State-of-the-art of design and operation of power systems with large amounts of wind power - summary of IEA Wind collaboration

Hannele Holttinen,
Operating Agent, IEA WIND Task 25

Business from technology

IEA WIND Task 25

OBJECTIVE:

to analyse and further develop the methodology to assess the impact of wind on power systems

Started in 2006, duration 3 years. 11 countries + EWEA participate.

GOALS:

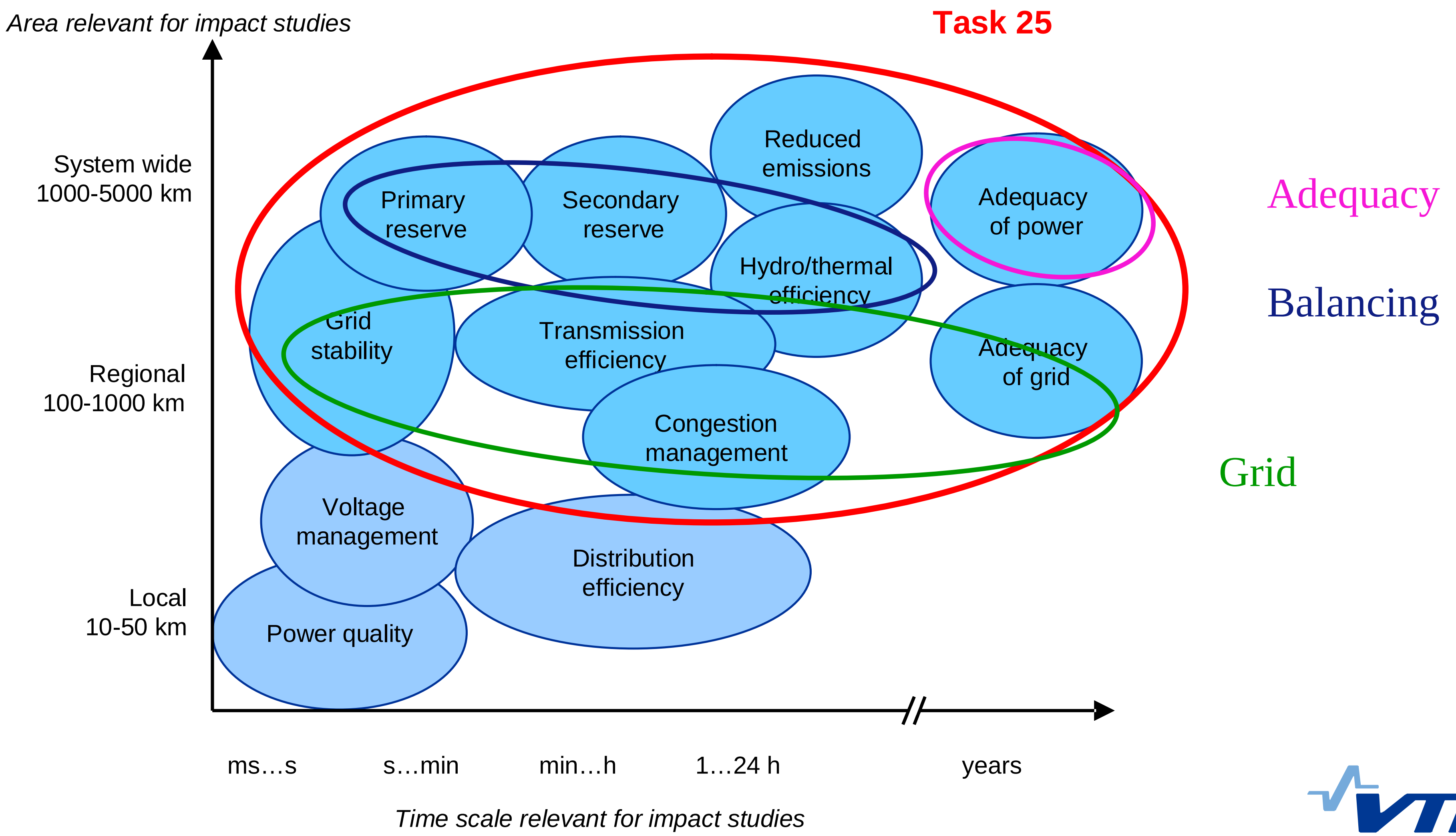
- Provide an international forum for exchange of knowledge
- State-of-the-art: review and analyse the studies and results so far
  - methodologies and input data, system operation practices
  - REPORT published in Oct, see www.vtt.fi Working papers, 2007 !
- Formulate guidelines:
  - recommended methodologies and input data when estimating impacts and costs of wind power integration
- Quantify the impacts of WP on power systems
  - range of impacts/costs; rules of thumb

