Balansering av sol og vind i Europa:

Gasskraft??

eller

Distribuerte batterier??

eller

Norsk pumpekraft??

eller..

Magnus Askeland, Magnus Korpås, Stefan Jaehnert
NTNU & SINTEF Energi

CEDREN-Hydrobalance (2013-2017)

WP 1 Roadmaps for balancing from Norwegian hydropower

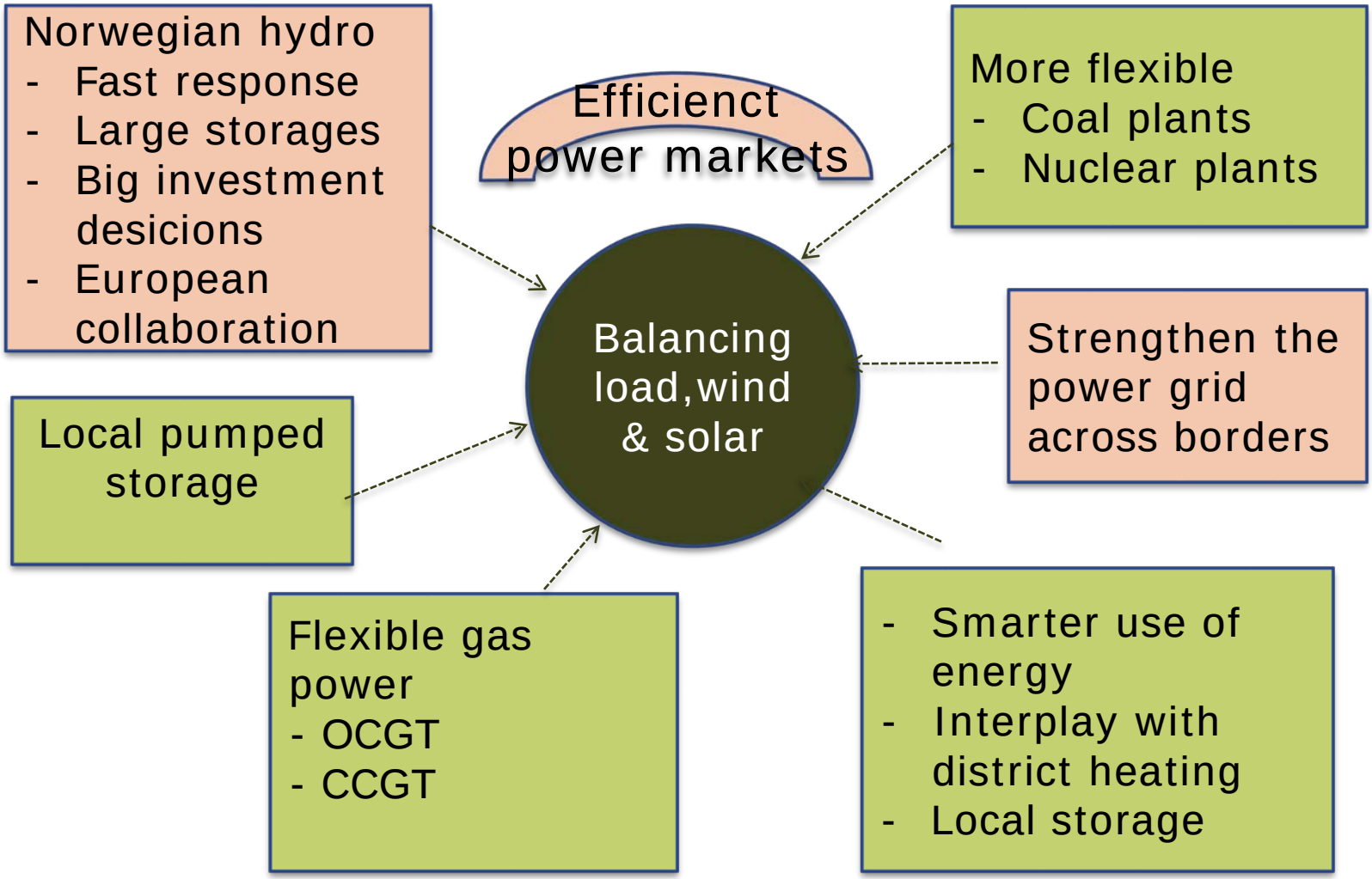
WP 2 Demand for balancing in Europe

WP 3 Business models

WP 4 Environmental impact

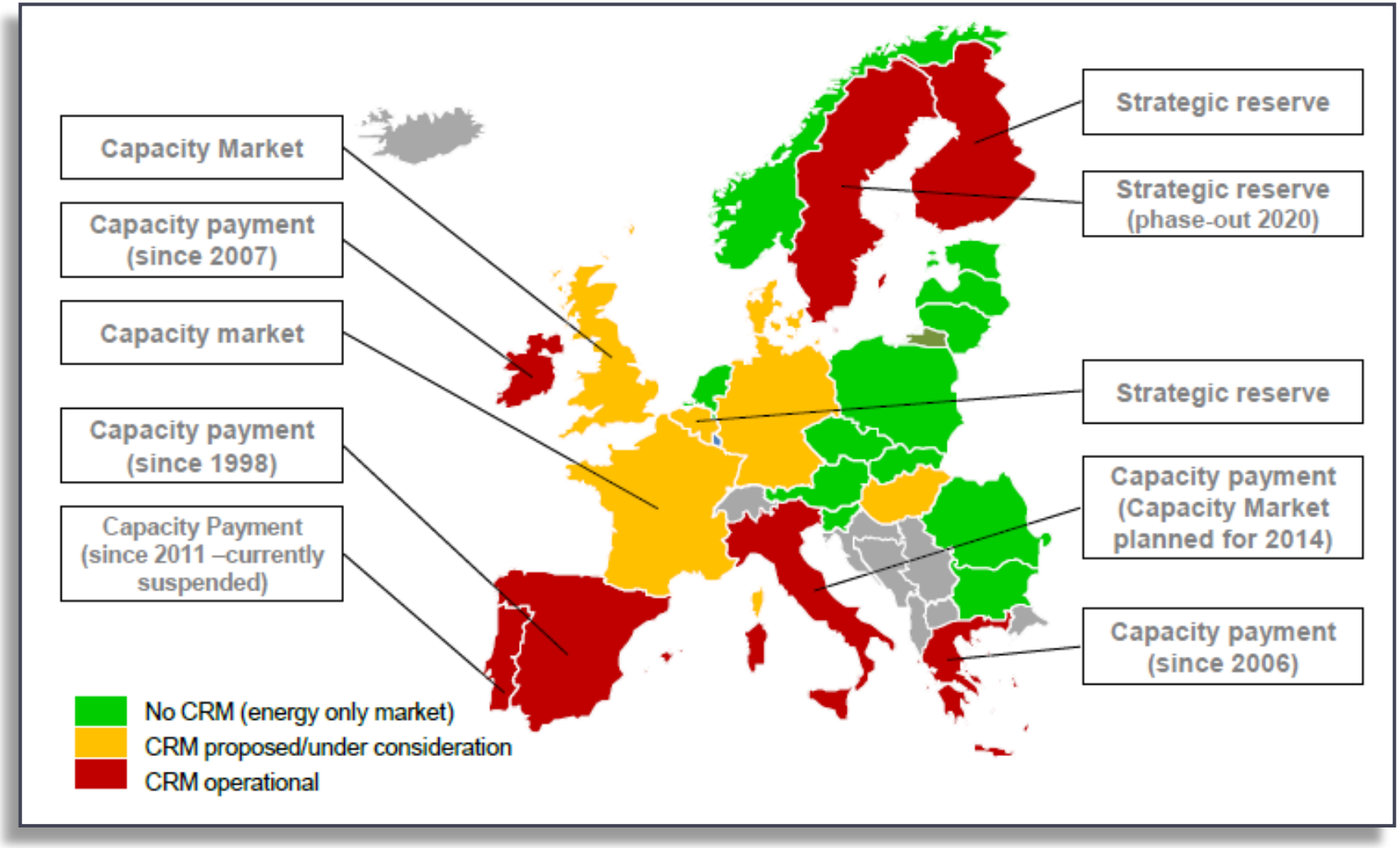
WP 5 Social acceptance and regulatory framework

