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Requirements to market design for an efficient use of hydropower reservoirs

Kristin L. Munthe, Statnett
RGI Storage Workshop, 27th January 2001, Montreux

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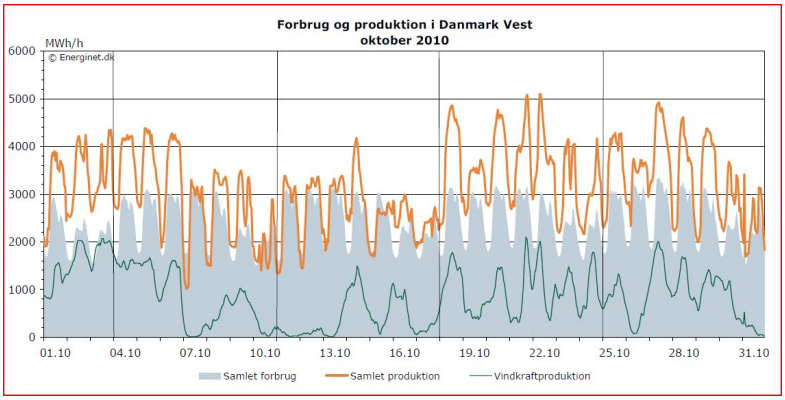
High penetration of intermittent production requires short term flexibility – eg storage
- Example from Jutland



Source: Energinet.dk

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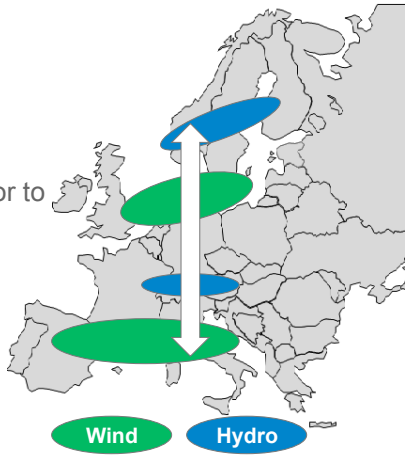
Two green batteries in Europe

Handling the wind production's variability

- Wind power developing from a minor to main part of the production portfolio with dispatch priority
- Creates new need for flexibility and reserves in other parts of the electricity system



→ Connecting systems with different characteristics

side 3

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Two hydro storage variations

1. Pumped storage
   - Usage
     - Production in high price period
     - Consumption in low price period
   - Together with wind:
     - Little wind: Production
     - High wind: Pump water into the reservoirs
2. Hydro power with reservoir
   - Usage
     - Water released in a limited number of hours
     - Hours with highest prices chosen
   - Together with wind:
     - Little wind: Production
     - High wind: Save precipitation in reservoirs

side 4

2.

Flexible hydro balancing power in Europe

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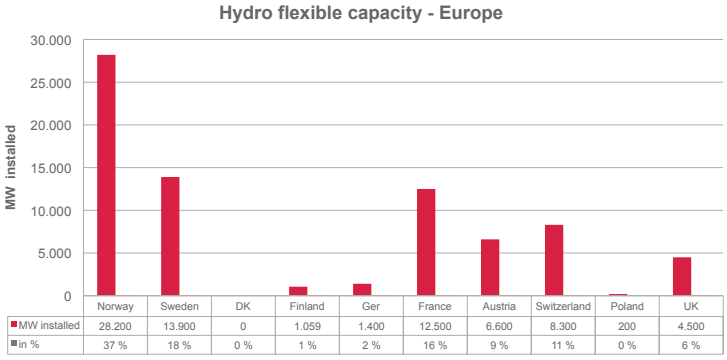

	Norway	Sweden	DK	Finland	Ger	France	Austria	Switzerland	Poland	UK
MW installed	28.200	13.900	0	1.059	1.400	12.500	6.600	8.300	200	4.500
in %	37 %	18 %	0 %	1 %	2 %	16 %	9 %	11 %	0 %	6 %

Sources : Official statistics

Expansion possibilities in southern Norway:
- Capacity with reservoir: 7 - 8 GW
- Pumped storage: 15 - 20 GW

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Beneficial to trade power between thermal/wind power systems and hydro power systems, eg Germany and Norway

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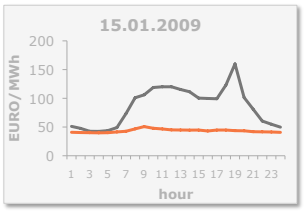
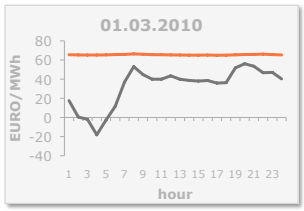
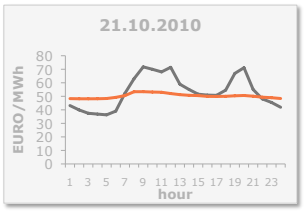




