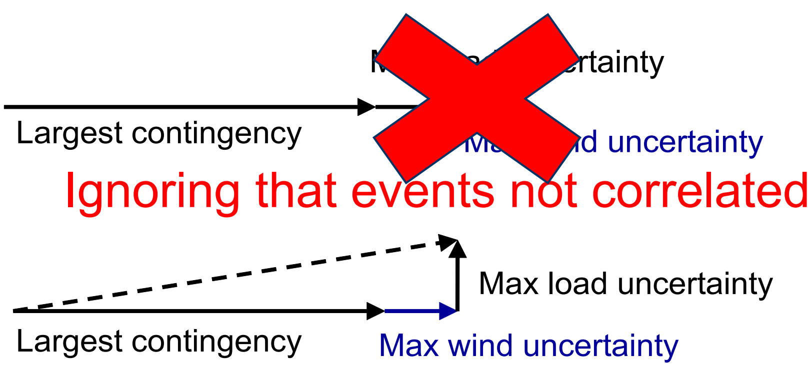
Experience from Wind and Solar Integration: first 5-10% share

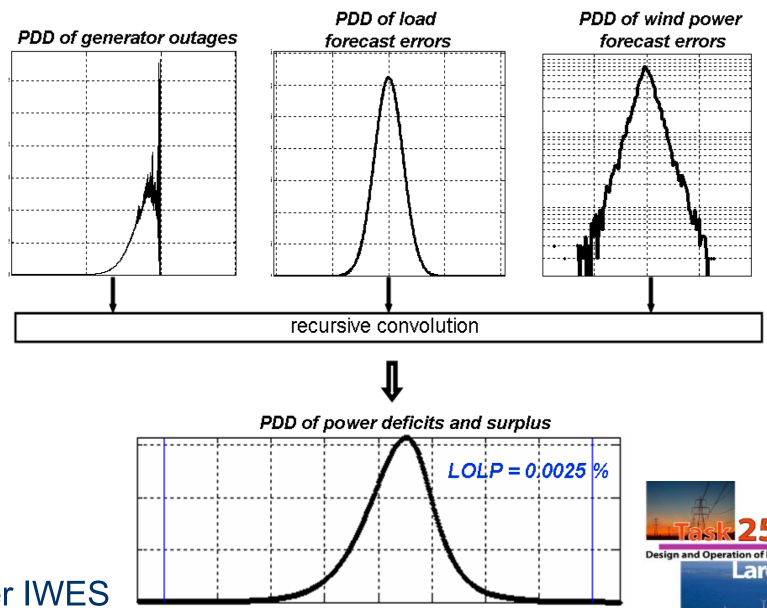
- Updated information from on-line production and forecasts.
- Possibility to curtail in critical situations.
- Grid connection codes



