

Balancing the European Electricity market with Norwegian hydropower

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Outline

- Background and main findings
- Assumptions and approach
- Results
- Wrap-up

Background and conclusions

Background

- ECN's contribution to the Hydrobalance project
 - Potential and opportunities for Norwegian hydropower in the European electricity market
 - Hourly price estimates based on ECN's European electricity market model
 - Analysis of future electricity market developments and the role of Norwegian hydro

Main findings

- Increasing shares of variable renewables in Europe provides greater opportunities for balancing with Norwegian hydro ...
- ... which can be realised with expanded transmission capacities between Norway and other NW-European countries.
- However, increasing interconnection capacities within Europe compete with hydro PS in Norway in providing flexibility to the European electricity market ...
- ... and hamper the business case of Norwegian hydro PS because price volatility is reduced ...
- ... while conventional hydro revenues increase because of higher average prices.

Assumptions and approach

Approach

- **COMPETES model**
 - Unit-commitment model of the transmission-constrained European power market
 - 28 nodes / countries or regions
 - Flexibility constraints
 - Minimum load, minimum up- and down time, ramping rates, start-up costs
 - Hydro run-of-the-river, hydro storage and hydro pumped-storage
- **Two markets**
 - Day-ahead
 - Intraday (including balancing)
 - Intraday market/balancing to addressing forecast errors of wind generation
- **Two scenario's from the four used in Hydrobalance**
 - Big storage and Niche storage

Assumptions

- Big storage versus Niche storage

- Stronger interconnections between Norway NW-Europe and within Europa in **Big**
- Integrated European intraday market in **Big**
- More hydro capacity in Norway in **Big**, more hydro PS in Germany in **Niche**

NTCs

CAP

- Background scenario

- ENTSO-E Vision 4 (“Green revolution”) for demand and capacity with additional interconnections

- Two climate years

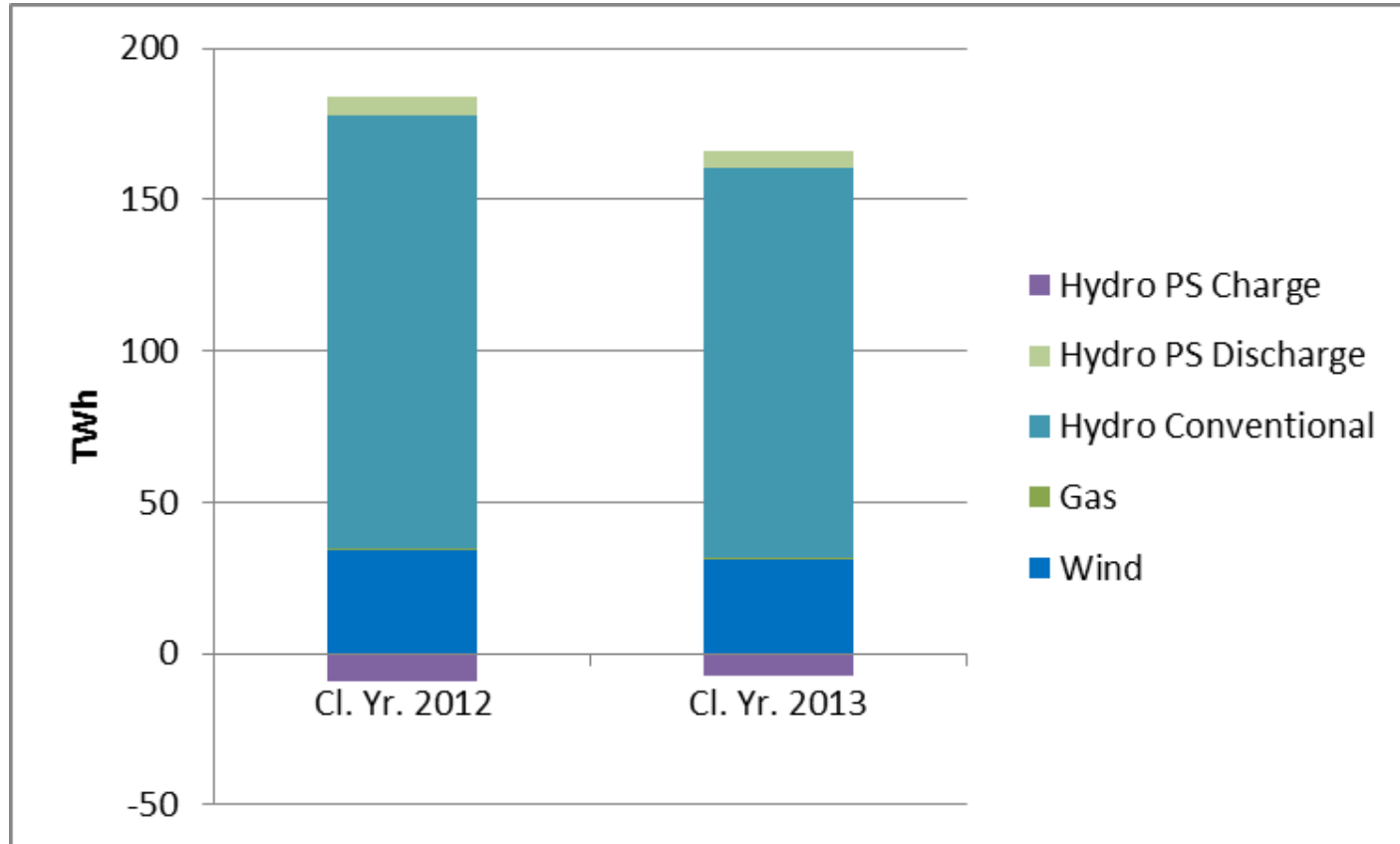
- Based on historic years: 2012 and 2013
 - Different volumes of wind and solar production and different levels of rainfall