Flexibility options in Europe



Capacity remuneration mechanisms

throughout Europe



- Source: ACER, "Report: CAPACITY REMUNERATION MECHANISMS AND THE INTERNAL MARKET FOR ELECTRICITY", 2013

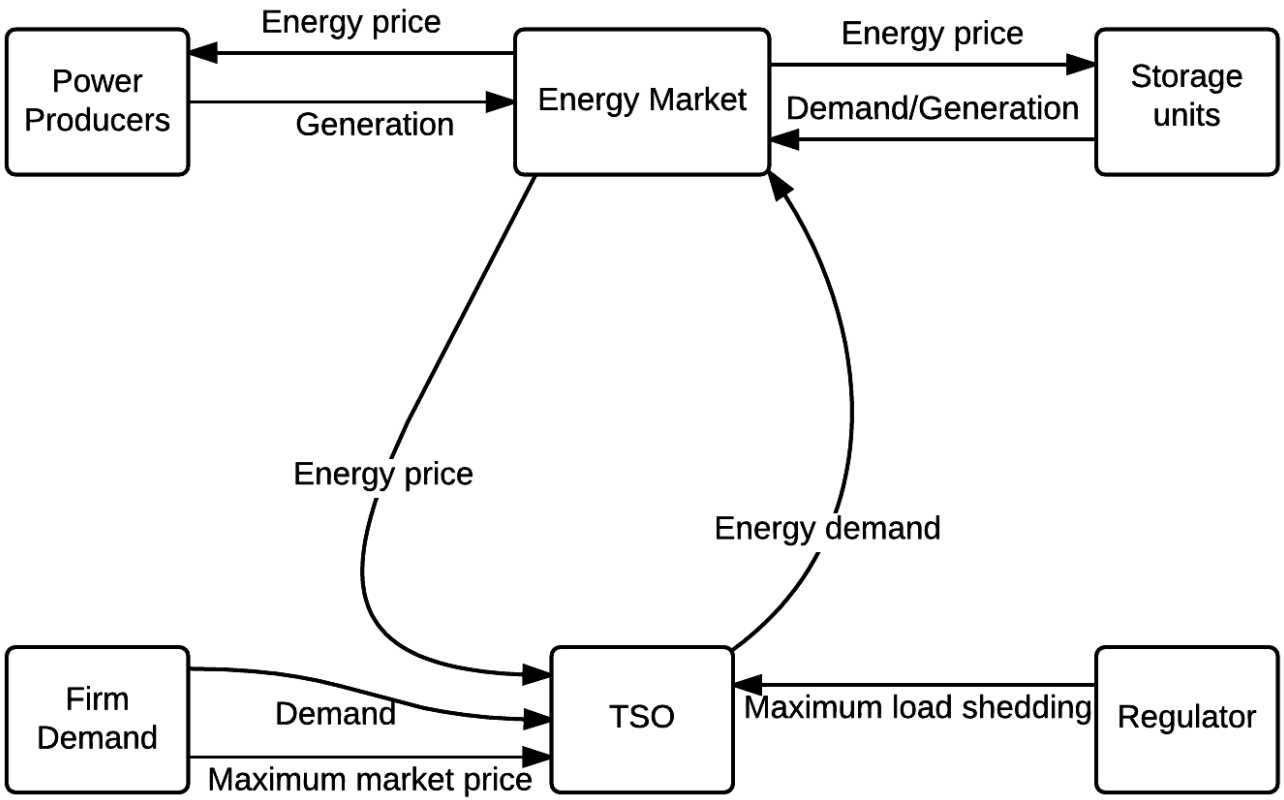
Background for study

- **Given:** Scenarios for large-scale RES in Europe and demand for electricty
- **Modelling challenge:** Find the optimal mix of the other energy sources
  - Investment costs
  - Operational characterstics and costs
- **Goal of study:** Analyze how energy storage affects the need for thermal power
  - Distributed batteries
  - Pumped storage from Norway