EpexSpot

Nord Pool Spot
Kristiansand



Different price structure
- Thermal power: capacity constrained
- Hydro power: energy constrained

Different price level volatility
- Thermal power: fuel and emission cost
- Hydro power: precipitation

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Transforming wind generation to peak generation

Import of wind power	10 000 MW in 1 500 h = 15 TWh
Storage in reservoirs	
5000 MW reduced production	5 000 MW = 7,5 TWh
5000 MW pumping (factor 0,7)	5 000 MW = 5,6 TWh
"Stored wind power"	13,1 TWh
Export of "wind power"	10 000 MW in 1310 hours
Value of transformation (13,1 TWh*68,5 €/MWh -15 TWh*35,4 €/MWh)	≈370 mill €

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Connecting the Norwegian battery to the thermal/wind belt is sensible!

- Technical perspective
  - Balance at all times requires a battery for the wind power
- Environmental perspective
  - Allows more wind to be integrated into the system
  - Can get more wind power production for the same amount of subsidy
- Economically
  - Incorporates the two perspectives in well functioning markets

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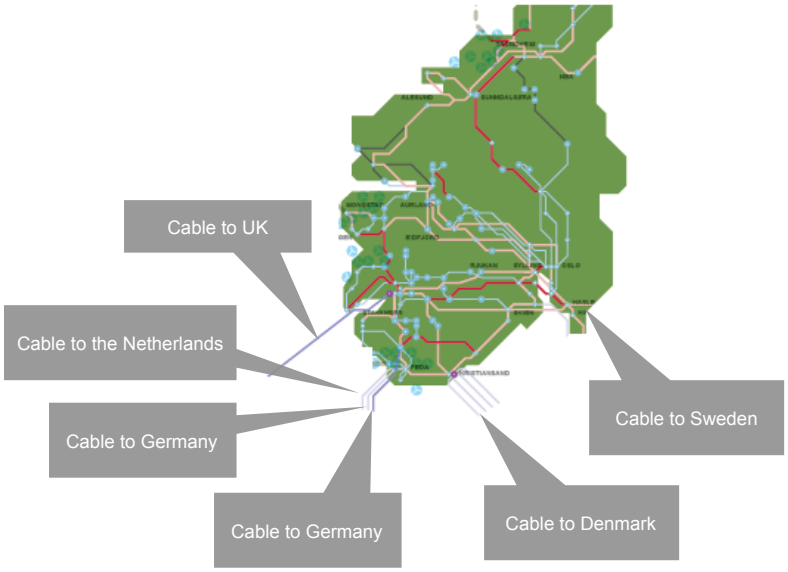
Possible new connections from Norway



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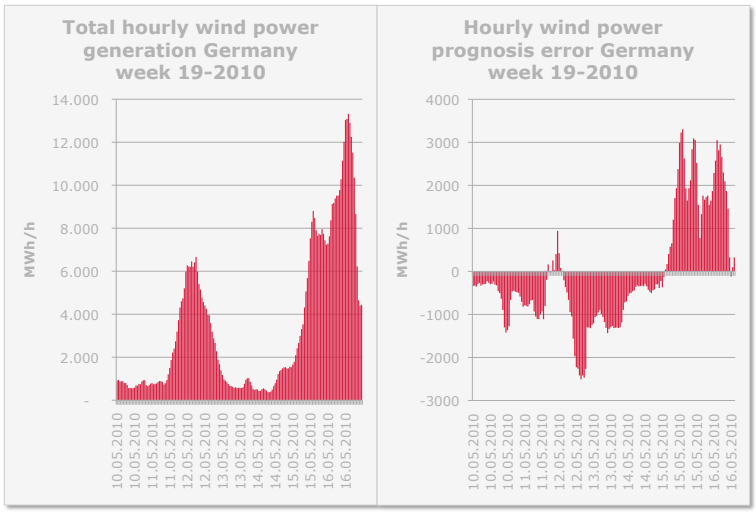
Wind power will also challenge other products - Intraday and reserves



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TSO must hold reserves – and activate them

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- Reasons for reseves
  - Outages/failures in production system, grid, consumption (industry plant)
  - Forecast error
  - Time resolution – neither wind, nor solar, nor consumption is producing/ consuming evenly through the hours!
- Some of the reserves must be spinning
  - Do not have time to wait for a plant to start up
- Spinning reserves are costly in a thermal/wind power system
  - CO2-emissions
  - Economically

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Spinning reserves in thermal power plants can be costly – economically and in terms of CO2 emissions

