



NTNU – Trondheim
Norwegian University of
Science and Technology



SINTEF

Balancing options and costs for offshore wind in the North Sea

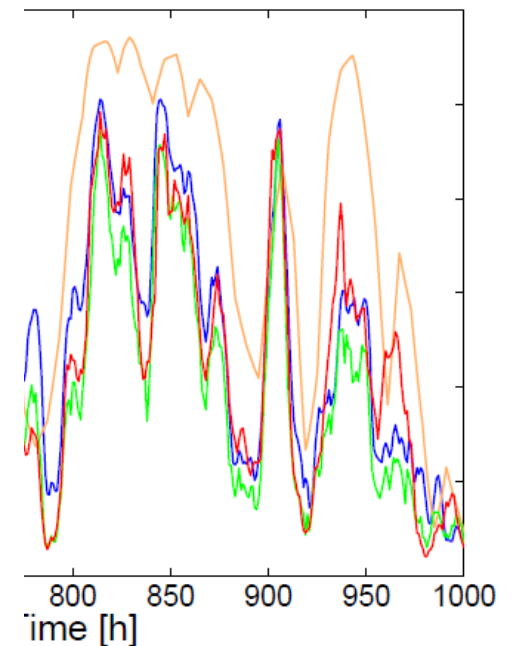
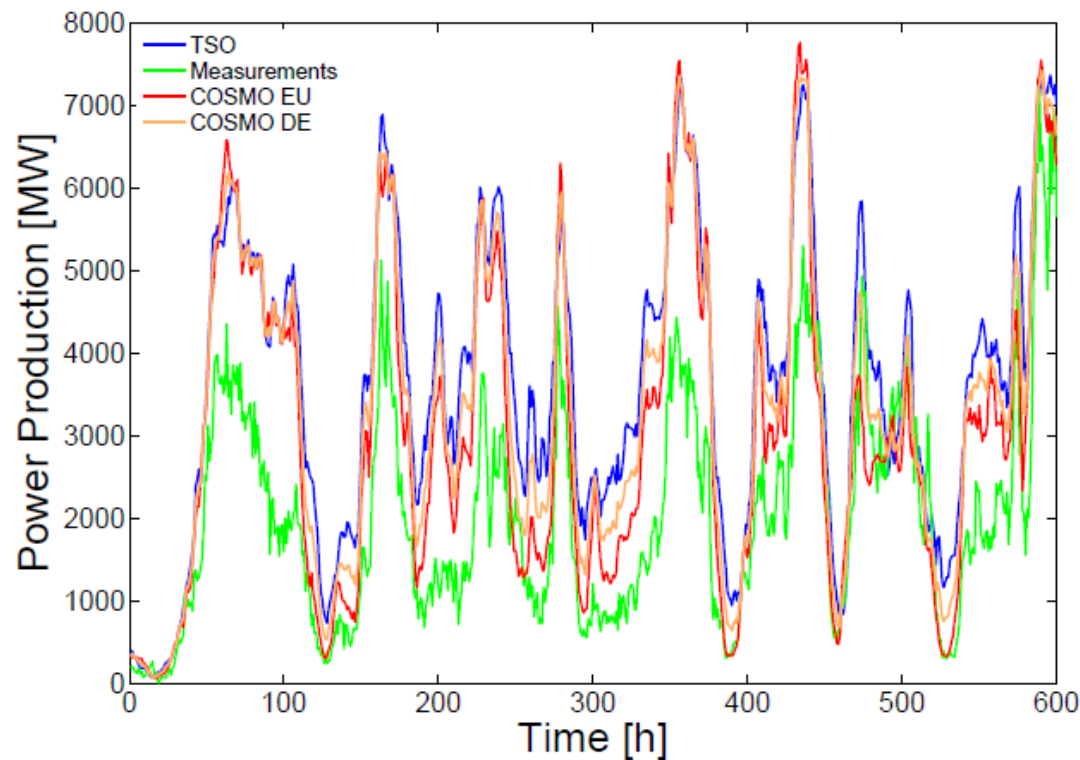
Deepwind 2015, Trondheim

Magnus Korpås

Professor

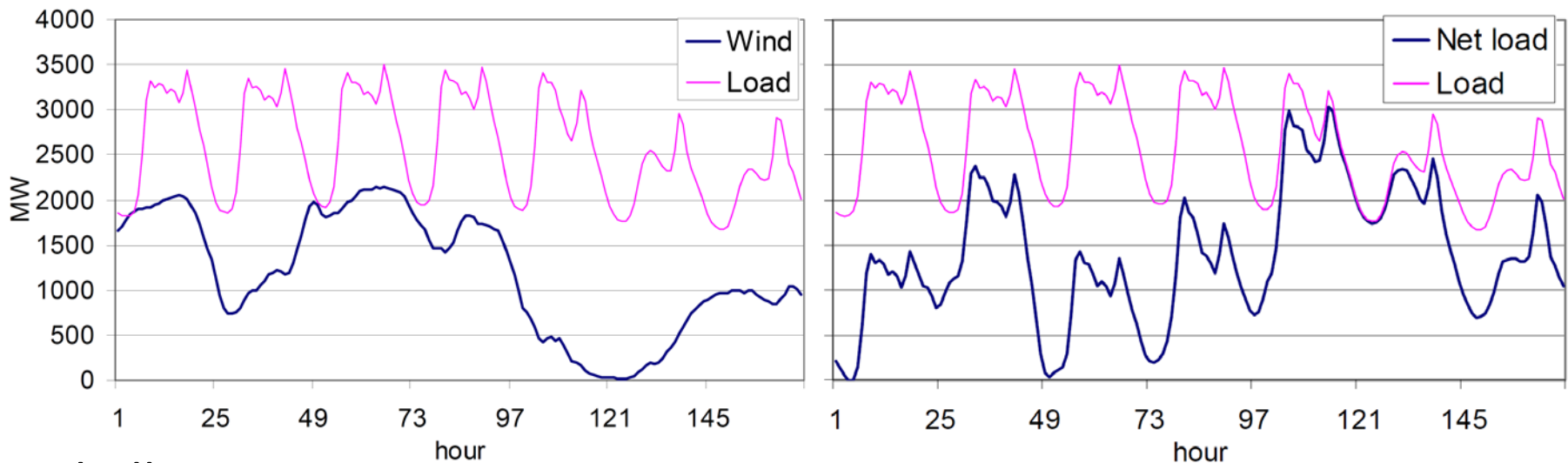
Dept. of Electric Power Engineering

Simulated 2030 North Sea wind power during the storm front of «Carmen»...