Method

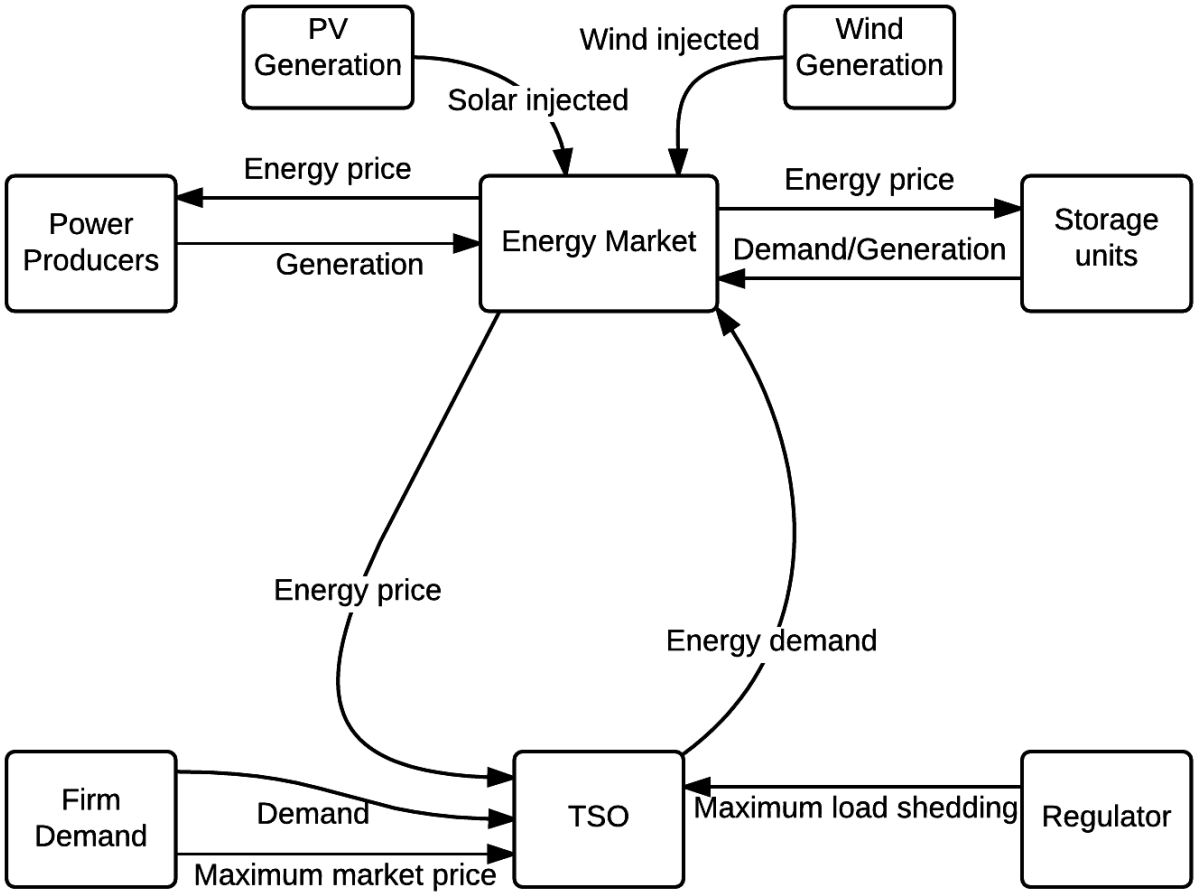
- Producers and storage units are price-takers
- Optimizes production and investments

Method



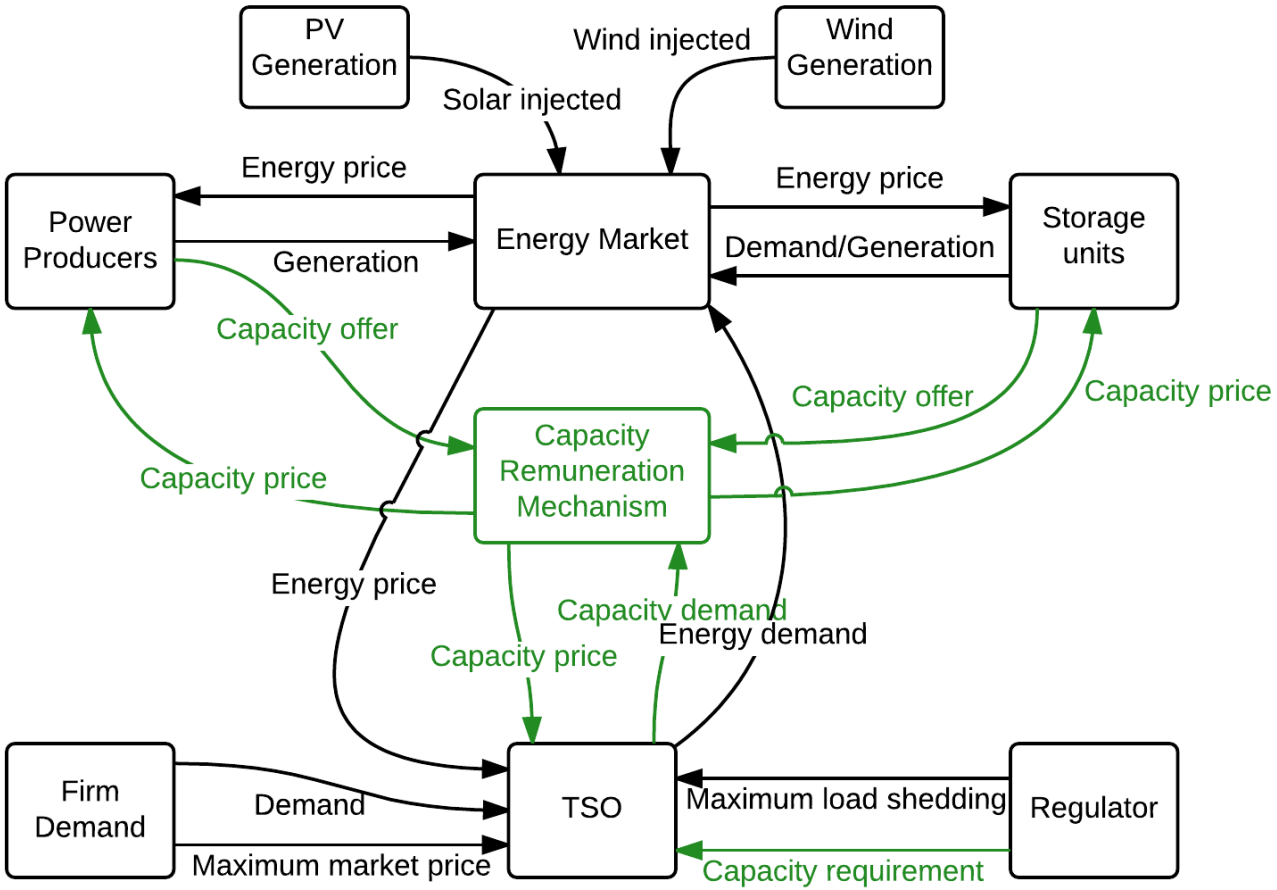
- Demand side and production coupled through the energy market

