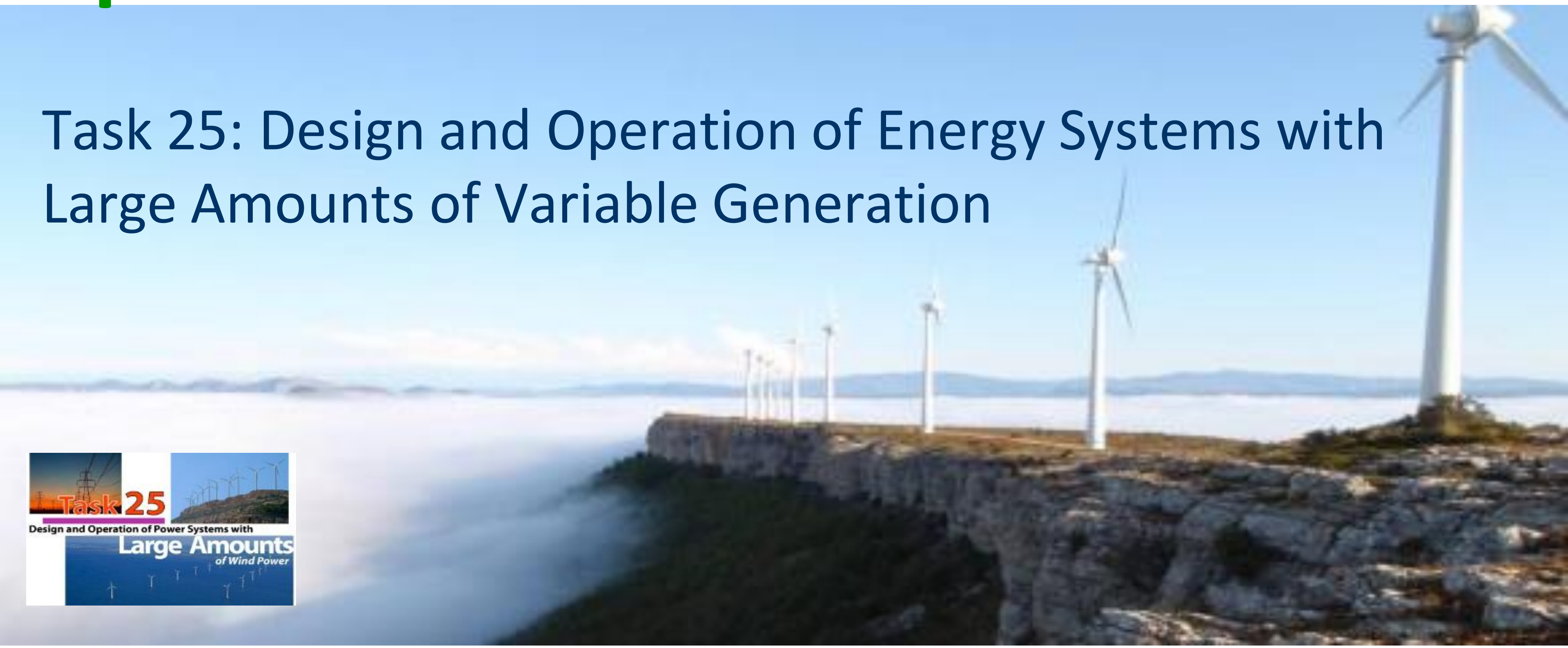
Maximising value of wind in system operation

