Grid challenges to wind deployment

Winterwind, 8th Feb 2017
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Operating Agent, IEA WIND Task 25

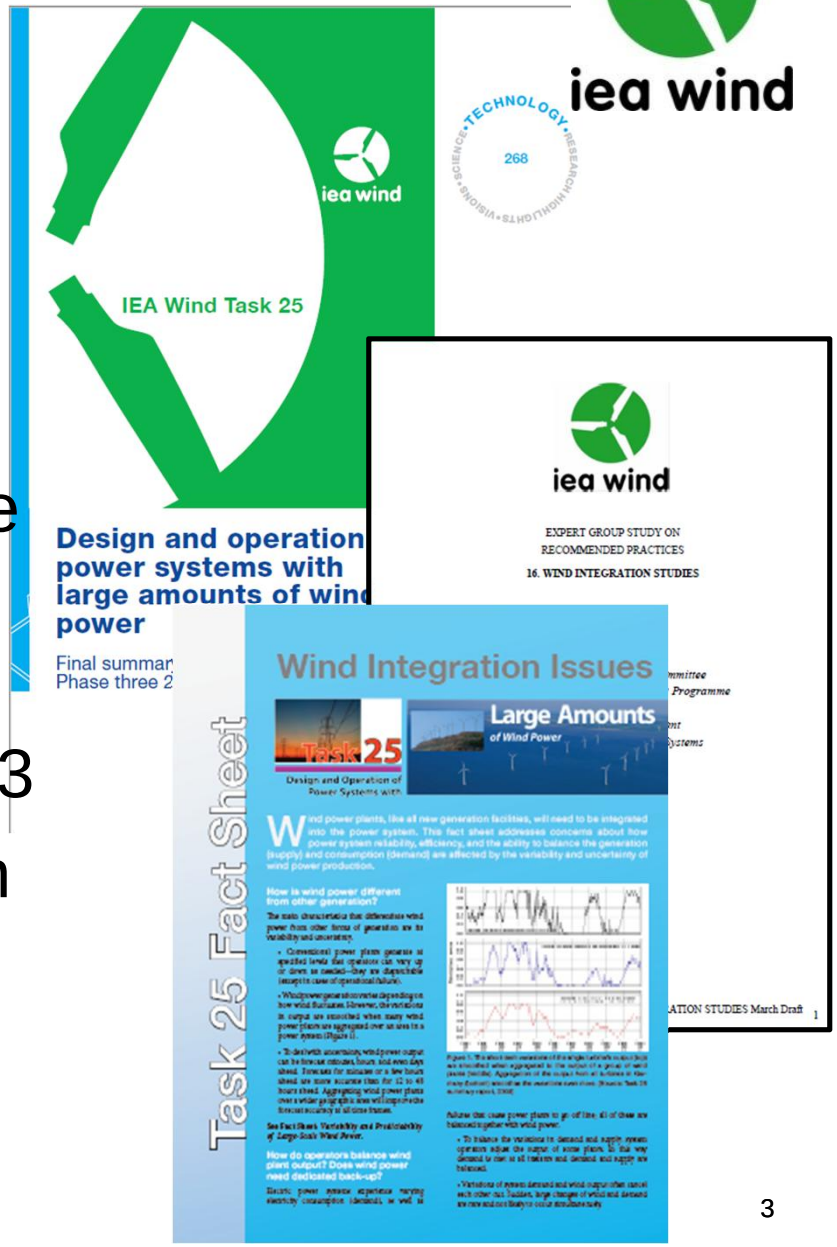
Contents

- Intro – wind integration international collaboration and experience
- Challenges:
  - Grid – connect and transport the electricity produced
  - Capacity value – what to do when it does not blow?
  - Balancing – what to do when it blows with no load, and variability

Cold/icing challenges linked to these

IEA Wind Task 25 – What Does It Do ?

- Started in 2006, now 17 countries + EWEA participate to provide an international forum for exchange of knowledge
- State-of-the-art: review and analyze the results so far: latest report June 2016
- Formulate guidelines- Recommended Practices for Integration Studies in 2013
- Fact sheets and wind power production time series



http://www.ieawind.org/task_25.html

IEA WIND Task 25:
Design and operation of power systems with large amounts of wind power

www.ieawind.org

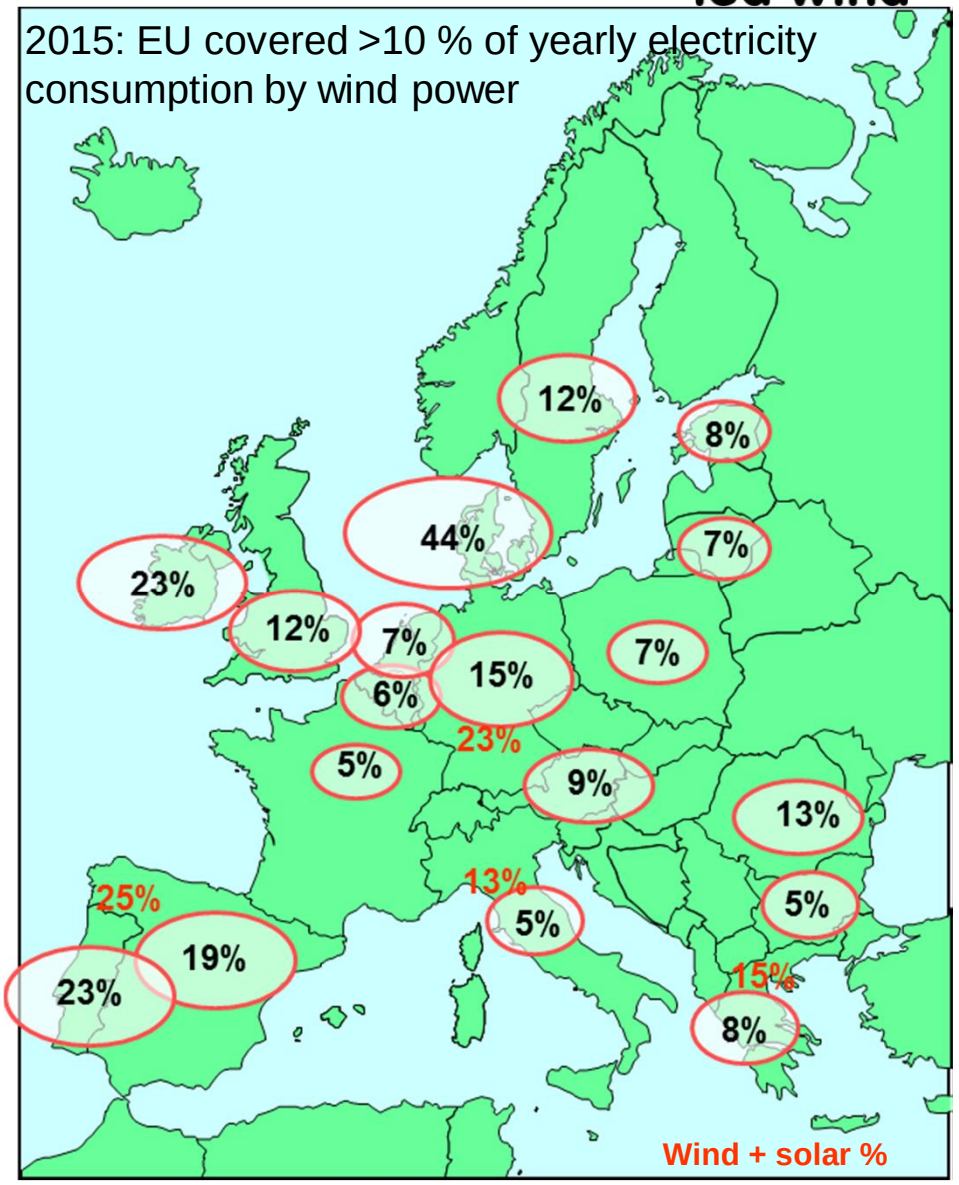
17 countries + Wind Europe participate

	Country	Institution
	Canada	Hydro Quebec (Alain Forcione, Nickie Menemenlis)
	China	SGERI (Bai Jianhua, Liu Jun);
	Denmark	DTU Wind (Nicos Cutululis); TSO Energinet.dk (Antje Orths)
	Finland	VTT (H. Holttinen, J. Kiviluoma) – **Operating Agent**
	France	EdF R&D (V. Silva); TSO RTE (E.Neau); Mines (G.Kariniotakis)
	Germany	Fraunhofer IWES (J. Dobschinski); TSO Amprion (P. Tran)
	Ireland	SEAI (J.McCann). UCD (Mark O'Malley)
	Italy	TSO Terna Rete Italia (Enrico Maria Carlini)
	Japan	Tokyo Uni (J.Kondoh); Kansai Uni (Y.Yasuda); CRIEPI (R.Tanabe)
	Mexico	IIE (Favio Perales)
	Norway	SINTEF (John Olav Tande, Til Kristian Vrana)
	Netherlands	TSO TenneT (Ana Ciupuliga), TUDelft (Jose Rueda Torres);
	Portugal	LNEG (Ana Estanquiero); INESC-Porto (J. Pecas Lopes);
	Spain	University of Castilla La Mancha (Emilio Gomez Lazaro)
	Sweden	KTH (Lennart Söder)
	UK	DG&SEE (Goran Strbac, Imperial; O. Anaya-Lara, Strathclyde)
	USA	NREL (M.Milligan); UVIG (J.C.Smith); DoE (C. Clark)
	WindEurope	Wind Europe (D.Fraile)