...but it is the Net Load that matters

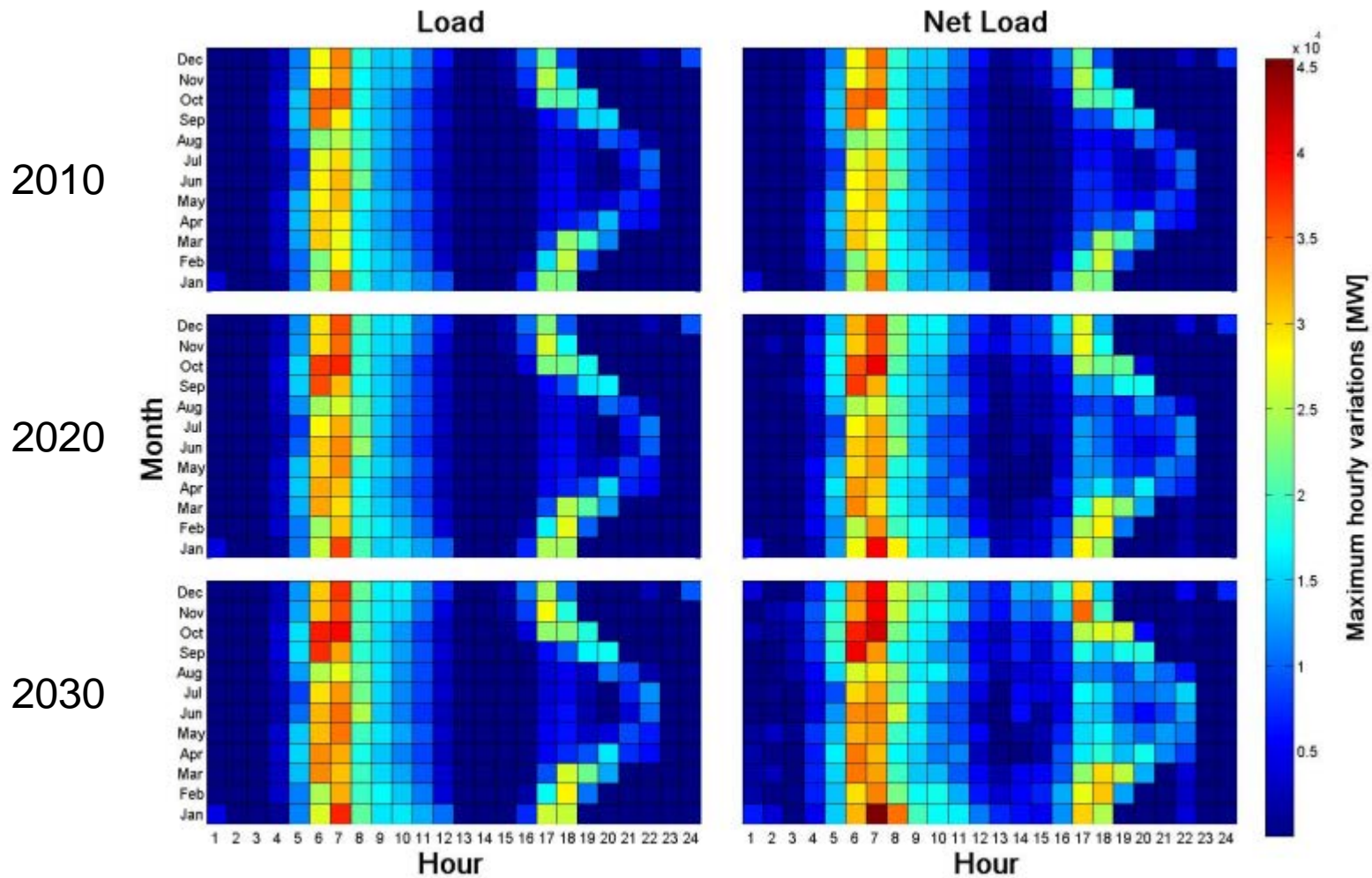
- The system will see the aggregated net imbalance
 - Unforeseen variations in load, wind and solar
 - $\text{Net load} = \text{Load} - \text{Wind} - \text{Solar}$



