



Twenties
Transmitting wind



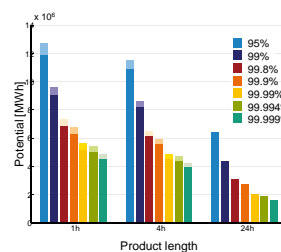
Results on economic impact assessment and EU wide upscaling




Poul Sørensen
Technical University of Denmark
Department of Wind Energy




Wind power in balancing market (Germany)

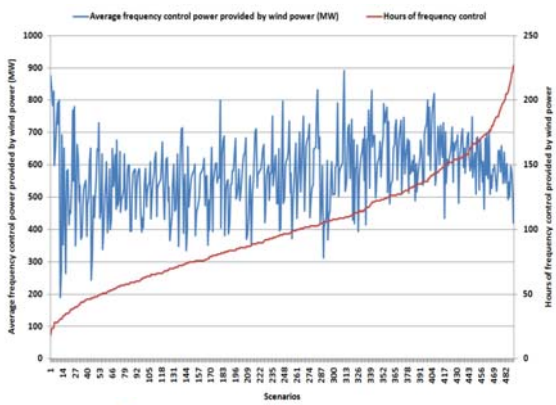
- Dependence on product length and confidence interval
- Significant cost savings potential on balancing reserve markets with wind farms (downwards reserves)
 - > 20% of procurement cost (in Germany)
- Requirements
 - Probabilistic forecasts for wind turbines
 - Regulatory changes








Wind power balancing in France




- 2% of freq reserves from wind
- cost savings ≈ € 2.3M/y



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VPP in Denmark




- VPP scenario:

Flexible electric power	2020 Scenario	2030 Scenario
Cold storage	200 MW	400 MW
EV's	#75,000 (600 MW)	#300,000 (2800 MW)




- Result (of cost optimisation):

Reduction (VPP-Base)	2020	2030
Total costs (M€)	6	26
CO2 costs (M€)	-3	7
Fuel costs (M€)	9	19
Wind curtailment (GWh)	7	180

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VPP in Germany

	2020	2030
Biomass	2,60 GW (49.649 TWh)	10,88 GW (56.866 TWh)
Heat pumps	2.7 GW	4.7 GW

Key indicators	Inflexible	Flexible	Change
Electricity Price (Avg.)	46.69 €/MWh	45.76 €/MWh	-2.18 %
CO₂-Emissions	102.80 mio. t _{CO2}	99.24 mio. t _{CO2}	-3.46 %
Primary Energy Demand	382.81 TWh	370.08 TWh	-3.33 %
Primary Energy Costs	11.51 bio. €	11.15 bio. €	-3.13 %
Emergency demand (Sum/Peak)	2.76 TWh / 31.42 GW	0.60 TWh / 21.05 GW	-78.26 % / 10.45 GW
Energy Supply from Pump Storage	12.90 TWh	7.30 TWh	-43.41 %
Pump Storage Losses	4.40 TWh	2.50 TWh	-43.18 %

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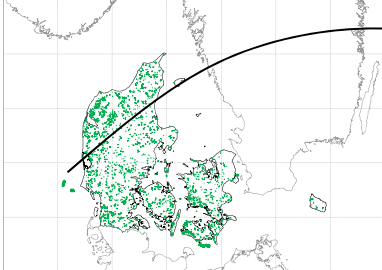
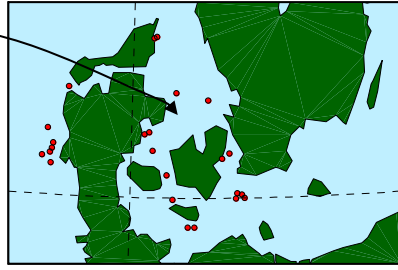

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Upscaling of Horns Rev 2 to > 3 GW offshore wind