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

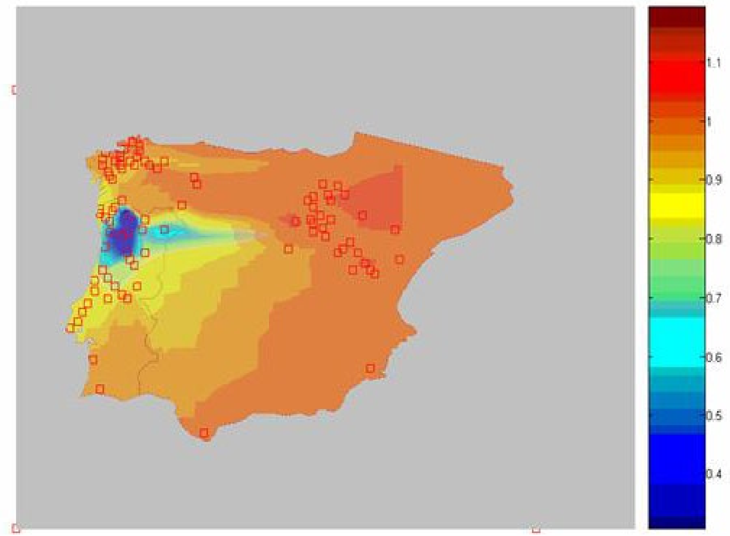




Source: Fraunhofer IWES

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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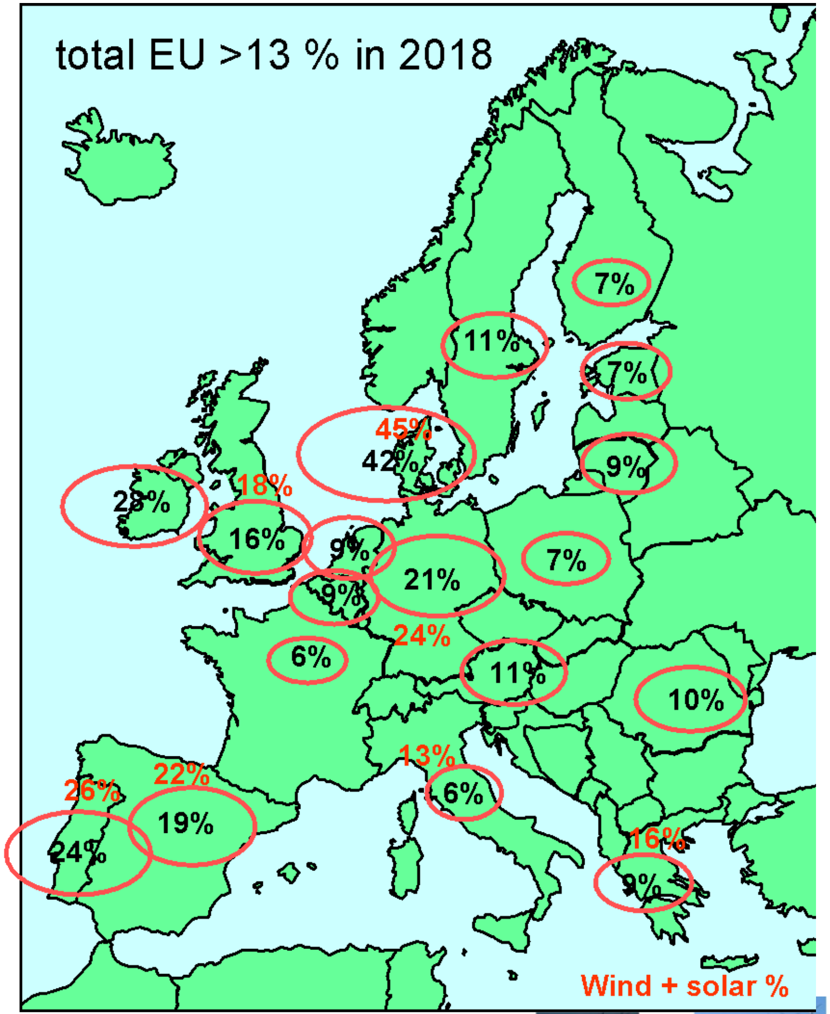
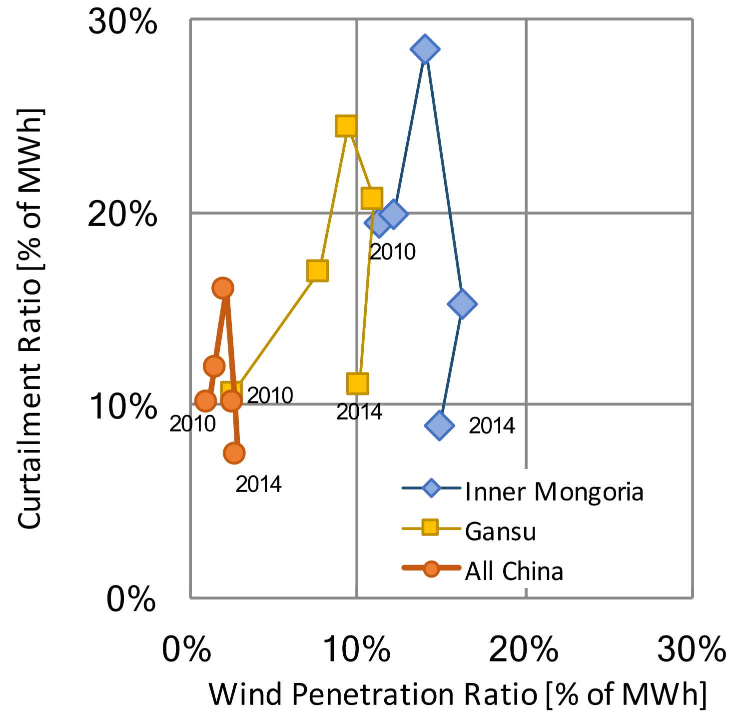
Experience from Wind and Solar Integration – next phase