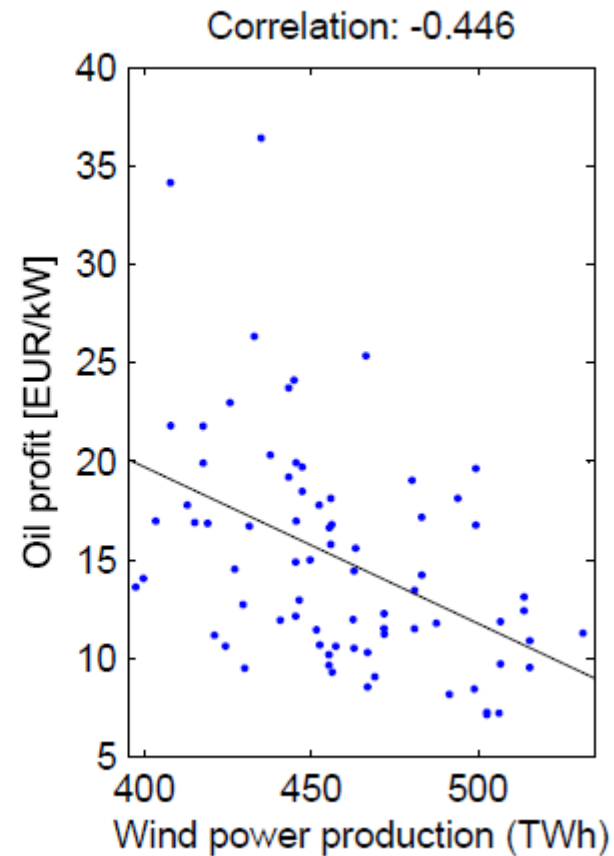
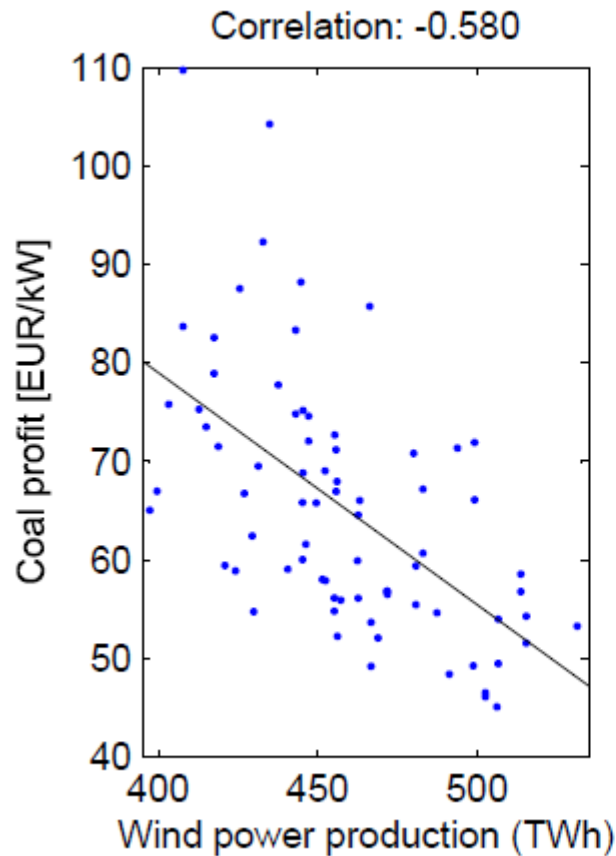
Challenges:

- Flexibility of thermal power plants (ramp rates, start/ stop operation)
- With very high RE share, thermal plants can be pushed out of the market – security of supply has to be fulfilled

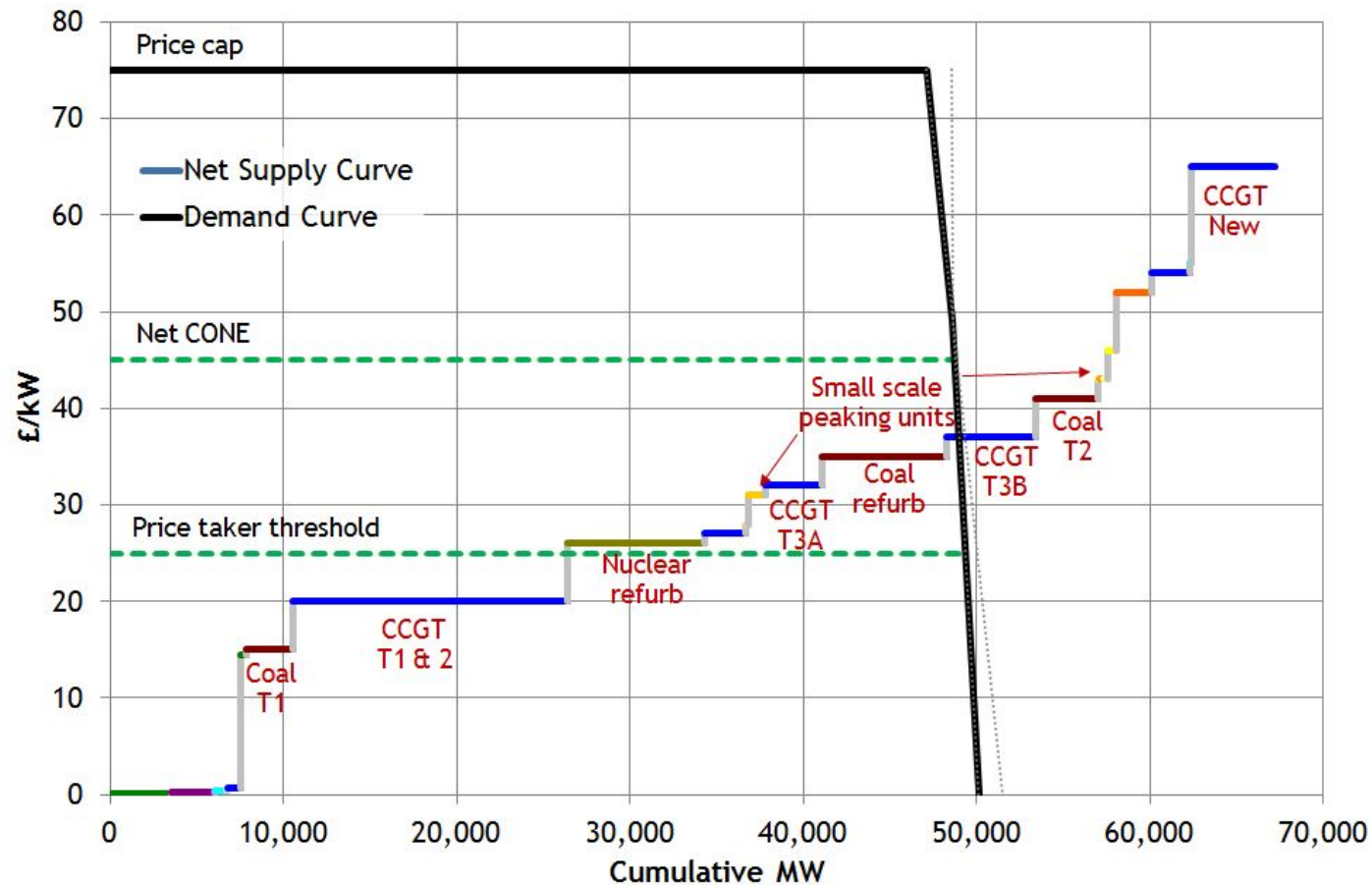
North Sea offshore wind lead to a large increase in Net Load variations



Wind pushes fossils out of the spot market...