- Prices based on WEO 2014 “450 ppm” scenario

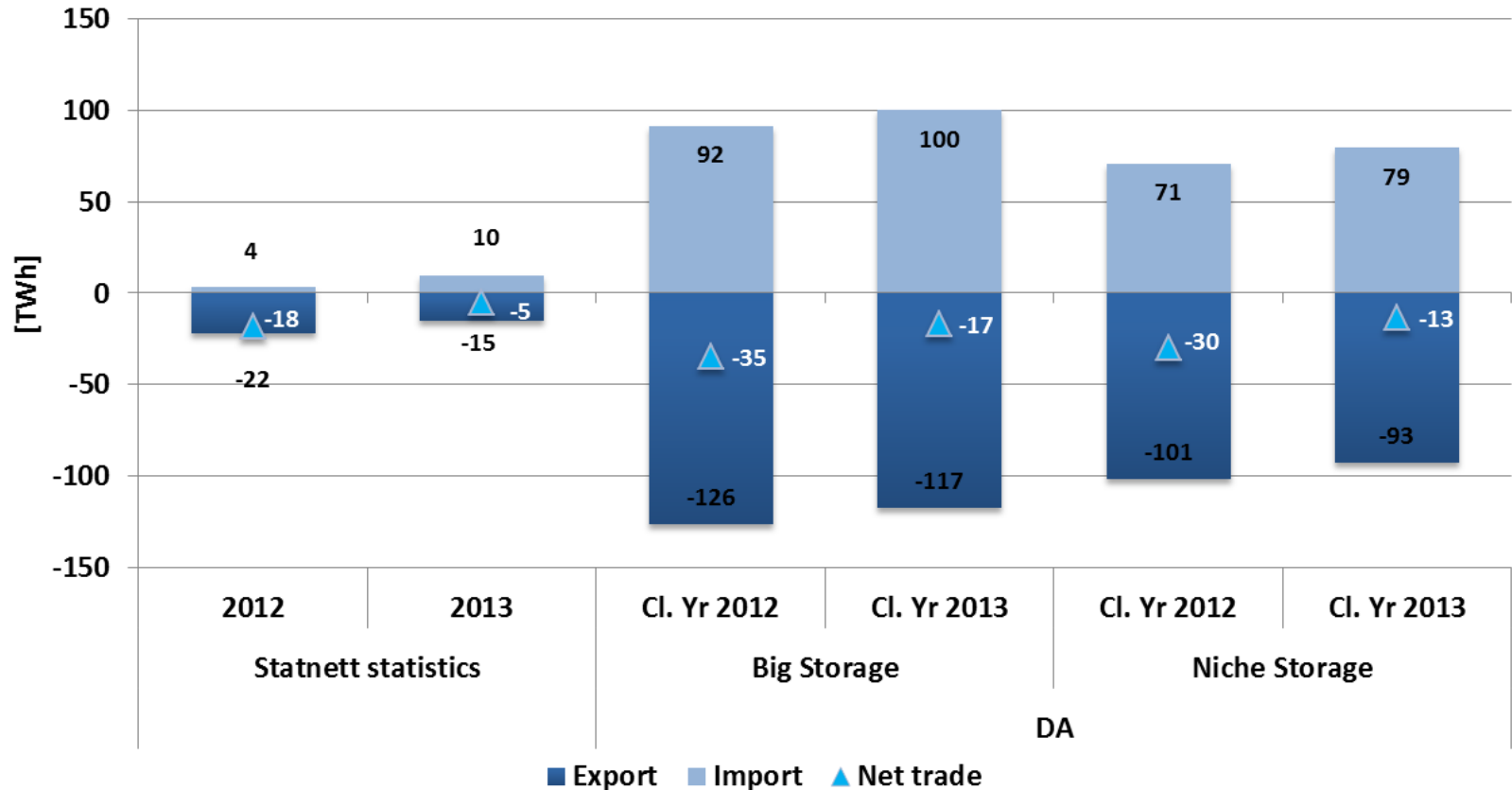
Results

- Generation
- Import and export
- Price volatility
- Hydro revenues
- Sensitivity interconnections