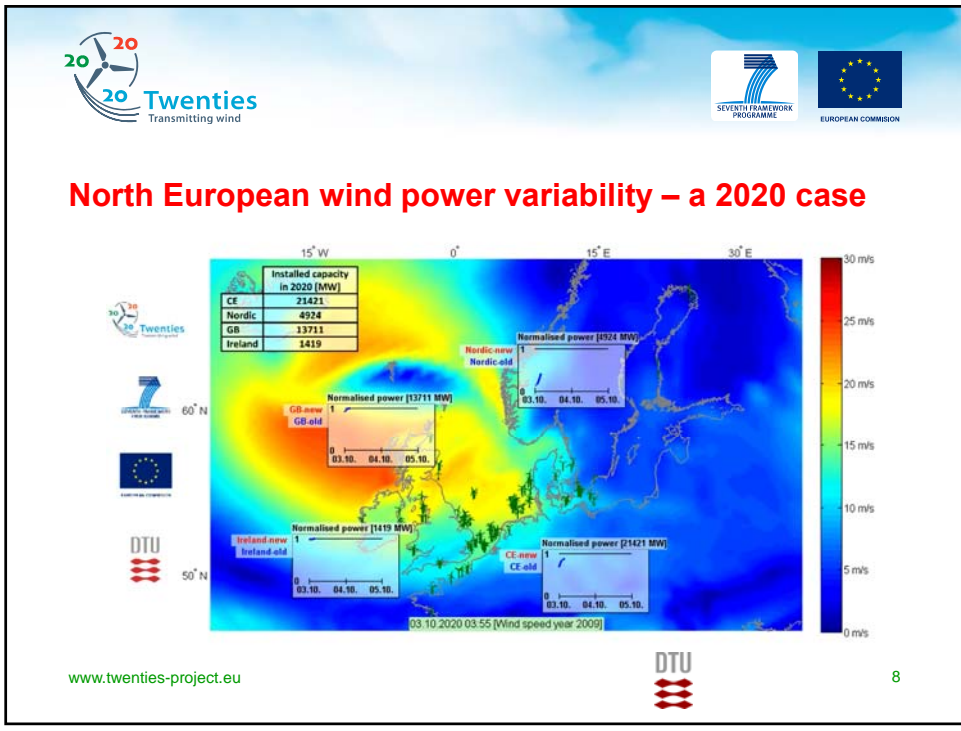
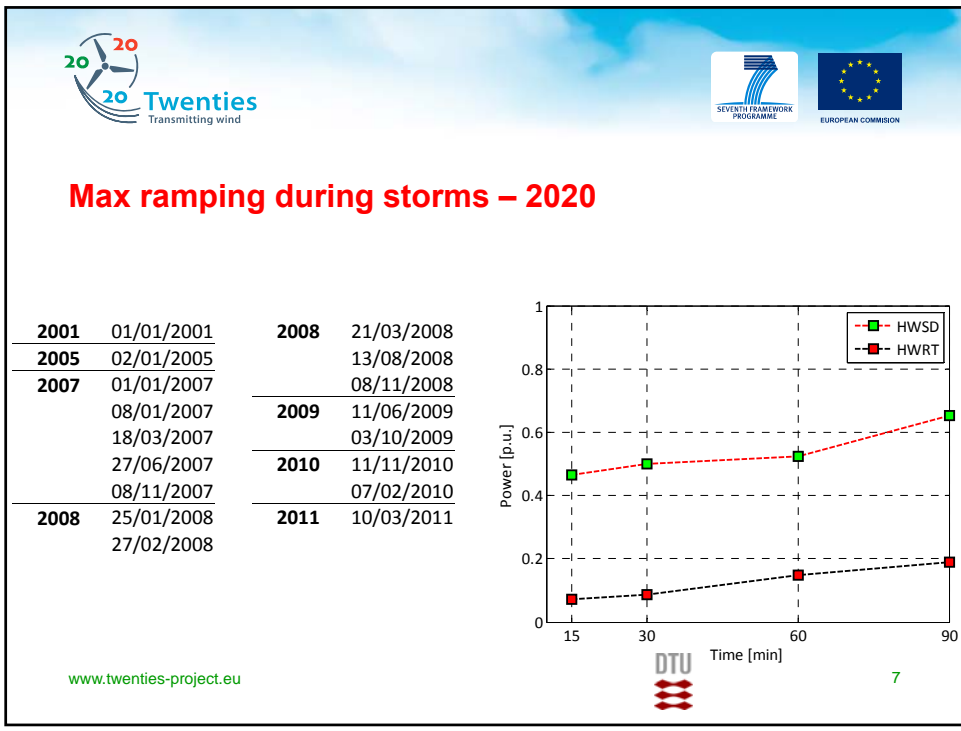
2020: 2.8 GW

2030: 4.6 GW

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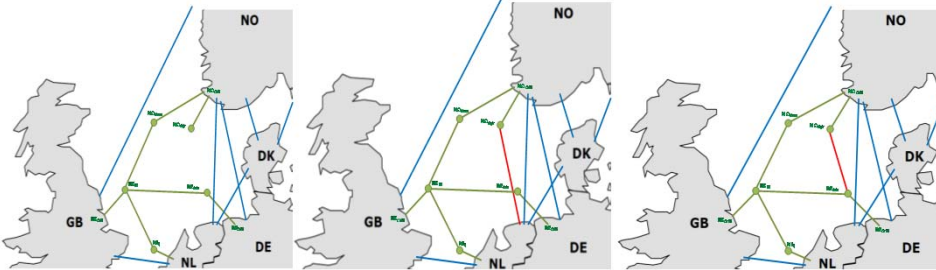
Hydro potential

- **Norway:**
 - 11.5 GW upgrade potential of existing plants
 - 3.5 GW new reservoir capacity possible
 - Most likely scenario: 10 GW by 2030
- **Sweden**
 - 50 GW theoretical potential, but not likely
- **Finland**
 - Upgrades unlikely


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Offshore Grid Alternatives



Case A Case B Case C


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Operating costs

Onshore Grid Constraints	Offshore Case	Cost (billion €/year)
EU system today	A	95.5779
	B	95.5273
	C	95.517
EU system with Expansions (TYNDP12+DE plan)	A	92.9928
	B	92.9288
	C	92.9274

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Summary of findings 1/2

- Wind power frequency control:
 - Impact in Germany 2020 is high: >20% reduction of reserve procurement cost
 - Impact in France 2020 is low: (2% of freq reserves, cost savings ≈ € 2.3M/y)
- Virtual power plant:
 - German VPP (10.9 GW biomass and 2.7 GW heat pumps by 2030) gives 2.2 % cost reduction and 3.5% CO2 reduction
 - Danish VPP (0.4 GW cold storage and 300.000 EV's (2.8GW)) reduces costs by € 26 M/y

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Summary of findings 2/2

- **Wind power variability:**
 - Maximum wind power ramping during storms reduced more than three times in Denmark 2020
- **Hydro potential:**
 - Most likely +10GW in Norway by 2030
- **Grid constraints**
 - Expansion plans in ENTSO-E TYNDP12 + German grid plan reduces generation costs by 2.5%
 - Selected cases for topography of offshore grid will have much less influence on costs

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Thank you








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