www.ieawind.org

Integration costs

- Costs for power system for accommodating wind power
  - Not covered by wind power producers (investment costs for grid connection, …)
  - Part of the these costs may be allocated to wind power in some power systems (network charges, imbalance payments, …)
- Should be compared with the benefits of wind power
- Information needed for
  - Policymakers to ensure that the benefits of increasing wind energy will not be offset by negative impacts
  - System operators, regulators to ensure fair treatment of all producers: market design and rules, tariffs, allocation of costs

Wind power in the power system: impacts on reliability and efficiency



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

Recent studies: levels of wind power studied

Nordic: 69 GW peak load, up to 20 GW wind (29 %)

UK: 65 GW peak, up to 26 GW wind (40 %)

Denmark: up to 100 % penetration

Ireland: 7 GW peak, up to 3.5 GW wind (54%)

Germany: 78 GW peak, up to 36 GW wind (46 %)

Netherlands: 16 GW peak, up to 6 GW wind (39 %)

Portugal: 10-12 GW peak, up to 5 GW wind (50 %)

VTT

Recent studies in USA

- Minnesota: 6000 MW of wind in 20 GW peak load system (=30 %)
- New York: 3300 MW of wind in 33 GW peak load system (=10 %)
- Colorado 1400 MW in 7 GW peak load system (=20 %)
- California: existing wind power, 4 % of peak load

Different ways of presenting the penetration level

	Load			Inter-conn. cap.	Wind power					
					2006	Highest studied		Highest penetration level		
Region / case study	Peak MW	Min MW	TWh/a	MW	MW	MW	TWh/a	% of peak load	% of gross demand	% of (min load + interconn)
West Denmark	3700	1300	21	2830	2380		5	65 %	24 %	58 %
Germany 2015 / dena	77955	41000	552.3	10000*	20622	36000	77.2	46 %	14 %	71 %
Ireland / ESBNG	5000	1800	29	0	754	2000	4.6	40 %	16 %	111 %
Ireland / ESBNG	6500	2500	38.5	0	754	3500	10.5	54 %	27 %	140 %
Portugal	8800	4560	49.2	1000	1697	5100	12.8	58 %	26 %	92 %
Spain 2011	53400	21500	246.2	2400*	11615	17500		33 %	19 %	73 %
Sweden	26000	13000	140	9730*	572	8000	20	31 %	14 %	35 %
UK	76000	24	427	2000*	1963	38000	115	50 %	27 %	146 %
Continued…	…	…	…	..	….	..	..	…	..	…

Summary of grid results

- Stability:
  - With limited penetration levels wind power can improve system performance by damping power swings and supporting post-fault voltage recovery
  - At higher penetration levels requiring FRT capability for large wind power plants is economically efficient compared with modifying power system operation to ensure system security
- Grid reinforcements
  - may be needed for stability, often needed if wind resource far from load centres and wead grid