Norwegian electricity generation in 2030



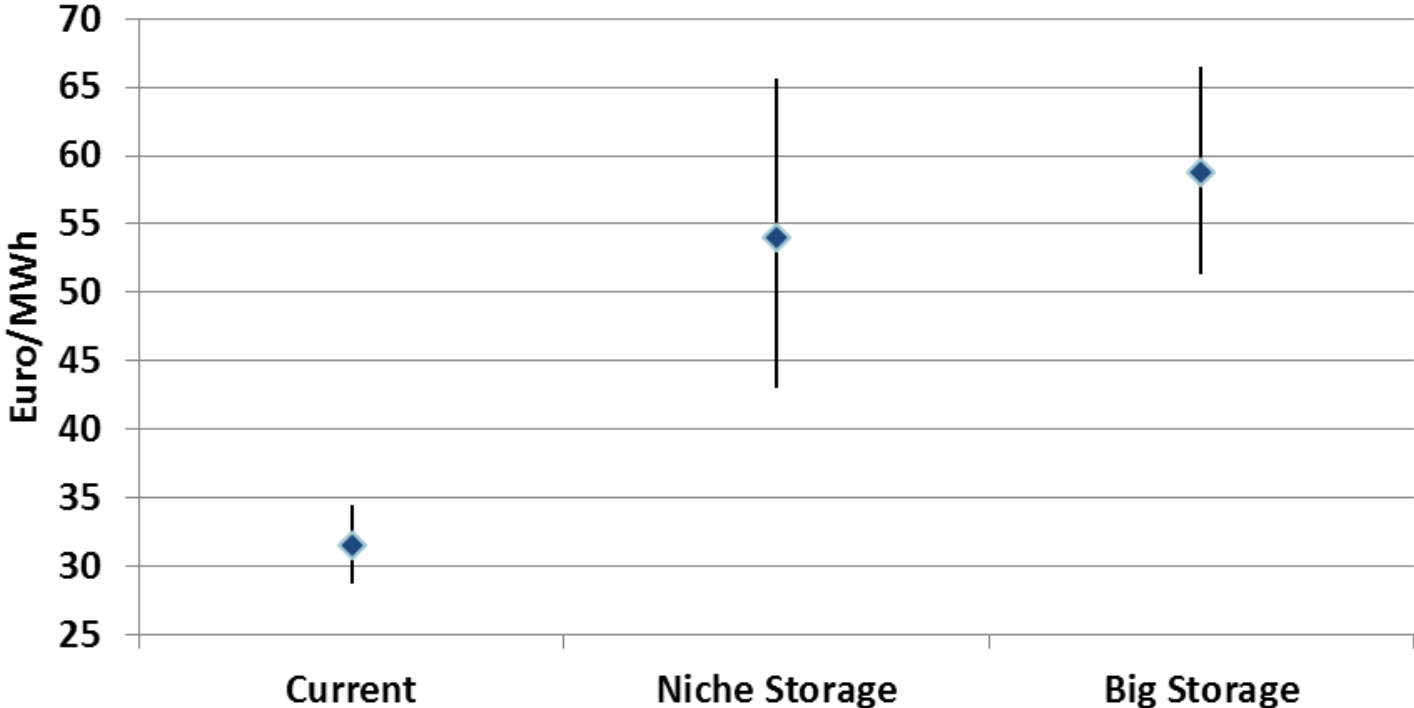
Imports, exports and trade flows Norway



Price volatility Norway

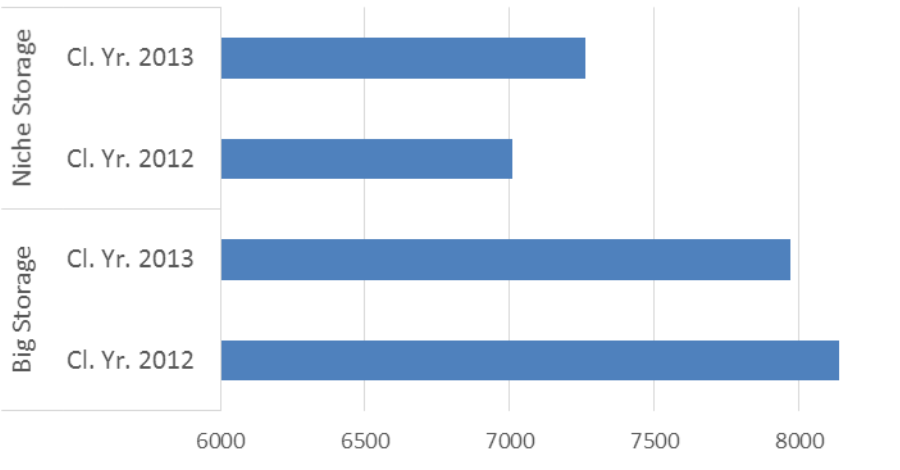


€₂₀₁₀/MWh , climate year 2012

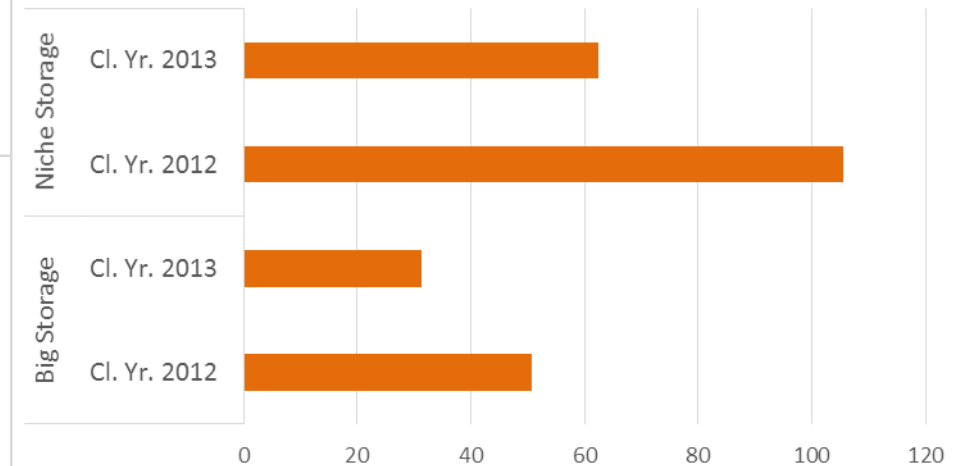


Hydro revenues

Hydro conventional

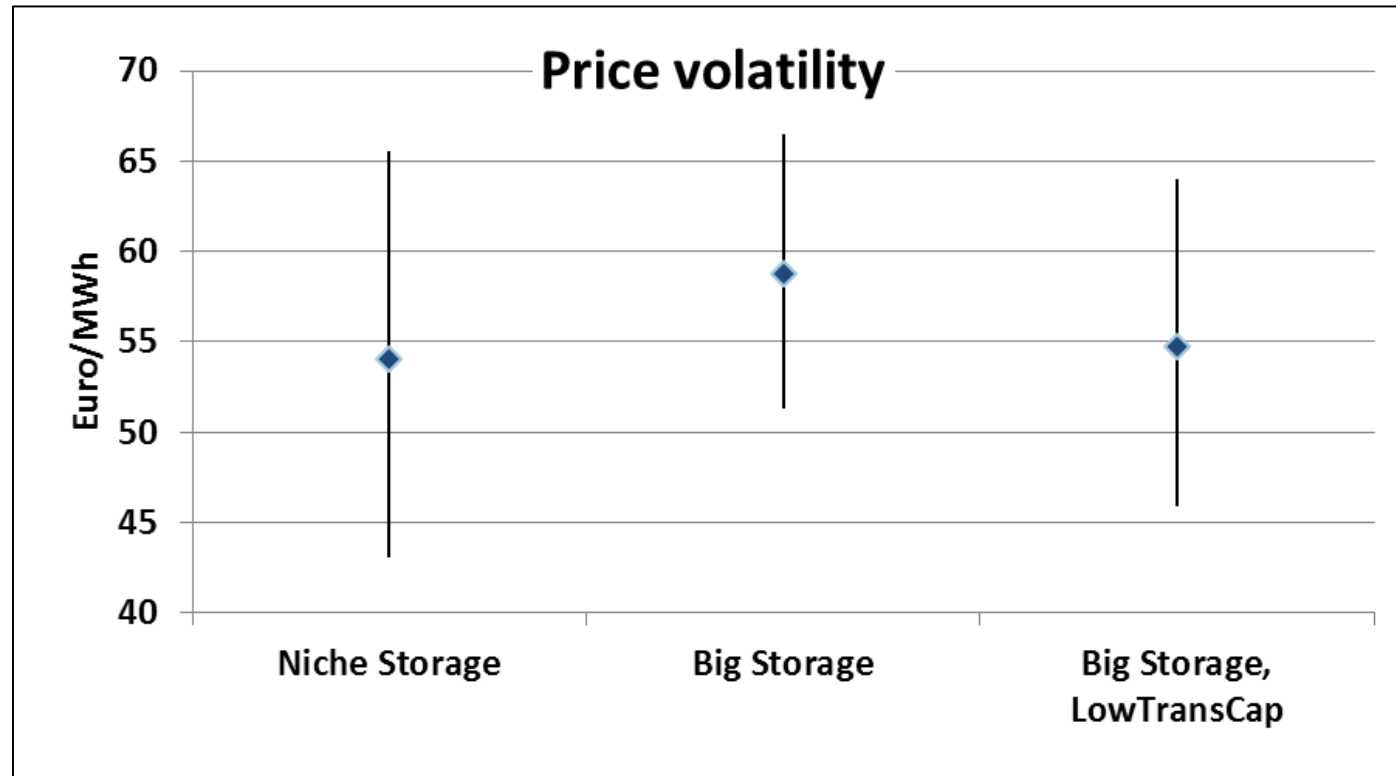


Hydro pumped storage



Sensitivity transmission capacities (1)

Big storage with transmission capacity from Niche storage: 20,3 instead of 25,4 GW in 2030



Sensitivity transmission capacities (2)

		Niche Storage	Big Storage	Big Storage LowTrans
Totals (TWh)	Hydro PS, Charge	10,2	9,7	11,9
	Hydro PS, Discharge	7,1	6,8	8,3
Utilization (%)	Hydro PS	30%	19%	24%
Total revenues (Meuro)	Hydro PS	100	45	63
	Hydro Conv.	6766	8139	6989

Wrap-up

Main findings

- Increasing shares of variable renewables and increased interconnections between Norway and the rest of Europe increase price volatility and provide greater opportunities for balancing with Norwegian hydro.
- Further strengthening of interconnections within the rest of Europe however reduces price volatility and therefore hampers the business case of Norwegian hydro PS.
- However, conventional hydro revenues increase with increased interconnections because of higher average prices.
- Different climate years (with different levels of rainfall, solar-pv and wind) affects the role of hydro.



Thank you for your attention

NTC values interconnecting Norway with neighbouring countries [GW]



From Norway to:	TYNDP 2014	TYNDP 2014 + Big Storage	TYNDP 2014 + Niche Storage
United Kingdom	2.8	6.8	5.4
Netherlands	0.7	6.2	4.4
Germany	1.4	7.0	5.1
Denmark	1.7	1.7	1.7
Sweden	3.7	3.7	3.7



Assumed hydro capacities