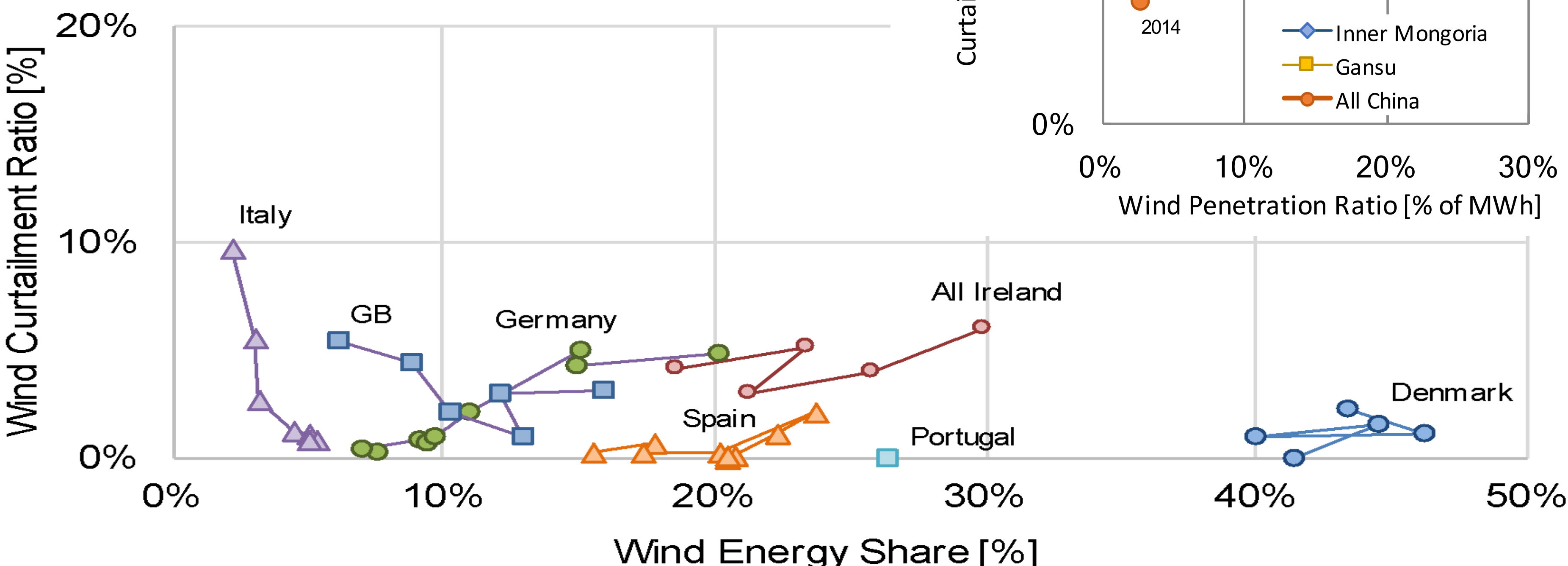
- Sharing balancing
- Enabling also wind and solar in grid support
- Generation – and demand - flexibility and adequacy
- Transmission a key enabler, with regional planning efforts
  - Local markets, PV and storages emerging as another solution
- Countries' flexibility differ
  - Interconnections, hydro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



