PRIBAS: FUNDAMENTAL MULTI-MARKET MODELLING

Brukermøte Produksjonsplanlegging
13.03.2019
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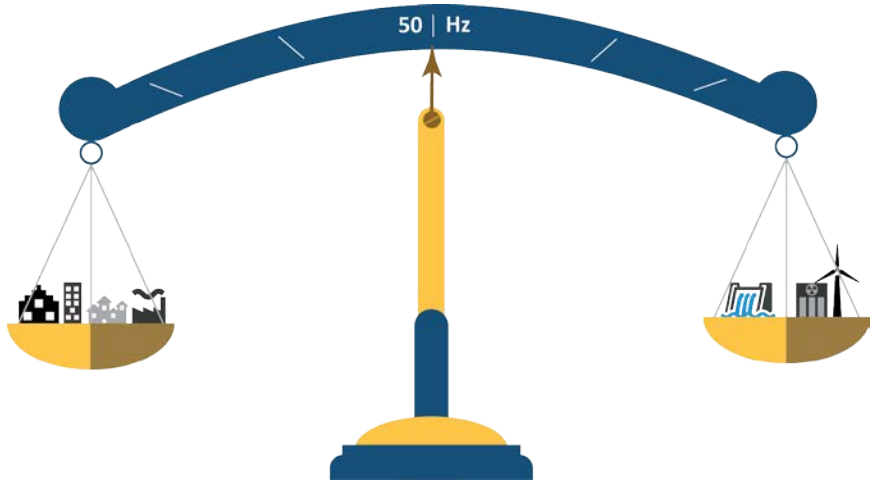
Pricing Balancing Services in the Future Nordic Power Market (PRIBAS)

- Knowledge building project (KPN) 2017-2020
- 17 MNOK, research council supports 67 %
- One PhD at NTNU



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agder energi

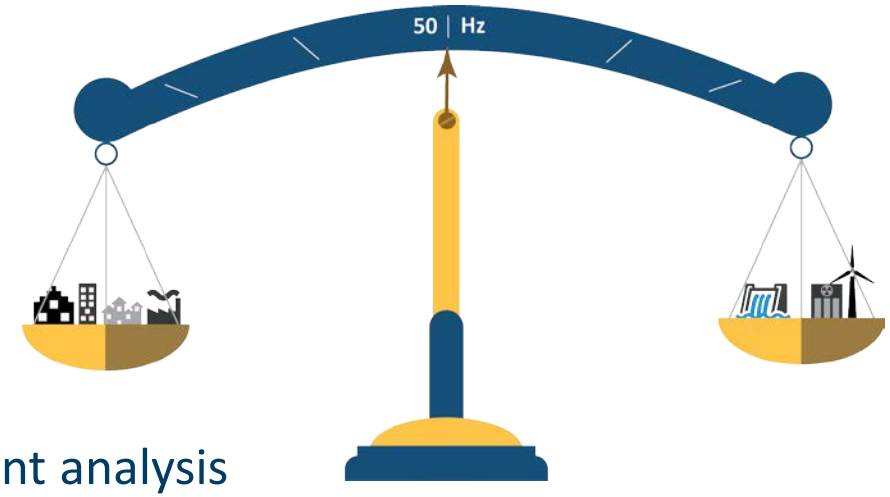
Lyse

ECO

Project Goal

Develop a fundamental multi-market ***model concept*** for the Nordic power system

- ✓ Compute marginal prices for all electricity products
- ✓ Including reserve capacity and balancing energy
- ✓ Including flexible consumption and local storages



Expected application of model concept

- Compute simultaneous market price time series, e.g. for investment analysis
- Estimate the value of flexibility in different market designs, e.g.
  - Spot market clearing closer to real time
  - Common reserve markets in the Nordics

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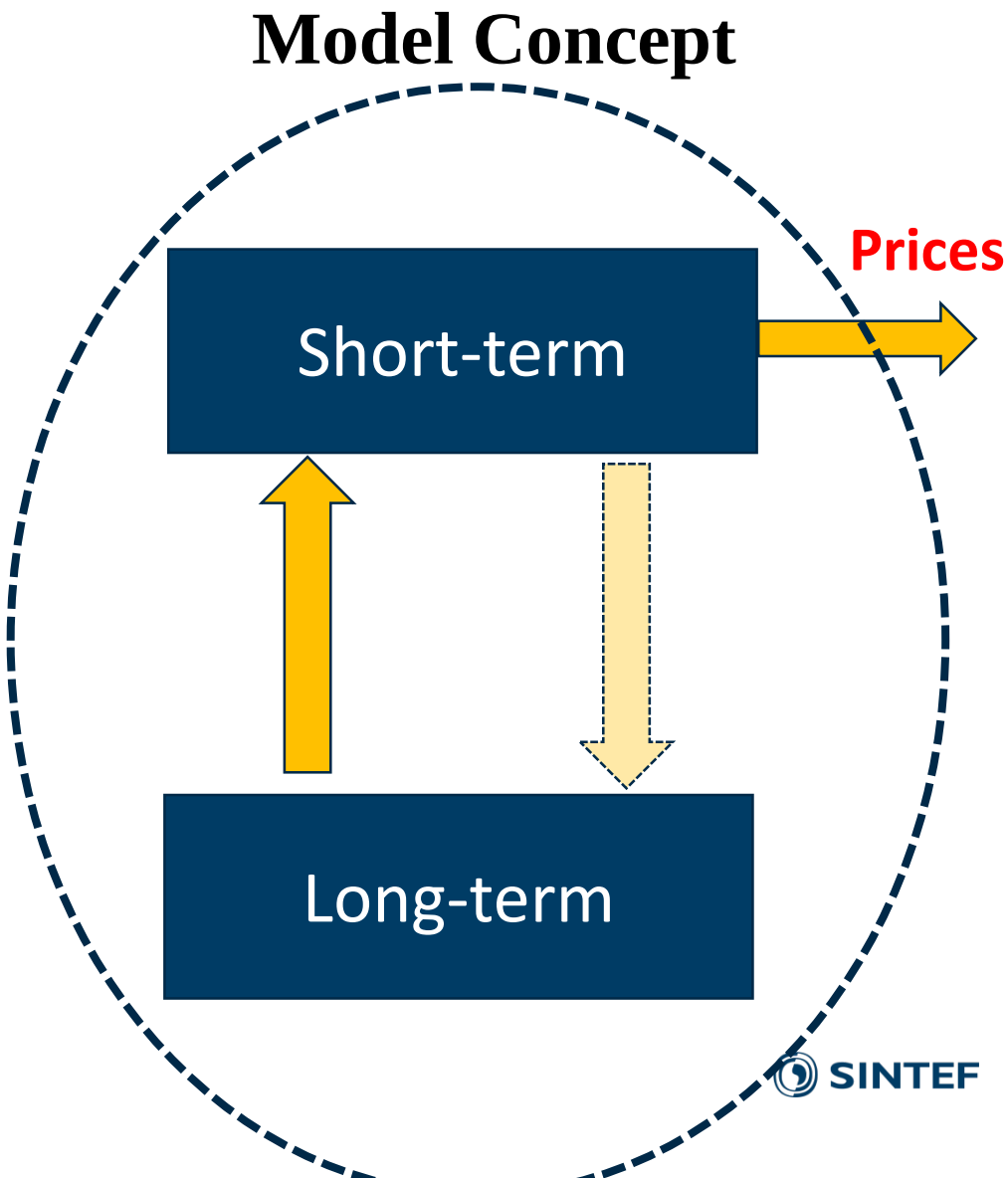
Price Forecasting by Short-term Hydrothermal Scheduling