Method



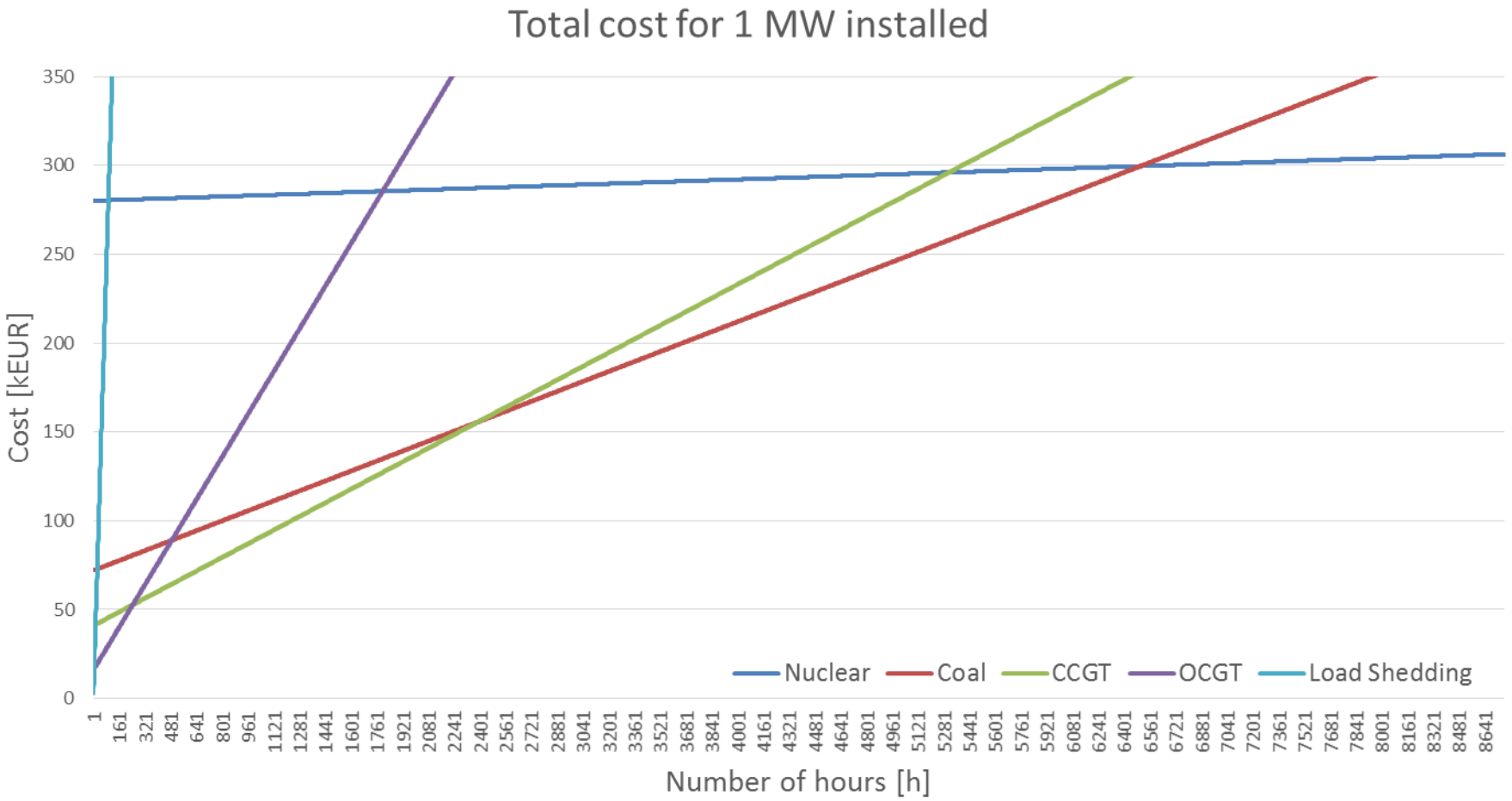
- Renewable production is injected into the system

Method



- Introduction of capacity remuneration mechanism

Cost functions



Scenario data

High RES scenario of the northern European power system: ENTSO-E Vision 4.

41 % RES-share

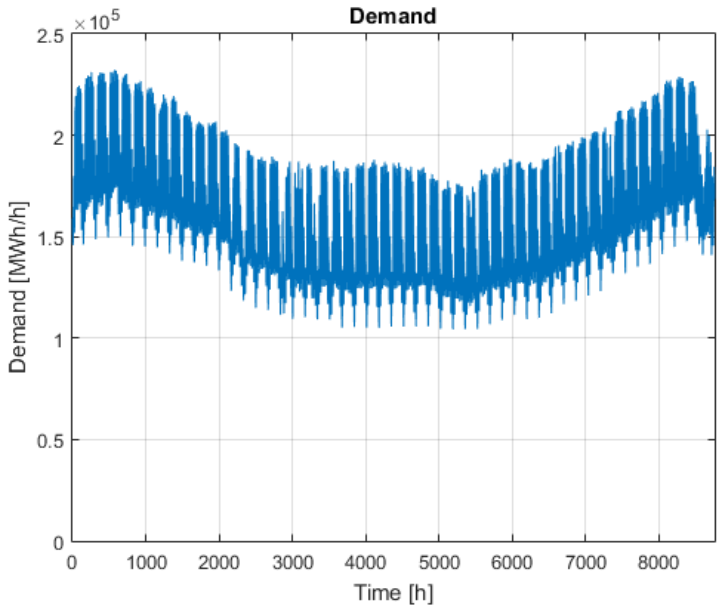
Four thermal technologies

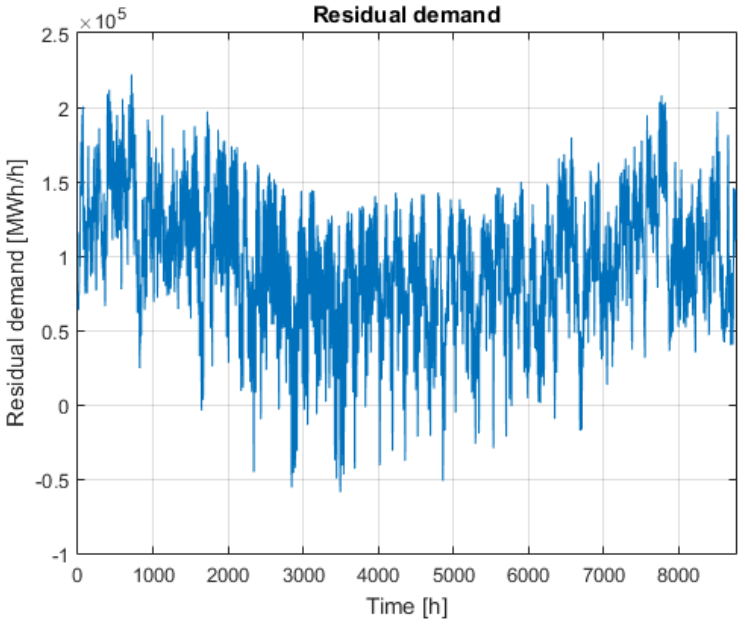
Nuclear, Coal, CCGT and OCGT.