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



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WESC2021, 26 May, 2021

iea wind

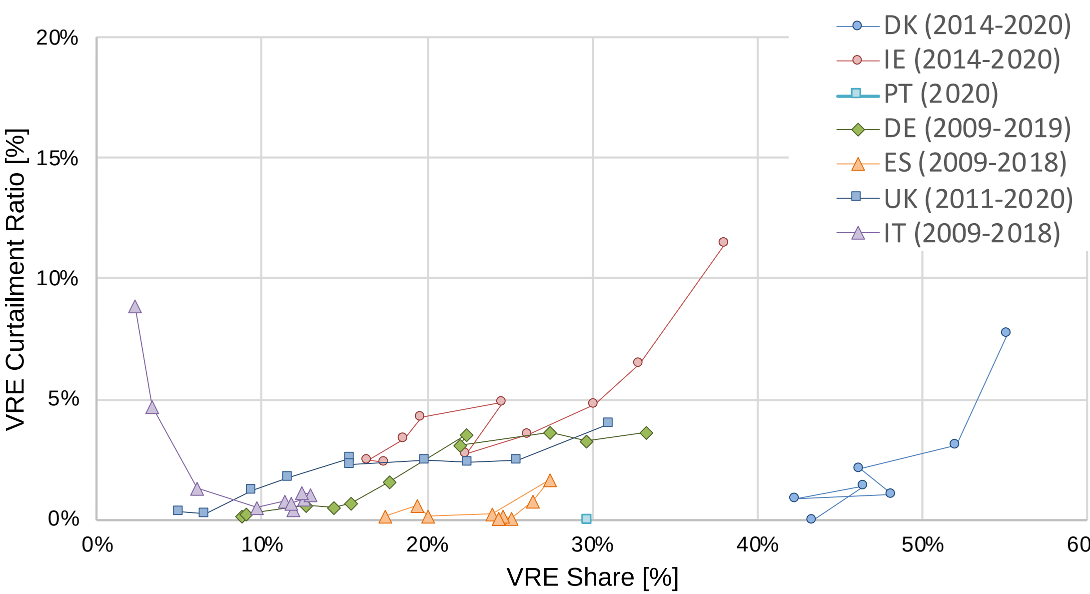
Contents

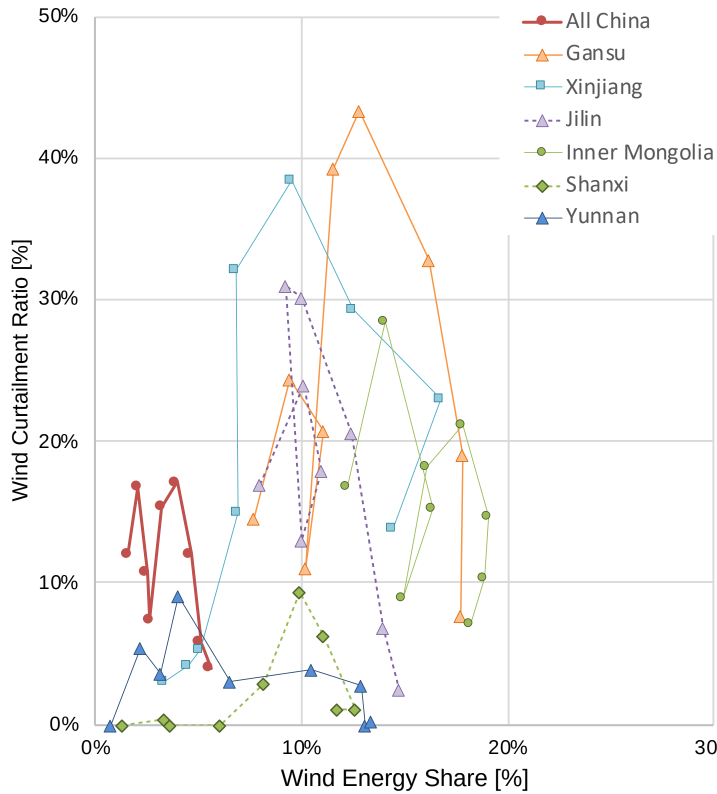
- Minimising curtailments
- Using wind power for system services
- Operational practices
  - grid
  - market design
- Using existing and new flexibilities