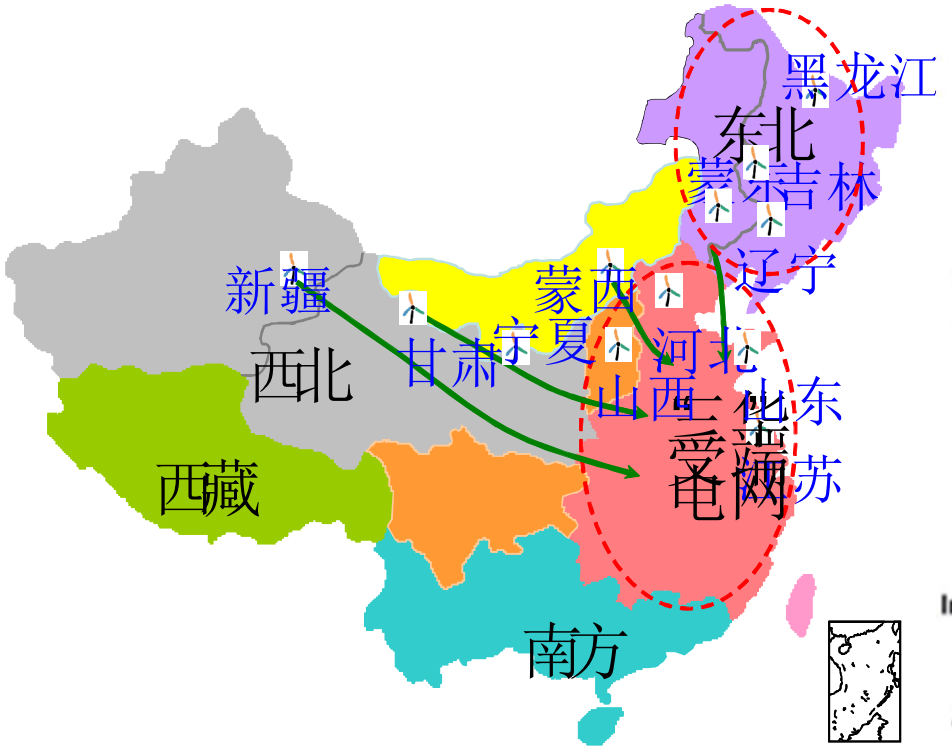
iea wind

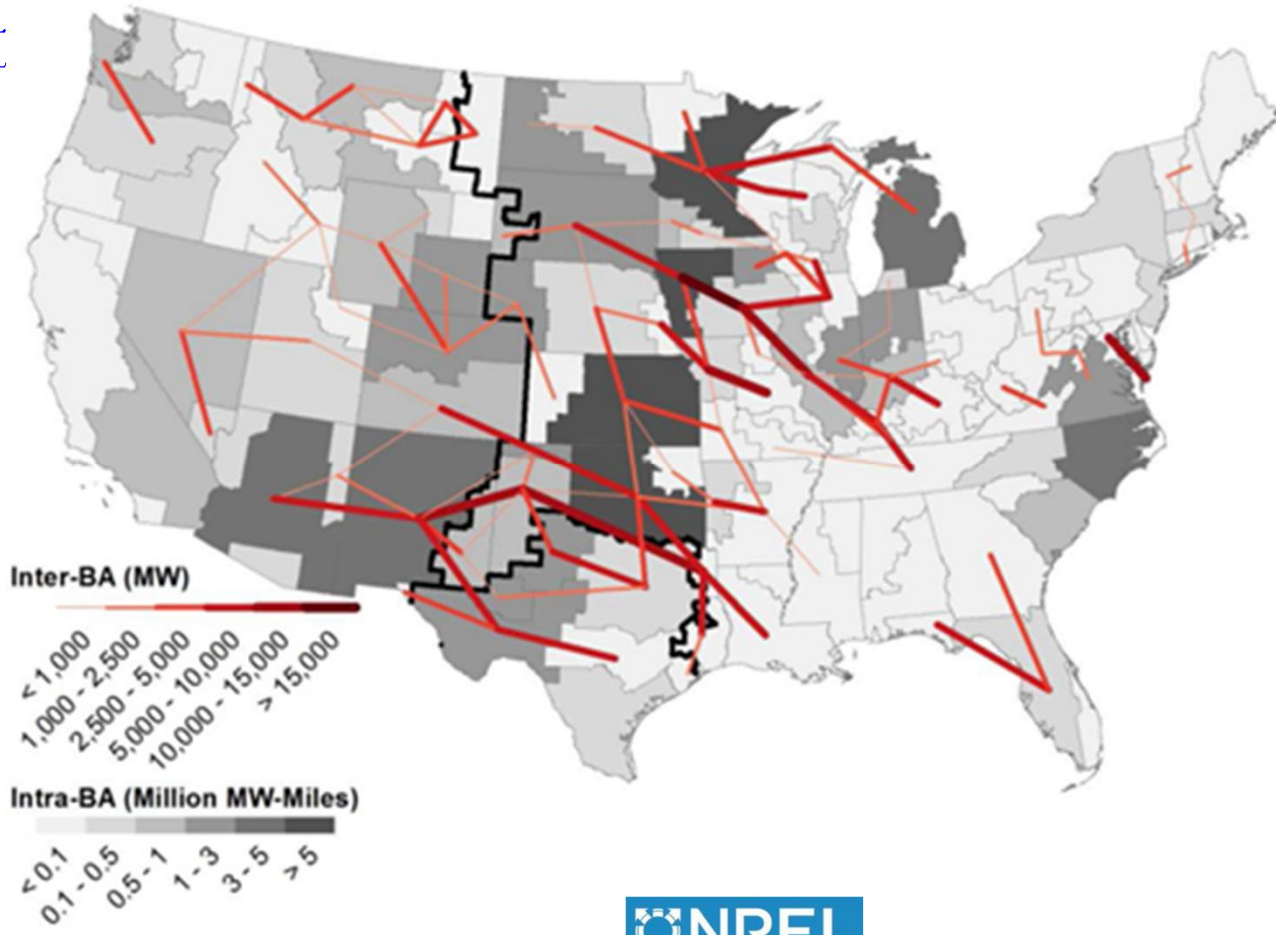
Experience from Wind Power Integration is Growing

- Updated information from on-line production and forecasts. Possibility to curtail in critical situations
- Increase in use of short term reserve/load following capacity
- Technical capabilities of wind power plants evolving
- Operational strategies for > 20-30 % shares of wind developed
- Transmission recognized as a key enabler, with regional planning efforts



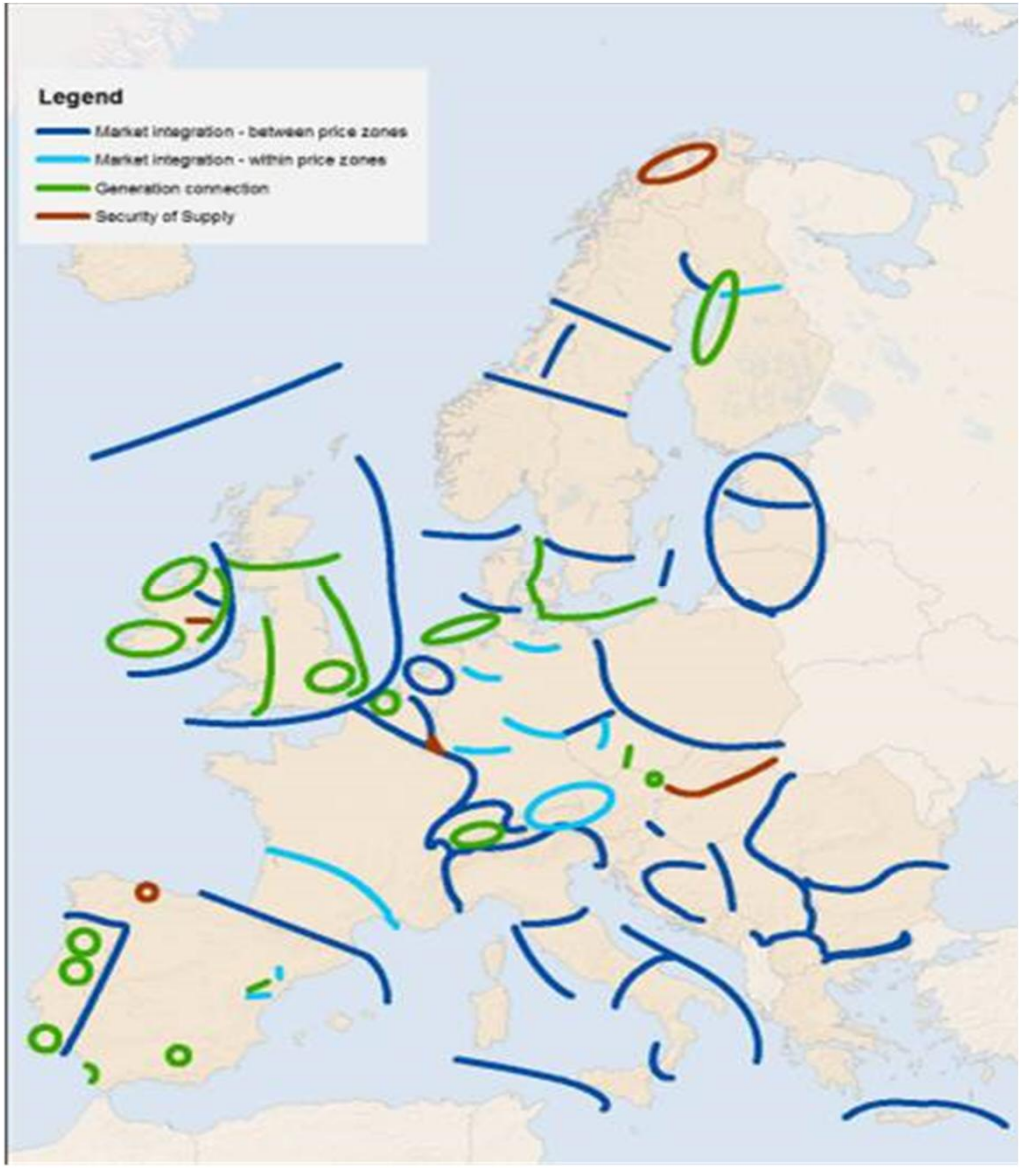
Challenges – transmission grid build-out