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

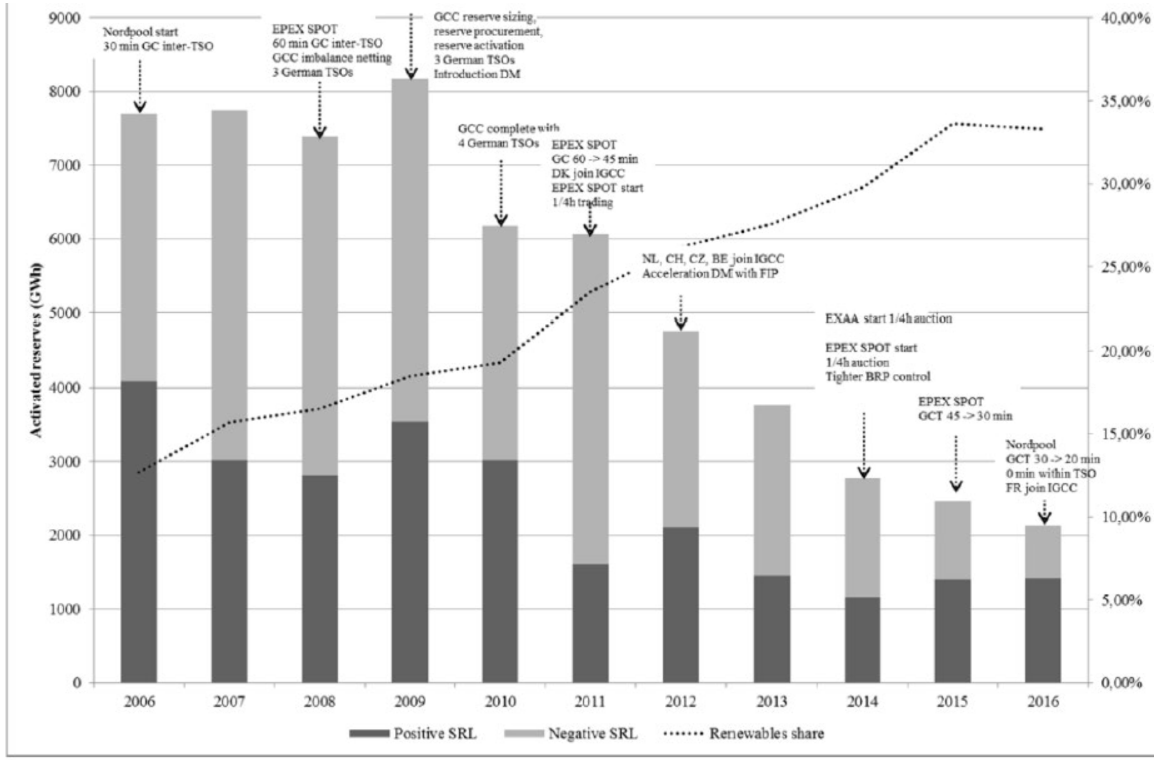
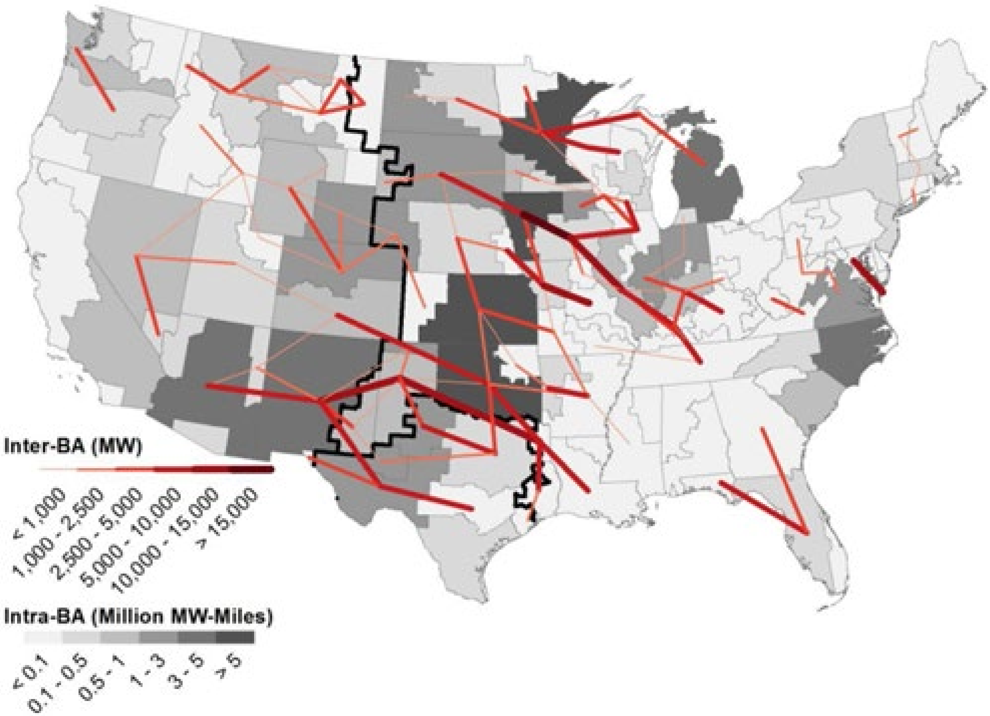