ENERGINET

Curtailments

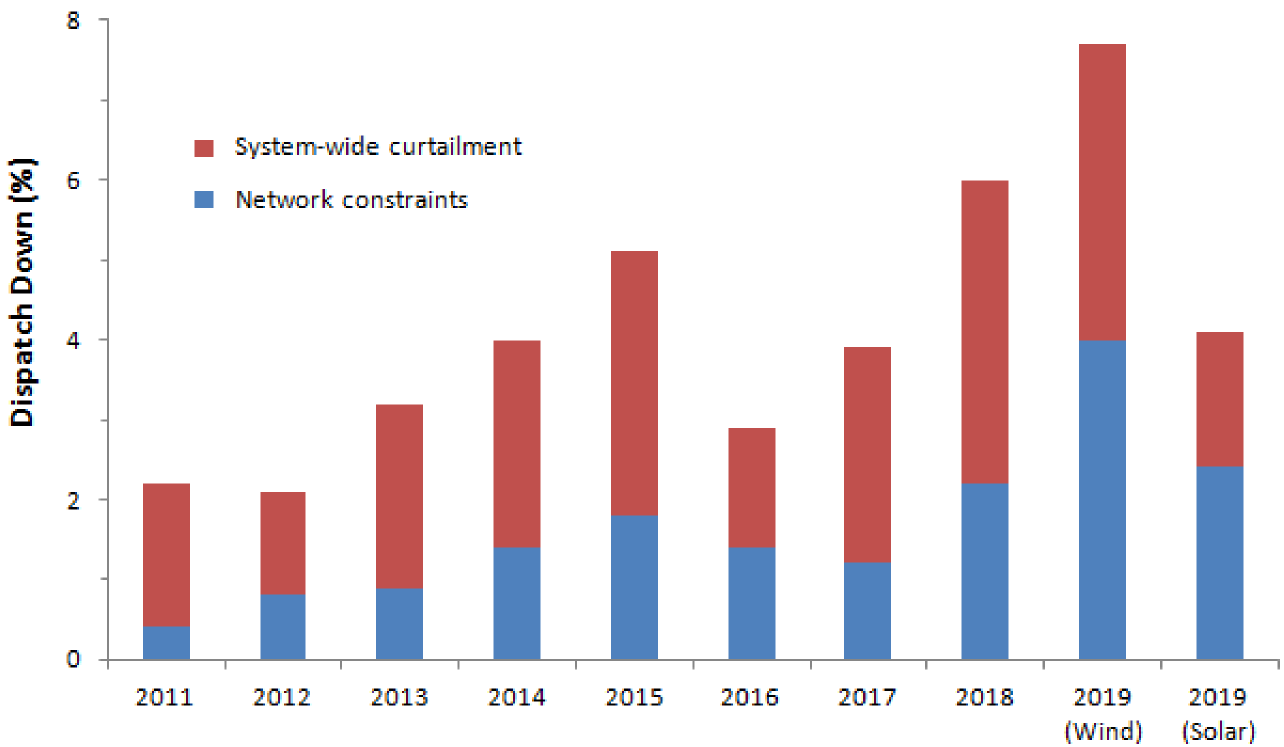
- up in Europe, down in China
- Reasons: grid inadequacy, inflexibility, system limits
- Solving by building grid (IT, CHI)
- market based curtailment
  - DK, ES: WPP bidding balancing





Ireland power system curtailments

- Network oonstraints are more local
- System wide: SNSP limit
  - increased to 75% instant share of async generation



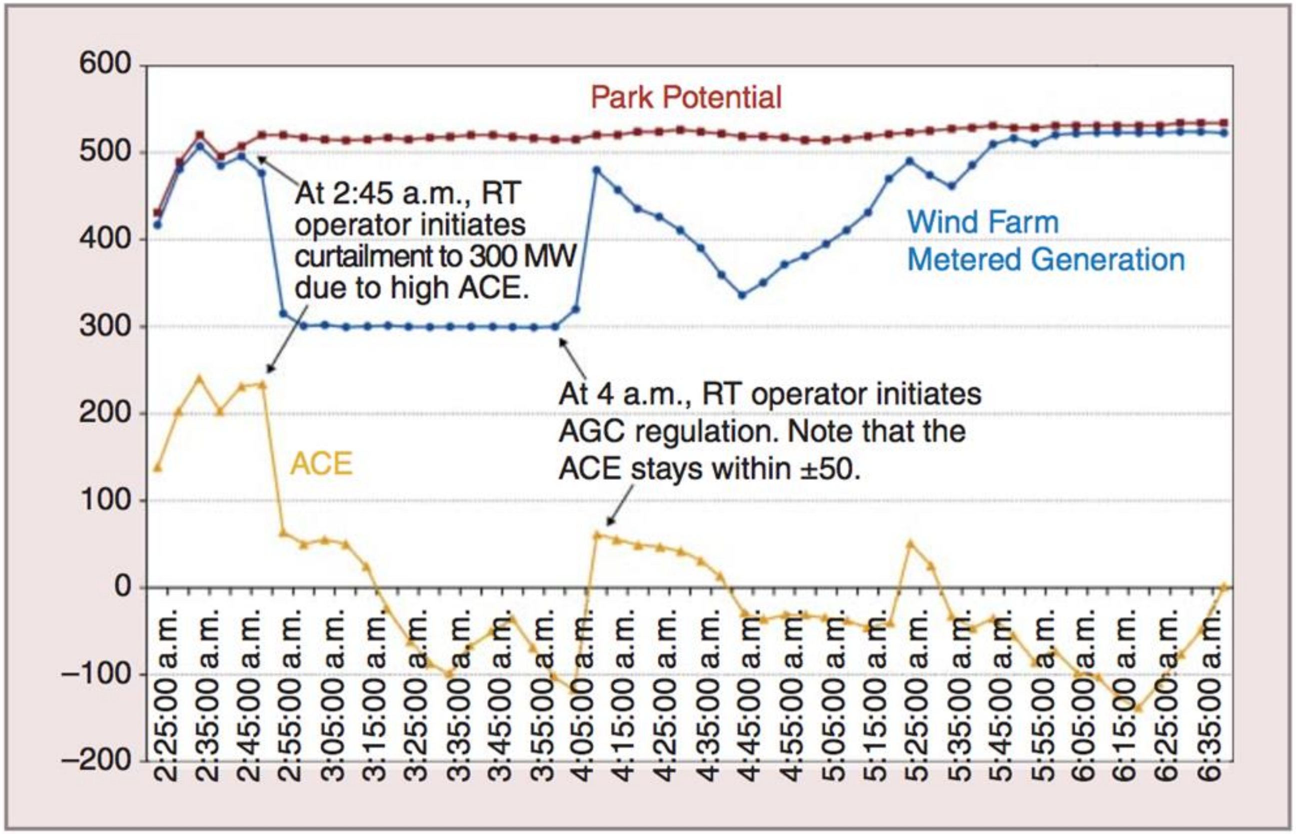
2020: 5.3% system wide, 6 % network = 11%, record high wind share 36%