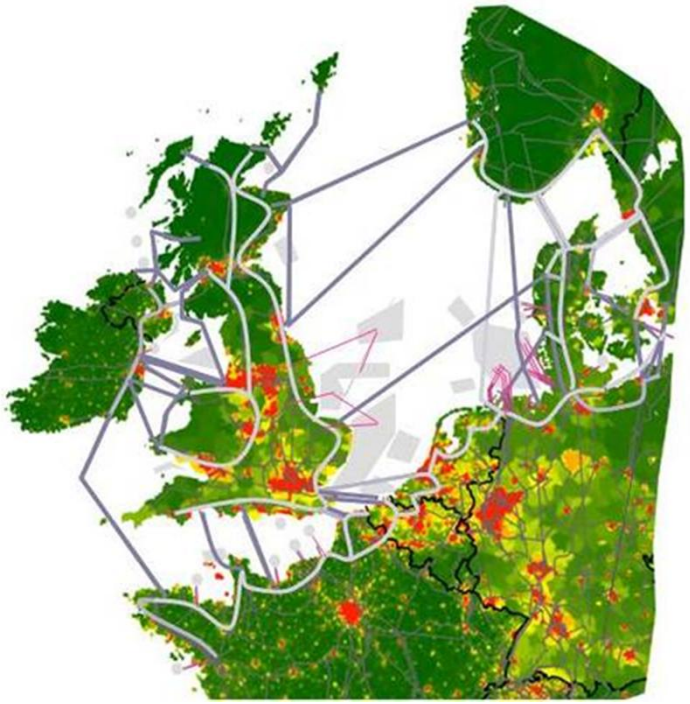


Source NREL NATIONAL RENEWABLE ENERGY LABORATORY
http://www.nrel.gov/analysis/re_futures/

Long term planning for grid adequacy



- Transmission planning – towards regional planning



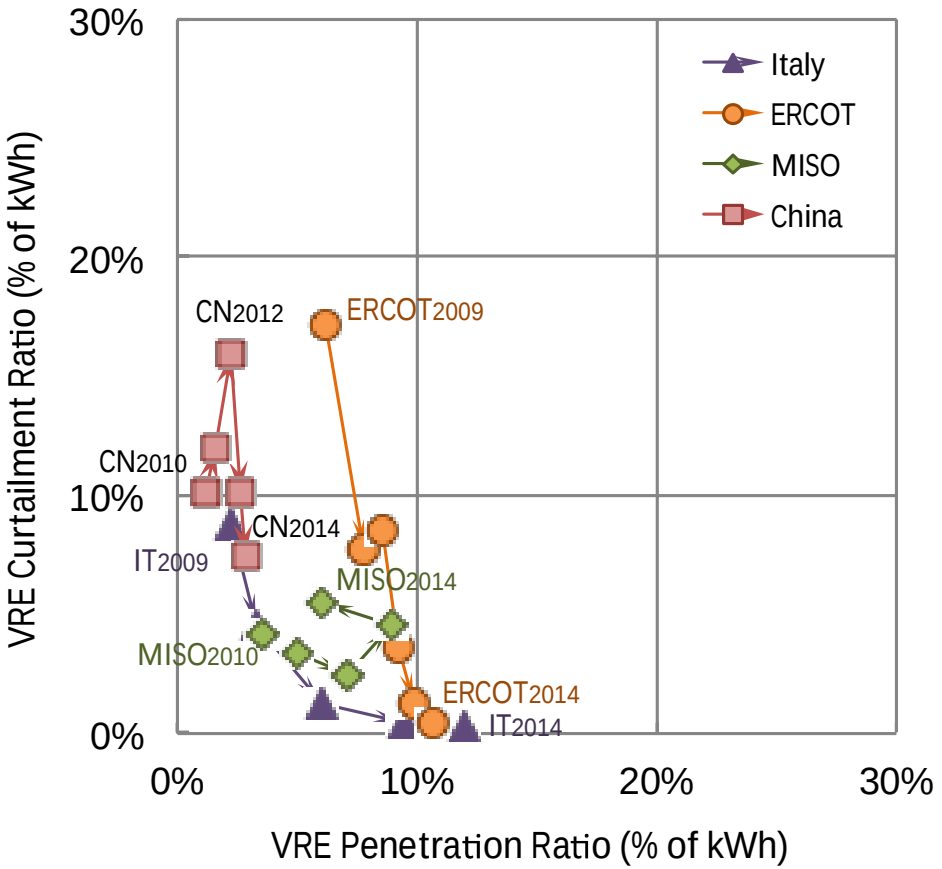
Source TYNDP (ENTSO-E, 2014)

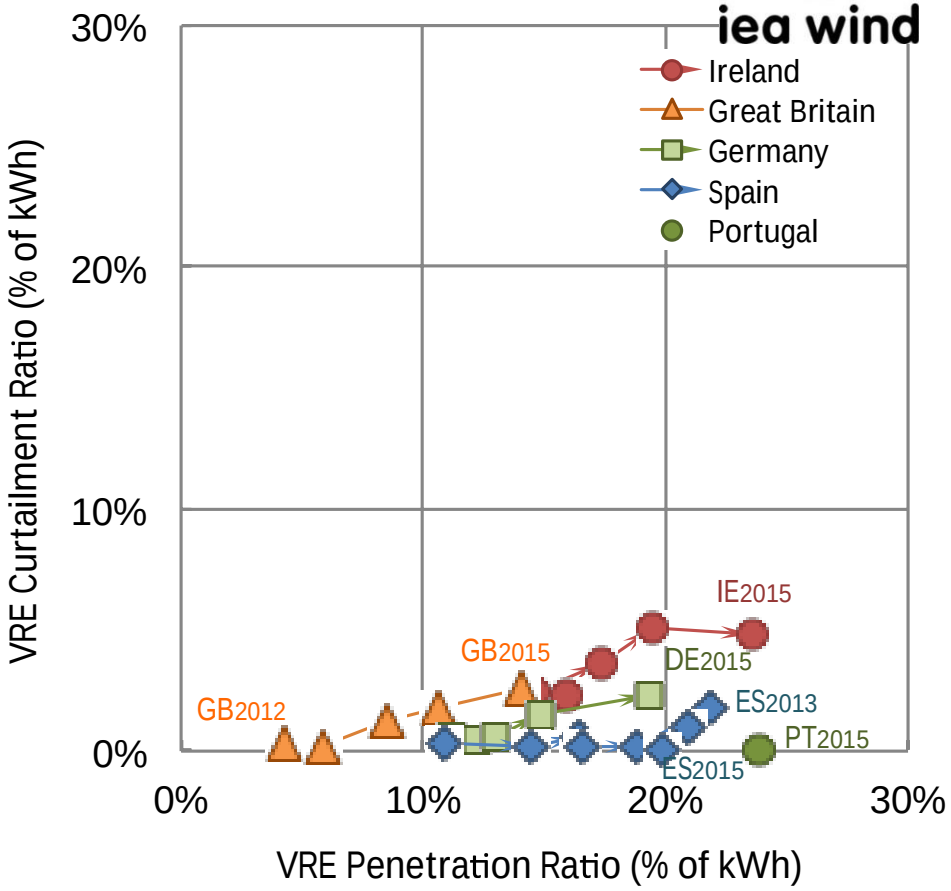
Cold climate wind – need for more transmission