Two storage technologies with fixed costs and efficiencies:

Norwegian PHES and batteries. PHES includes cost of HVDC cables

Optimal installed capacities and operation each hour is determined by the model



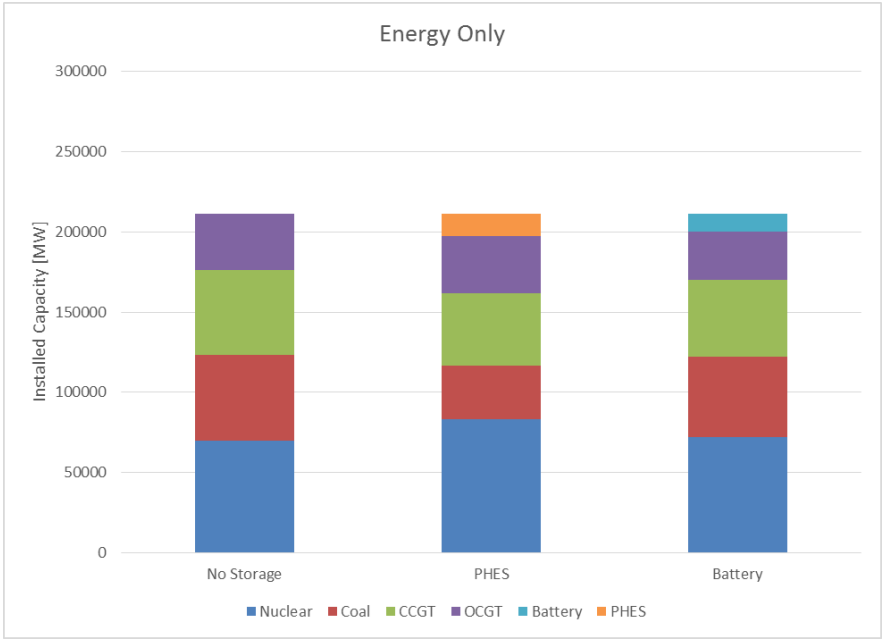


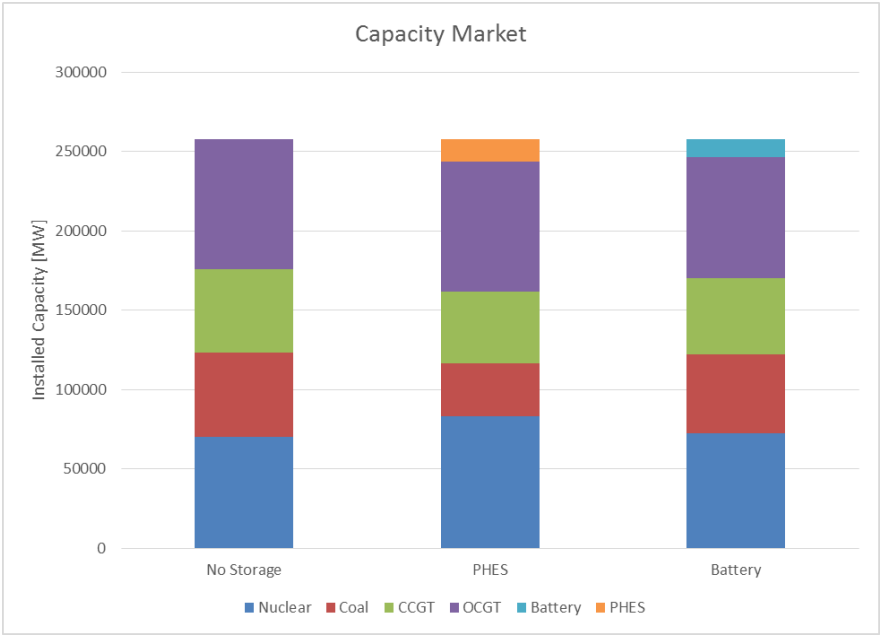
Results: Installed Capacity

Introduction of Norwegian PHES decrease coal power

Battery reduces the OCGT capacity

The additional capacity with a capacity market is OCGT





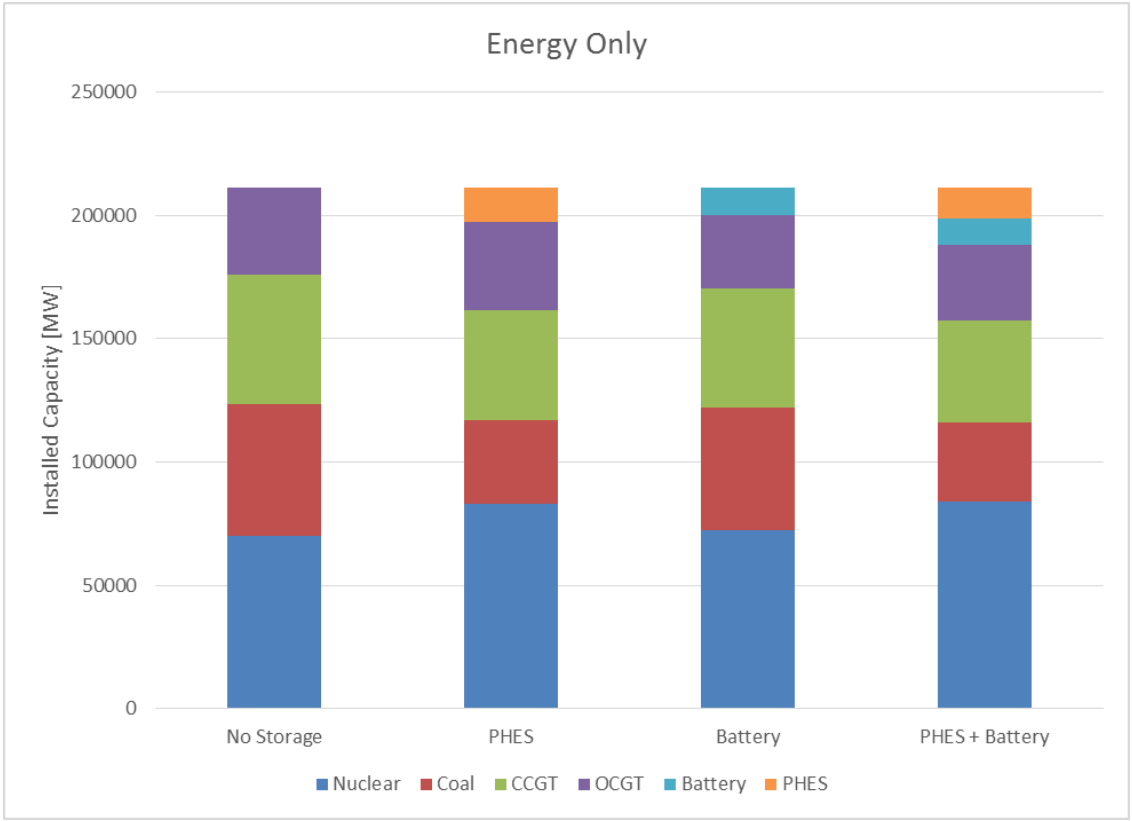
Results: Installed Capacity

PHES + Batteries in the same system: Nearly the same installed capacity.