Using wind power for AS

- When surplus of wind and PV, important to provide AS, otherwise risk being curtailed to commit a synchronous generator for providing the services
- Frequency control, and balancing markets already have experience from several power systems
  - **Spain:** 14 GW (54%) of wind power participate in the ancillary services (Oct 2019), increasingly being used:
    - of total downward reserves 14.4% in 2018 and 14.8% in 2019 from wind
    - of total upward reserves, 4.8% in 2018 and 7.5% in 2019 from wind

Regulation / AGC

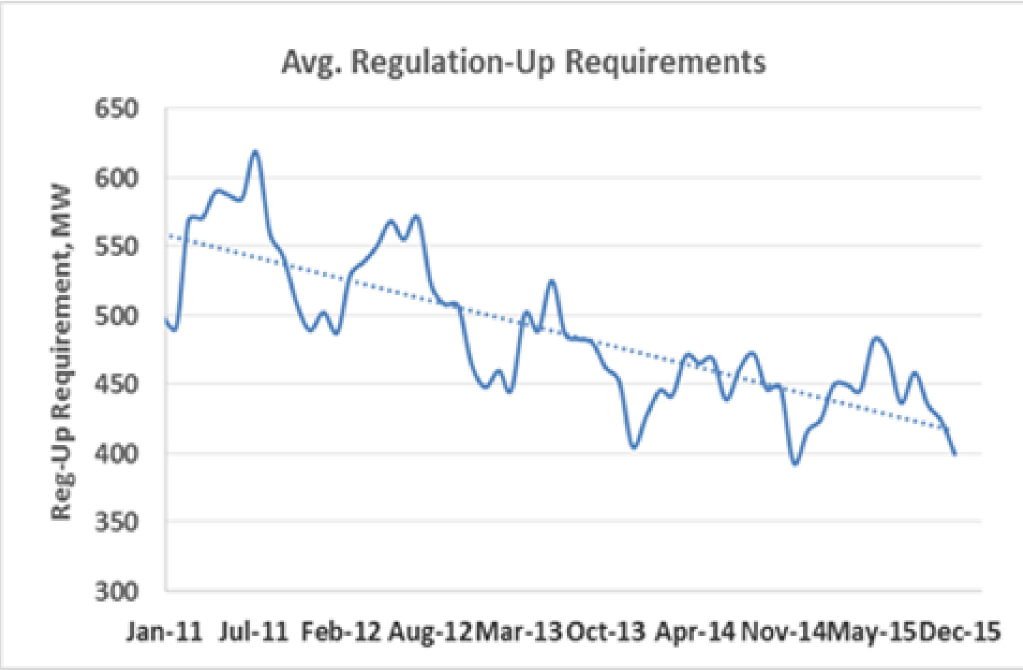
- Experience Colorado Xcel
- Curtailed wind & solar can provide also up-regulation



Primary / Fast frequency response

- ERCOT, Texas: FFR (0.5s) High wind, low load: 1,400 MW of FFR provides same response (and reliability impact) as 3,300 MW of PFR
- Hydro Quebec event 28 Dec, 2015, frequency nadir of 59.08 Hz, wind power plants response contributed to the recovery of the system frequency