Short- and long-term hydrothermal models coupled

- ✓ Share basic input data
- ✓ Price-based end-valuation of storages
- ✓ Short-term model in high-level language (Pyomo)



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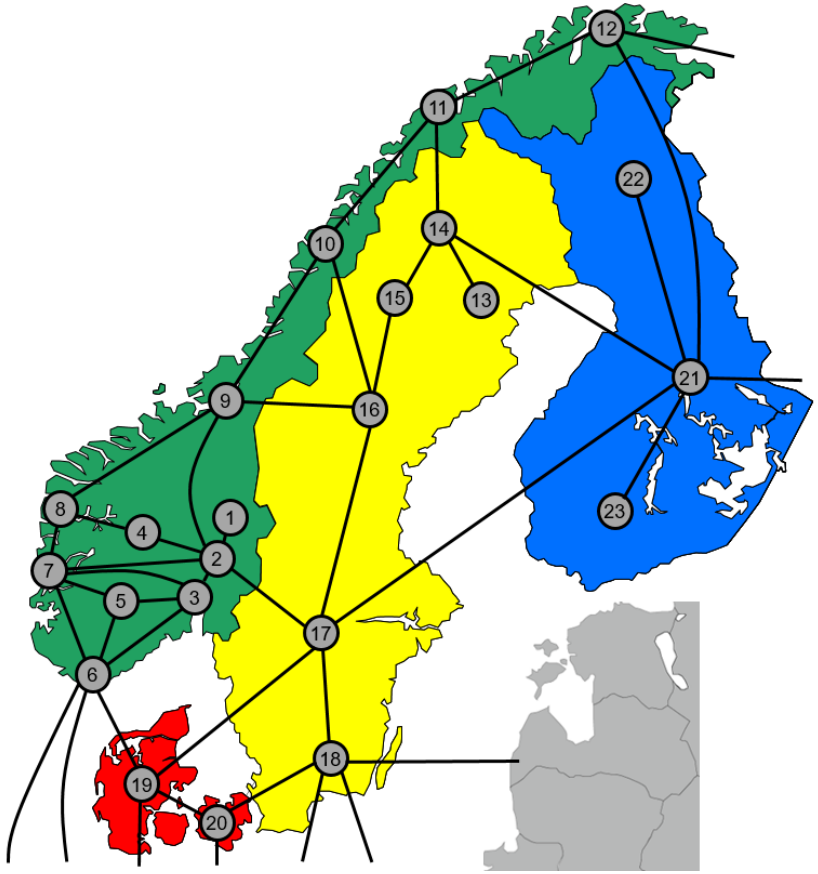
Short-term Hydrothermal Scheduling

Minimize operational cost for short-term period

Subject to:

- Hydro reservoir balances
- Basic environmental constraints
- Power balances
- Reserve requirements
- Constraints on the thermal system
- Ramping on cables
- Etc.



Future expected cost function or water values

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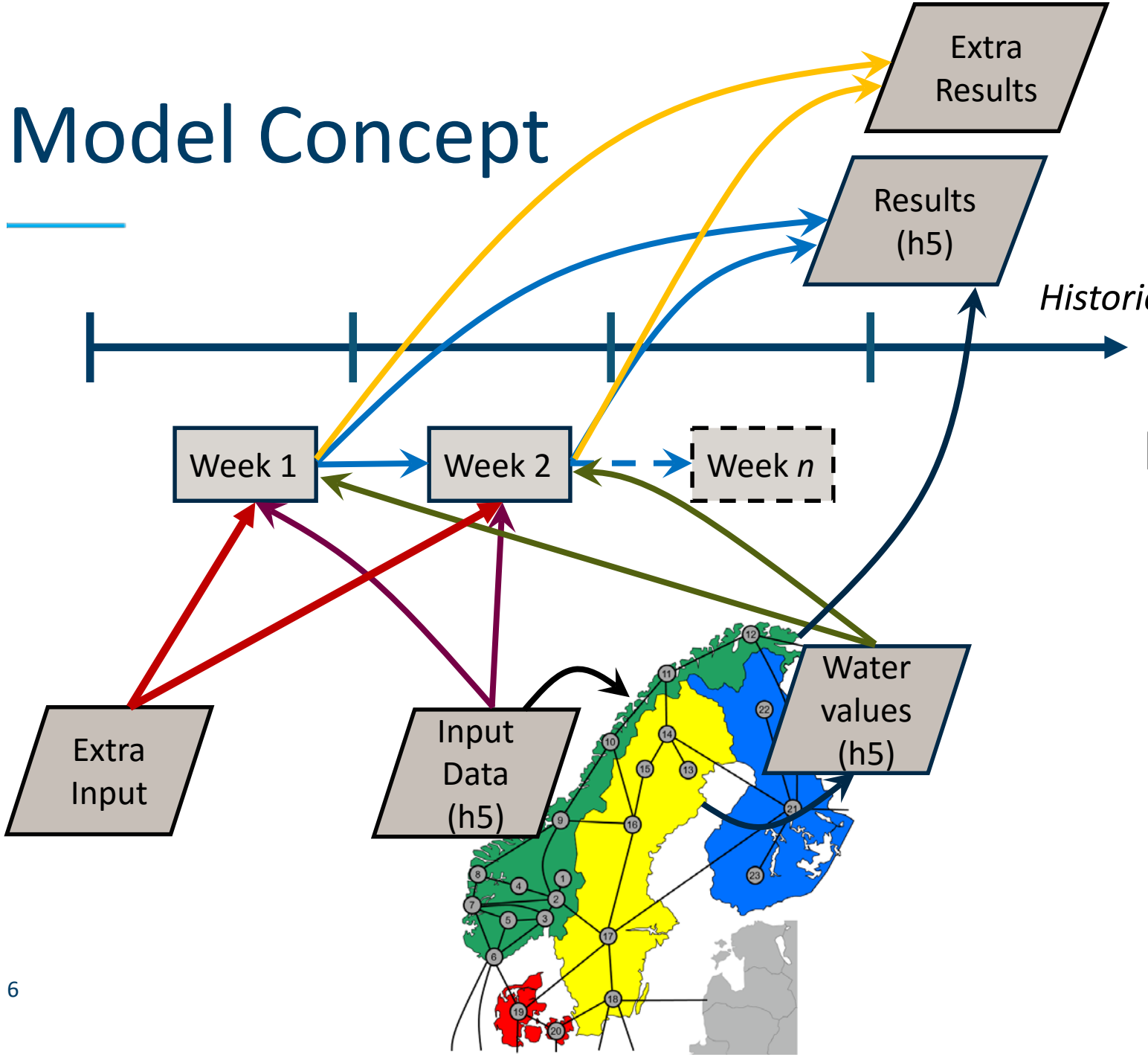
Model Concept



