



NTNU – Trondheim
Norwegian University of
Science and Technology

Vannkraft

Ren energi som verdens batteri

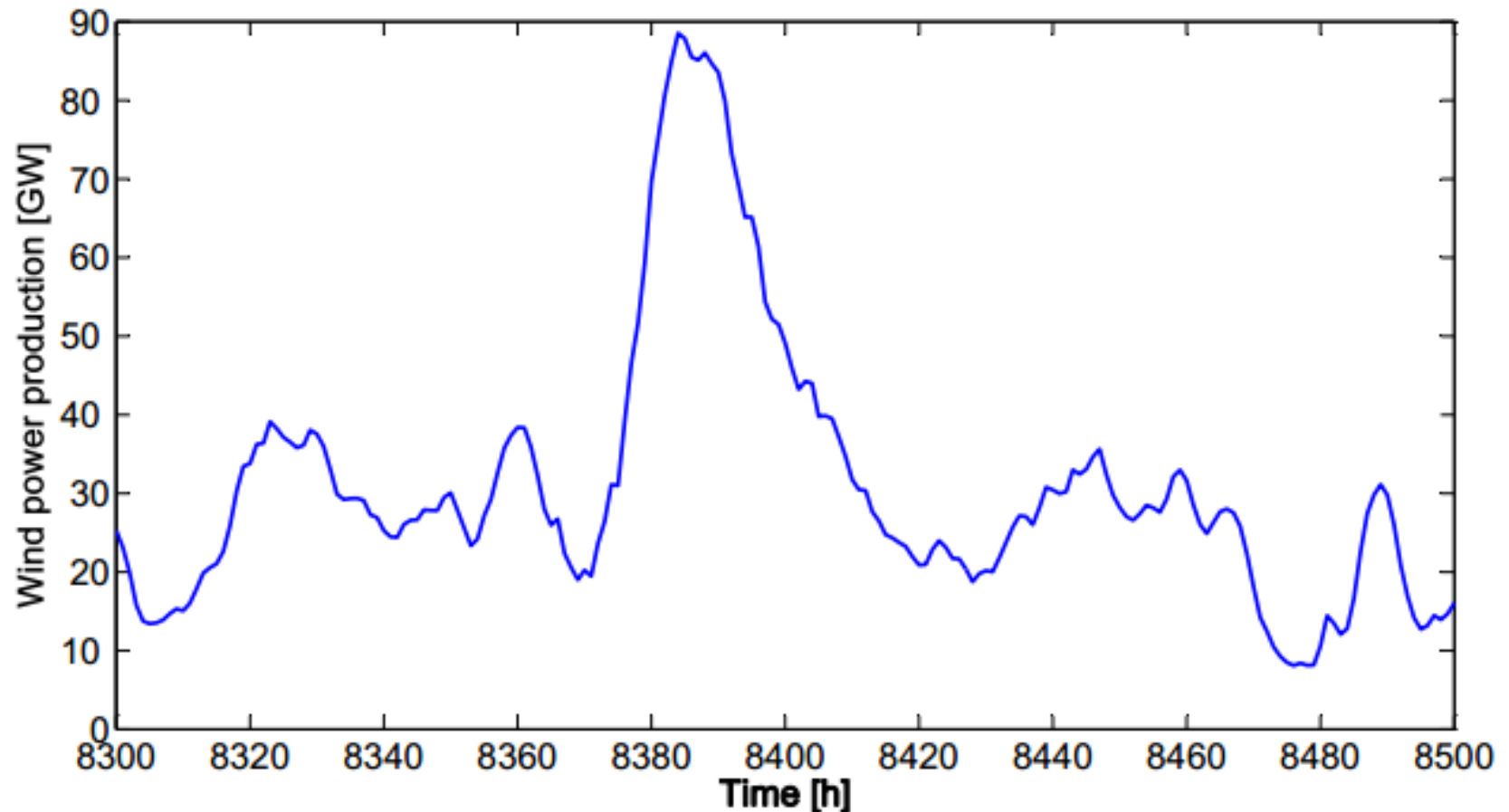