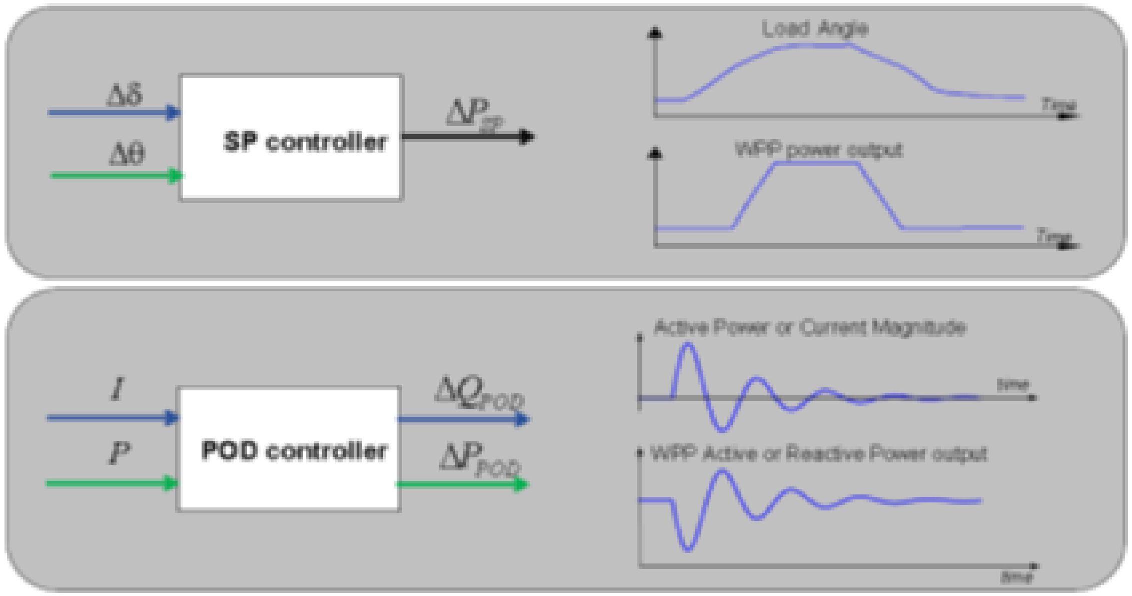
Faster response is more valuable



Texas experience, less need for fast frequency support after wind power plants provide good response (Source: Julia Matevosjana, ERCOT)

New services + paying for them

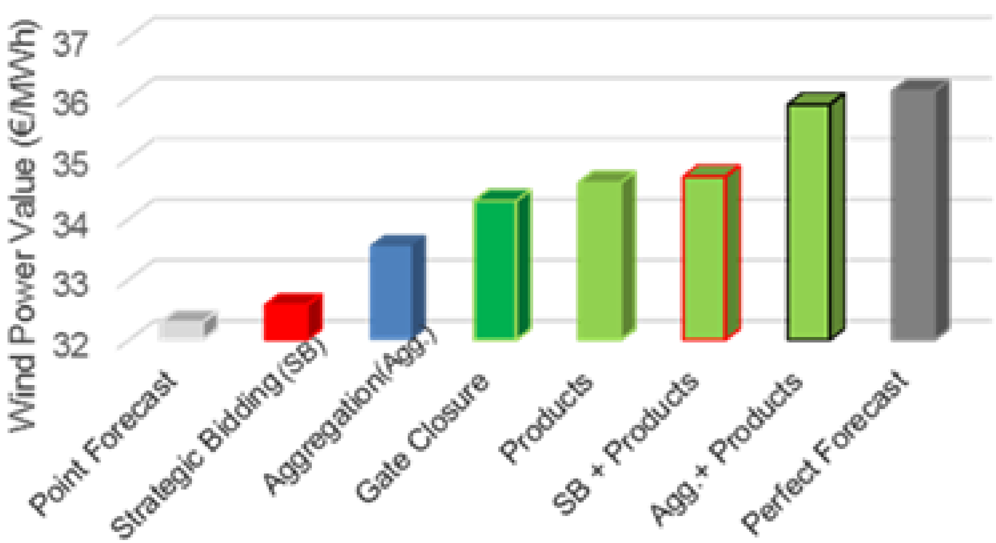
- New: Power oscillation damping POD, Synchronising power SP, Restoration, Grid forming inverters
- Start paying for Inertia, Ramping, Voltage
- introducing services when system benefits and need