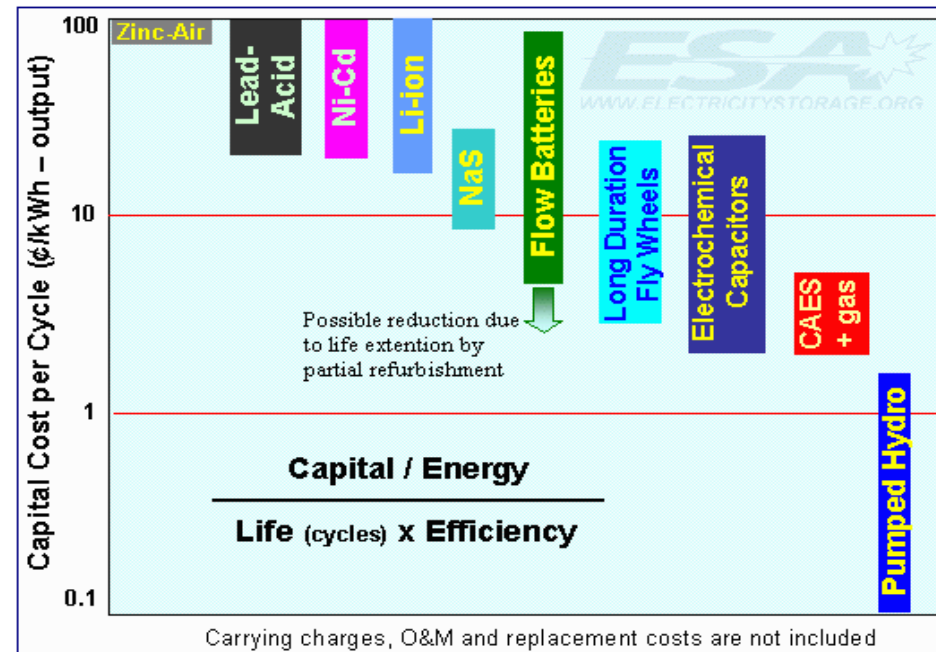
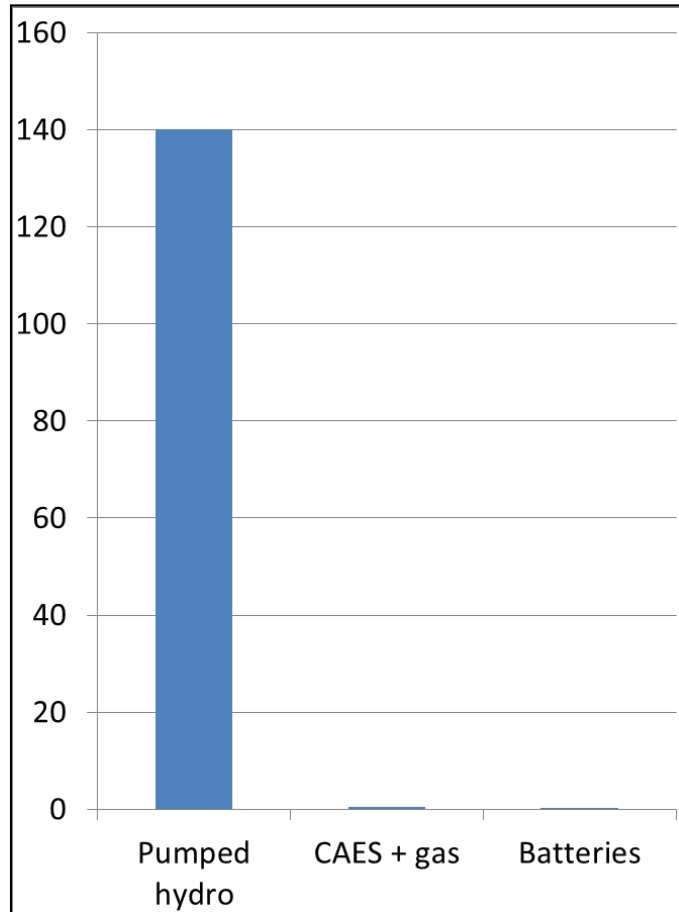