EFIKS 2015

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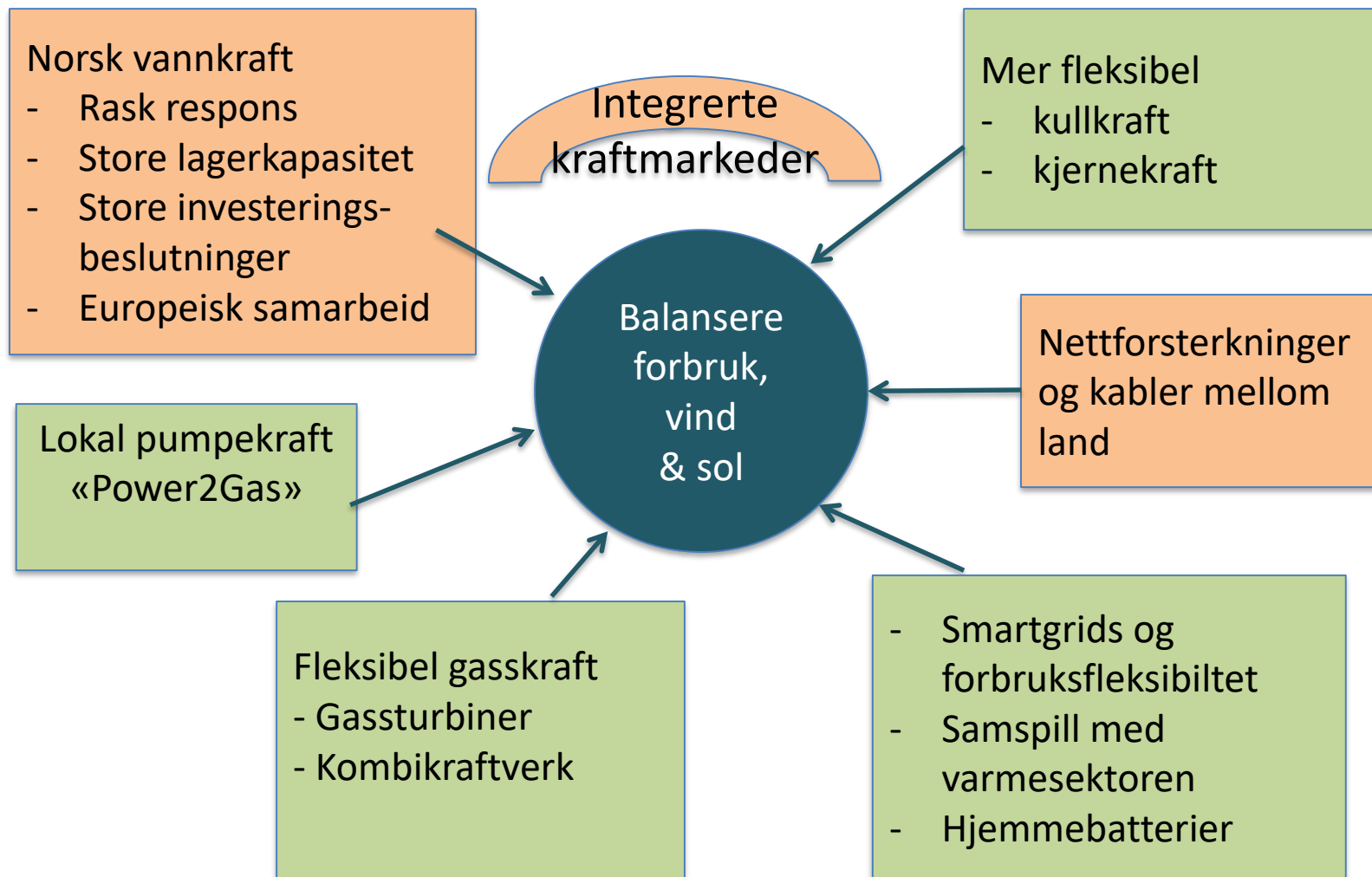




Houston, we have a ~~problem~~ ..challenge!