- Paying for all services – now many required in grid codes without compensation

Market design to enable grid support services income to wind

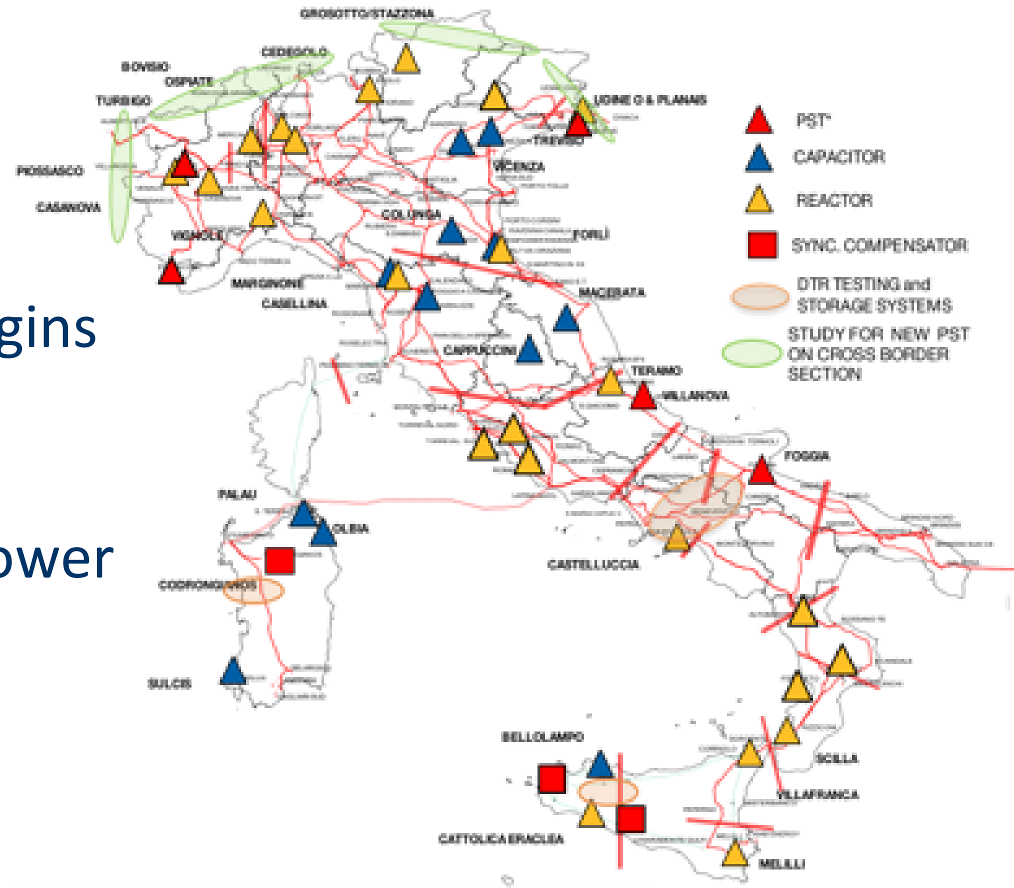
- Possibility to bid close to delivery (for example hour ahead); smaller amounts of MWs
- Local flexibility markets – DSO/TSO coordination



Increasing wind energy value to the market using different approaches: strategic bidding based on probabilistic forecast (SB), aggregation (Agg.), shorter gate closure and balancing products (Source: Algarvio & Knorr, 2017).

Operational practices – grid

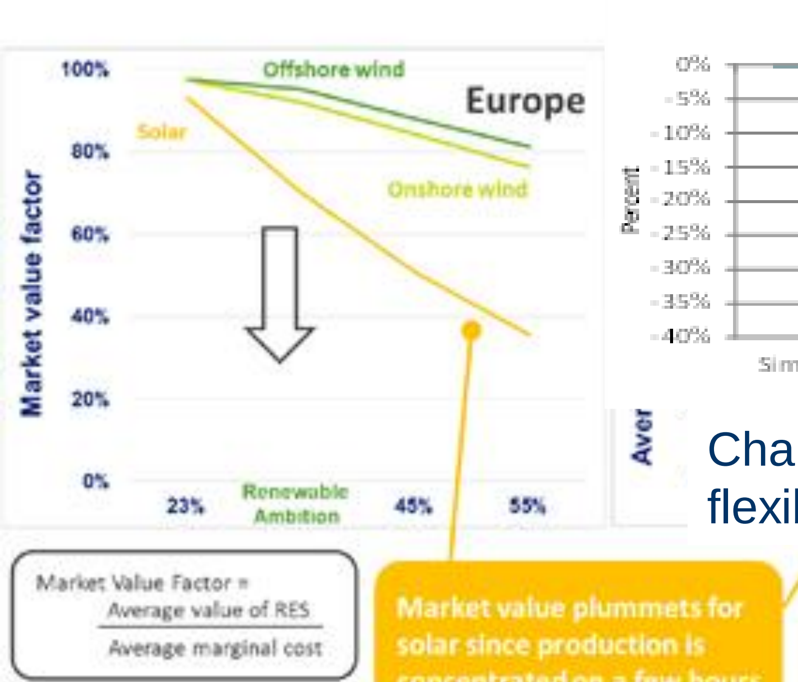
- Congestion management
  - to avoid curtailments and increase efficiency
  - Using existing grid to the limits: Setting security margins with stochastic weather forecasts; Dynamic Line Ratings (DLR); Advanced Power Flow Control; Topology Optimisation
- TSO-DSO coordination
  - flexibility from distributed resources, ensuring secure operation of the distribution