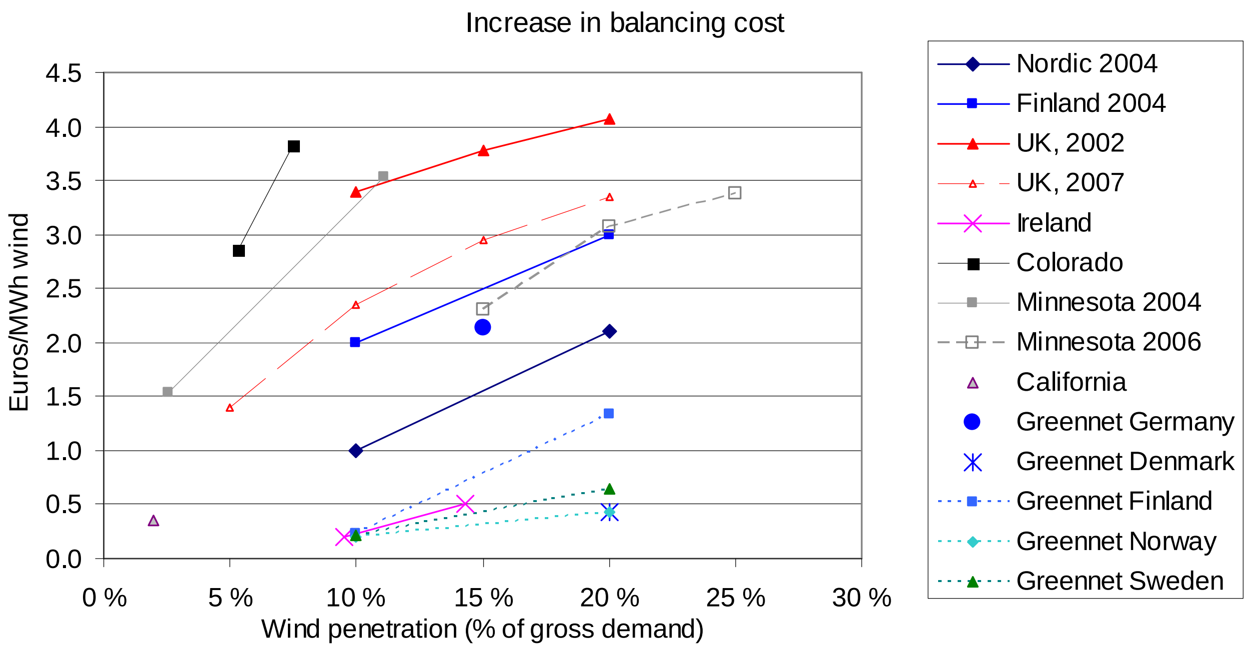
Grid reinforcement costs from studies

- UK : £50-100 / kW (70-140 €/kW) for 26 GW wind
- Netherlands : 60-110 €/kW for 6 GW offshore wind
- Portugal : 53 €/kW for 5.1 GW wind
- German dena study:100 €/kW for 36 GW wind

- Not comparable:
  - Depends on wind resource location versus load centres
  - Grid reinforcement costs are not continuous, there can be single very high cost reinforcements
  - The way that grid costs are allocated to wind power can differ:
    - Shallow/deep costs
    - Wind farm and power system interface

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

Summary balancing costs



- Integration costs 0.5 - 4 €/MWh
  - Small compared to production cost /market value of wind power (~ 40-60 €/MWh)
  - Not directly comparable due to: different time scales; only use of reserves or allocating investment for new reserve; interconnection taken into account or not; calculating costs based on assumptions on thermal power