...and a whole lotta solutions!



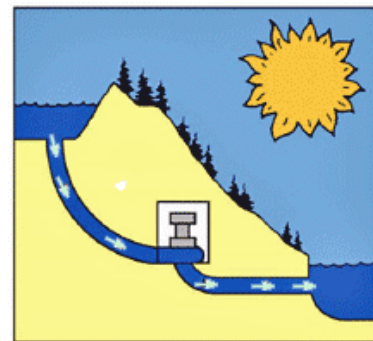
Nordisk vannkraft har unike kvaliteter..

- Hurtig reguleringskapasitet for levering av effekt
- Store vannmagasiner for lagring av energi
- Store effekt- og pumpeutvidelser mulig i eksisterende vannkraftsystem
- Det er et sterkt økende behov for fleksibel kraft i Europa. Hva slags rolle kan nordisk vannkraft spille?



Norwegian hydropower for balancing

- The reservoirs are natural lakes
 - Multi-year reservoirs
 - Largest lake stores 8 TWh
 - Total 84 TWh reservoir capacity
- Balancing capacity estimates 2030
 - 29 GW installed at present
 - + 10 GW with larger tunnels and generators
 - + 20 GW pumped storage
 - 30 GW total new capacity
 - Within today's environmental limits
 - Requires more transmission capacity



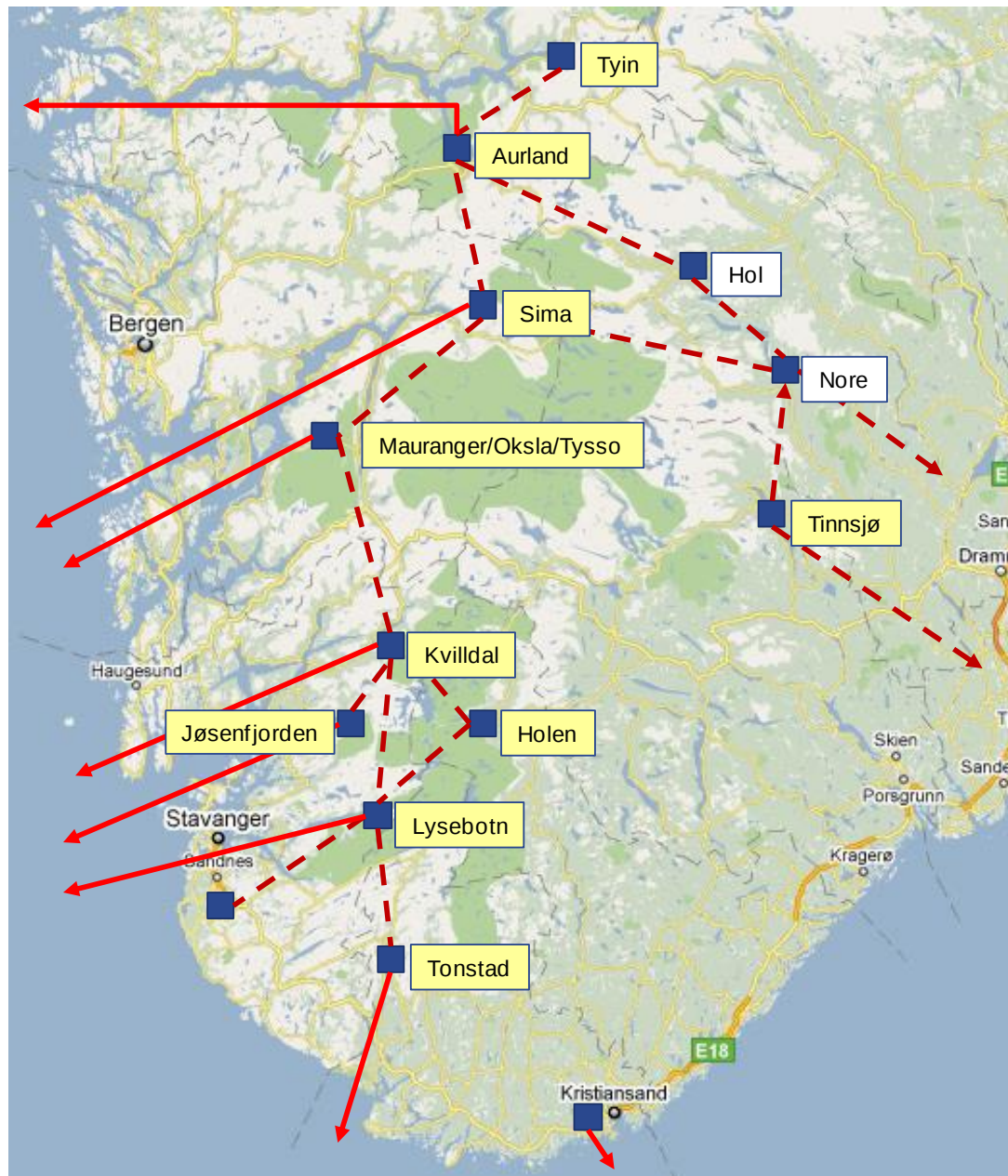
What is the value of the lake Blåsjø??