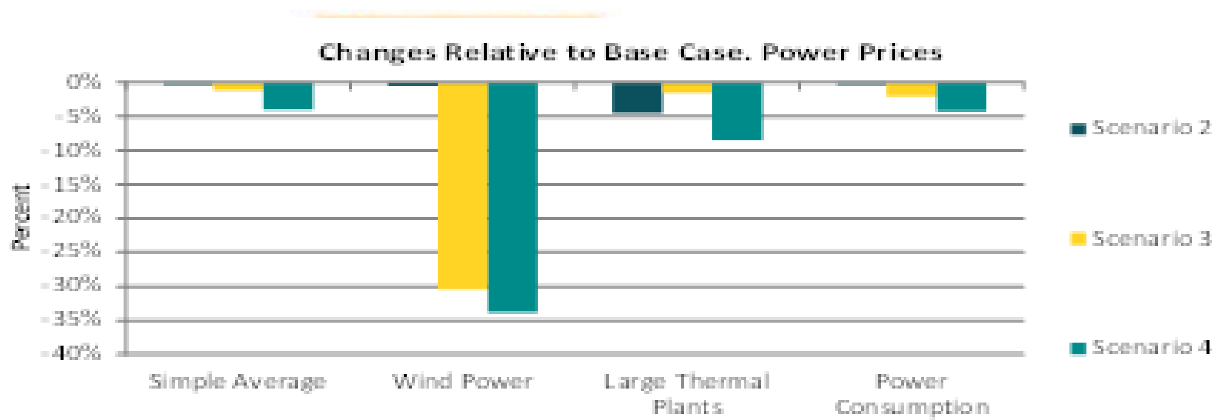
Example of grid investments to active and reactive power management in Italy (DTR = dynamic transmission rating). (Source: Terna)

Flexibility will increase value of wind energy in markets

- “profile losses” of wind and solar are smaller when other generation, and loads, flex according to wind and solar available



Source: EU-SYSFLEX D2.5



Changes in market prices in case of non-flexible system in Denmark

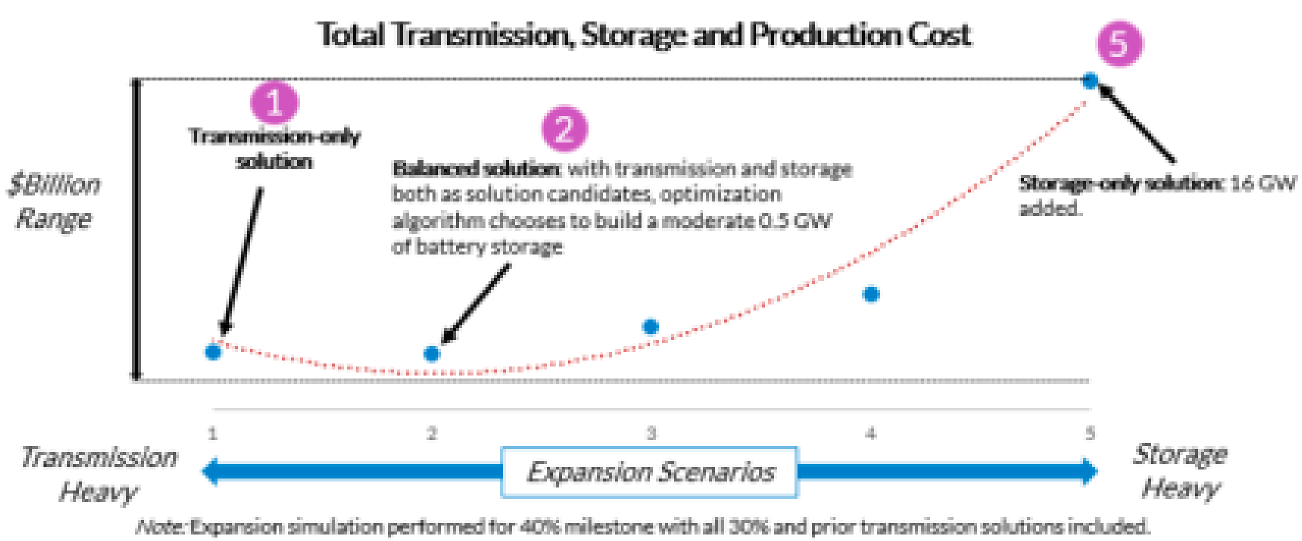
(Energinet)