State-of-the-art report – main messages

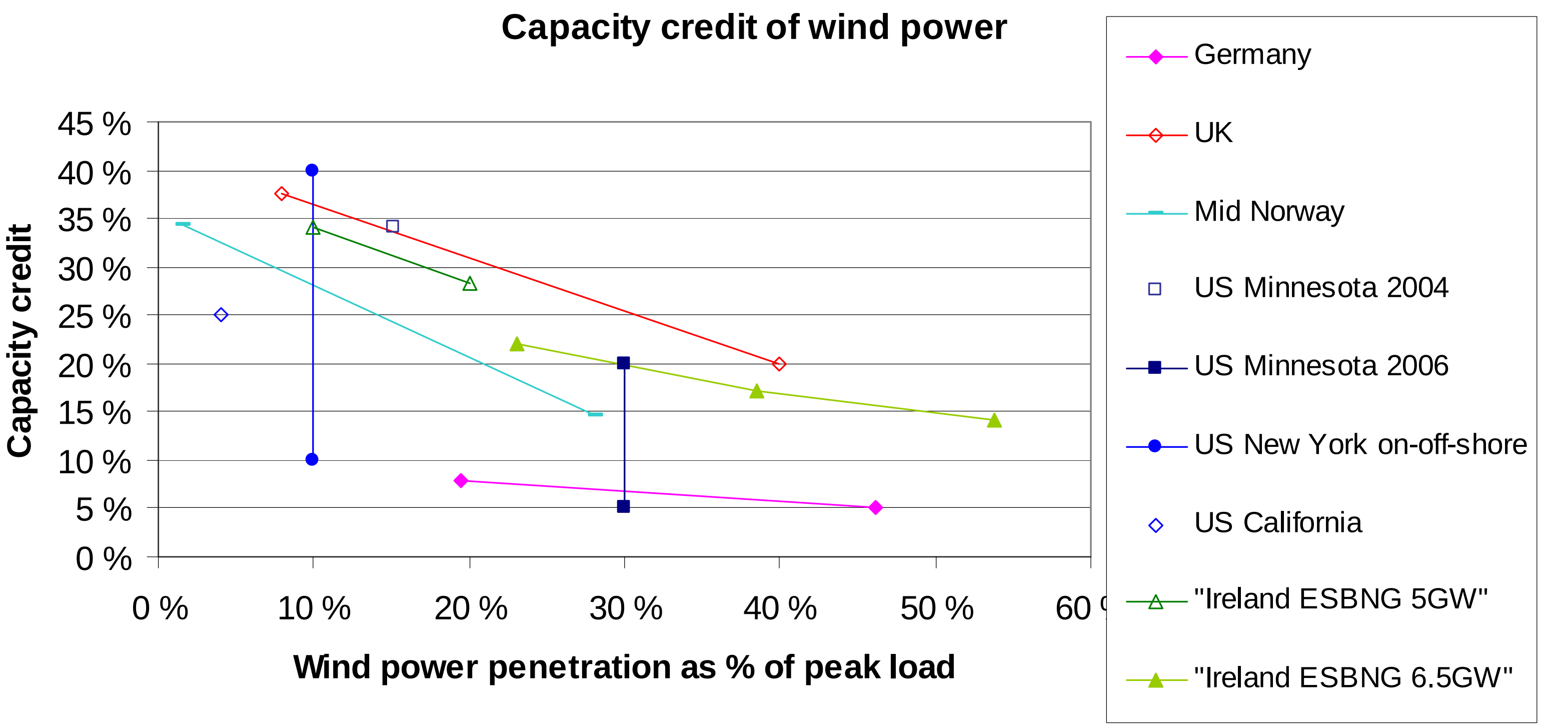
- The case studies summarized not easy to compare
  - Different methodology, data, assumptions on interconnection
  - Integration costs to be compared to f.ex. production costs or market value of wind power, or integration cost of other production forms
  - **Cost-benefit analysis** : benefit reducing total operating costs and emissions
- Issues impacting on the amount of wind that can be integrated:
  - Large balancing areas: aggregation benefits help reducing variability and forecast errors of wind power as well as help pooling more cost effective balancing resources.
  - System operation/electricity markets at less than day-ahead time scales help reduce forecast errors of wind power.
  - **Transmission is the key** to aggregation benefits, electricity markets and larger balancing areas.

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

- started in 2006
- duration 3 years
- www.ieawind.org

	Country	Participating institution
	Denmark	Risø National Laboratories (Peter Meibom) TSO Energinet.dk (Antje Orths)
	EWEA	European Wind Energy Association (Frans van Hulle)
	Finland	VTT Technical Research Centre of Finland (OA)
	Germany	ISET (Cornel Ensslin à), TSOs RWE (Bernhard Ernst) and E.ON Netz (Lutz Hofmann à)
	Ireland	UCD à (Mark O'Malley), TSO Eirgrid (Paul Smith, Jody Dillon)
	Norway	SINTEF (John Olav Tande), Statkraft (Espen Hagstrøm)
	Netherlands	we@sea, ECN (Jan Pierik), TUDelft (Bart Ummels)
	Portugal	INETI (Ana Estanquiero), UTL-IST (Rui Castro), TSO REN (João Ricardo), INESC-Porto (J. Pecas Lopes)
	Spain	University of Castilla La Mancha (Emilio Gomez)
	Sweden	KTH (Lennart Söder)
	UK	DG&SEE Centre for Distrib.Gener. & Sustainable Electrical Energy (Goran Strbac)
	USA	NREL (Brian Parsons), UWIG (Charles Smith)