	BLÅSJØ	POWERWALL
Capacity (kWh)	8 000 000 000	10
Installation cost (\$)	-	3,500
Lifetime (years)	∞	10

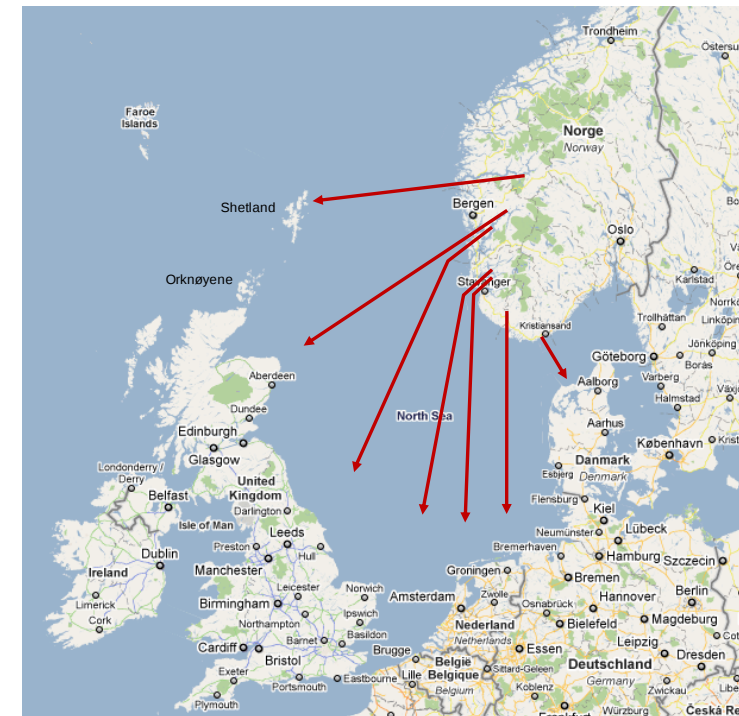


8 TWh of Powerwalls cost 2800 Billion \$



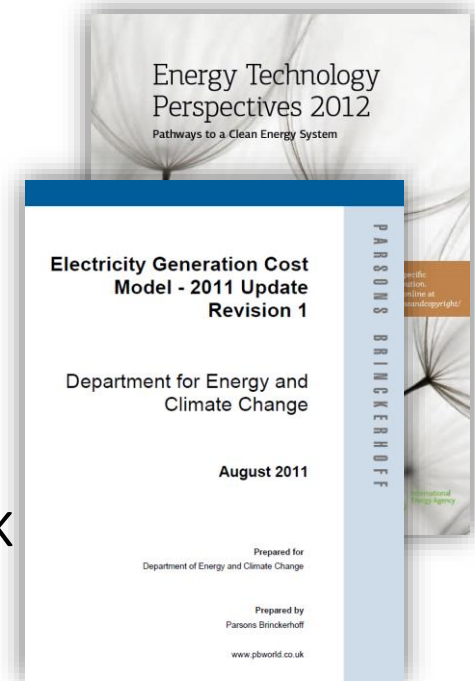
Case study 2030

10-20 GW new pumping and generation capacity using existing reservoirs

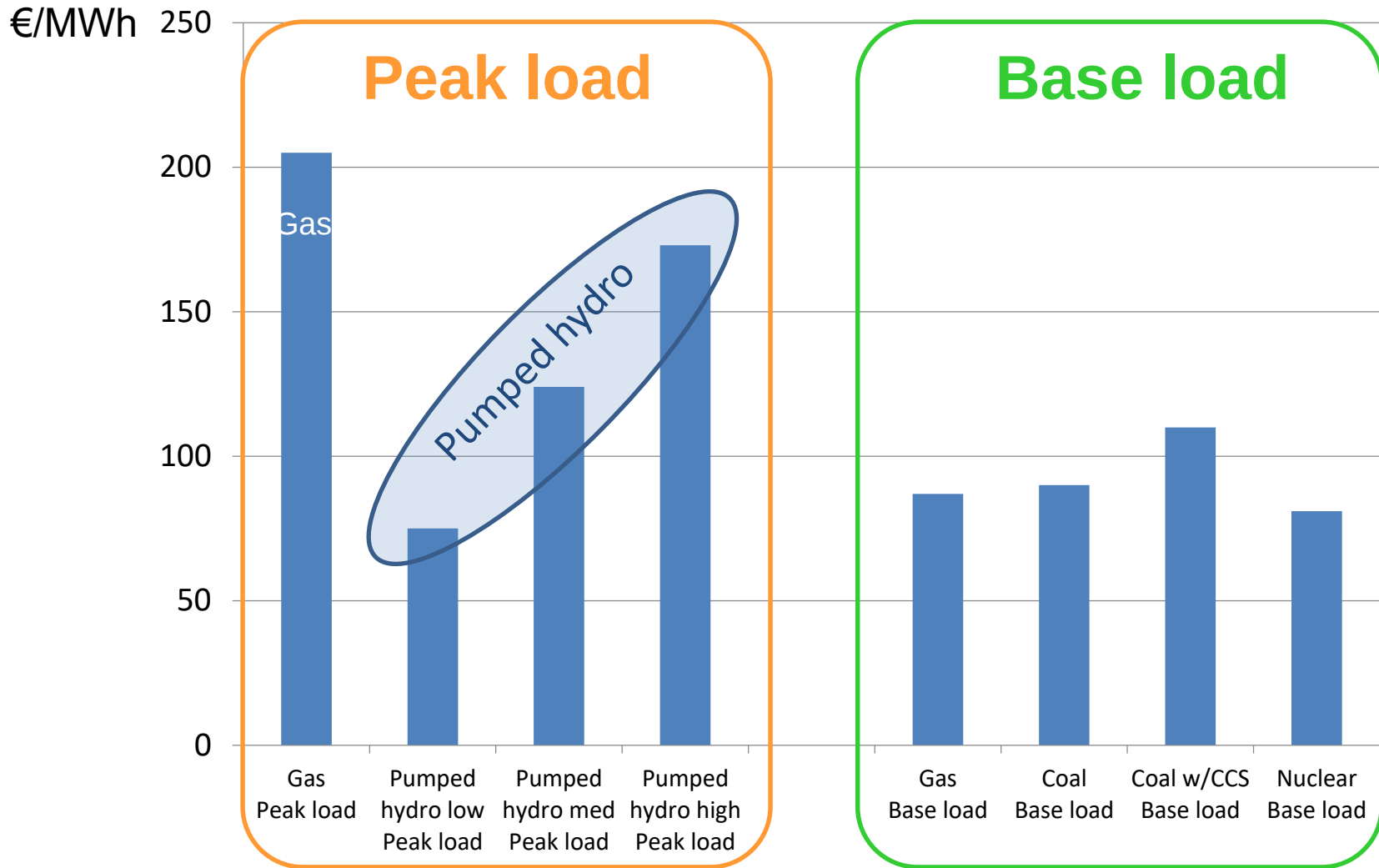


Overview of cost comparison study

- Only cost is considered
 - Market operation “translated” to load factors
 - Assessment of the most cost-effective flexibility options in the near term
- Input data
 - Time period 2030-2040
 - Based on IEA WEO scenarios and figures
 - Gas plant models and costs according to report for UK Dept. of Energy and Climate Change
 - Pumped hydro storage and grid data based on Norwegian figures; Producers, Regulator, TSO, Univ.