Icing of power lines - challenge

KJELLER
VINDTEKNIKK

Maximising the value of wind power – minimising curtailments



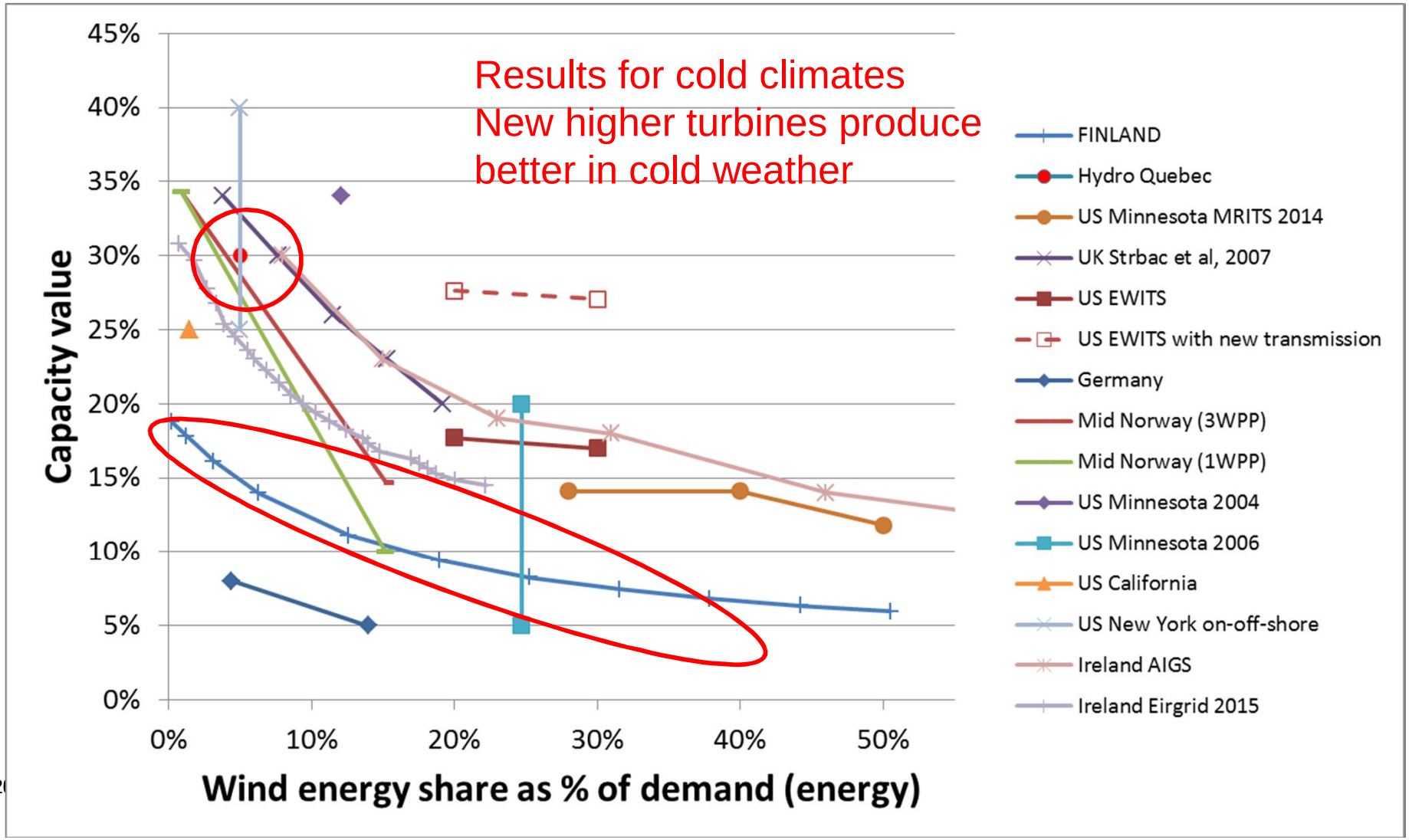


- Curtailments, mitigated by transmission build-up, in some cases
- Most European countries still experience little/moderate curtailments

Source: Update from Yasuda et al, International Comparison of Wind and Solar Curtailment Ratio. Proceedings of WIW2015, Oct 19-22 2015 Brussels.

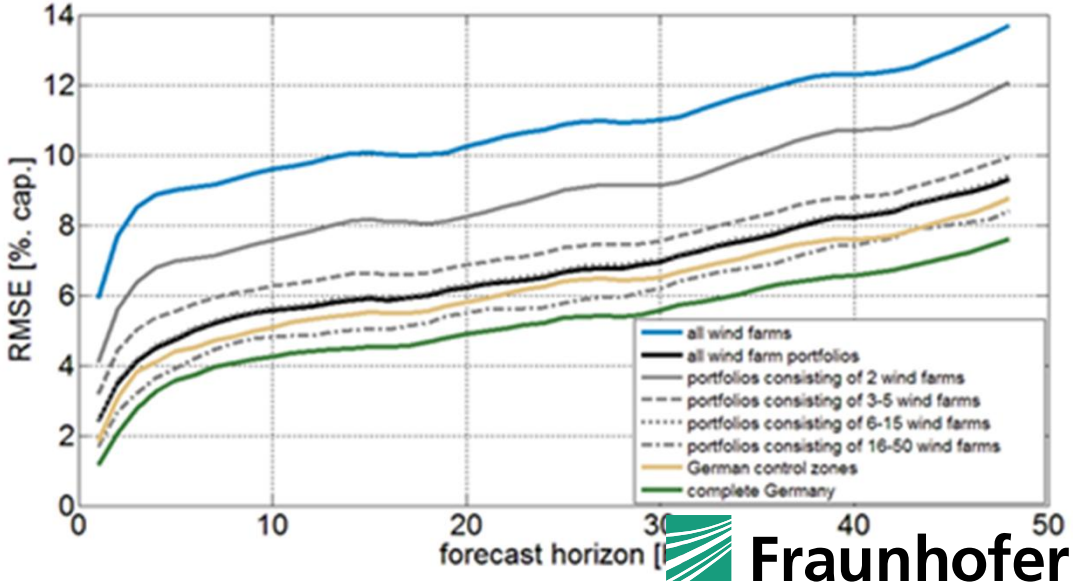
Long term planning for generation capacity adequacy

- Decreasing capacity value of wind power – reducing more slowly with larger areas



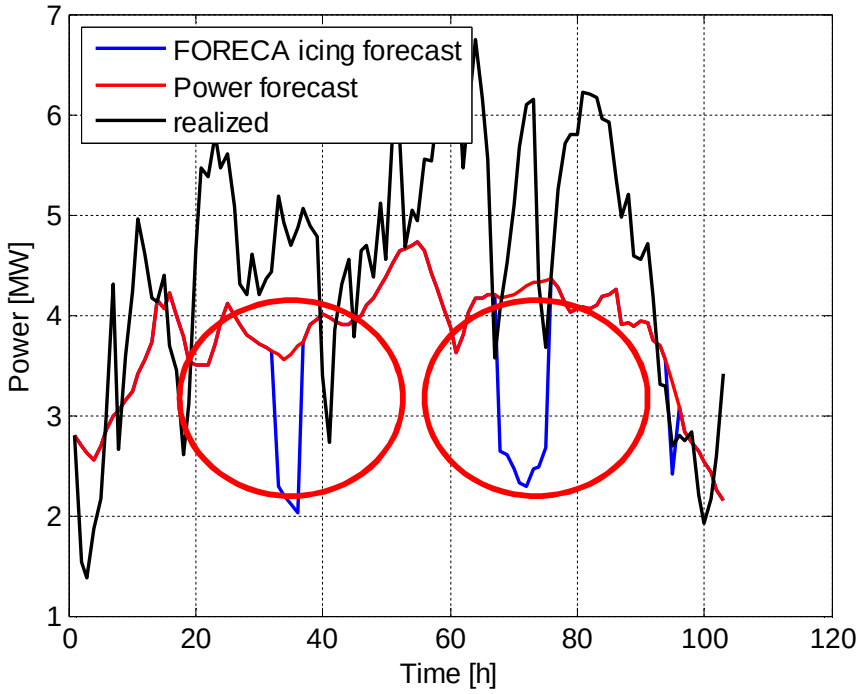
Challenge - uncertainty

- Smoothing effect with larger areas, dispersed sites
- Improved accuracy with shorter forecast horizons – and improved models
- Icing forecasts!