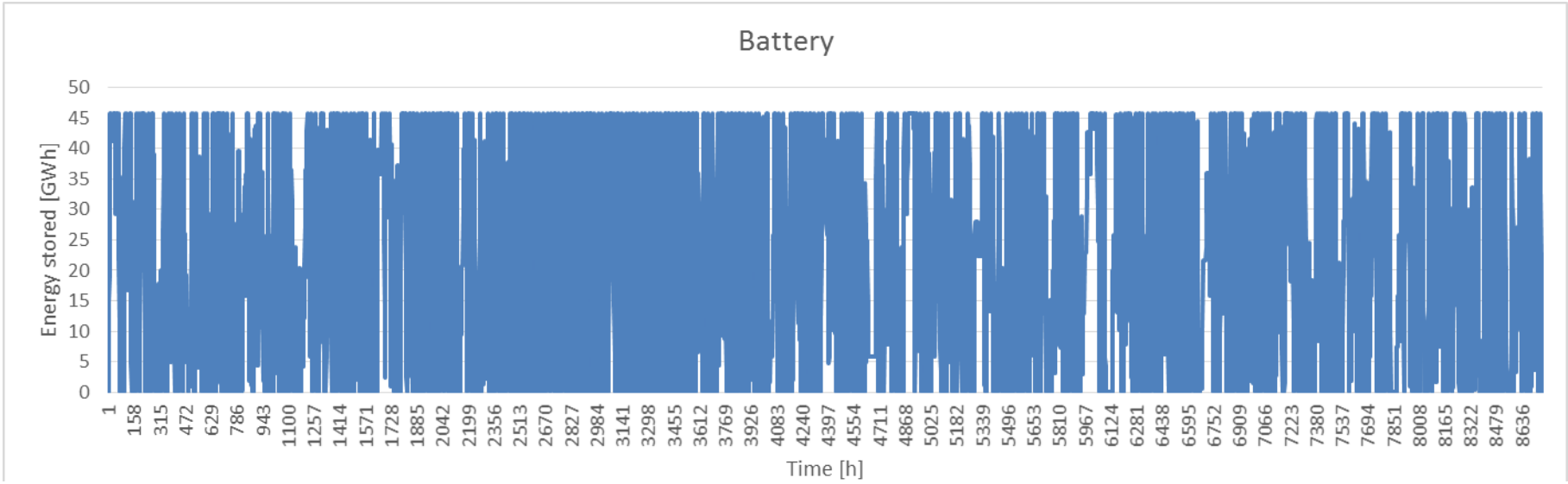
Increased base load capacity.

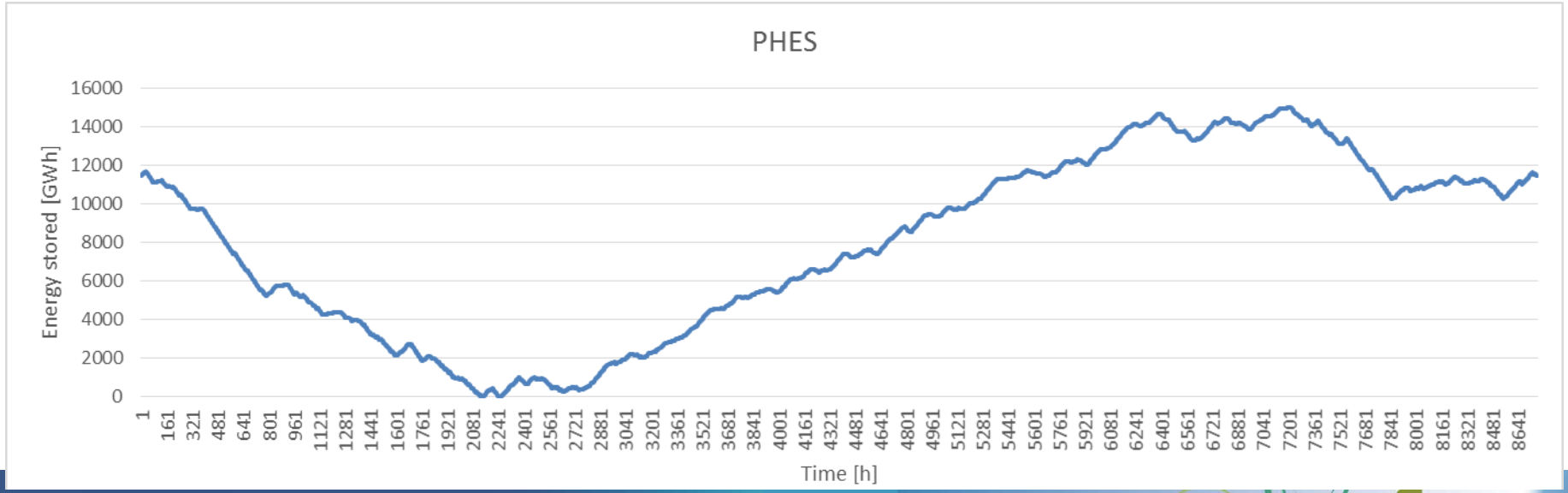
Decreased mid-merit capacity.

This suggests that both technologies are needed in the system.



Which storage technology?