...and into the capacity market

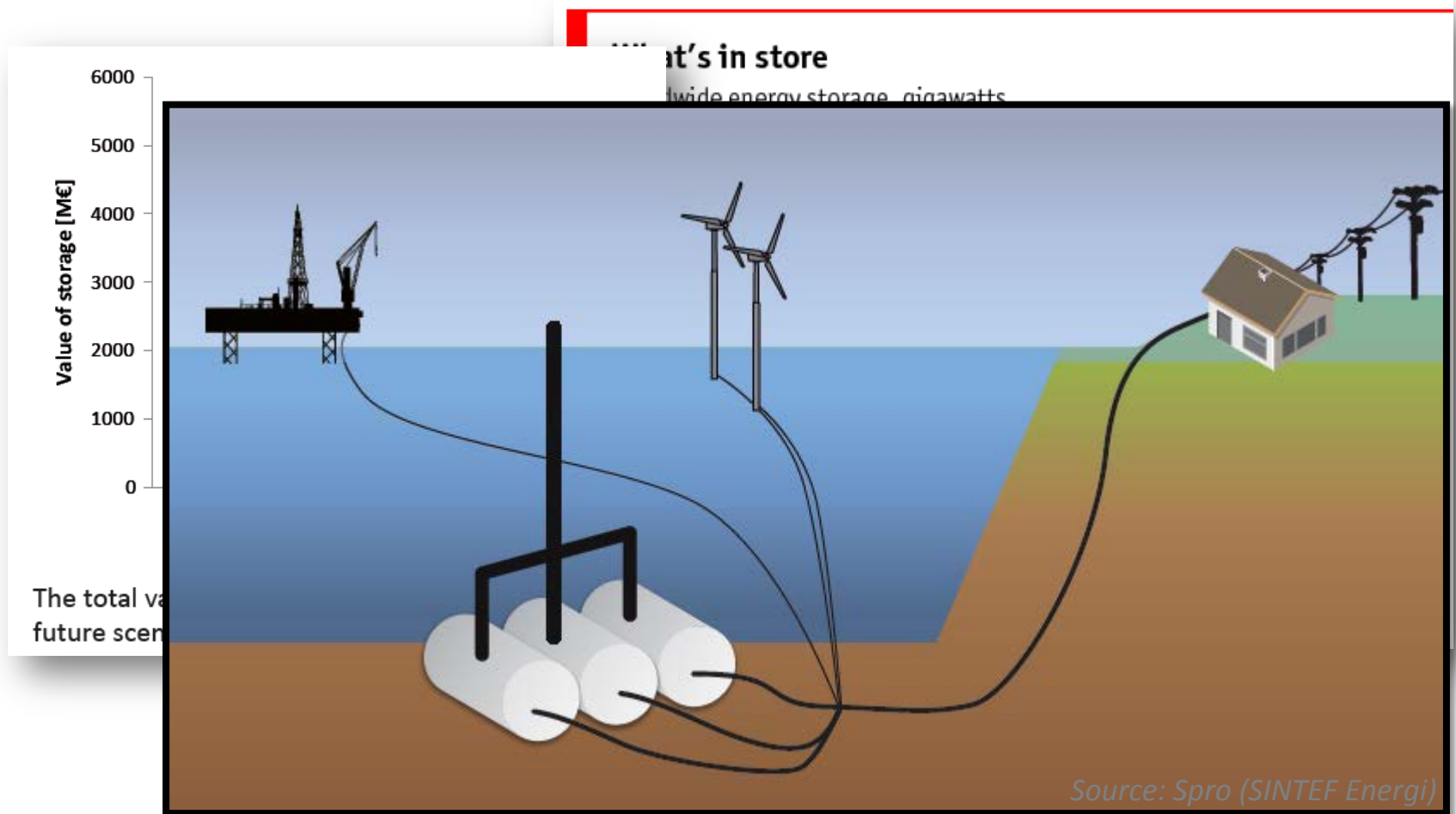


What about energy storage?

GW installed capacity

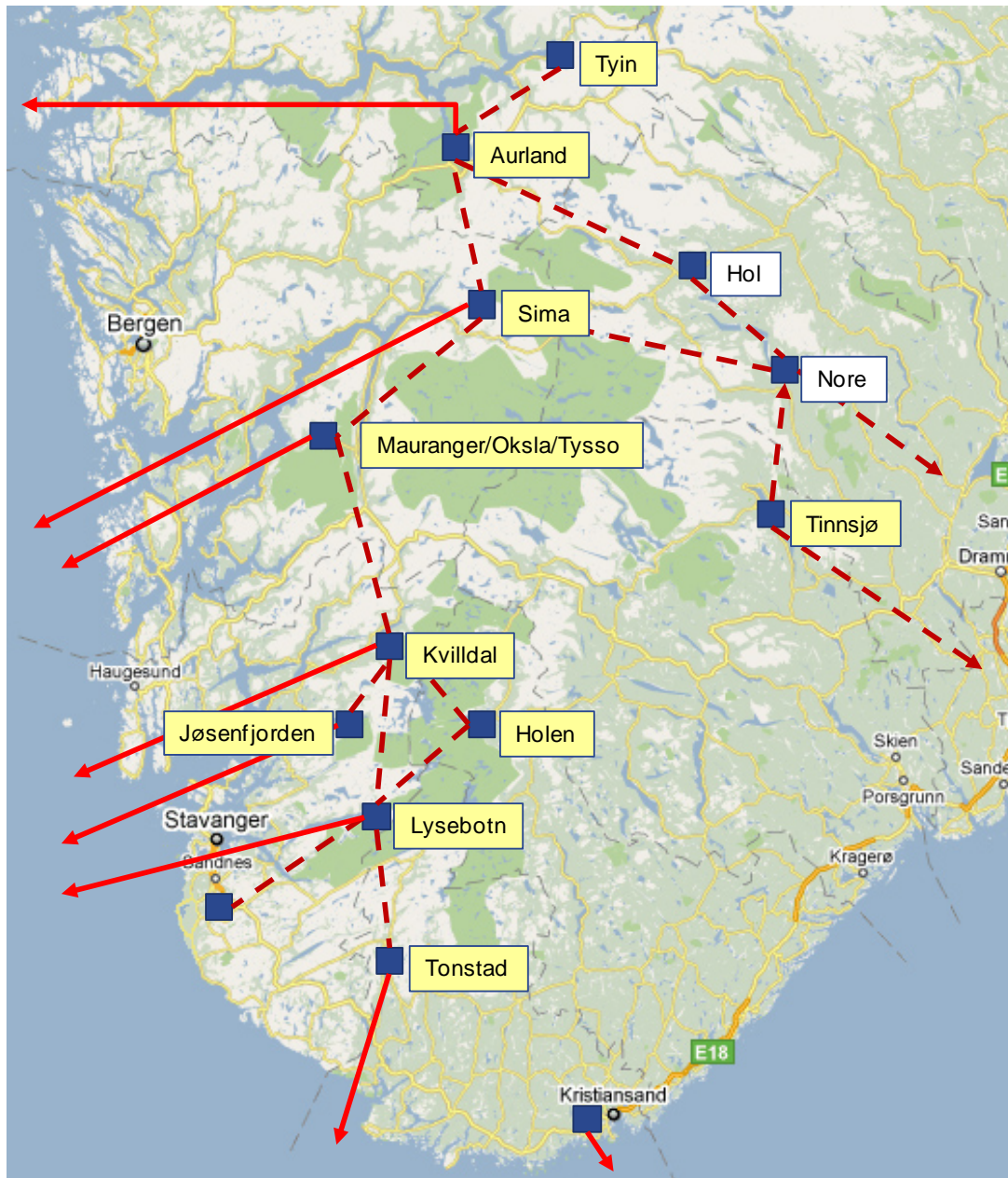


The future says...