Flexibilities

- Hydro power
  - pumped hydro useful for longer than few hours, hydro storage costs driven by the kW costs (cables + reversible pumps), reduces the need for CCGT (Askeland et al., 2016).
- Thermal power
  - retrofits to lower minimum on-line power helps reduce curtailments
  - Combined heat and power and heat pumps, with heat storage
- Storage
  - Batteries provide short-term balancing over one to some hours, reduce the need for peaker power plants
- Increasing transmission has good cost benefit
- Demand response – short term flexibility for existing loads and longer term flexibility for Power2X loads

Comparing cost benefit of flexibility options

- Curtailments indication of inflexibilities, estimating future curtailments in integration studies – and adequacy of flexibility
- Flexibility options for different time scales, and may compete eating each others' benefits



comparison of transmission-only solutions, storage-only solutions, and combined transmission/storage solutions for 40% wind and solar in Eastern Interconnection of the US (source: MISO RIIA)

Summary – revenue sufficiency

- Larger market area – keeping prices up
  - less correlated wind power production
- Faster markets – balancing costs down
  - Improved load/net load following dispatch
- Flexibility to avoid low price energy
  - New loads to take cheaper electricity
- Grid support from wind and solar
  - Becomes cost effective at larger (>20%) shares of wind /PV
  - At surplus energy /very low prices, wind/PV can operate part load and offer fast response up/down, and other services
  - System needs – what exactly is needed in different operational situations, and how much

Based on IEA WIND Task 25 collaborative publications

- Summary report **"Design and operation of energy system with large amounts of variable generation"** to be published fall 2021
- "**Towards 100% Variable Inverter-based Renewable Energy Power Systems**" by Bri-Mathias Hodge, C Brancucci, H Jain, G Seo, B Kroposki, J Kiviluoma, H Holttinen, J C Smith, A Estanqueiro, A Orths, L Söder, D Flynn, M Korpås, T K Vrana, Yoh Yasuda. WIREs Energy and Environment vol 9, iss. 5, e354 https://doi.org/10.1002/wene.376
- "**System impact studies for near 100% renewable energy systems dominated by inverter based variable generation**" by H Holttinen; J Kiviluoma; D Flynn; C Smith; A Orths; P B Eriksen; N Cutululis; L Söder; M Korpås, A Estanqueiro, J MacDowell, A Tuohy, T K Vrana, M O'Malley , IEEE TPWRS Oct 2020 open access https://ieeexplore.ieee.org/document/9246271

- https://www.researchgate.net/project/IEA-Task-25-Design-and-Operation-of-Power-Systems-with-Large-Amounts-of-wind-power

IEA Wind Task 25: Design and operation of energy systems with large amounts of variable generation

Country	Institution
Canada	Hydro Quebec (Alain Forcione, Nickie Menemenlis); NRCan (Thomas Levy)
China	SGERI (Wang Yaohua, Liu Jun)
Denmark	DTU (Nicolaos Cutululis); Energinet.dk (Antje Orths); Ea analyse (Peter Börre Eriksen)
Finland (OA)	VTT (Hannele Holttinen, Juha Kiviluoma)
France	EdF R&D (E. Neau); TSO RTE (J-Y Bourmaud); Mines (G. Kariniotakis)
Germany	Fraunhofer IEE (J. Dobschinski); FfE (S. von Roon); TSO Amprion (P. Tran)
Ireland	UCD (D. Flynn); SEAI (J. McCann); Energy Reform (J. Dillon);
Italy	TSO Terna Rete Italia (Enrico Maria Carlini)
Japan	Kyoto Uni (Y. Yasuda); CRIEPI (R. Tanabe)
Netherlands	TUDelft (Arjen van der Meer, Simon Watson); TNO (German Morales Sspana)
Norway	NTNU (Magnus Korpås); SINTEF (John Olav Tande, Til Kristian Vrana)
Portugal	LNEG (Ana Estanquiero); INESC-Porto (Ricardo Bessa)
Spain	University of Castilla La Mancha (Emilio Gomez Lazaro); Comillas (Adres Ramos)
Sweden	KTH (Lennart Söder)
UK	Imperial College (Goran Strbac);
USA	NREL (Bri-Mathias Hodge); UVIG (J.C. Smith); DoE (Jian Fu)
Wind Europe	European Wind Energy Association (Vasiliki Klonari, Daniel Fraile)

https://iea-wind.org/task25/

old web site: *https://community.ieawind.org/task25/*

Thank You!!

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