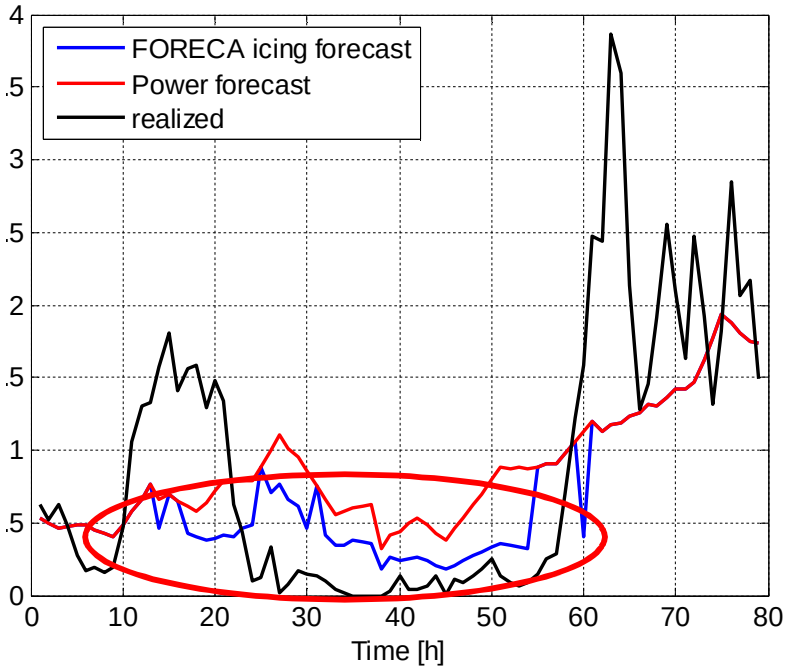


Fraunhofer IWES

Bad



Good

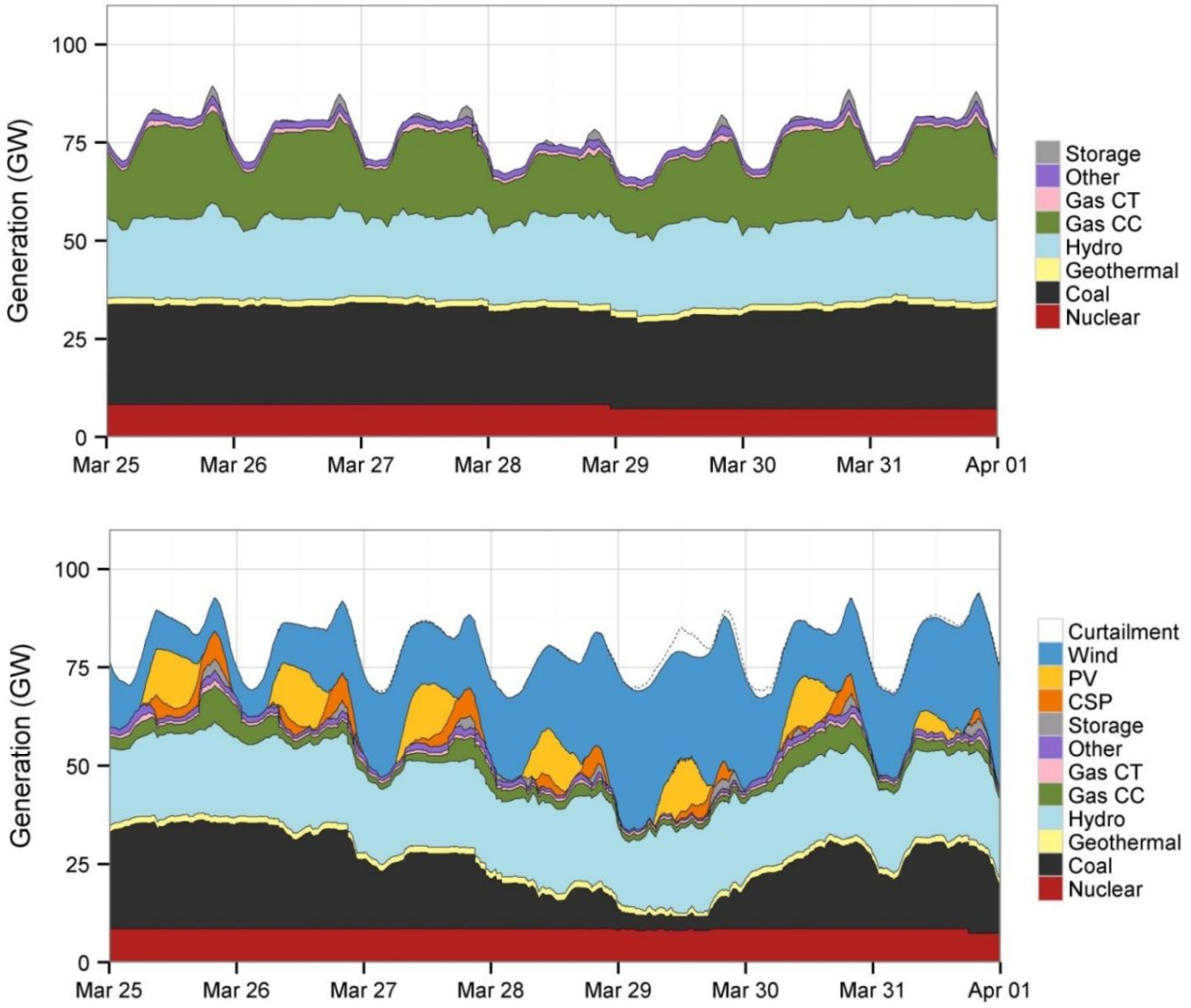


Source: Winterwind2015. On the influences of icing on regional forecast errors. J Miettinen, H Holttinen, T Karlsson, Ø Byrkjedal

Challenge- managing variability and uncertainty

- Increasing variability and uncertainty: more balancing – ramping and cycling (starts/stops)
- Cycling costs and impacts on emissions are low

	Emission Reduction Due to Renewables	Cycling Impact
CO_2	260–300 billion lbs 29%–34%	Negligible Impact
NO_x	170–230 million lbs 16%–22%	3–4 million lbs
SO_2	80–140 million lbs 14%–24%	3–4 million lbs



Source NREL / WWSIS II study

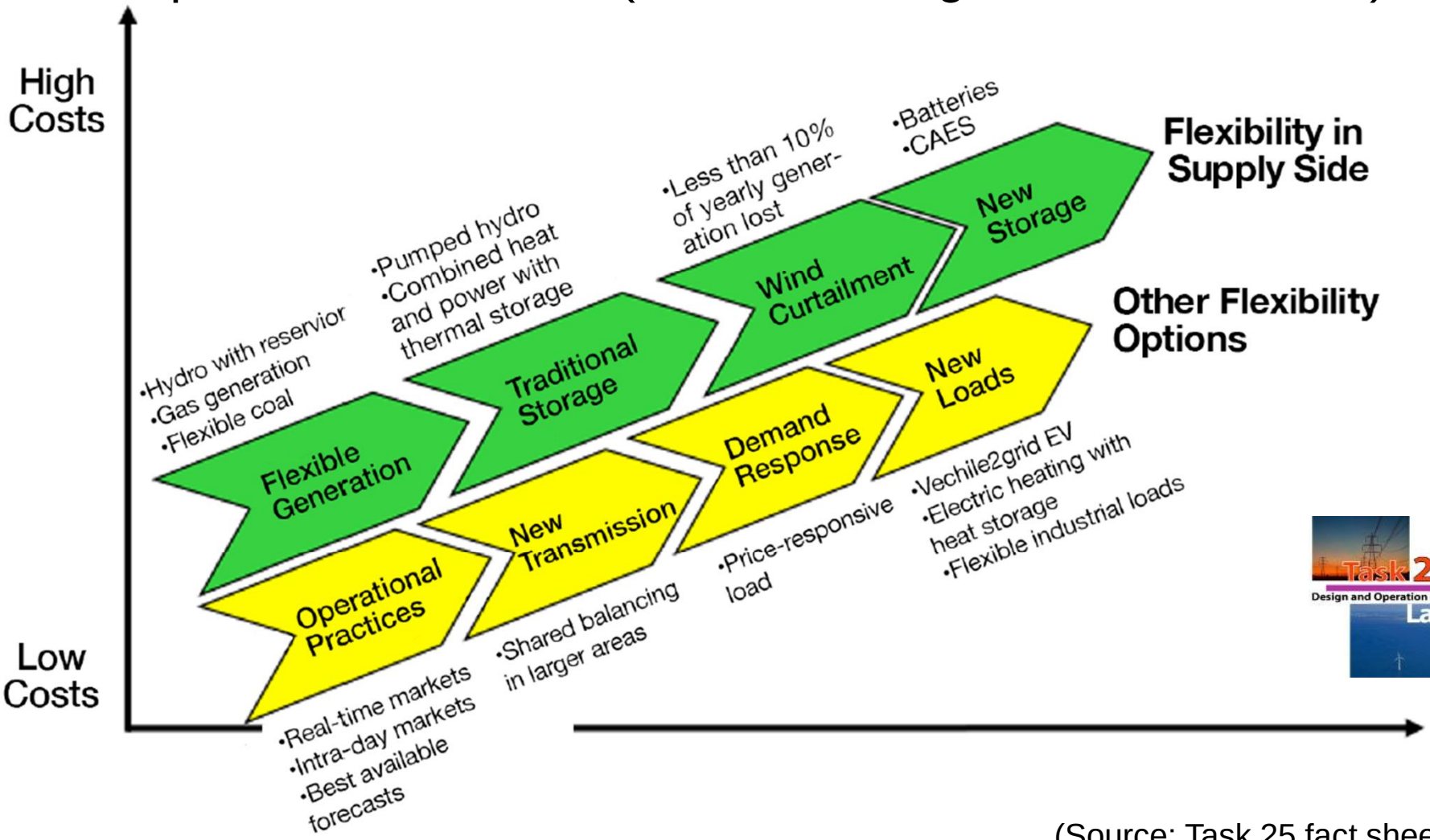
Extreme event from icing?

- Sudden loss of wind power from many sites, ~several GW
- Icing events are local, so far not seen large area of synchronous power systems affected simultaneously
  - Ice storms in North America probably the largest areas seen.