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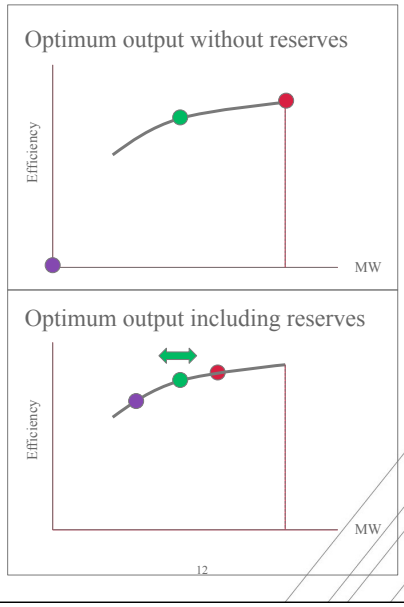
Cost A – reduced efficiency
- Costly due to higher use of fuel
- Higher CO2 emissions

Cost B – power not needed
- Costly due to price lower than cost
- Higher CO2 emissions

Cost C – when activated
- More expensive use of plant
- Higher CO2 emissions



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The "purple situation" seems to become important

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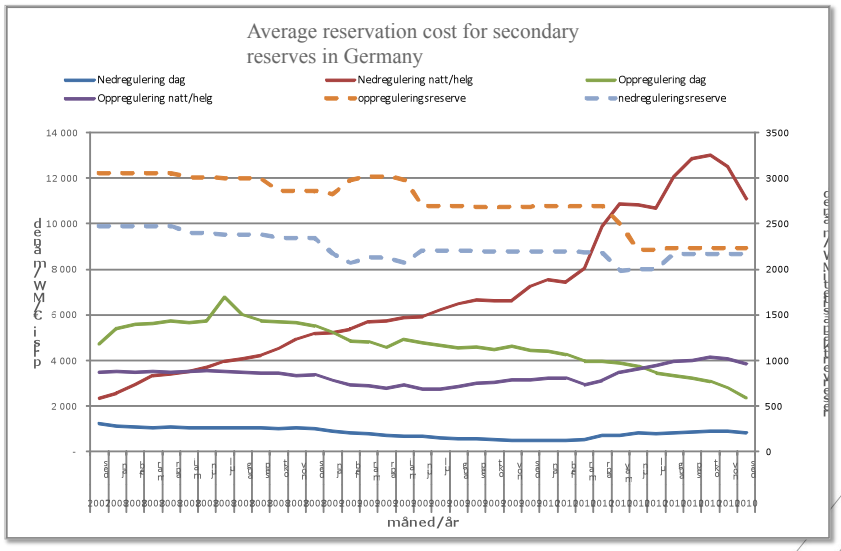

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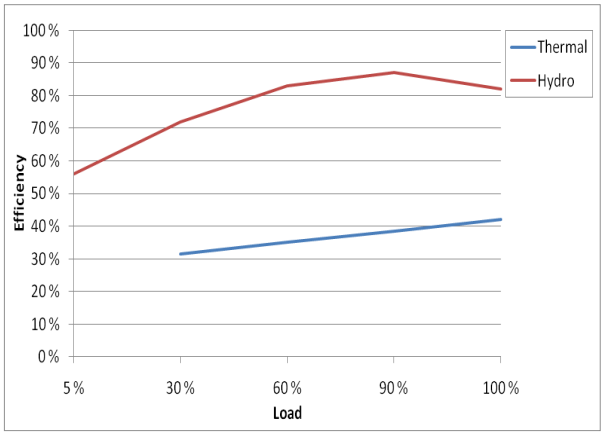
Hydro power is better suited to provide spinning reserves

Efficiency curves, thermal and hydro.



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Historic value of trade between Germany and Norway
- Empirical analysis of period 1st January 2009 – 30th June 2010

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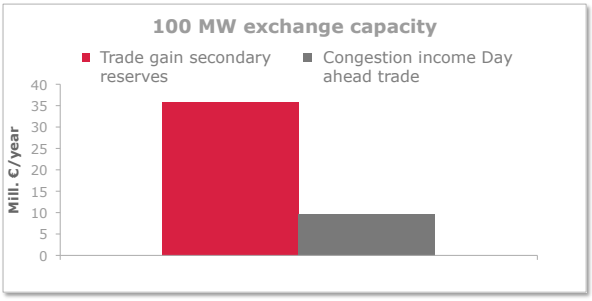

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Conclusions

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- Hydro power storage can play an important role in combination with wind power
- Interconnectors between hydro power areas and wind power areas can be, environmentally, as important as connections from off shore wind power farms
- Transmission capacity should be allocated to all products
  - Beneficial: technically, environmentally and economically
  - If markets are well functioning, CO2 emissions must have a price, market based solutions will give the optimal solution

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