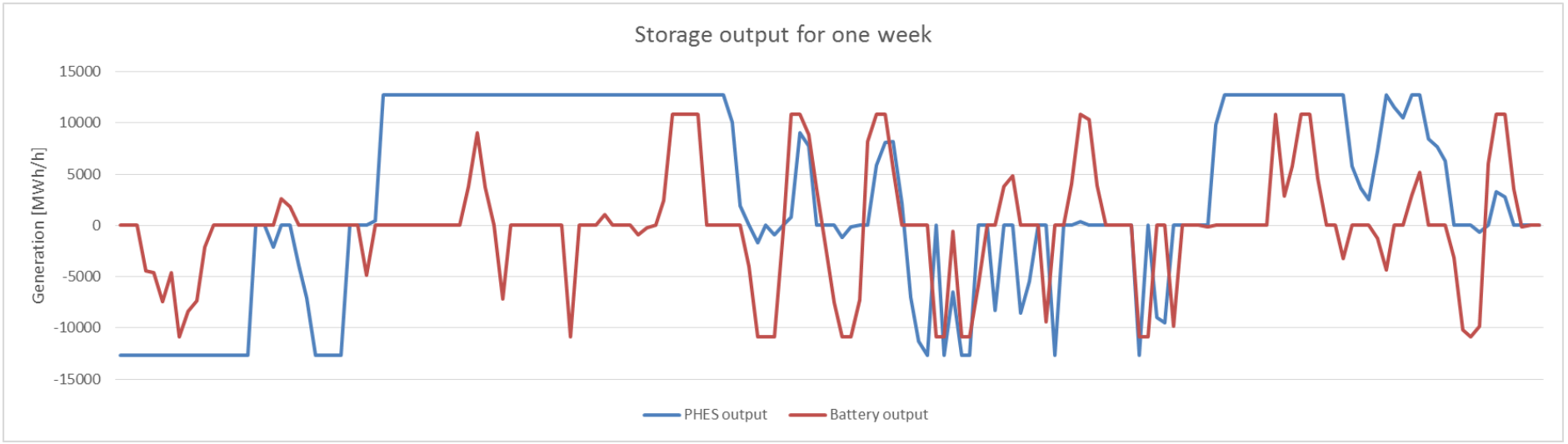




Which storage technology?

PHES need a bigger price difference due to higher losses

PHES can store much more due to abuntant reservoir capacity



Battery: Sensitivity to costs

Reference investment cost based on lead acid:

Converter cost:

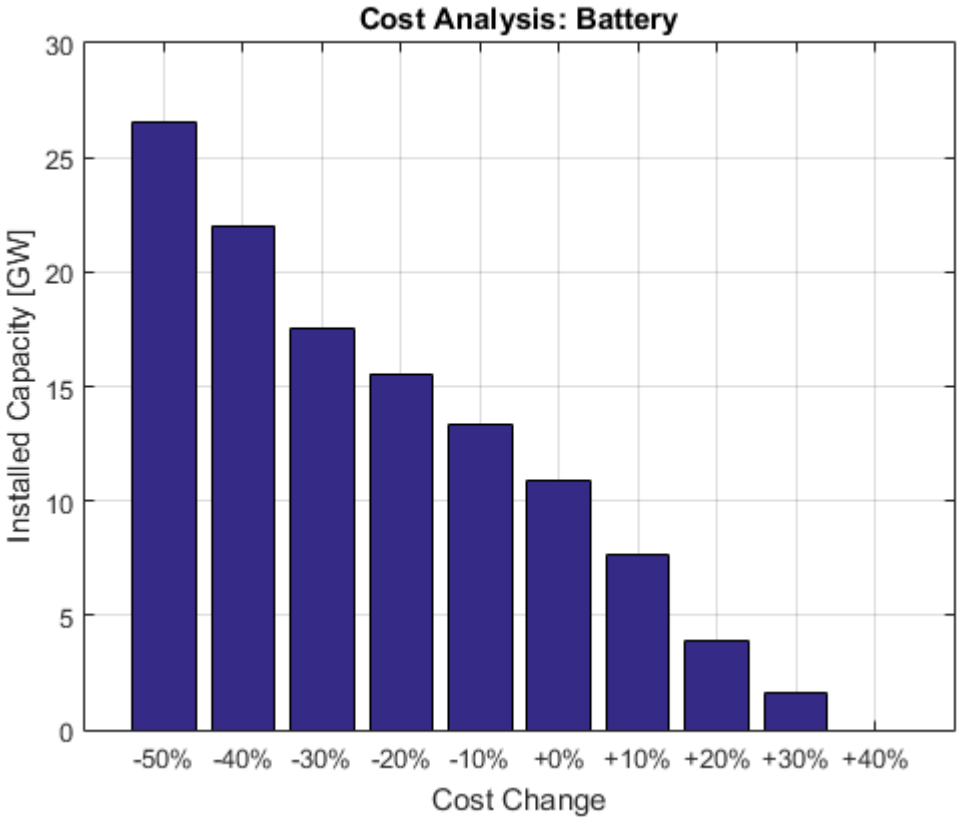
200 EUR/kW

Storage size cost:

50 EUR/kWh

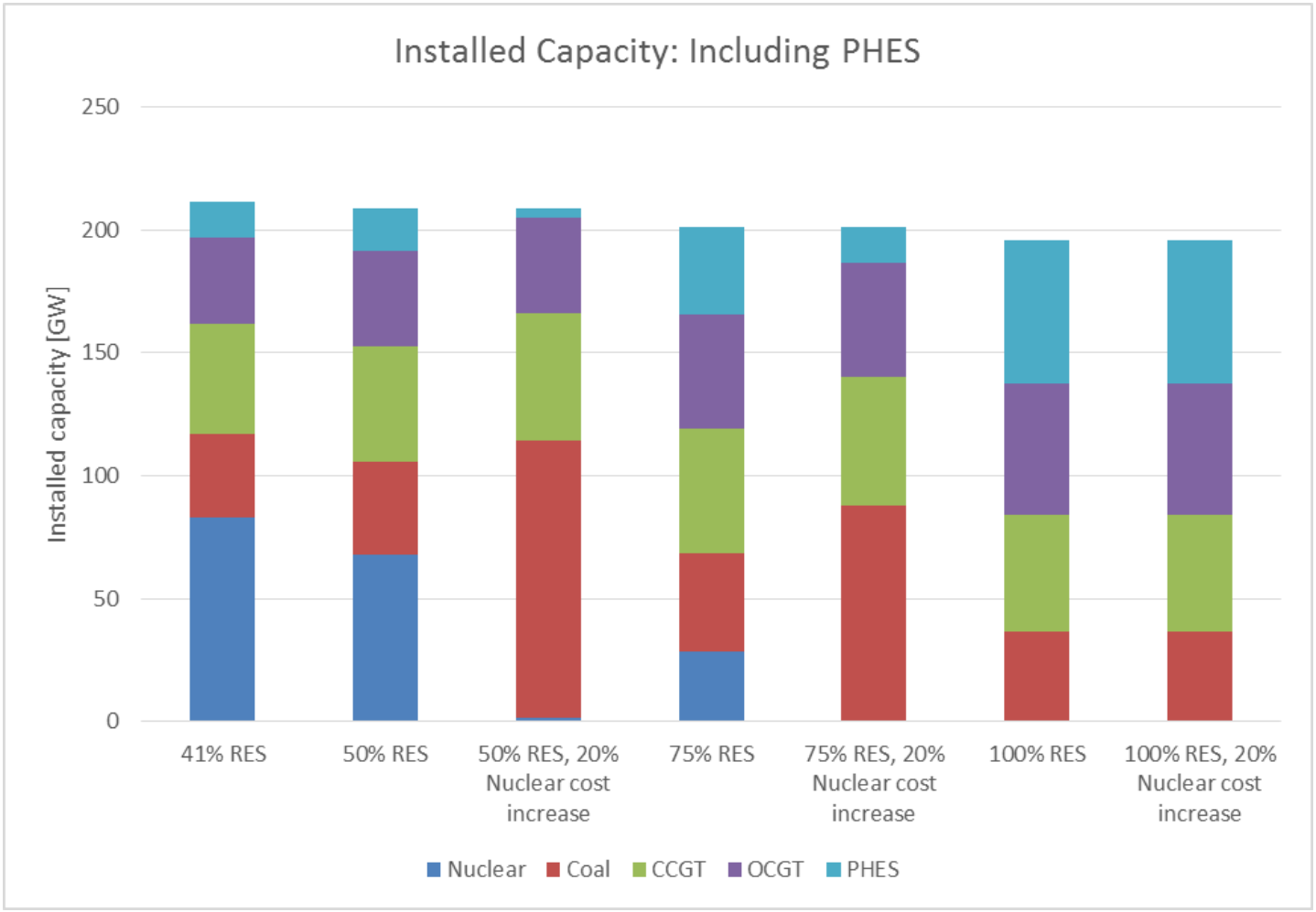
With ~4,5 hour storage capacity, this corresponds to 100 €/kWh (converter included)

