Energy Storage Seminar Trondheim, 21/10/2014

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Large-scale balancing and energy storage from Norwegian hydropower – Potential and challenges

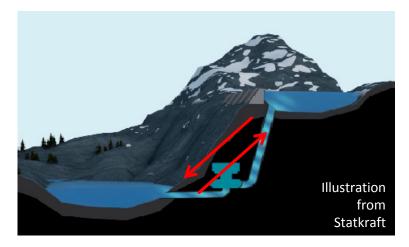
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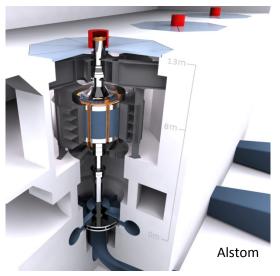


Energy balancing using hydropower

Hydro storage vs. pumped storage



- Storage across entire time scale
- Efficiency up to 80% round-trip
- Most economic means of storing energy on large scale
- Various types of ancillary services

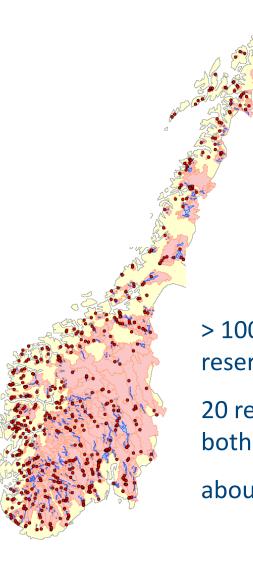




Hydropower in Norway

- Large number of reservoirs
- Storage capacity







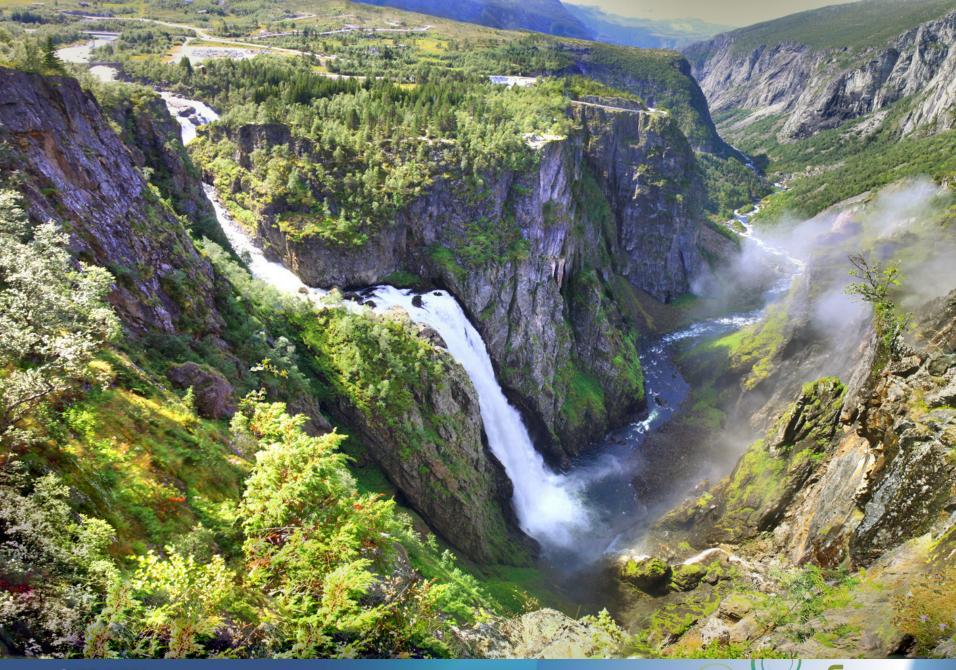
20 reservoirs > 100 Mm³ both up- and downstream