NTNU

Primod

- *Research prototype*
- *Python/Pyomo*
- *Rapid prototyping*

FanSi or EMPS

- *Compiled*
- *Computational speed*

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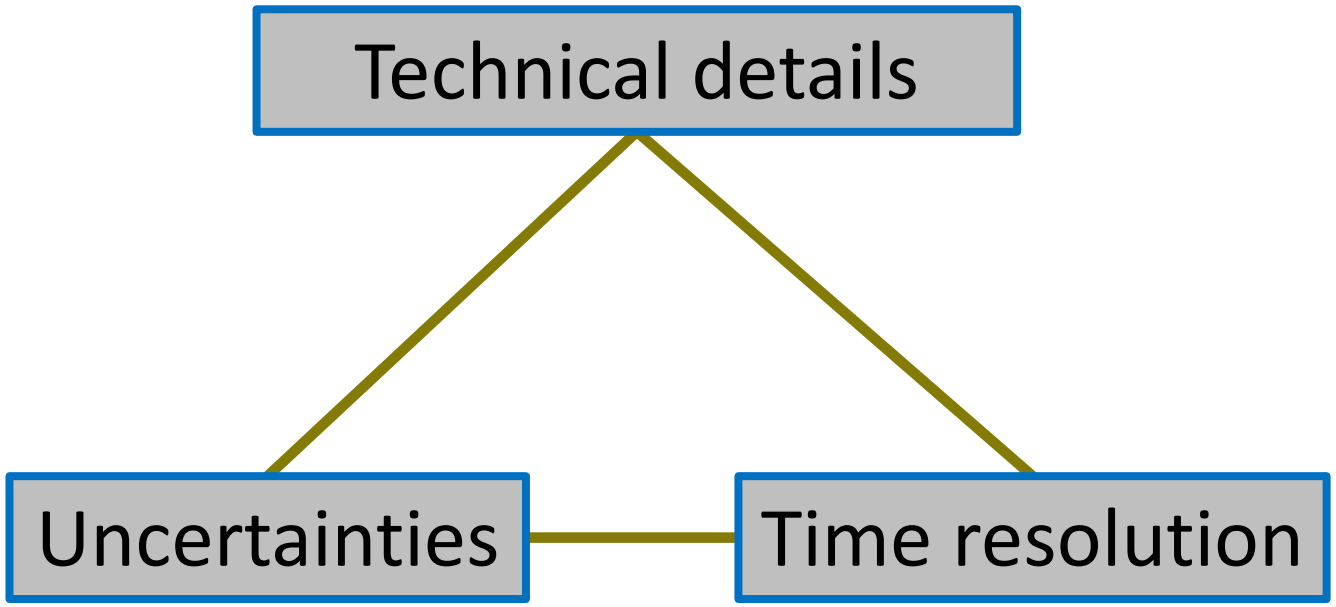
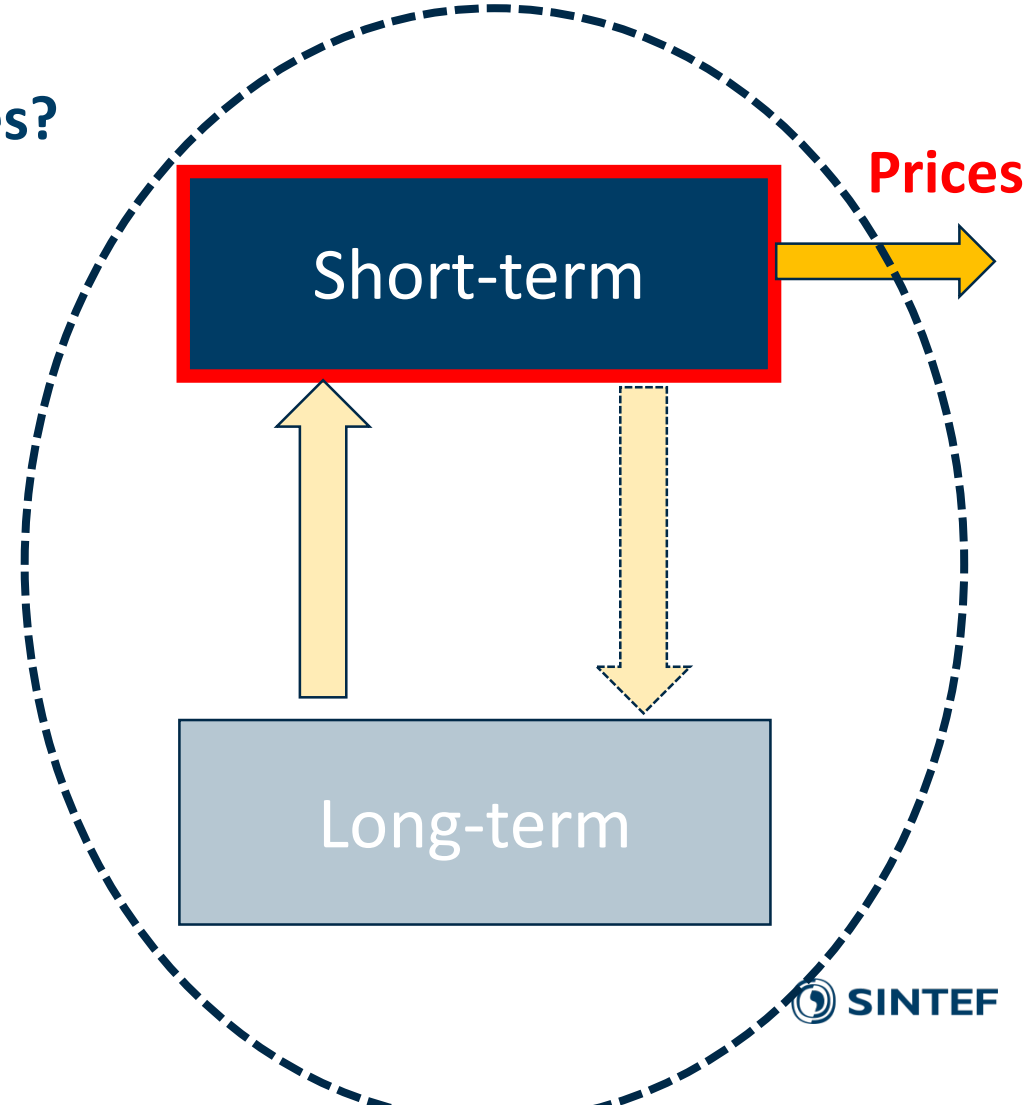
Short-term Hydrothermal Scheduling

Level of detail needed to capture realistic prices?