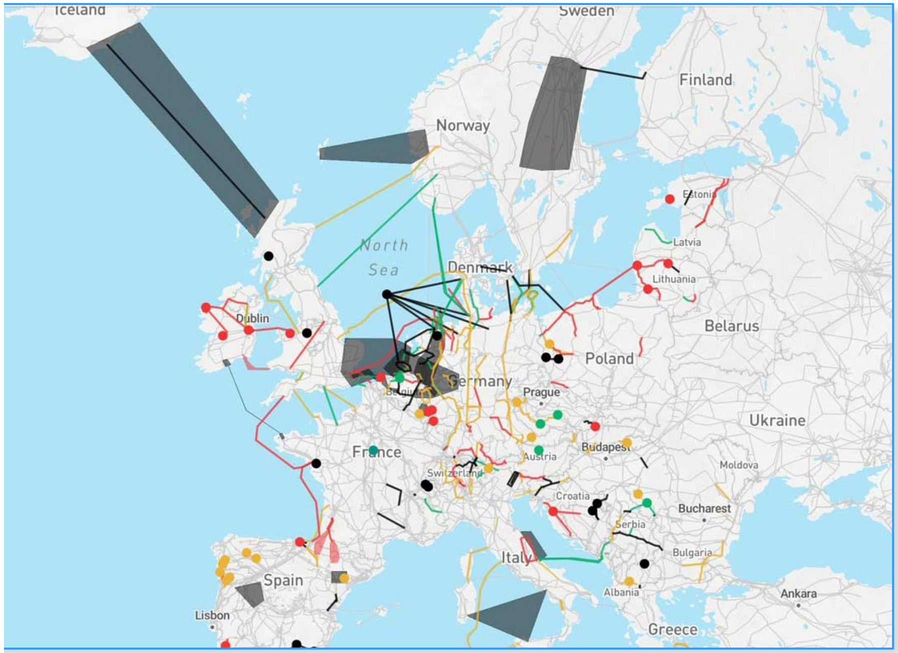
Figure 13: Total activated German Secondary Reserves (or aFRR) per year marked with events considered in this paper.

Rena Kuwahata, Peter Merk, WIW17

Long term planning for grid – enabling sharing balancing

- Transmission planning – towards regional planning





Source TYNDP (ENTSO-E, 2018)

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

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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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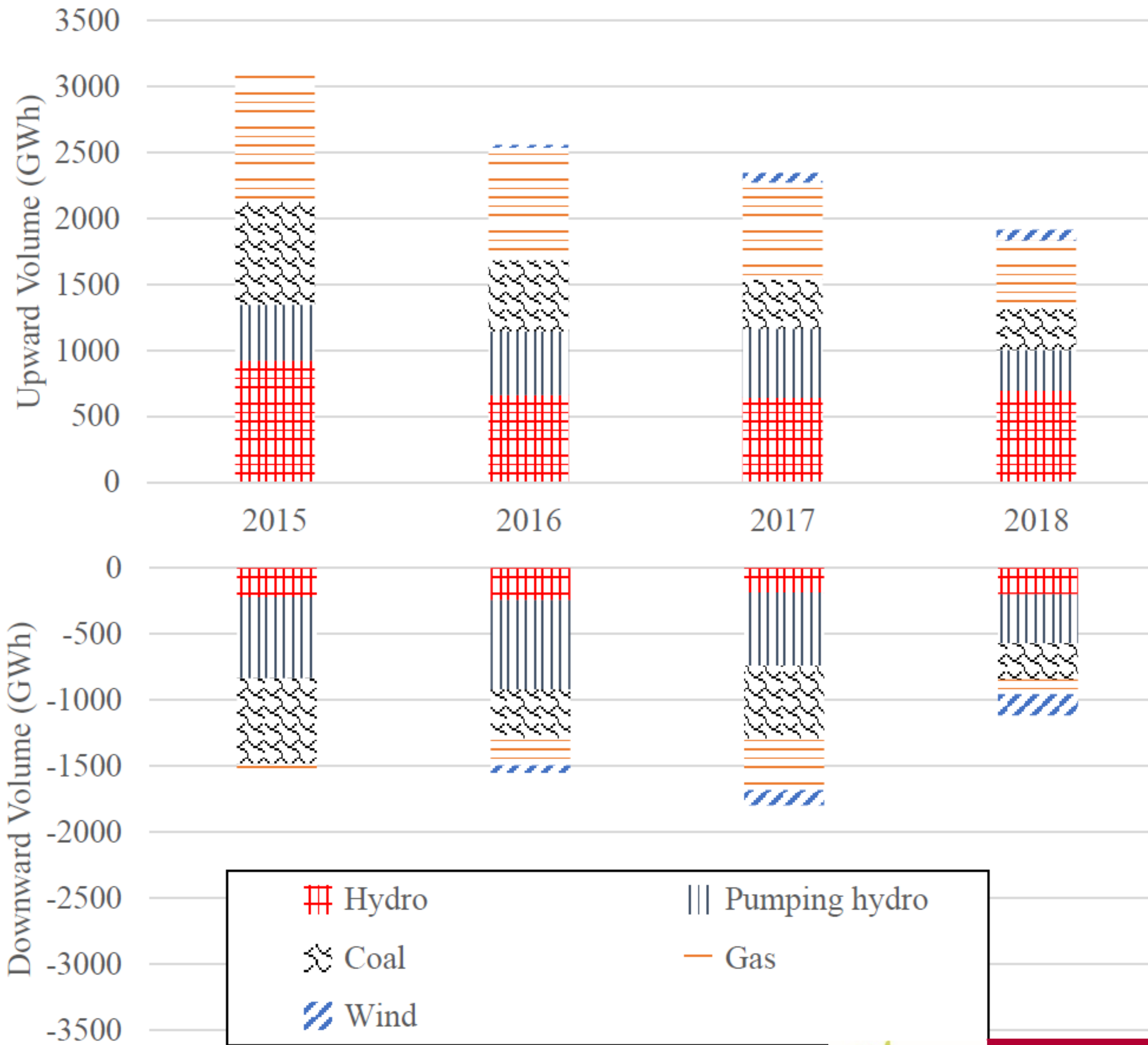
Using system services from wind and solar