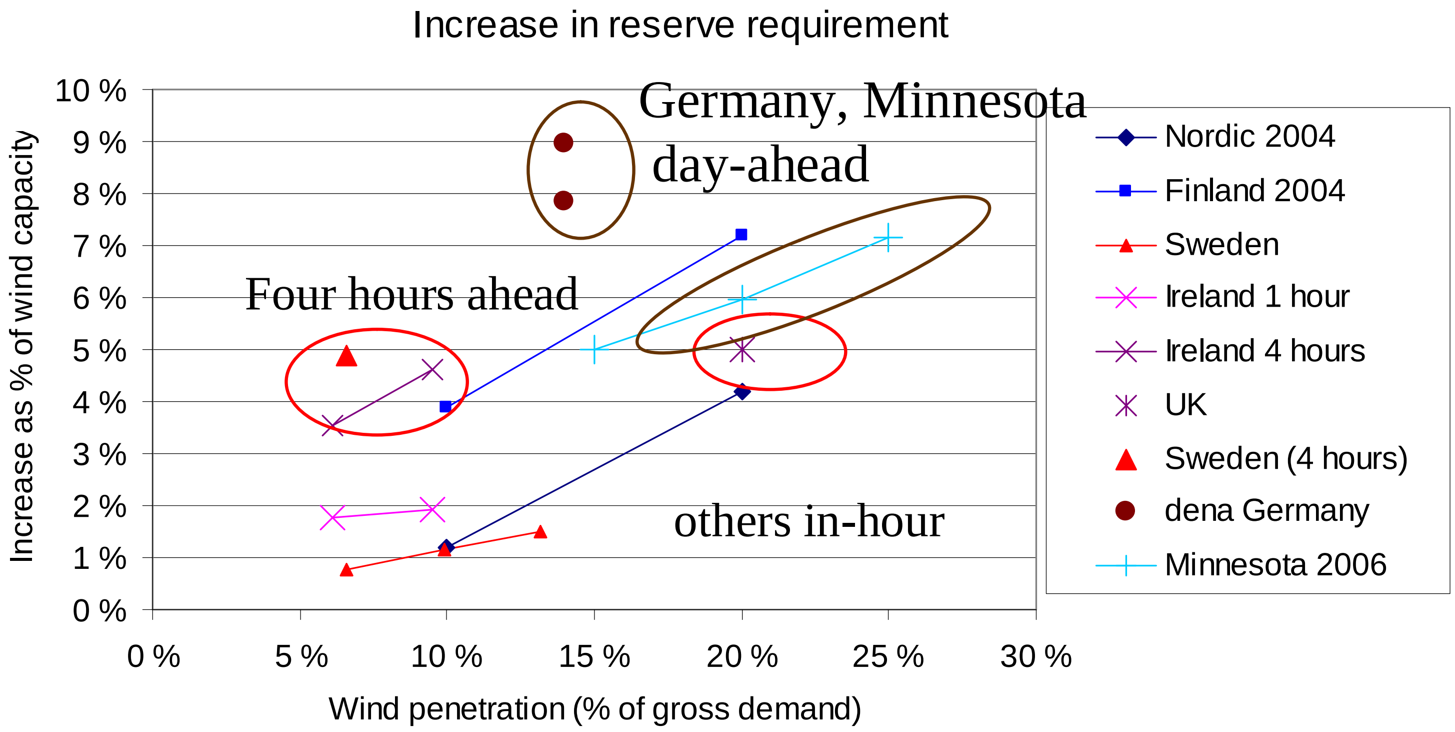
Summary capacity credit



- Even if mainly energy resource, wind has a capacity value to power systems. However, at larger penetrations the value decreases. Value decreases faster for smaller areas.

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

Summary balancing requirements



- different time scales for estimating the reserve requirement
- different methodology used