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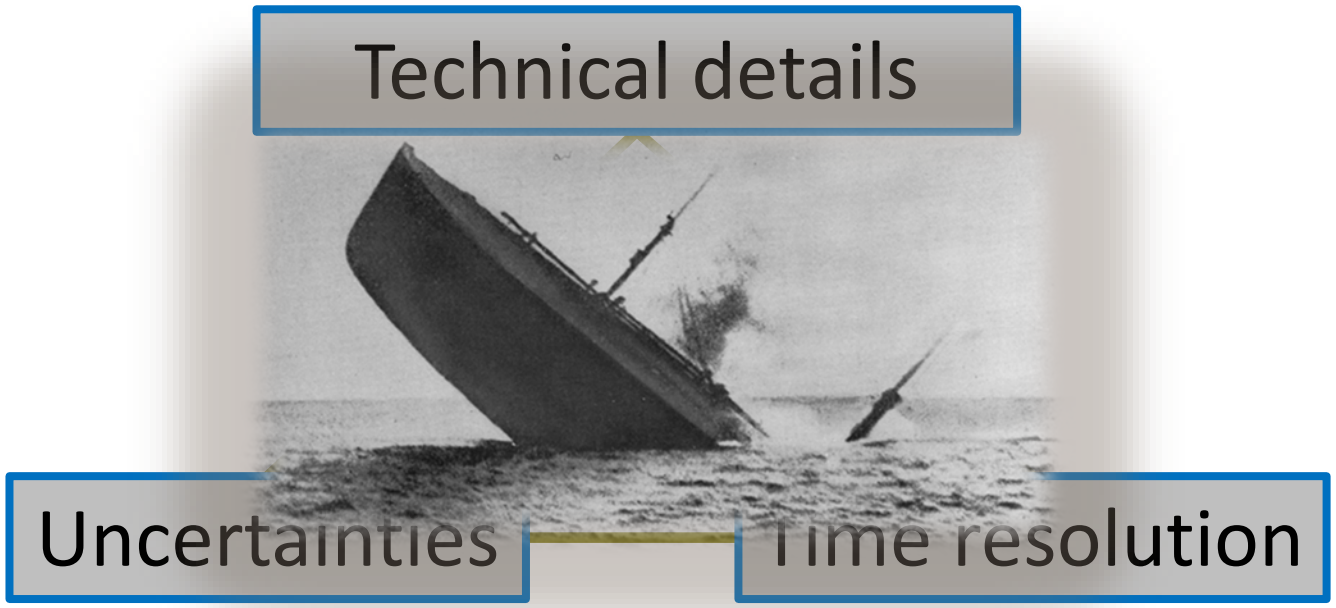
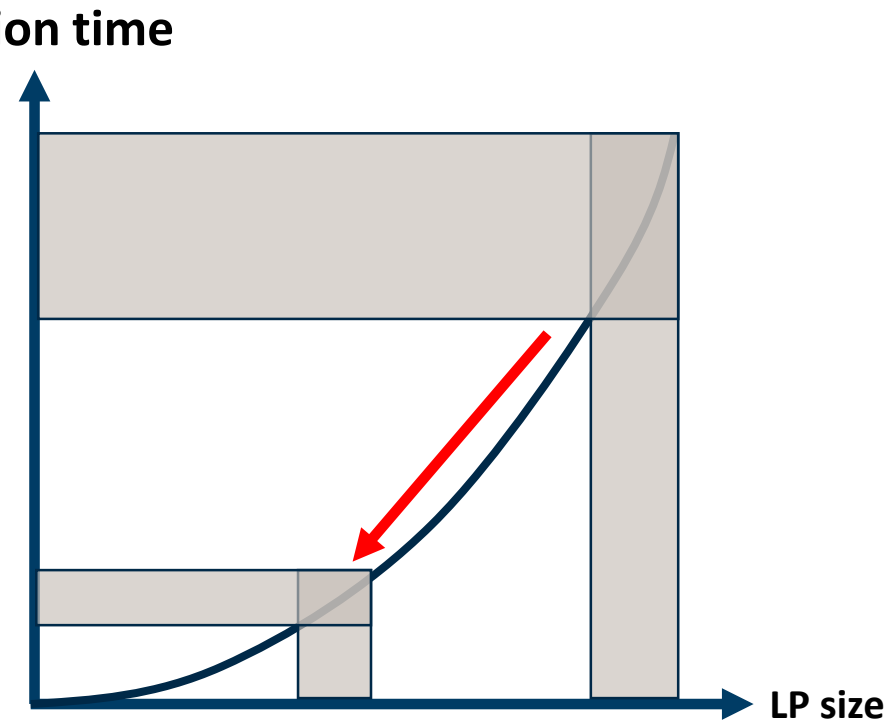
What about computation time?

Decomposition is necessarry!





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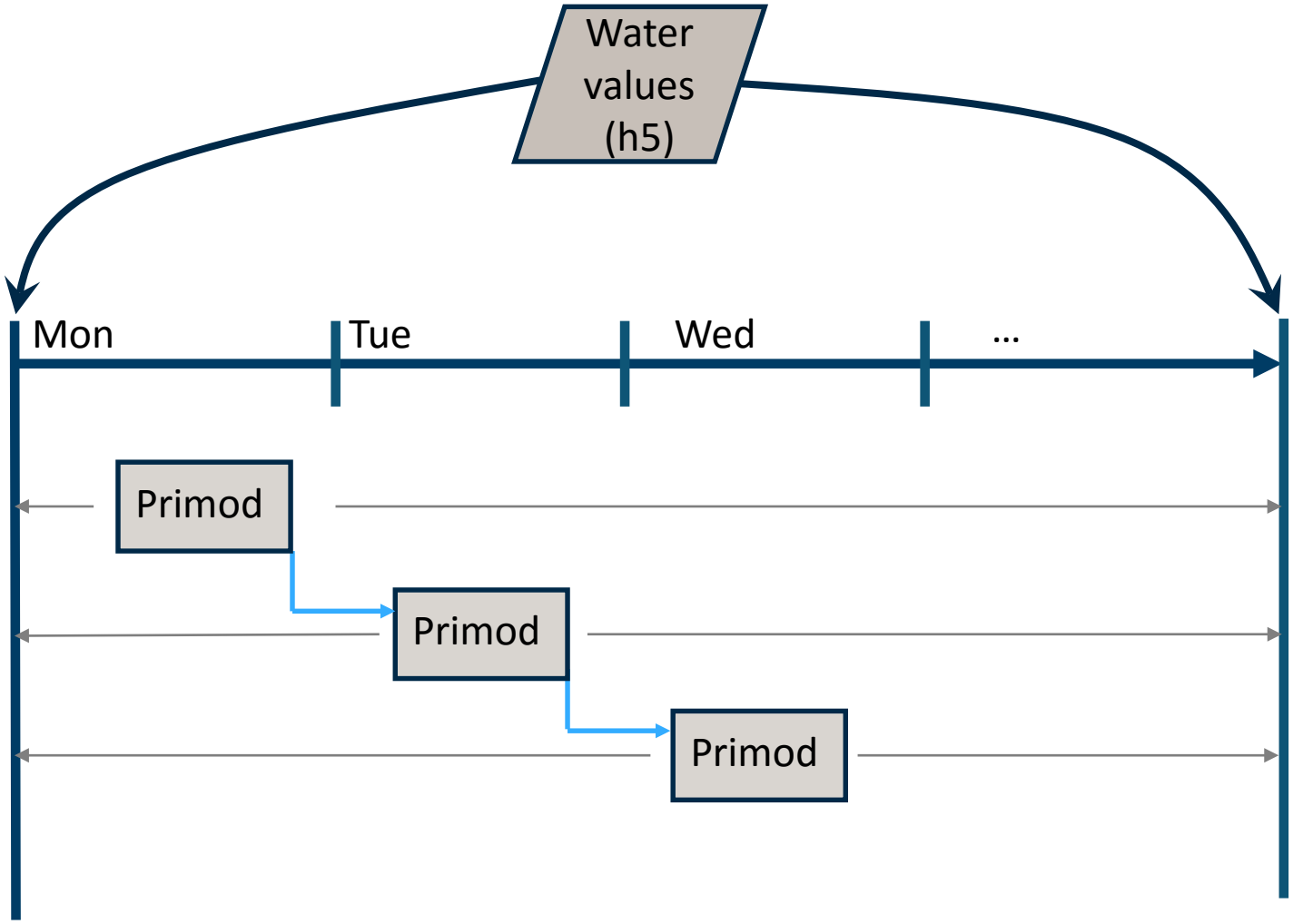
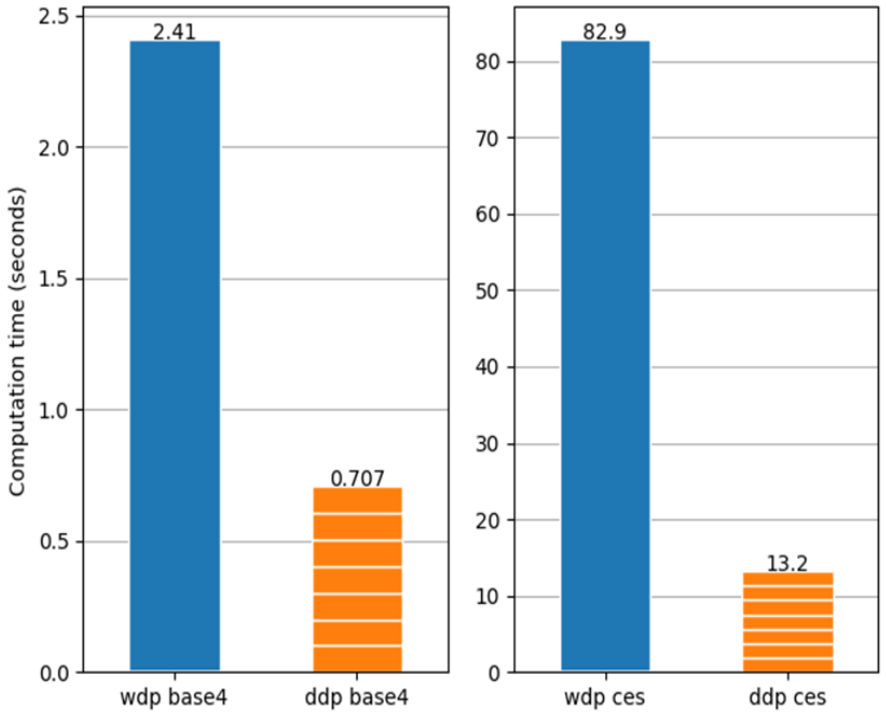
Test#1 – Decomposition, weekly →daily