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

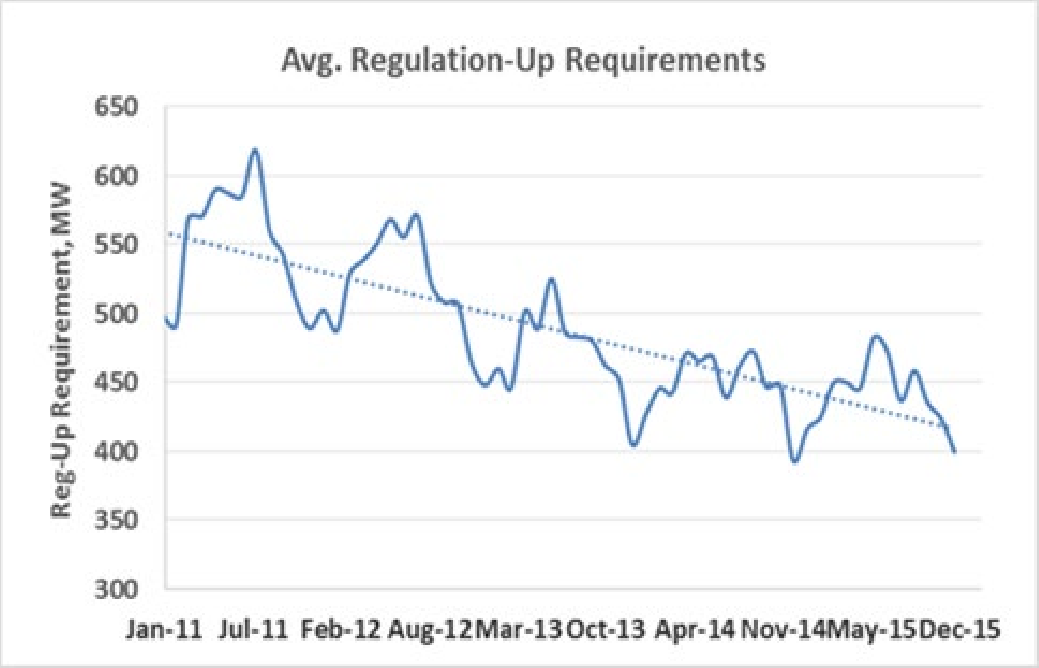


Spain tertiary reserves

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

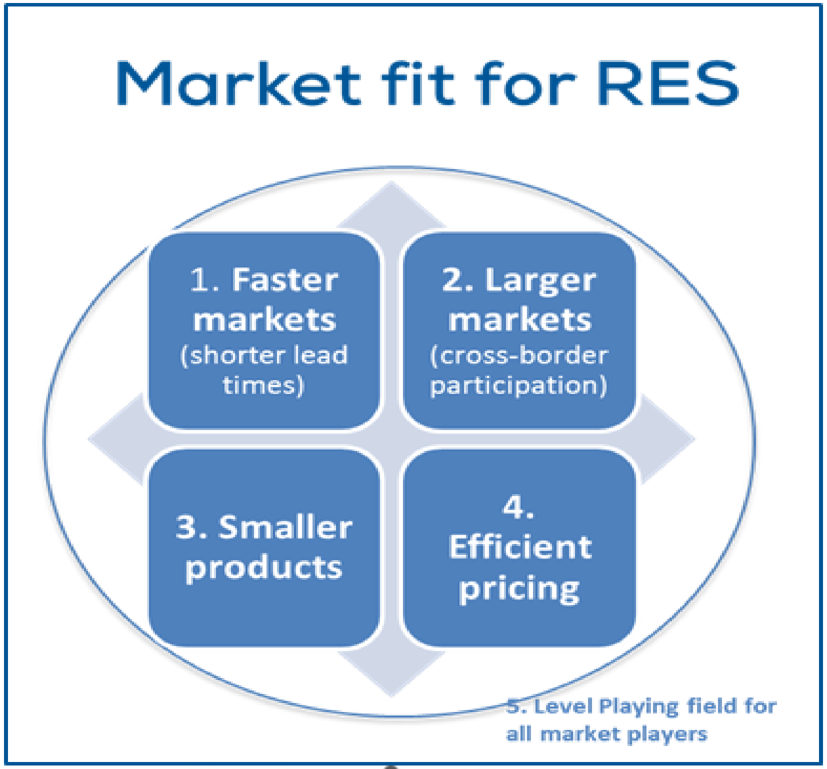


Source: Julia Matevosjana, ERCOT

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

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



MarketRES

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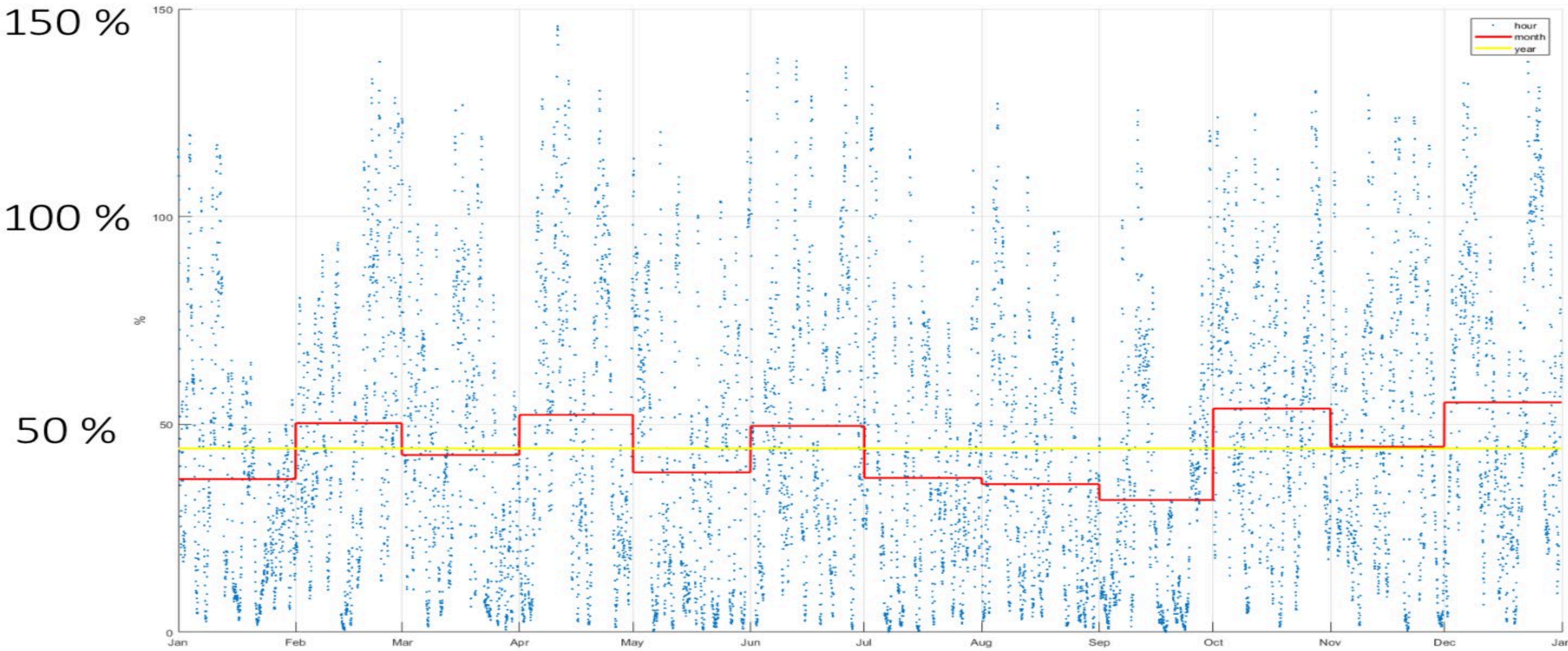
Very high shares of 50% and beyond