- Storm situations another extreme event, not reaching all of one balancing area simultaneosly, and storm front moving in hours, not minutes
  - Ireland synchronous system could be impacted but so far no events reported
  - Offshore wind power more concentrated, could be seen in future

Solution- flexibility

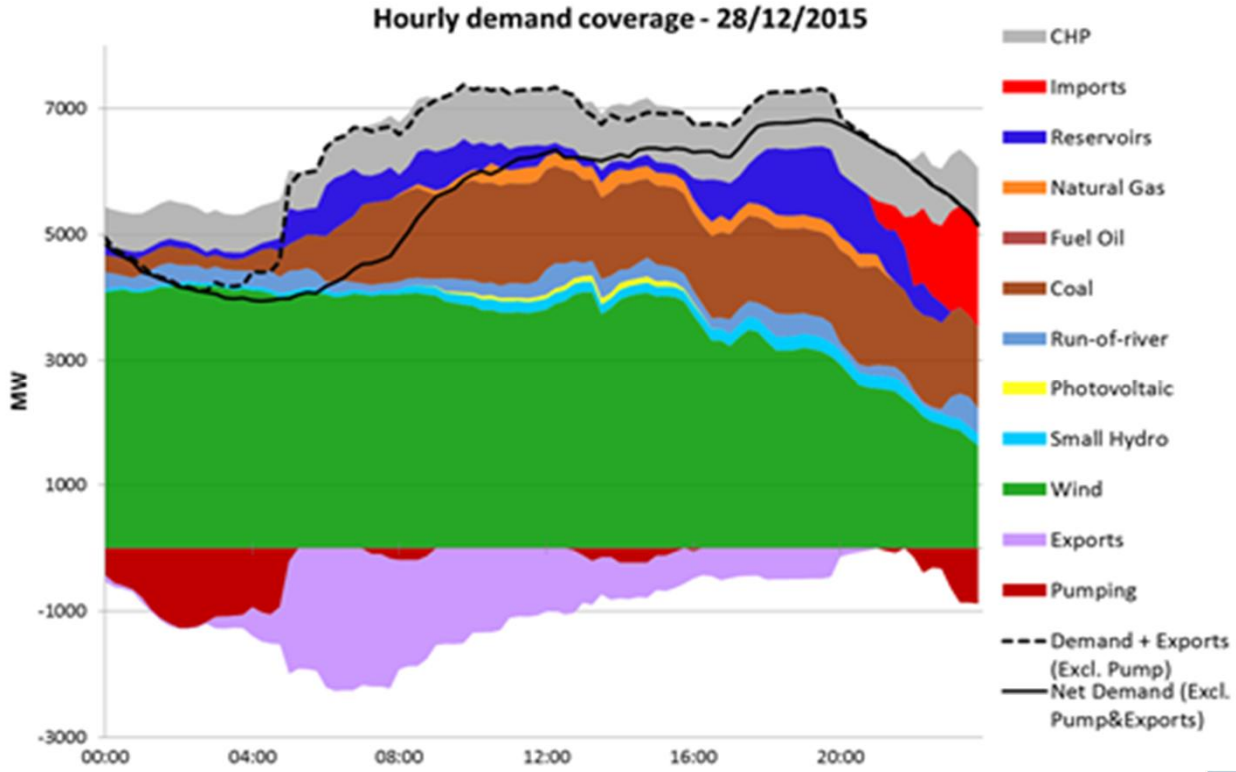
- Increase / incentivise flexibility in generation and demand, with flexible operational methods (transmission/grids as an enabler)



(Source: Task 25 fact sheet)

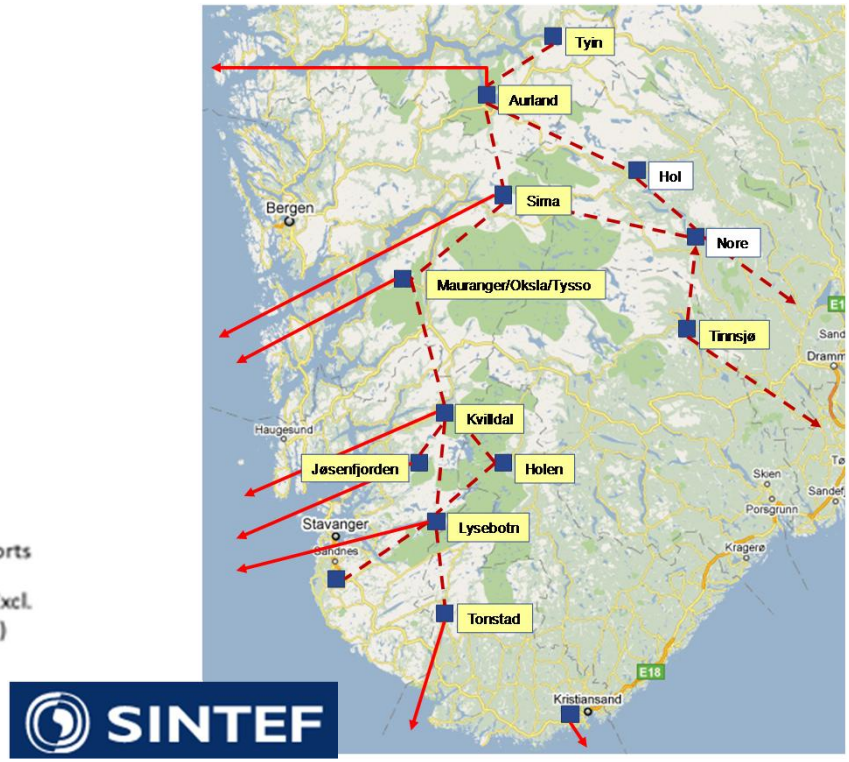
Hydro power flexibility

Portugal: managing close to 100% wind share.



Source for data REN: http://www.centrodeinformacao.ren.pt

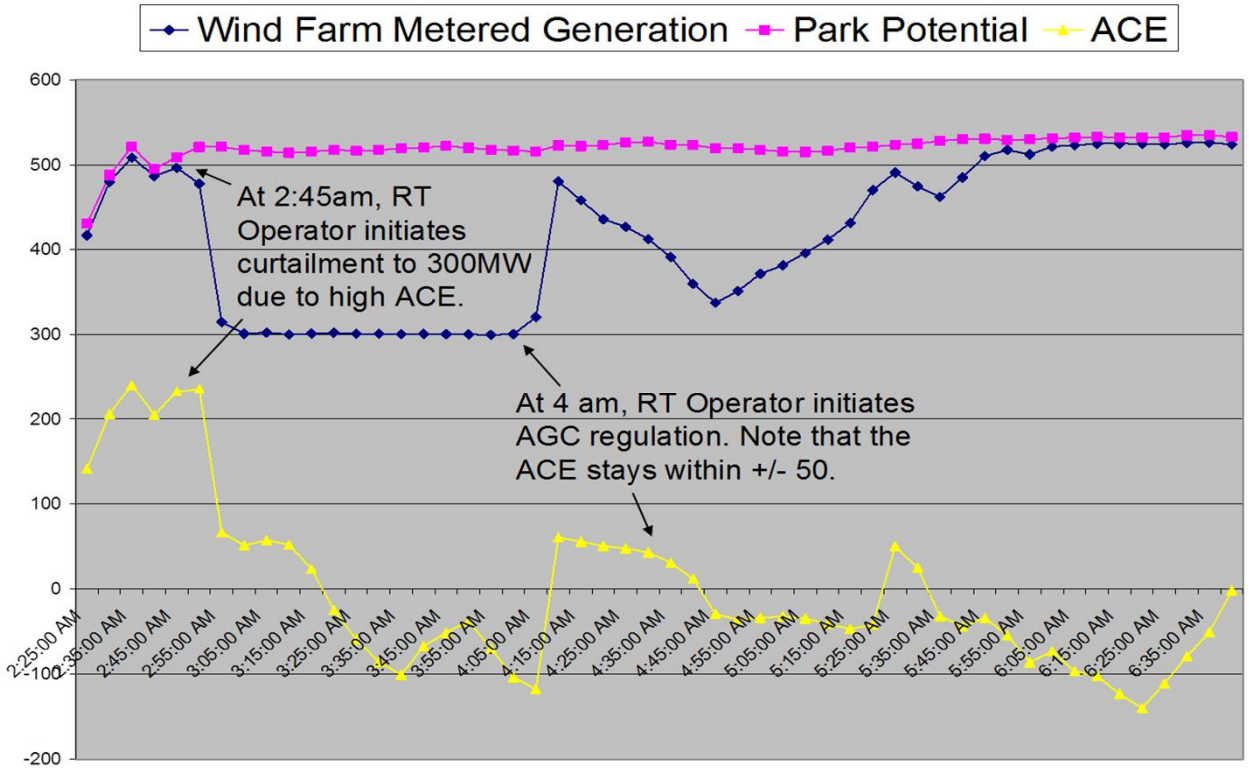
Norway, building transmission to manage North Sea wind.



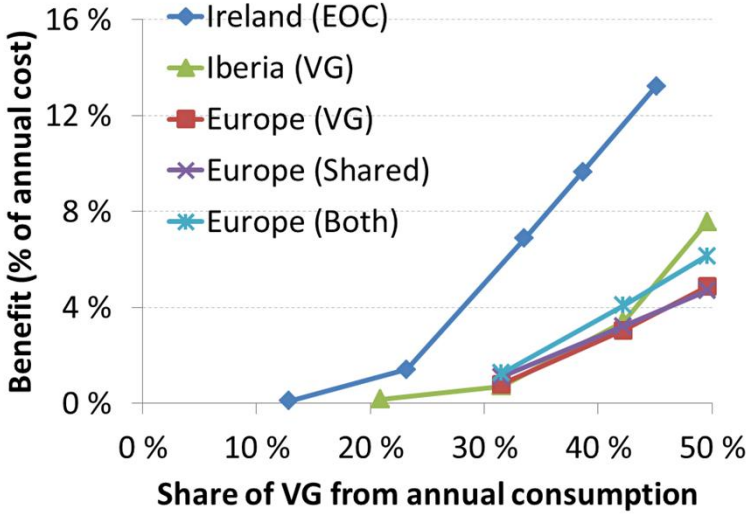
Source: Farahmand, H. et al. Nordic hydropower flexibility and transmission expansion to support integration of North European wind power. Wind Energy 2015, 18: 1075–1103

Flexibility from wind power

- Ancillary services provision from wind power plants: voltage and frequency support.
- Fast and slow frequency response possible, with loss of energy. Also up-regulation, used during curtailments.