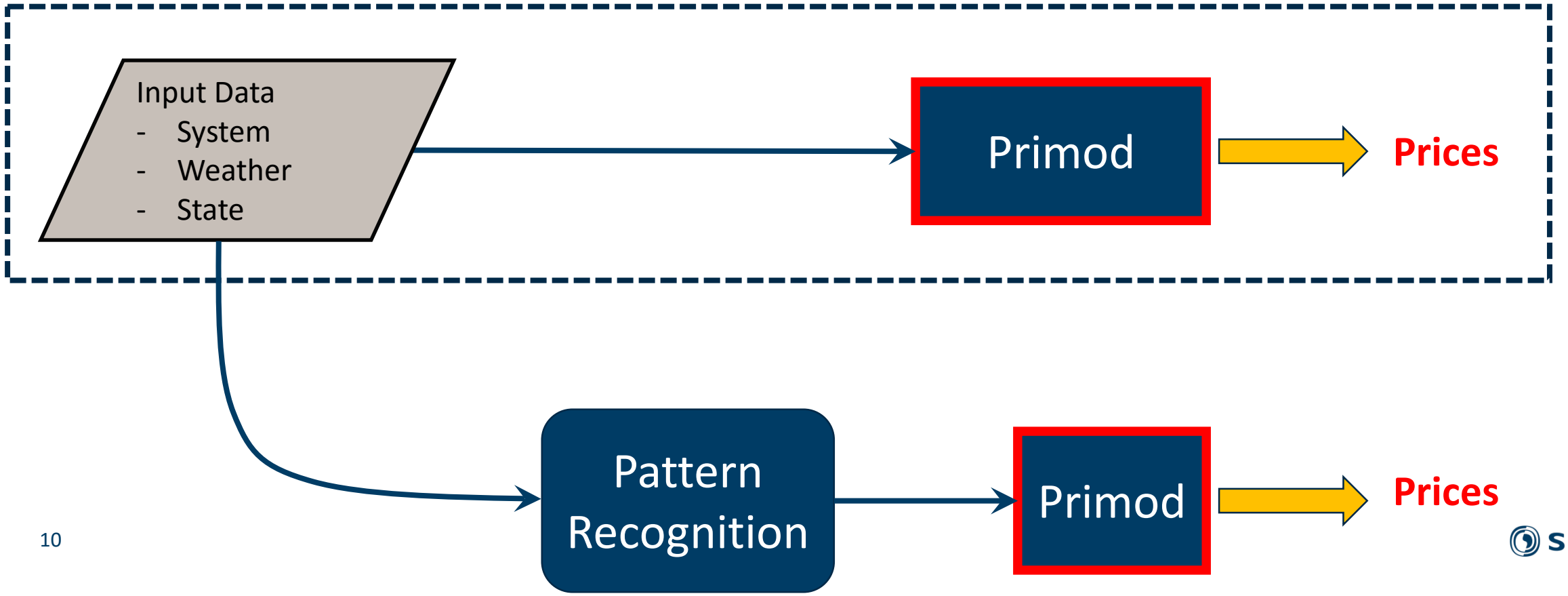
Interpolation in cost functions:

- Rolling horizon towards end-of-week
- Capture seasonal trends
- Break the "deterministic structure"



Test#2 – Problem reduction by pattern recognition

Which constraints are needed to capture realistic prices?