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



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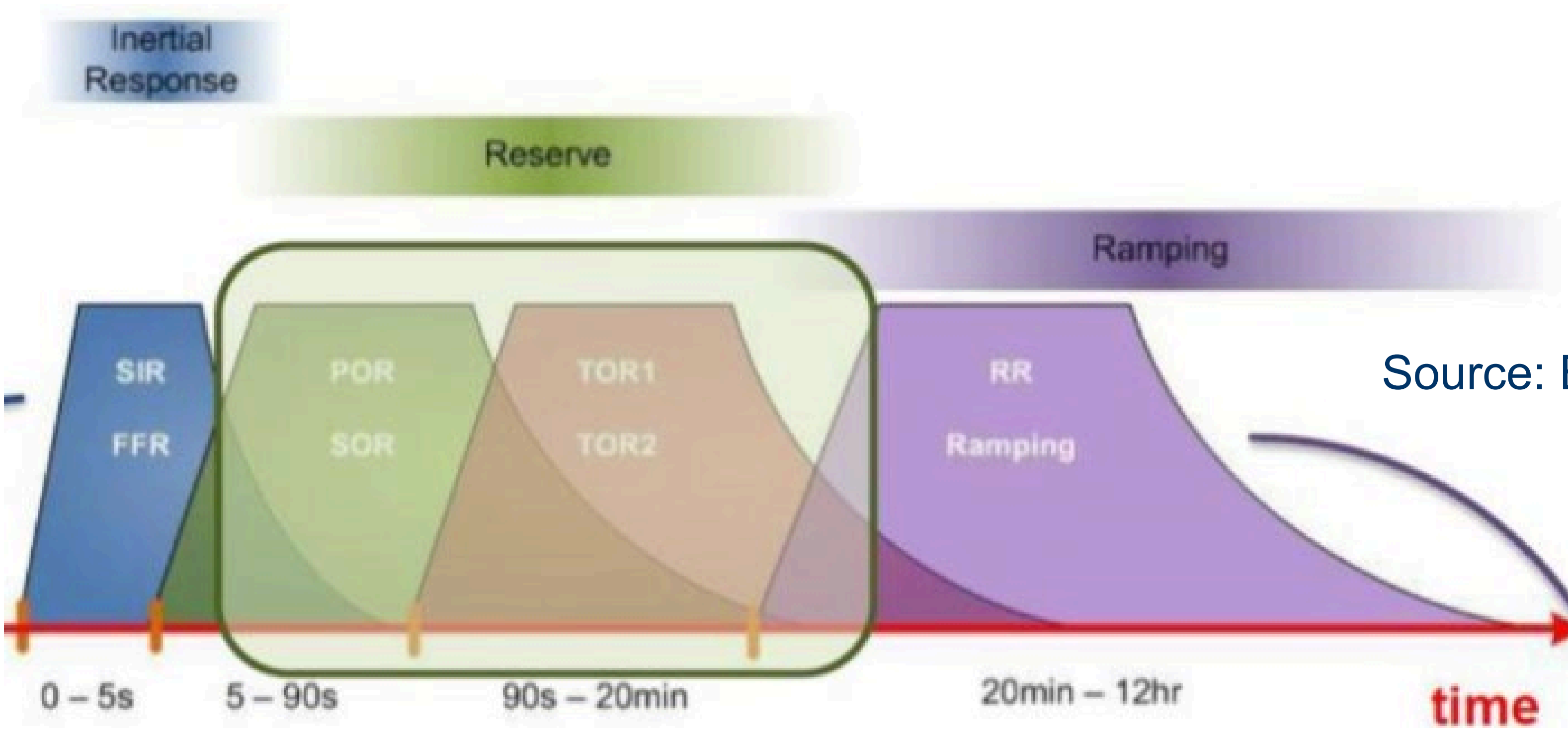
Example DK 2017 43 % on average

Experience Ireland: a range of system services

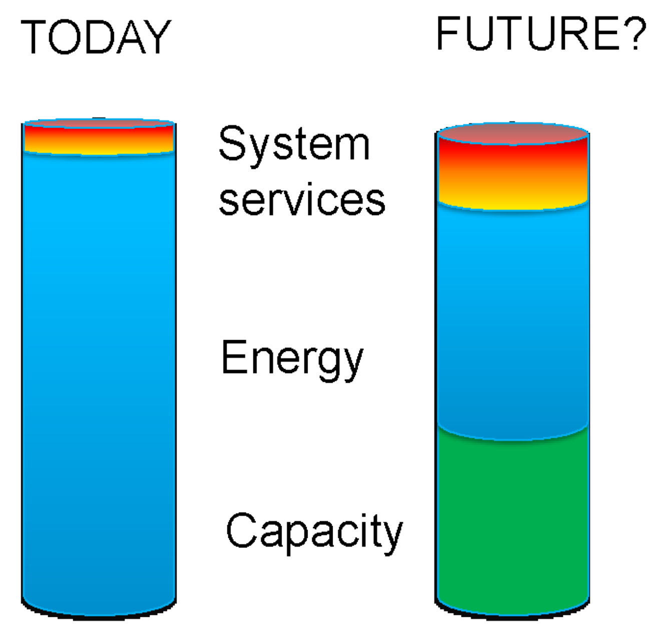
- Adding faster response, and slower ramping services
- Enabling high VG – low inertia – protection settings
- Situational awareness tools WAMS