about 85 TWh storage







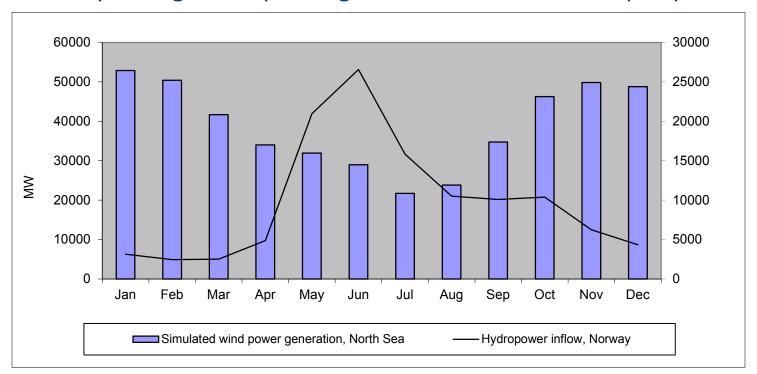




Hydropower in Norway

Hydropower and wind power are complementary

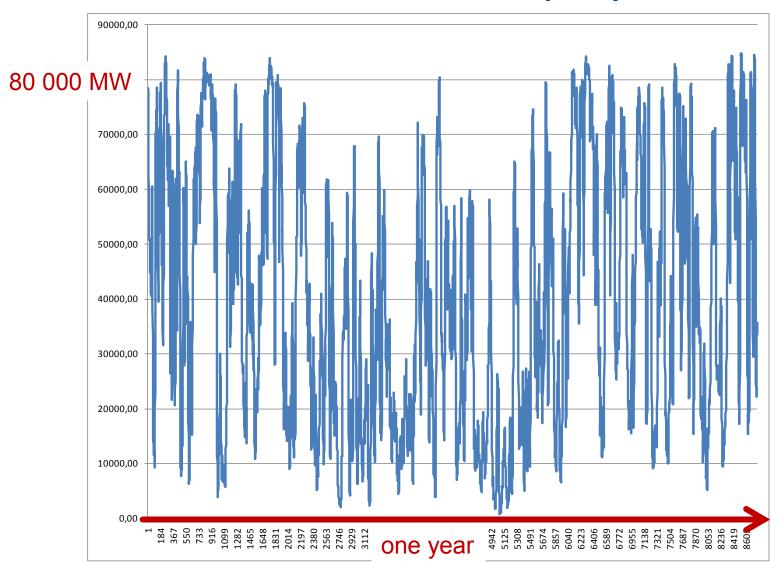
Monthly average wind power generation and inflow to hydropower







Simulated wind power production in the North Sea area in 2030 95 000 MW installed capacity

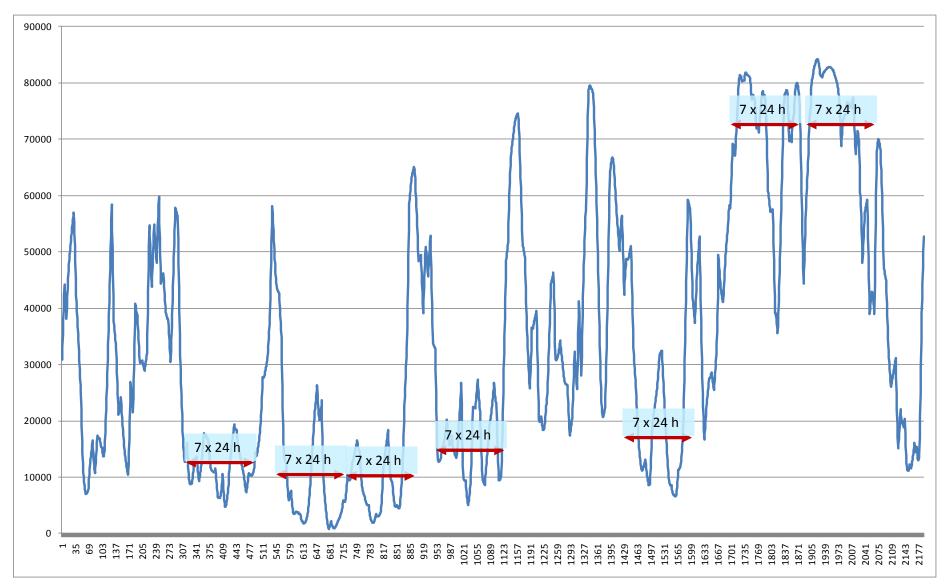








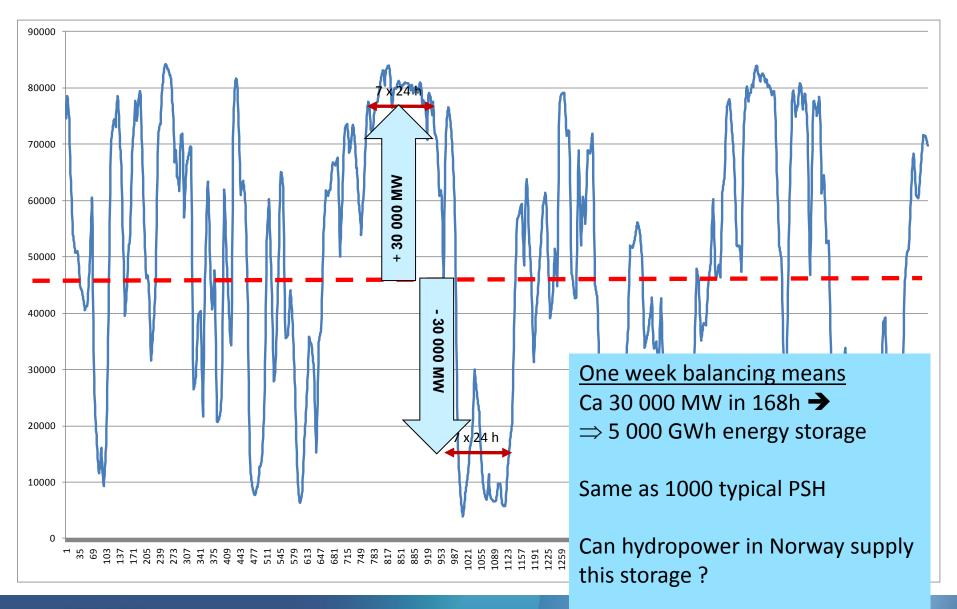
Wind power North Sea area – July-September 2001