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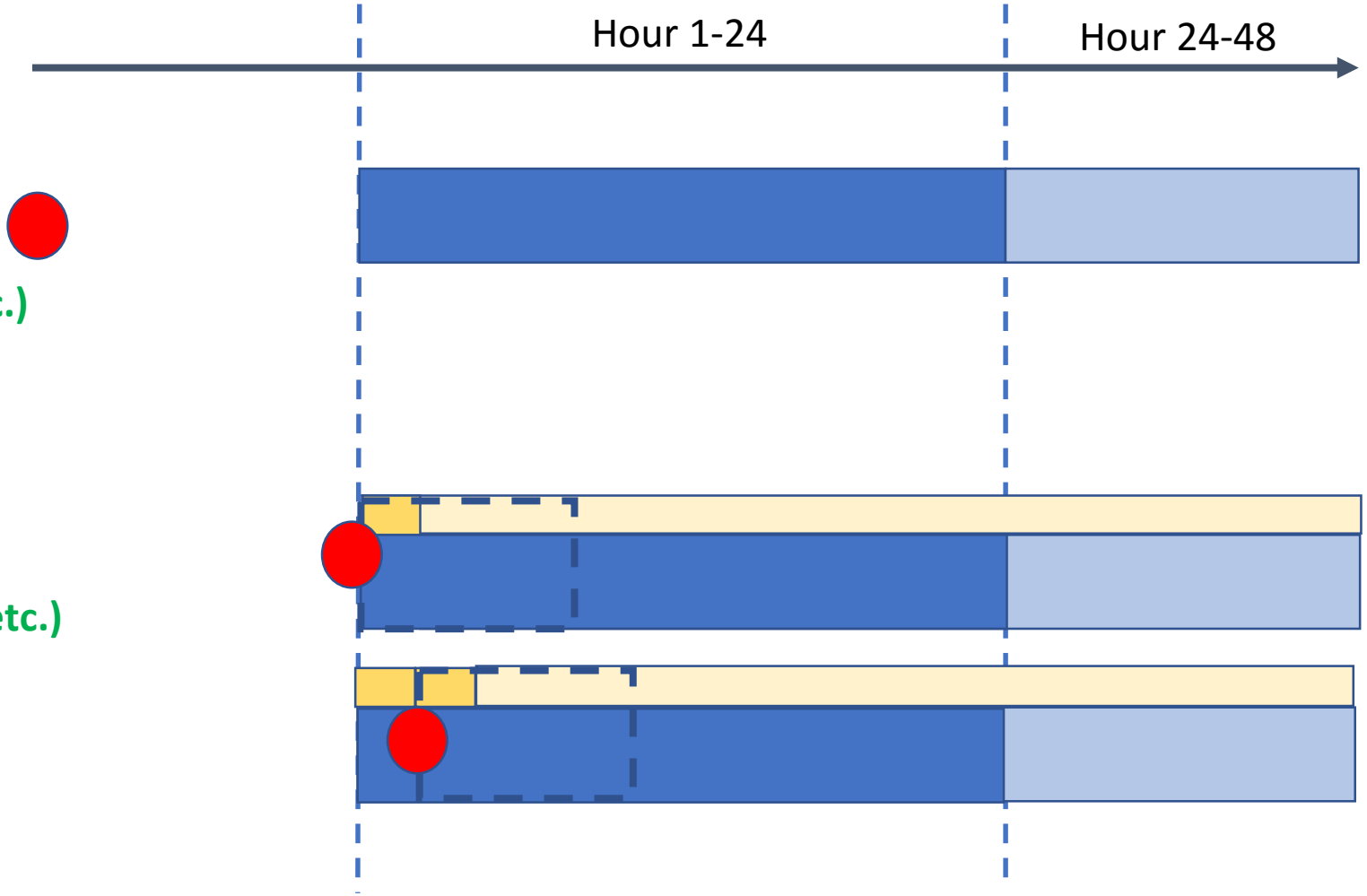
Short-term model design



Energy schedule

Reserve procurement

Forecast (Wind, Load, etc.)

Energy balancing

Imbalance (Wind, Load, etc.)

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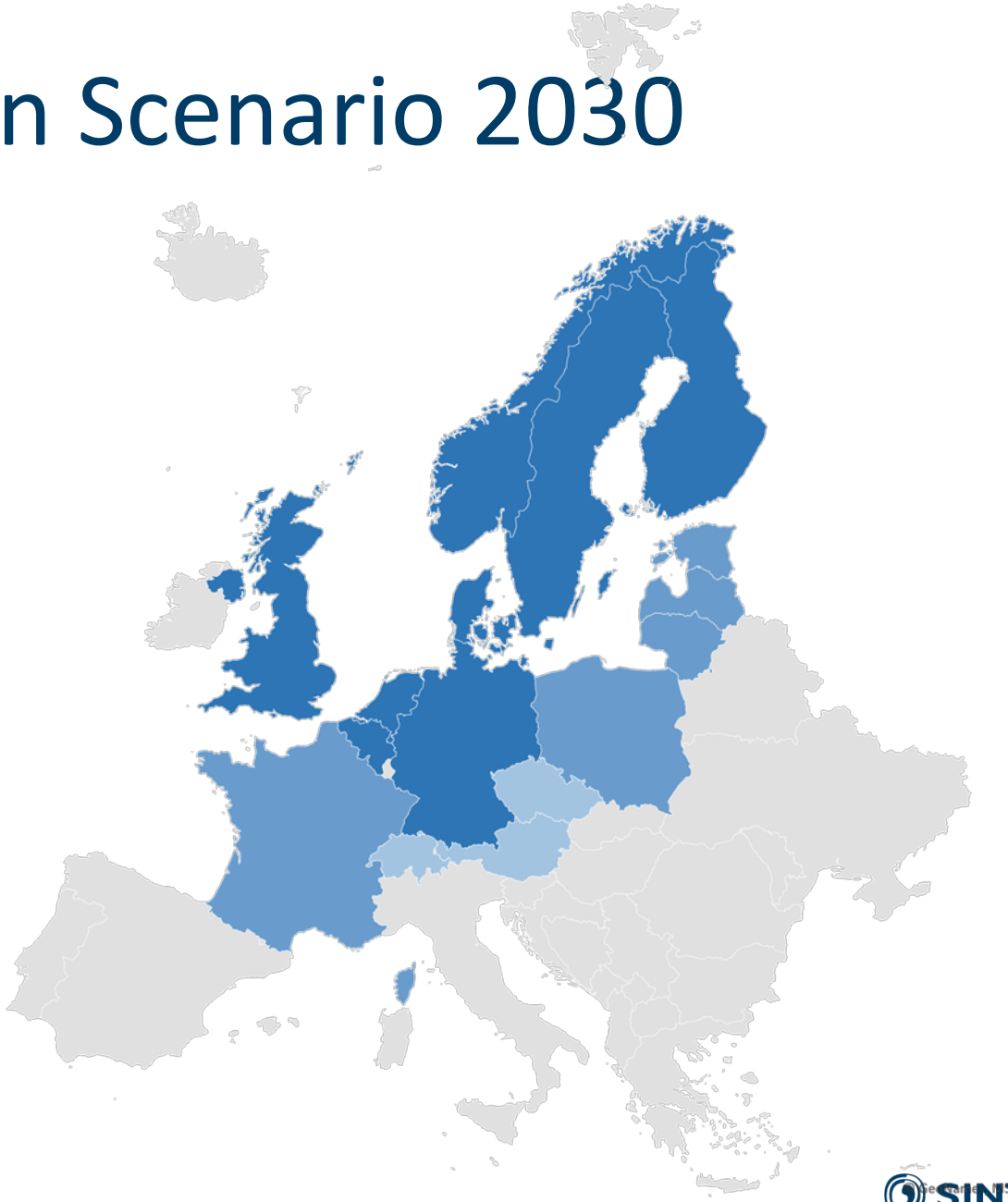
Case Study: Low Emission Scenario 2030

EMPS set-up:

- 57 areas, onshore and offshore
- 3h time steps (56 steps/week)
- 58 historical weather years

- Detailed hydro for the Nordic region
- Hourly wind and solar series
- Thermal power with start up costs
- Transmission capacities
- Limited demand flexibility
- Wide range of assumptions for 2030