Source: Eirgrid

Revenue sufficiency from markets– mitigating low prices

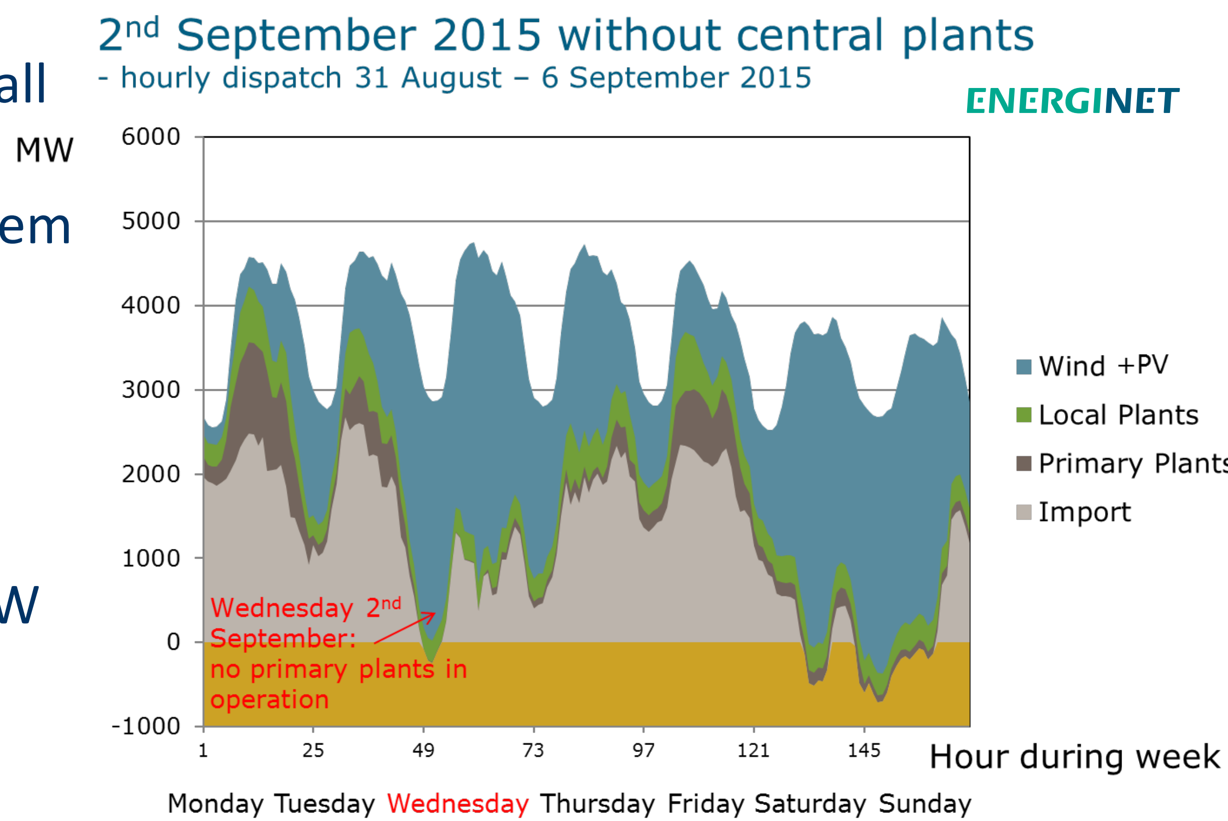
- Larger market area – keeping prices up
  - less correlated wind power production
- New loads to take cheaper electricity
- Faster markets – balancing costs down
  - Improved load/net load following dispatch
- Frequency control from wind and solar
  - where surplus energy /very low prices, wind/PV can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



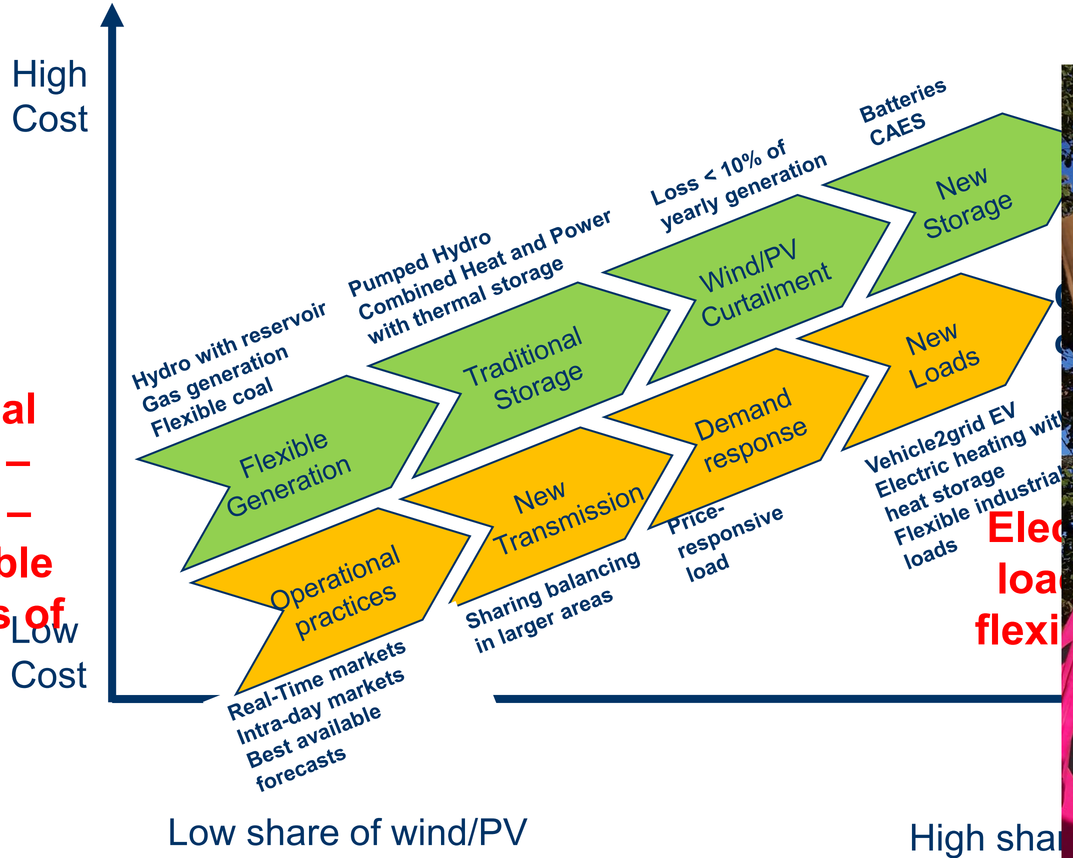
Pushing the limits: Denmark operating the system without central power plants

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

Elec
loa
flexi

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

Thank You!!

Hannele Holttinen

Hannele.Holttinen@recognis.fi

+66 61 473 5255

+358 40 5187055