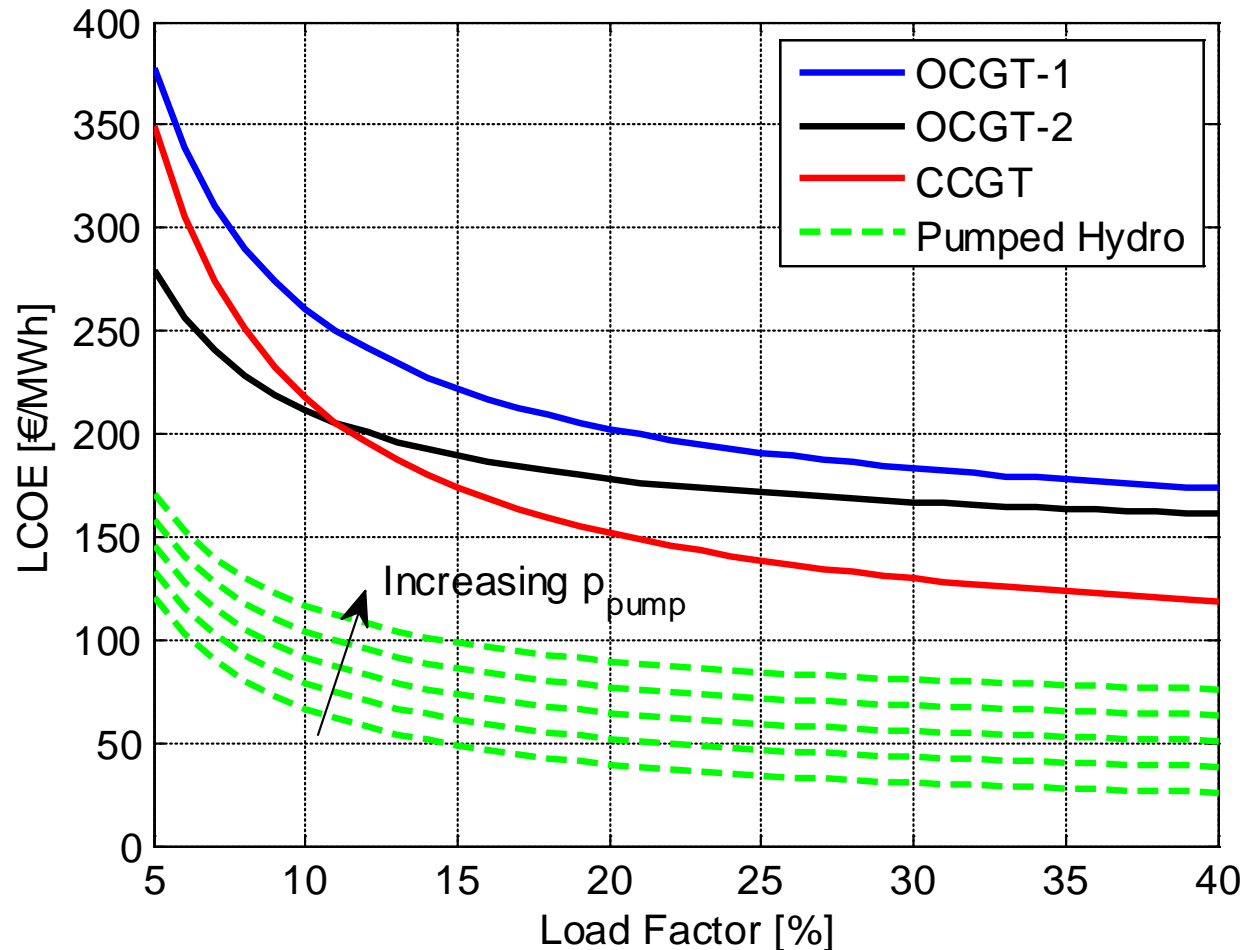


CEDREN Case study 2030

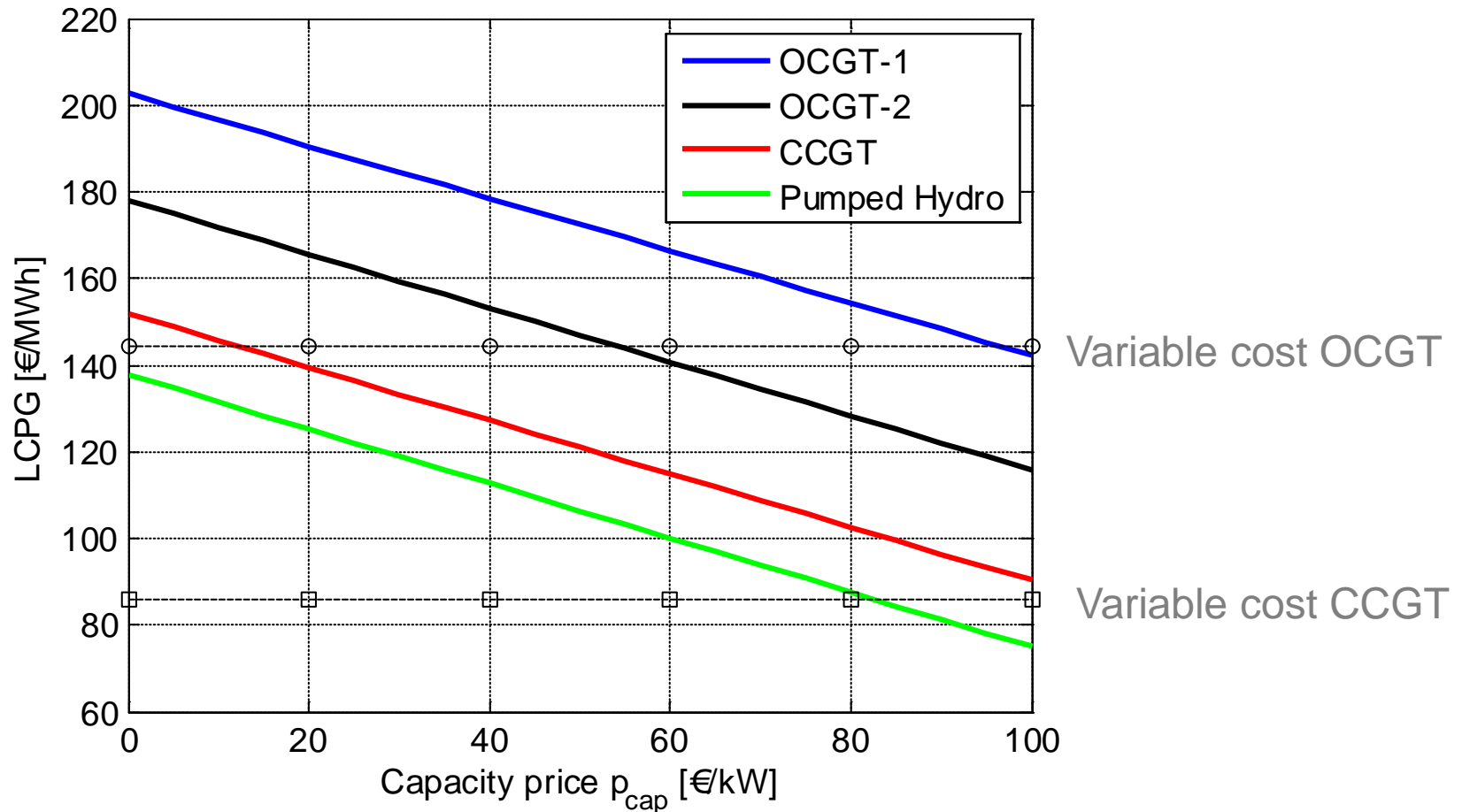
*10-20 GW new pumping and
generation capacity using
existing reservoirs*



