Estimating the impacts of wind power on power systems

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IEA WIND Task 25

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

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, planning methodologies and modifications that have been necessary with high penetration, concepts and technologies enabling enhanced penetration
- 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

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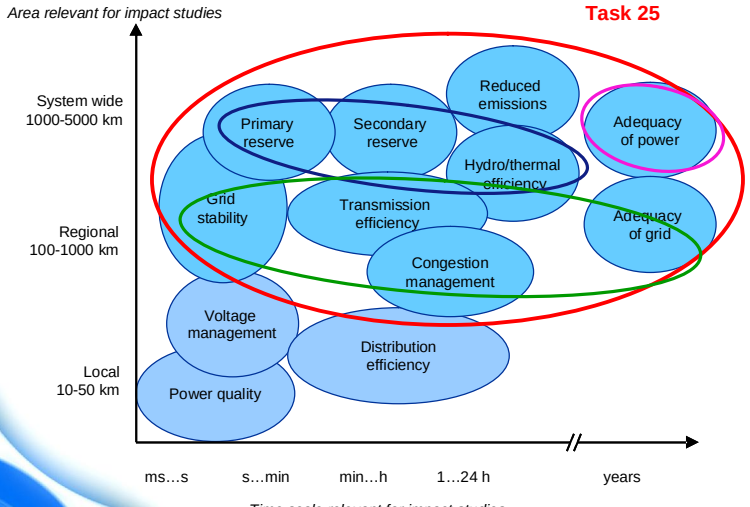
Wind power in the power system: impacts on reliability and efficiency



Adequacy

Balancing

Grid

3

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 %)

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

Denmark: up to 100 % penetration

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 %)

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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

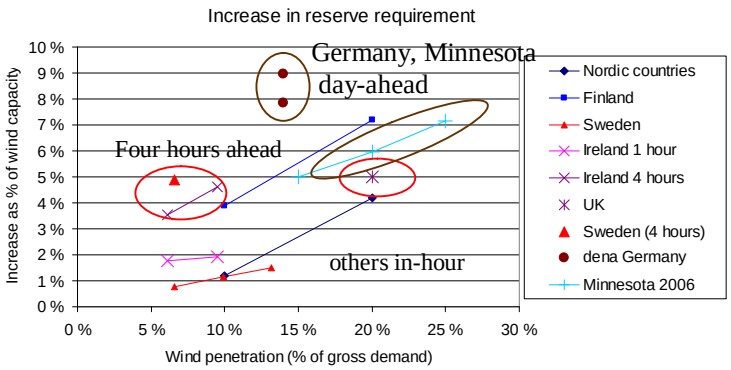
Penetration levels - existing

Region	LOAD			Interconnection	WIND		Penetration level		
	Peak (MW)	Min (MW)	TWh/a	MW	MW	TWh/a	% of peak	% of gross demand	% (min load + interconn)
West Denmark	3700	1200	21	2700	2350	5	**64 %**	**24 %**	**60 %**
Ireland	6127	2192	30	500	754	2	**12 %**	**7 %**	**28 %**
Spain	45000	20000	250	1000	11615	23	**26 %**	**9 %**	**55 %**
Germany	75000	40000	510	10000	20622	31	**27 %**	**6 %**	**41 %**

Challenge: grid

- Impact depends on wind resource location versus load centres
- Grid reinforcement costs are not continuous per MW of wind
  - single high cost reinforcements
- Grid costs are allocated to wind power differently:
  - Shallow/deep costs ; Wind farm and power system interface
- Summary grid reinforcment costs
  - 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
- Costs not comparable

Challenge: balancing



- Impact of variability and predictability reduced when
  - larger balancing area – access to balancing resources and smoothing
  - shorter time scales for estimating the reserve requirement

Integration impacts of wind power

- Extra 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, …)
- Challenges in estimating integration impacts
  - Comparison – impacts compared to what option?
  - Cost-benefit assessment
    - For example, adding wind power will reduce operating costs of a power system due to avoided fuel costs, however, at high penetrations these benefits will be offset to some extent due to more unoptimal way of running thermal plants

Managing impacts of large scale wind power

- Plant interconnection
  - Grid codes: fault-ride-through not to lose > 2000 MW at dips
  - Wind plants providing system services: voltage and power control
- Integration of production forecasts
  - Updating information close to delivery
  - Aggregating wind imbalances of larger areas, and of other imbalances
- Using flexibility of other production and demand
  - Larger balancing areas – more resources, aggregation benefits
  - Increasing flexibility may be needed at high penetrations
- Transmission: availability of, access to, efficient use of
  - IS THE KEY TO AGGREGATION BENEFITS AND LARGER BALANCING AREAS
- Modifications to system configuration and operational practices may be needed