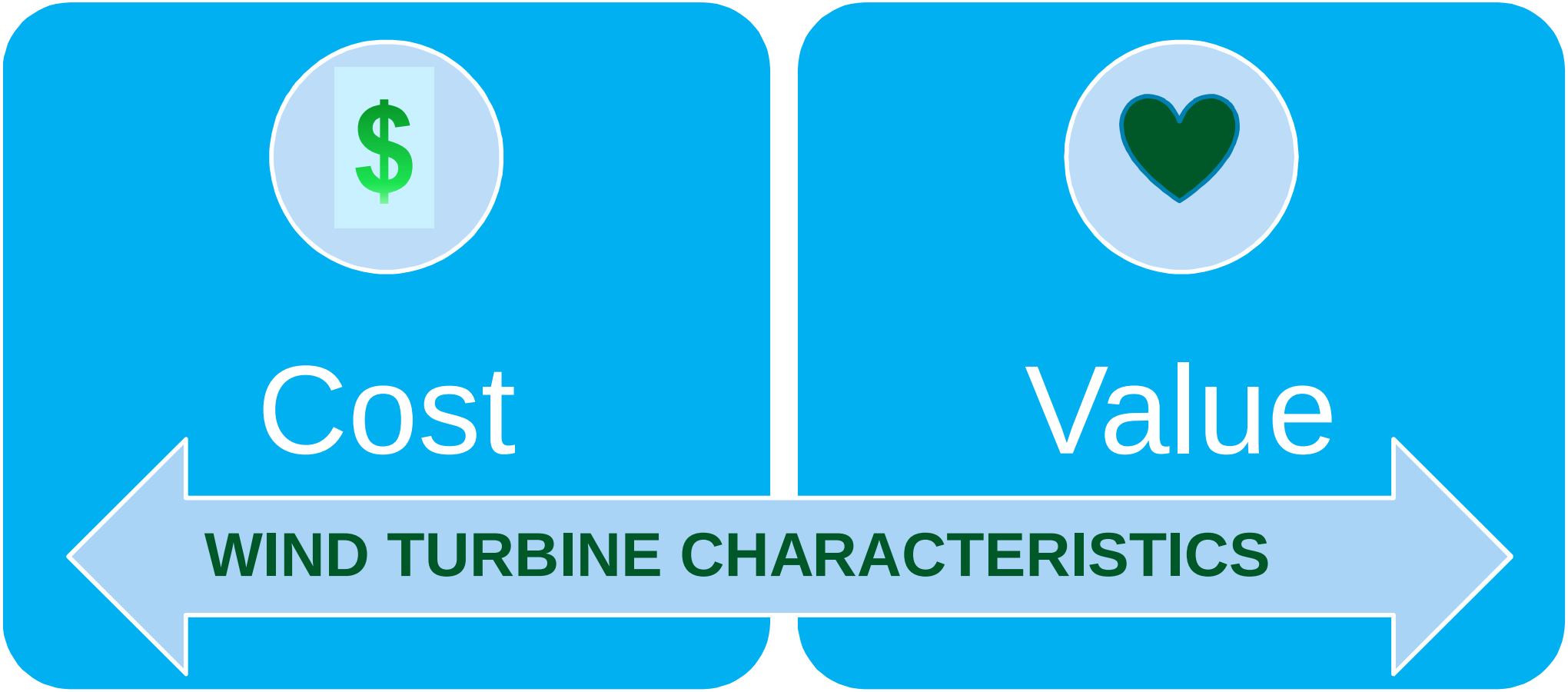


Source: US Xcel/PSCo Wind power providing AGC



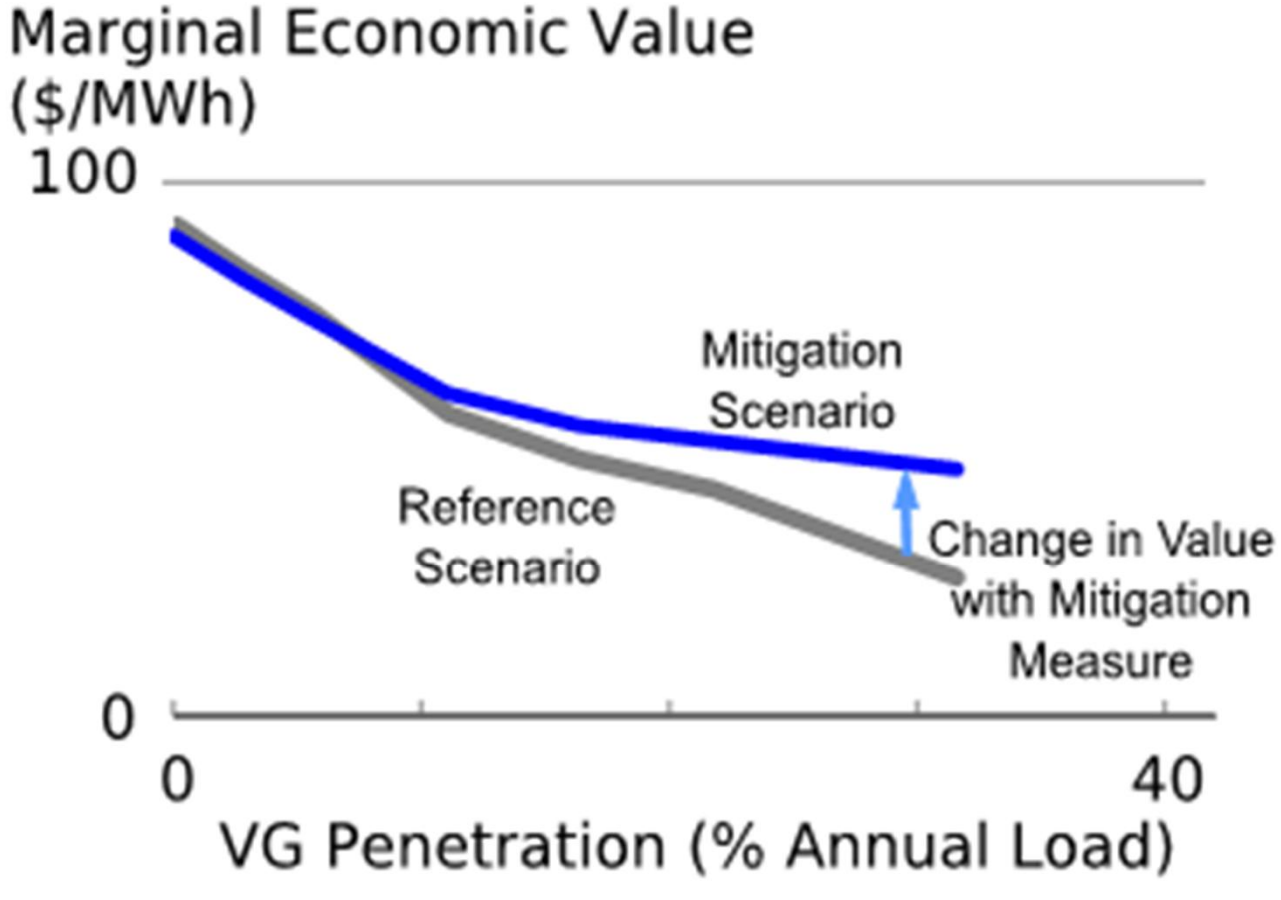
System benefits for frequency support from wind and PV. Source: ReServiceS, VTT D5.5

Cost and value of wind are equally important in decision making, but cannot be considered fully independent because they are linked by wind technology



How Much Would the Value of VG Change if Mitigation Measures Were Implemented?