Norwegian pumped hydro has low electricity costs compared with other flexible plant types

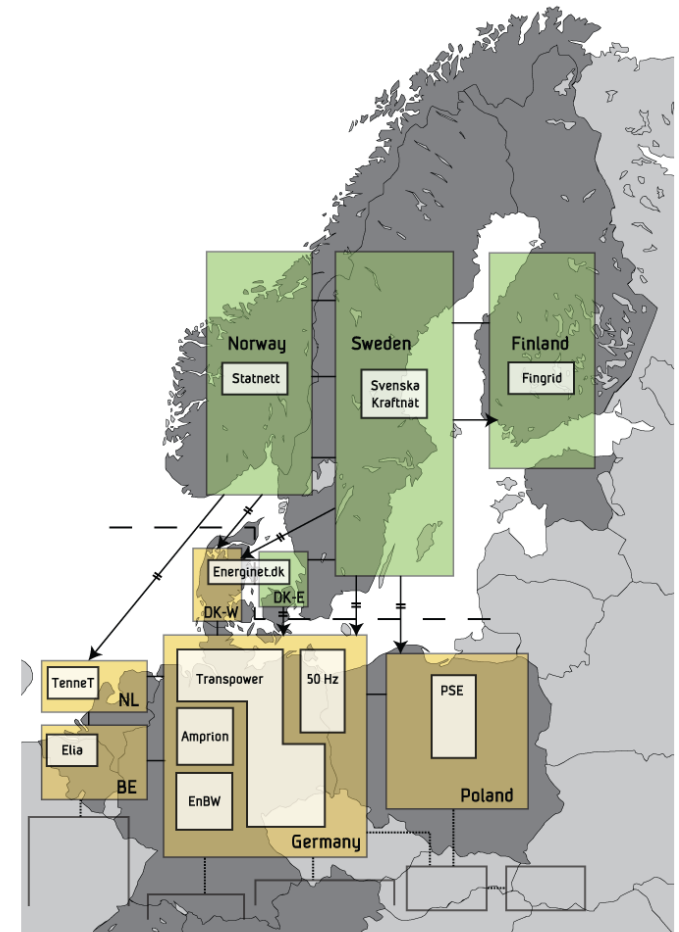
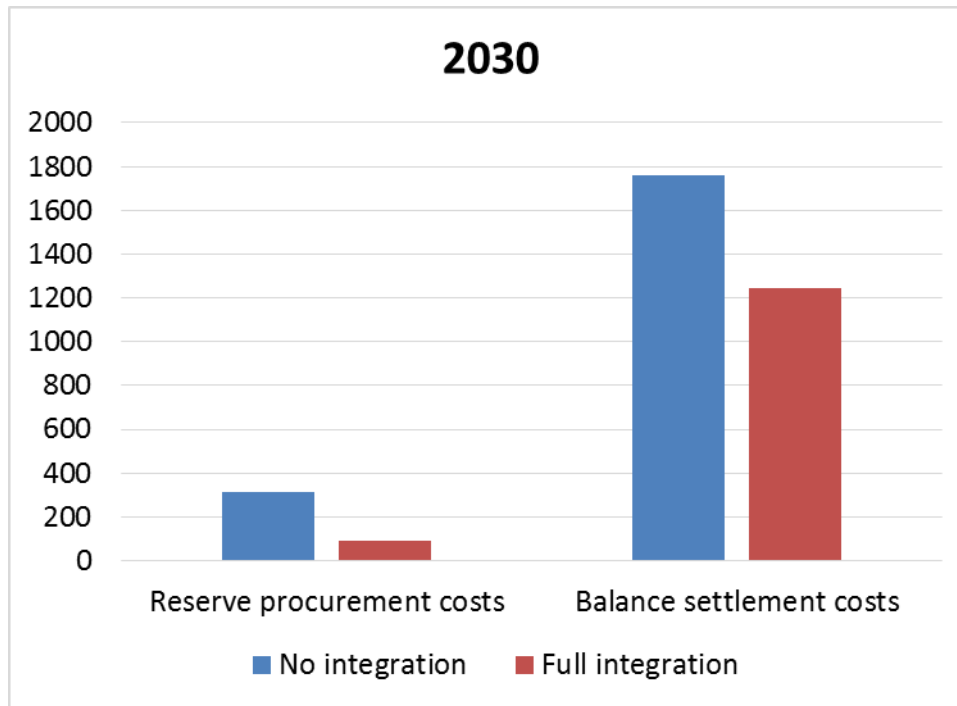