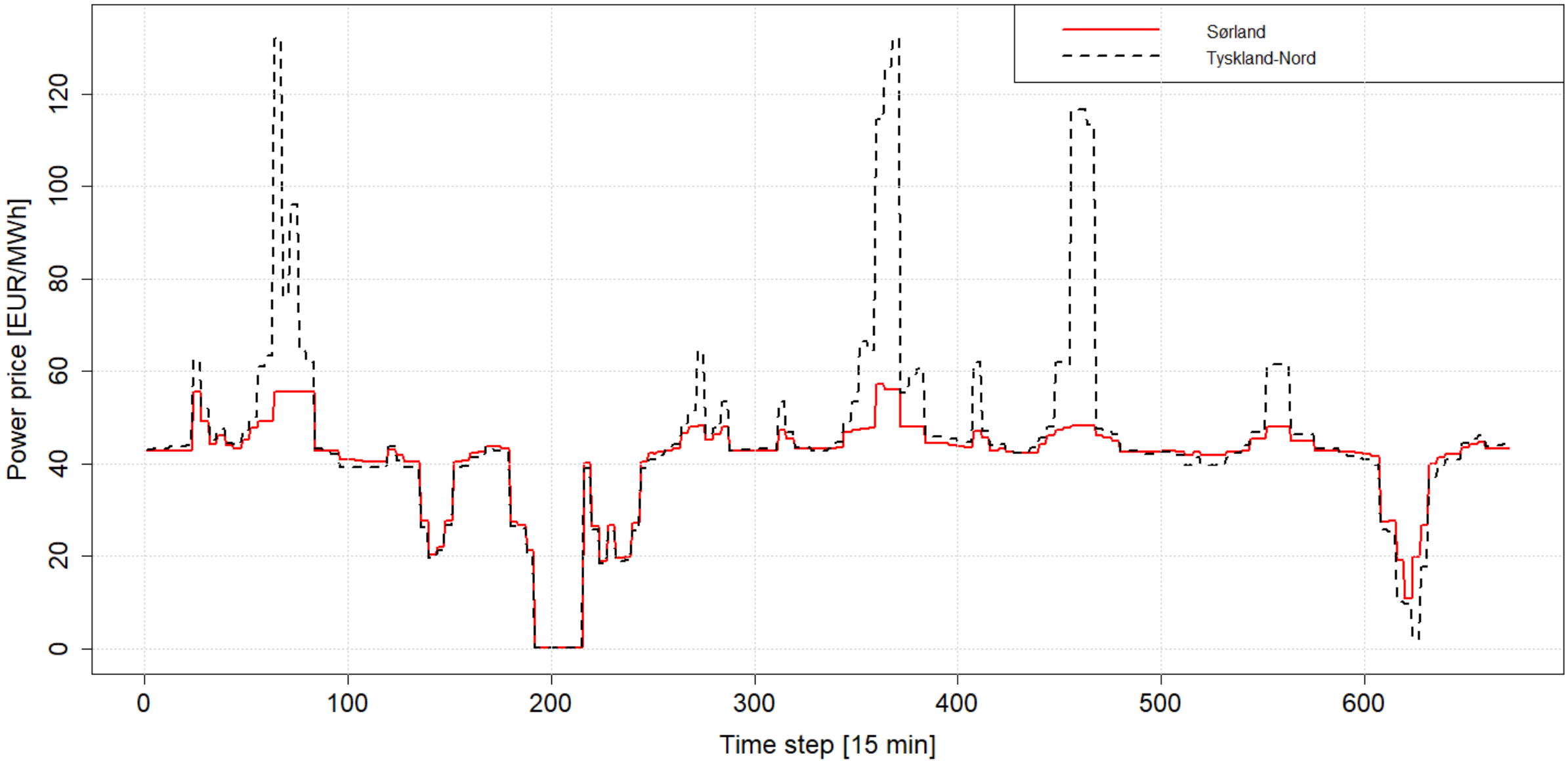


Case Study: Low Emission Scenario 2030

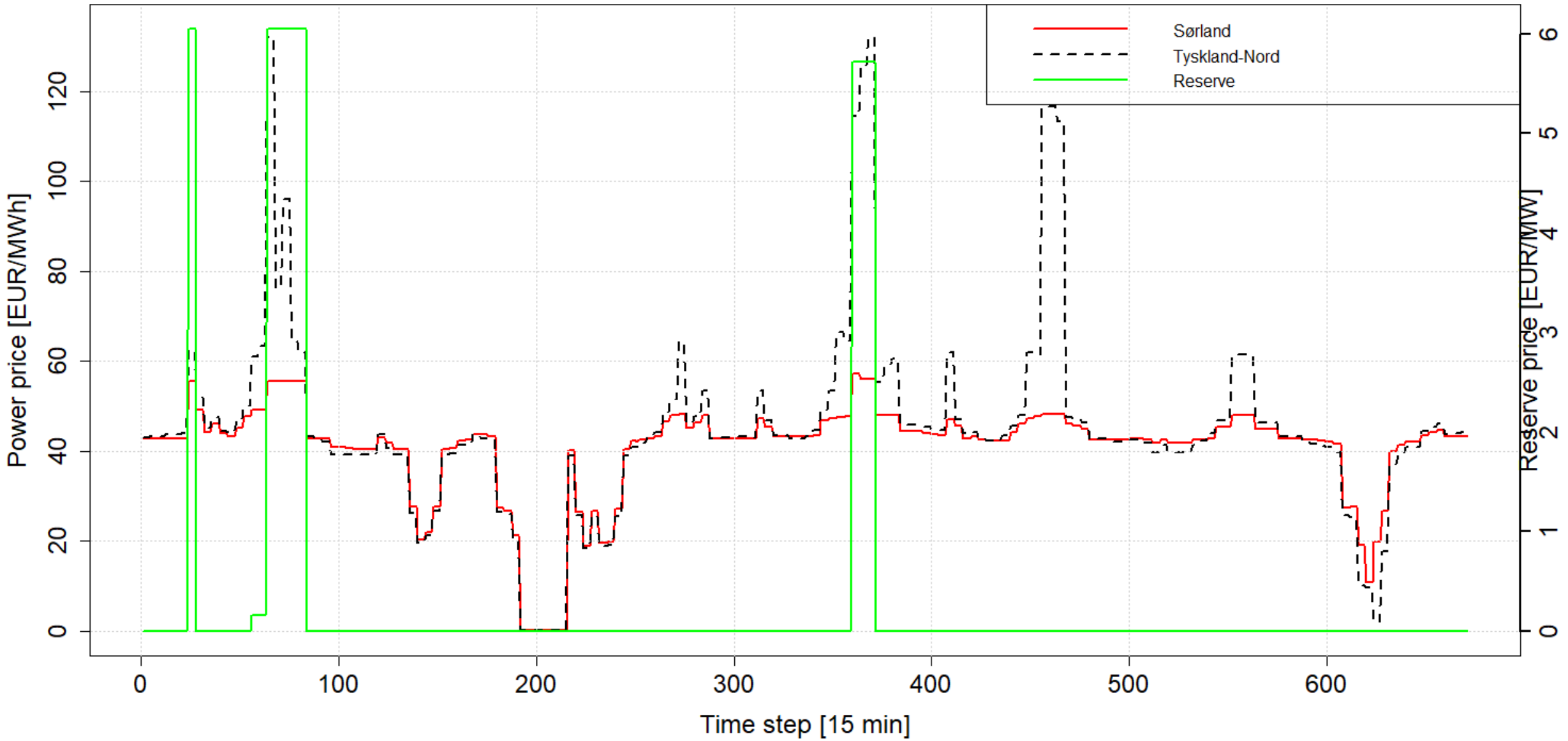
- Energy and Reserve scheduling per day
- Reserves
  - Symmetric requirement: 550 MW for whole of Norway
  - Approx. 30 selected hydropower plants in Norway (mainly NO2 and NO5)
- Startup-cost for thermal units, minimum up- and down-time
- 15 min time resolution
- No grid constraints for reserves
- No ramping constraints

Study two weeks (9 and 31)