Tesla Powerwall (6,4 kWh without converter) presently costs ~3000 $*

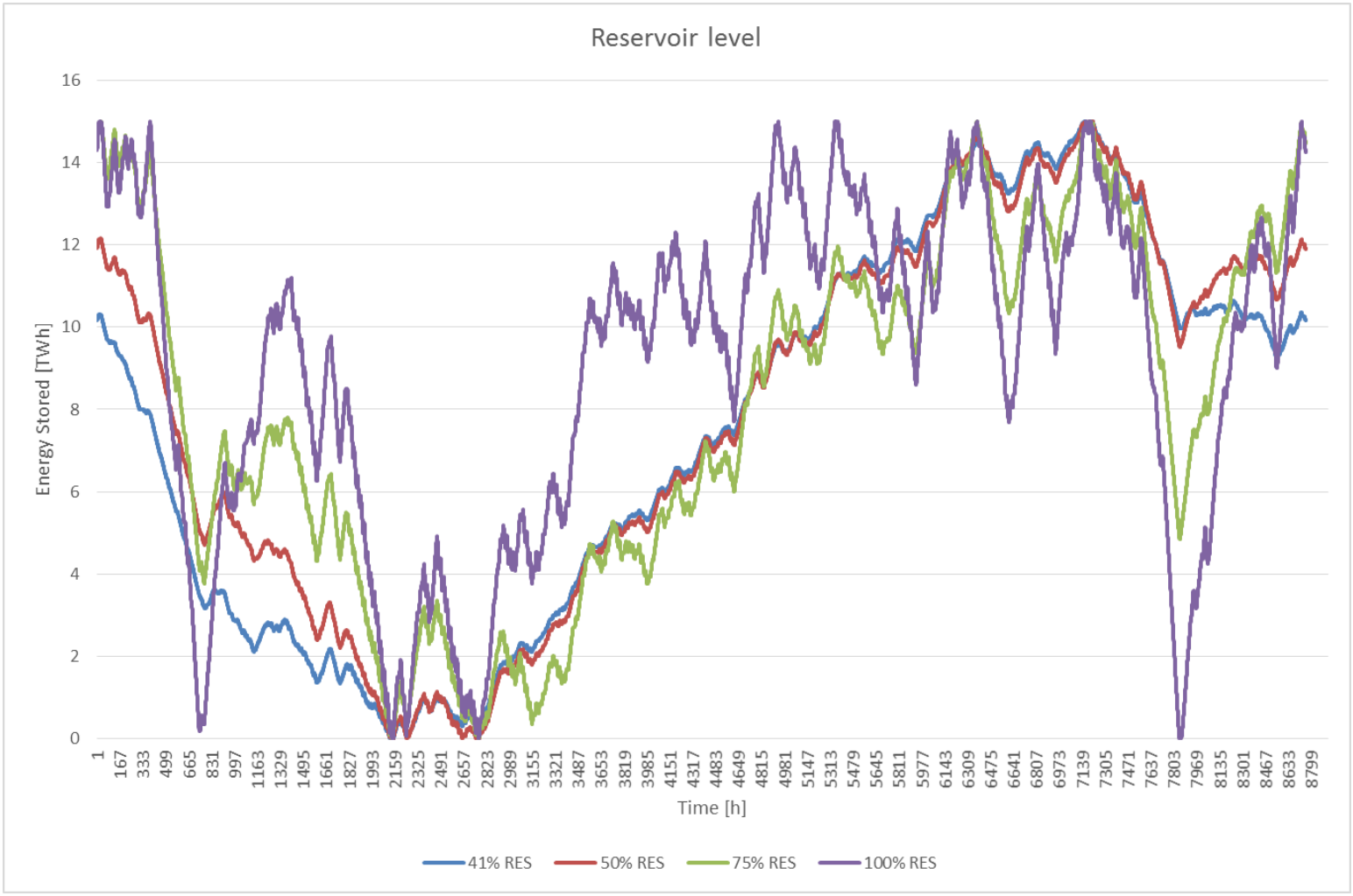


* http://www.wholesalesolar.com/

Sensitivity: Increased renewable share and nuclear costs



Sensitivity: Increased renewable share



Conclusions

- Well-proved modelling approach has been applied
  - Sensitivity analysis on cost data is crucial
- Distributed Batteries and Norwegian Pumped Hydro complements each other
  - Batteries
    - Balances short-term variations
    - Replaces open-cycle gas
  - Pumped hydro
    - Balances long-term variations
    - Replaces coal + some combined cycles gas
- Nuclear disappears from the mix with 20% increase in costs or higher RES-share

Industrial partners

Fornybar energi
på lag med naturen

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