Wind Power North Sea area – January-March 2001







Potential in Norway

Increasing balance power capacity in

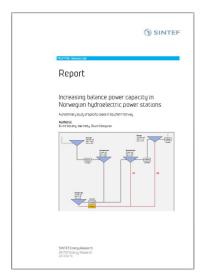
Norwegian hydroelectric power stations —

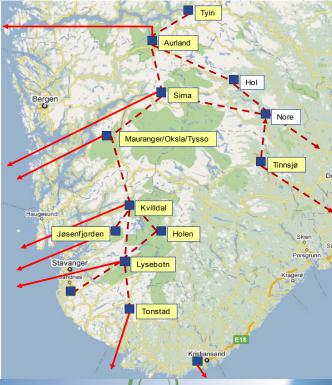
A preliminary study of specific cases in

Southern Norway

Solvang et al. (2011)

- New power stations
- Hydro storage + pumped storage
- Existing reservoirs and dams
- Outlet into reservoir or fjord/sea
- 20.000 MW possible by 2030

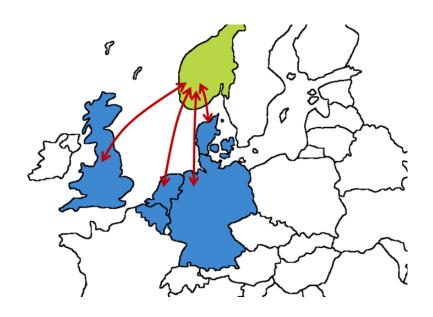






HydroBalance Project – Environmental, technical, economic and social challenges

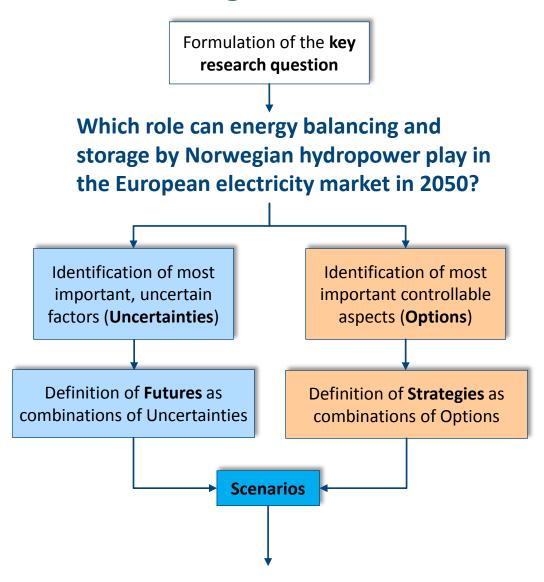
Oct 2013 - Oct 2017



- Scenarios for different futures of the Norwegian hydro system in 2050
- Roadmap
- Analyses, simulations and case studies of
 - energy system
 - energy market
 - environmental impacts
 - regulatory framework and public acceptance



Scenario building

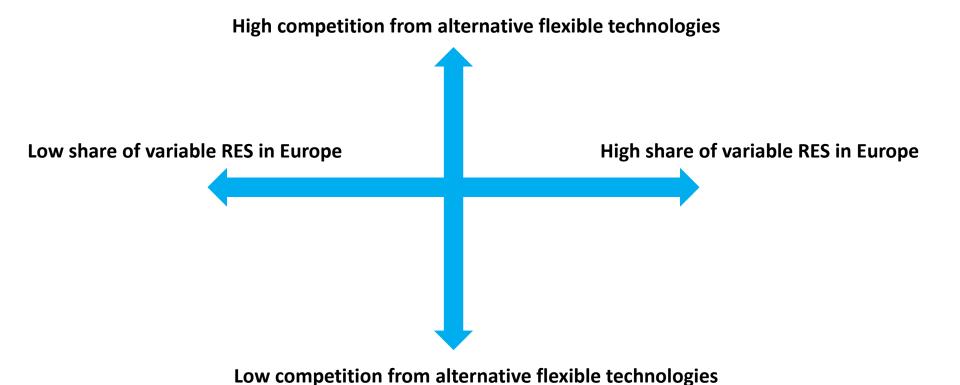




HydroBalance scenarios

Among most important uncertainties:

- 1. Share of variable renewable energies
- 2. Competition from other alternative flexible technologies

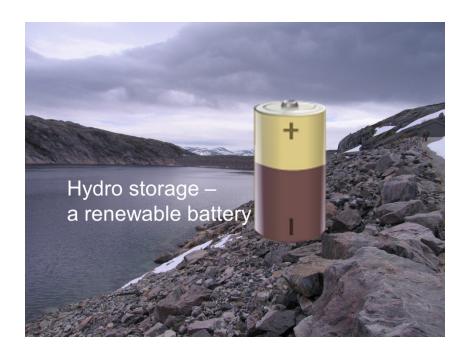






Conclusions

- Importance of time horizon
 - different types of services
 - different technologies
 - different power markets
- Potential of Norwegian hydropower
- Challenges to solve
 - Economic viability
 - Environmental impacts
 - Public acceptance







Thank you for your attention



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