Use the same model and data to estimate the degree to which different mitigation measures can stem the decline in the marginal economic value of variable generation

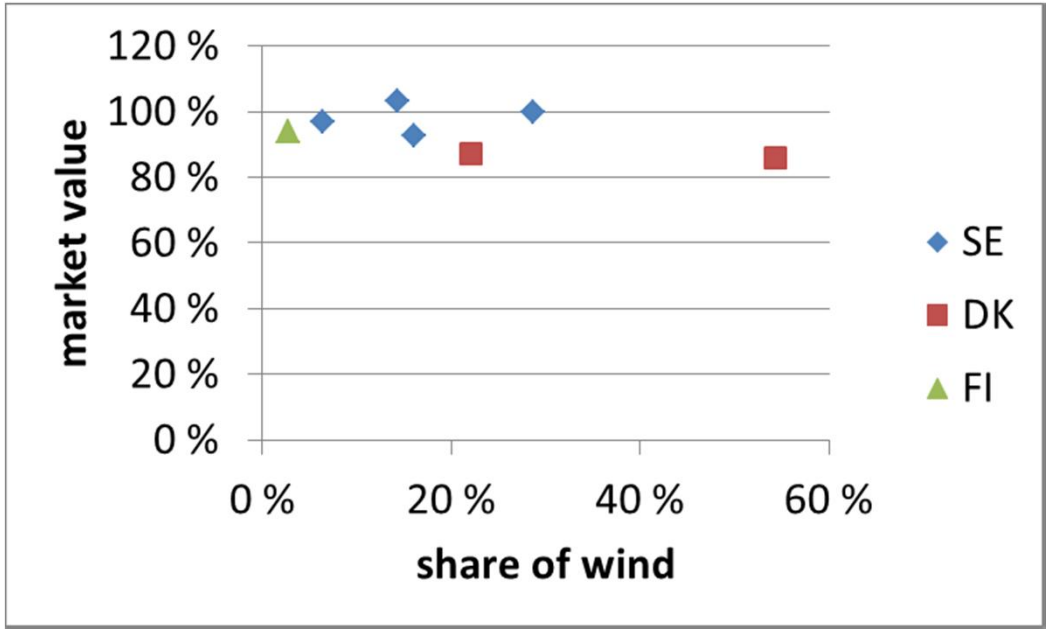


The mitigation measures considered include:

- increased geographic diversity
- technological diversity
- lower-cost bulk power storage
- price elastic demand subject to RTP

Nordic market - hydro power, not as much reduction in value from spot market

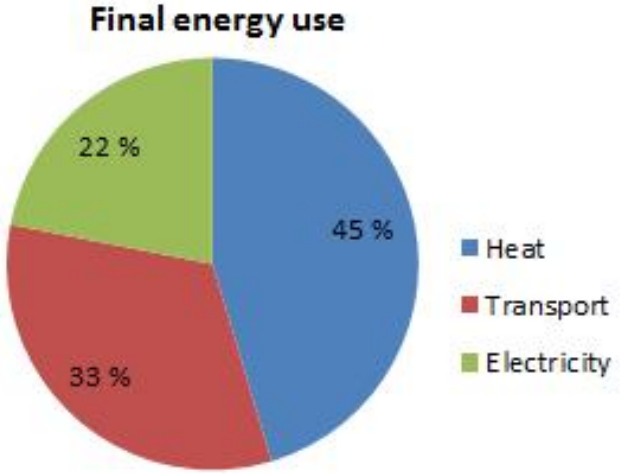
- Wind power production data and market prices, from price areas in Nordpool, year 2015
- Share of wind in Nordic market area ~9%
- As long as enough transmission capacity, no impact to area prices – the share in individual price areas is not directly comparable



Note: for solar power the value is decreasing faster

Long-term value of wind power

- Value of wind power is generated by avoided investments and avoided fuel use → the value of avoided investments is not in the market price
- Wind power will start to suppress prices especially when it is producing well
  - Less valuable contribution (in operational terms)
- Can be improved by better siting and higher capacity factor
- Electrification of energy and transmission can increase the value
  - Transmission allows to export part of the excess
  - Electricity replaces fuels → the price/value of the fuel is the new marginal cost



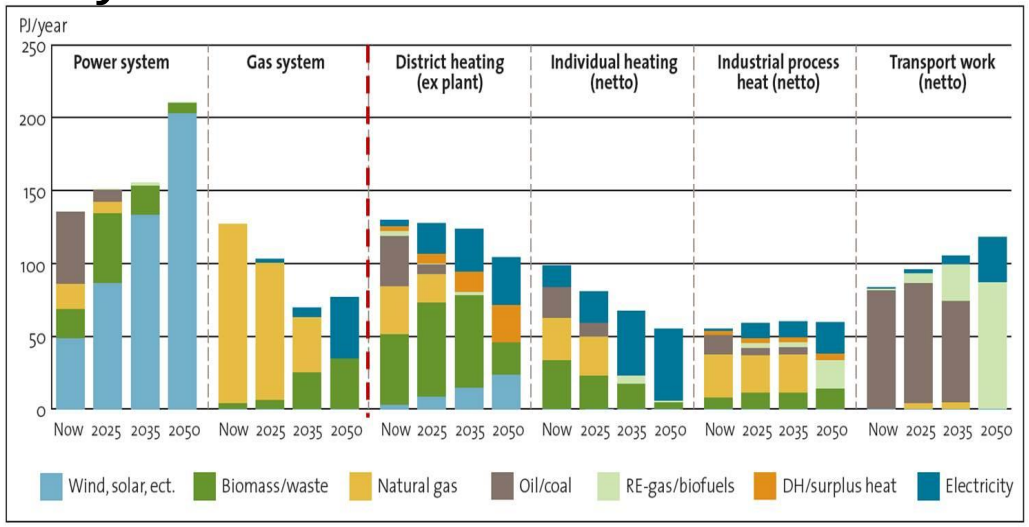
Transition towards renewable future means adaptation

Integration challenge is easier if

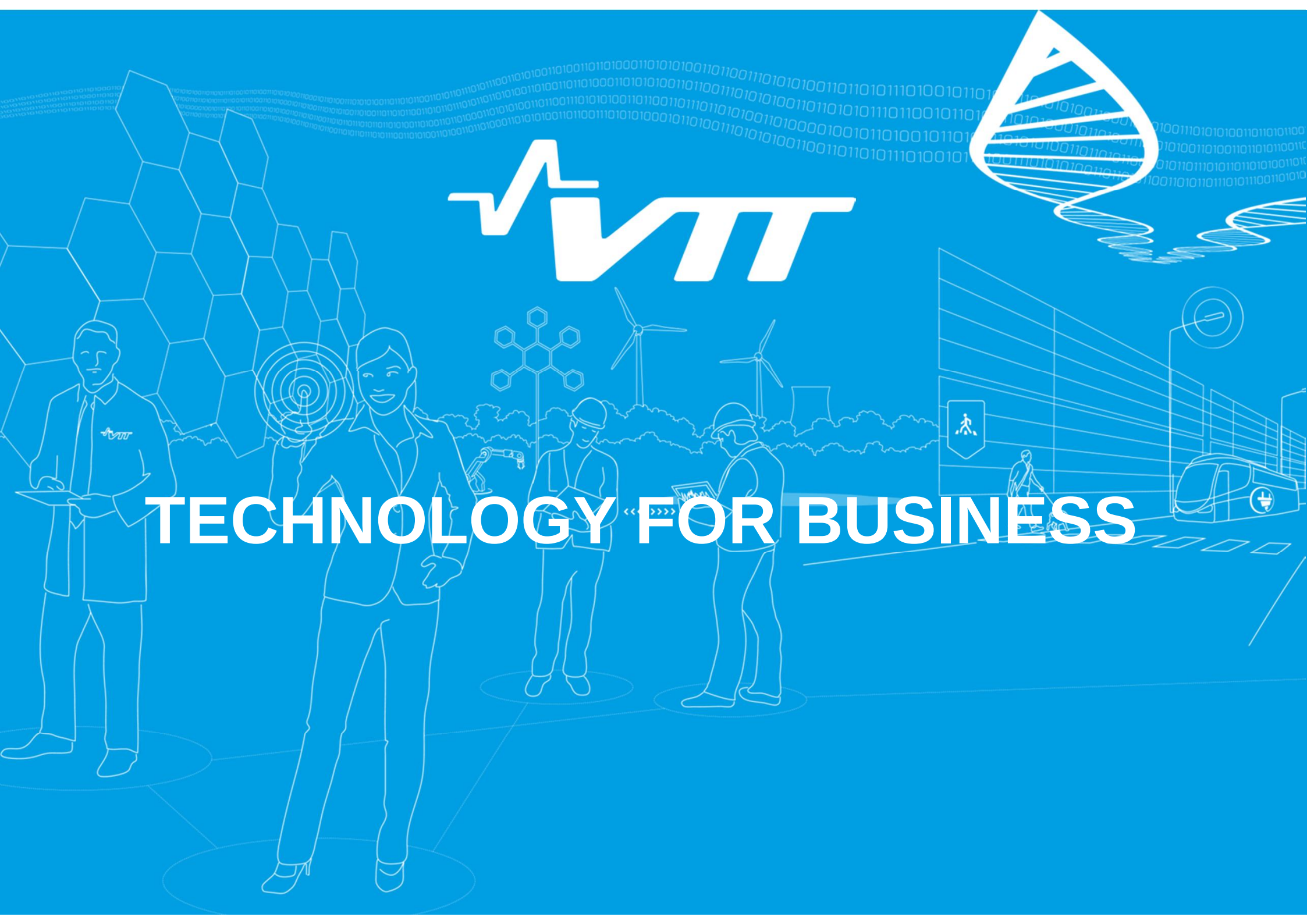
- variable generation is built dispersed to larger area – smoothing
- **power system operation** enables aggregation benefits from larger area: strong transmission/distribution grid and sharing balancing
- there is **flexibility** in the generation fleet – and in demand

Integration effort and costs will be different for different systems and adaptation will greatly reduce the costs.

Electrification and integration between energy sectors helps integrating large amounts of wind power (>50 %)



Source: Energinet.dk. 2015. Energy Concept 2030 – Summary. An analysis of concepts and development paths to sustain a competitive and strong RE based energy system.


TECHNOLOGY FOR BUSINESS