Pumped hydro also requires lowest capacity auction price for peaking needs

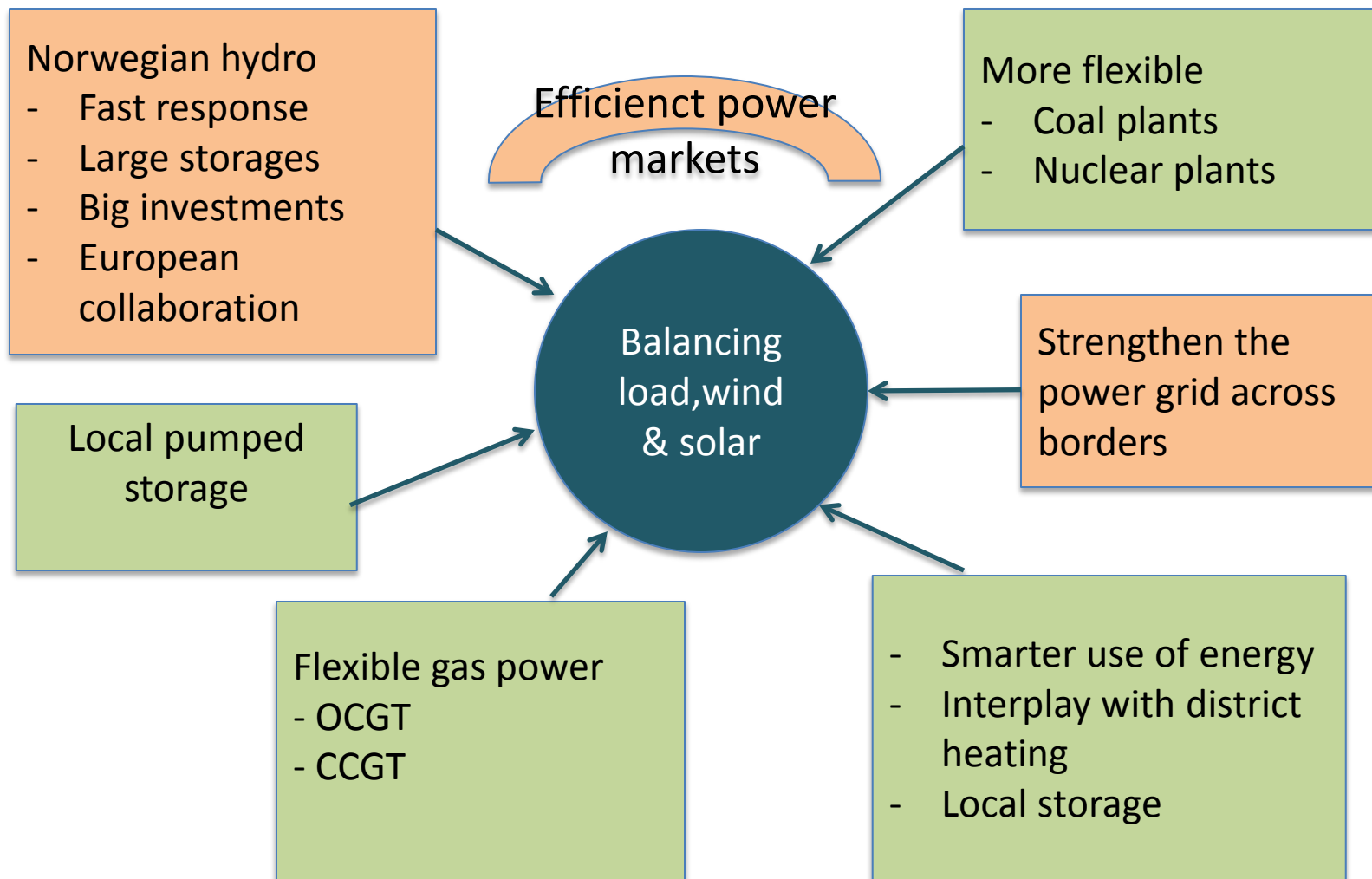


Large benefits of integrating the Northern and continental balancing markets

Total annual balancing cost savings (Mill.EURO)



Balancing options for OFFSHORE WIND & Co



Summary

- Norwegian pumped hydro is cost-effective for balancing
 - Large potential
 - Large flexibility and multiple uses
 - Requires European collaboration
- An efficient and integrated power market is an enabler for high RE penetration
 - Reduces the need for expensive storage
 - Reduces the need for expensive reserves
- Comprehensive studies of balancing markets in Northern Europe
 - Large benefits of integrated markets for balancing resources
 - Large benefits of integrated markets for intra-day trading