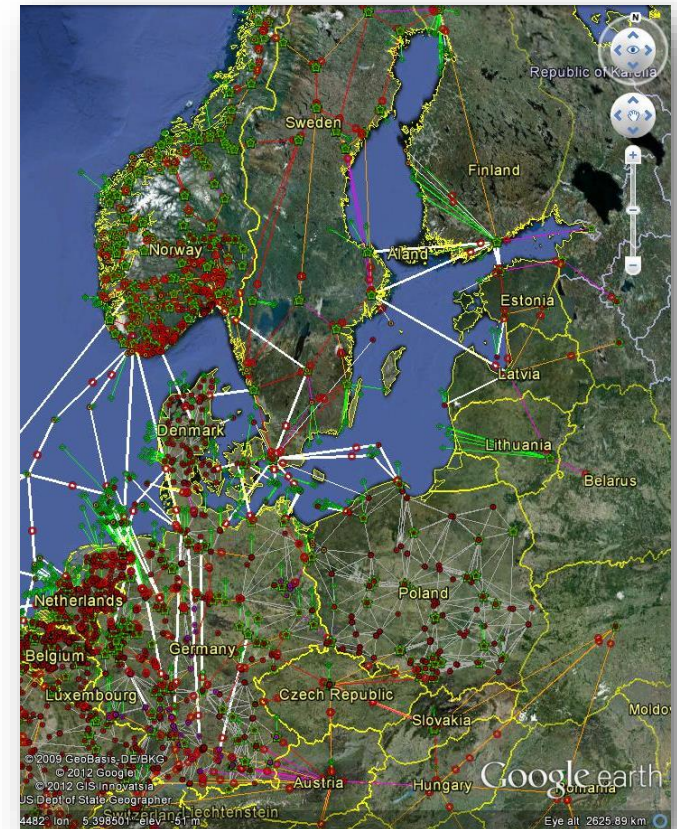


Peak load and base load have different cost



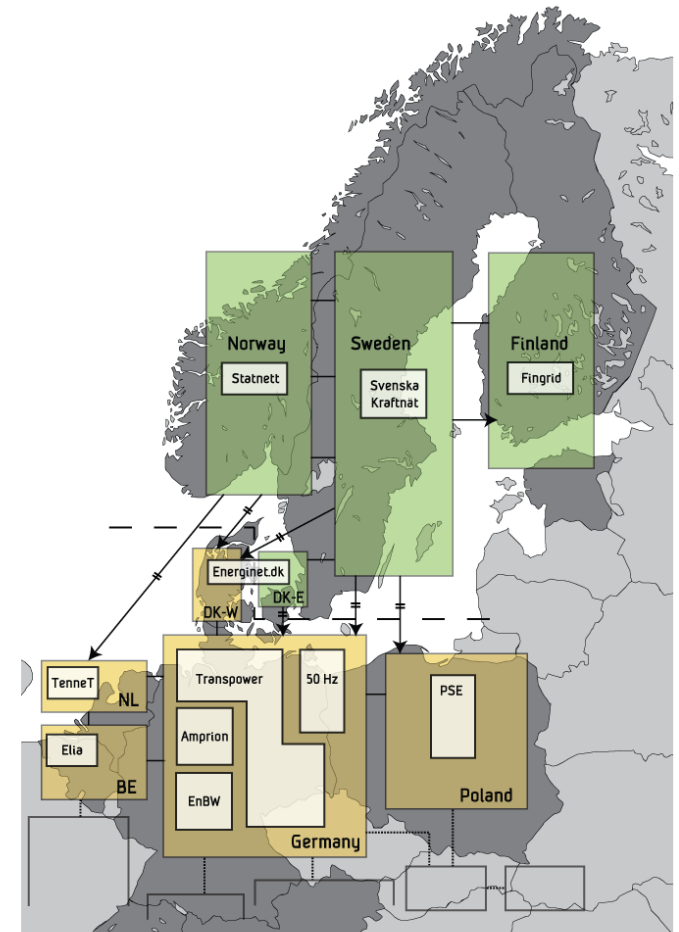
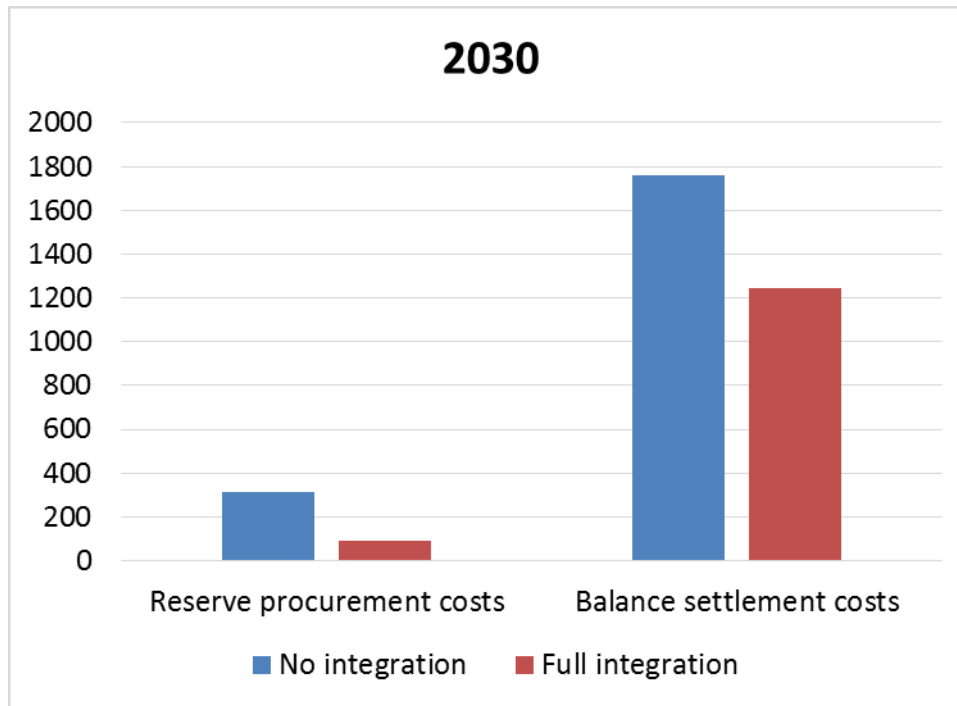
Integration of balancing markets

- Detailed European grid model based on DC power flow
- Representation of day-ahead, intra-day and balancing markets
- Co-optimizing day-ahead schedules and reserve procurements based on forecasts
- Scenarios for load, generation and grid capacity year 2020 and 2030



Large benefits of integrating the Northern and continental balancing markets

Total annual balancing cost savings (Mill.EURO)



Nytteverdien av å dele balanse-ressurser i Europa er formidabel

- UK-Frankrike: Årlig nytte **400 mill NOK**
- Norden: Årlig nytte **1,8 Mrd NOK**
- Hele EU: Årlig nytte **24 Mrd NOK**
- Tallet fra Norden viser hvor mye brenselkostnader som er blitt spart i året siden vi innførte et felles marked
- EU-kommisjonen benytter den nordiske modellen som eksempel til etterfølgelse

Kilde: EC DG ENER/B2524/2011, mars 2013

...dette betyr at

Kabler må bli gitt full adgang til alle markeder (spot, regulerkraft, reserver, kapasitet) for å kunne utnytte den mest økonomiske og miljøvennlige kilden til energilagring og fleksibilitet i Europa