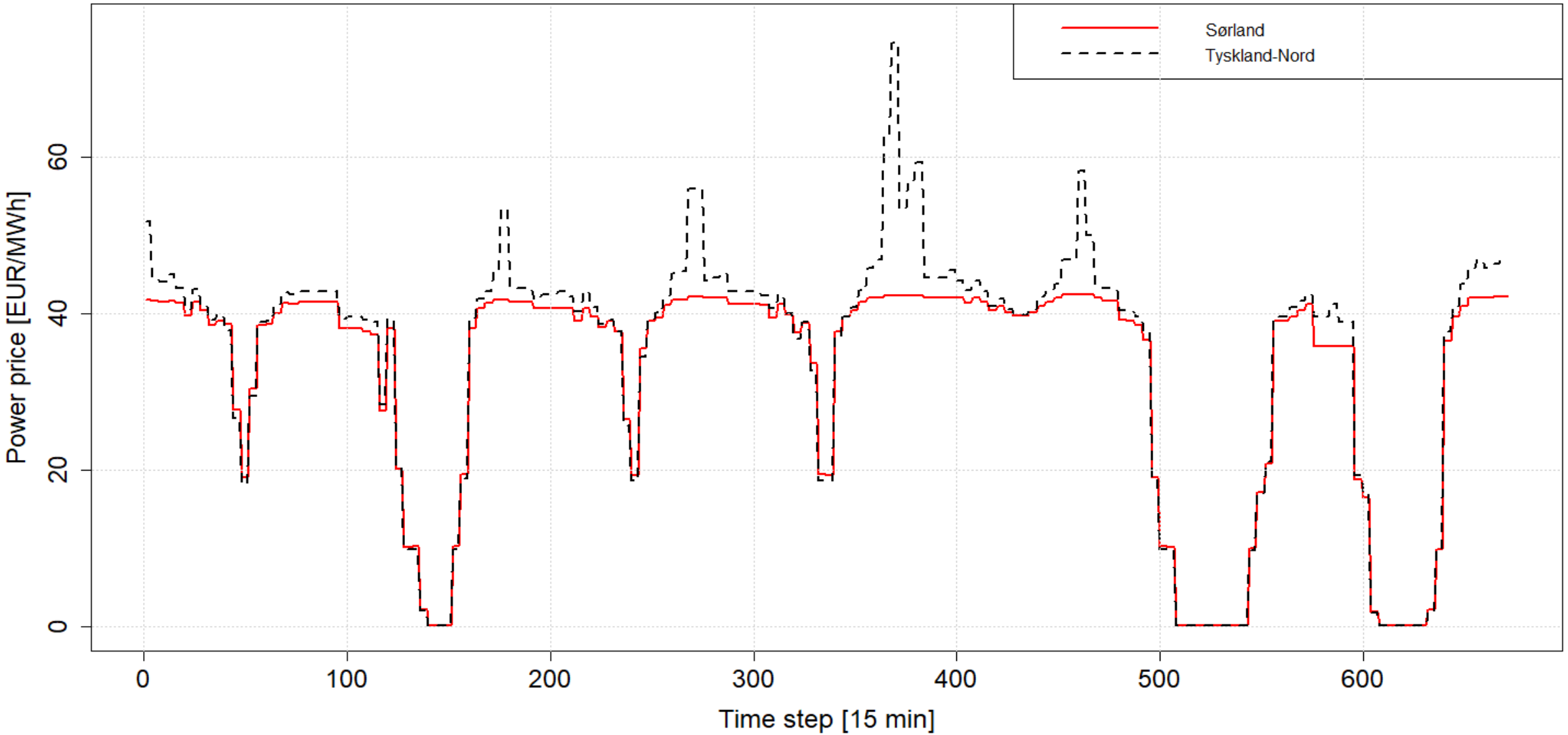
High-load week



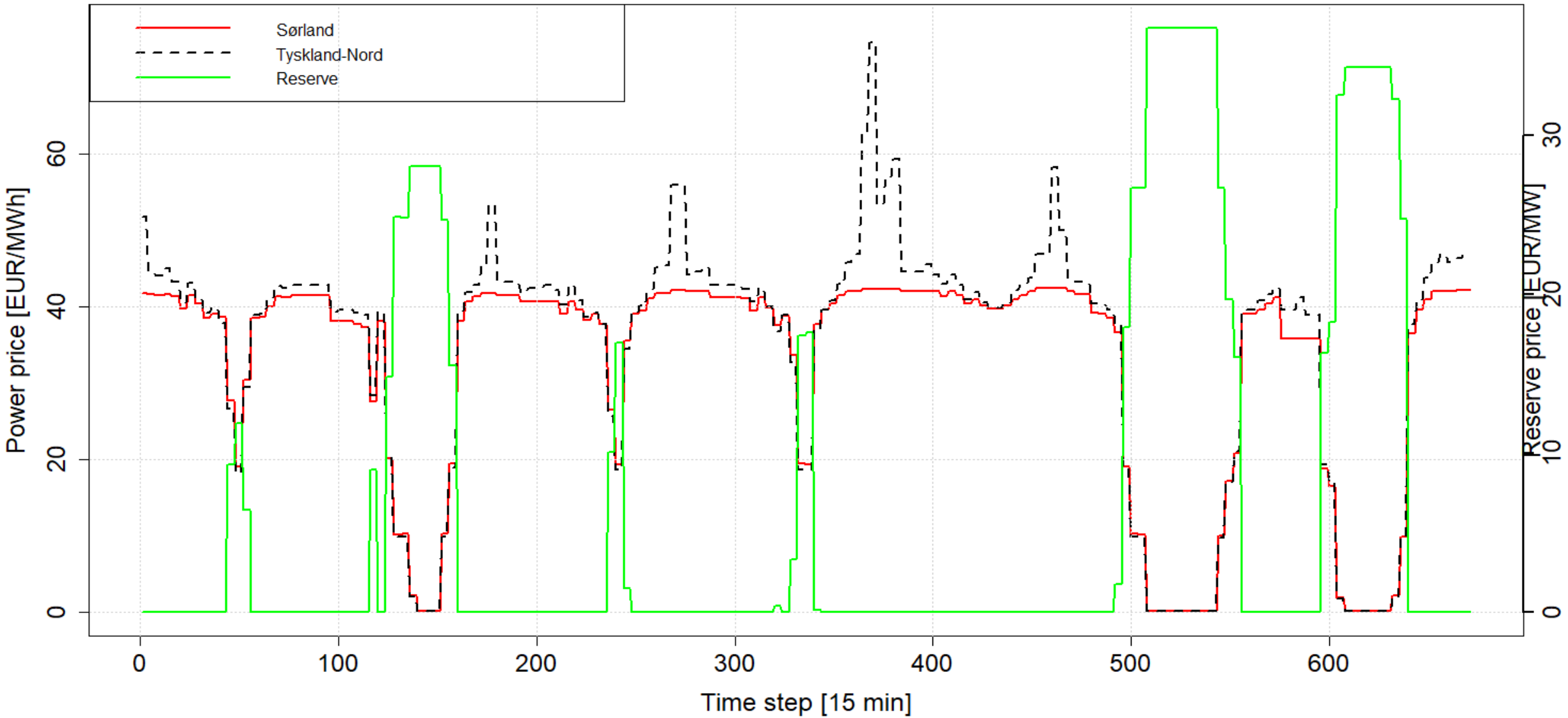
High-load week



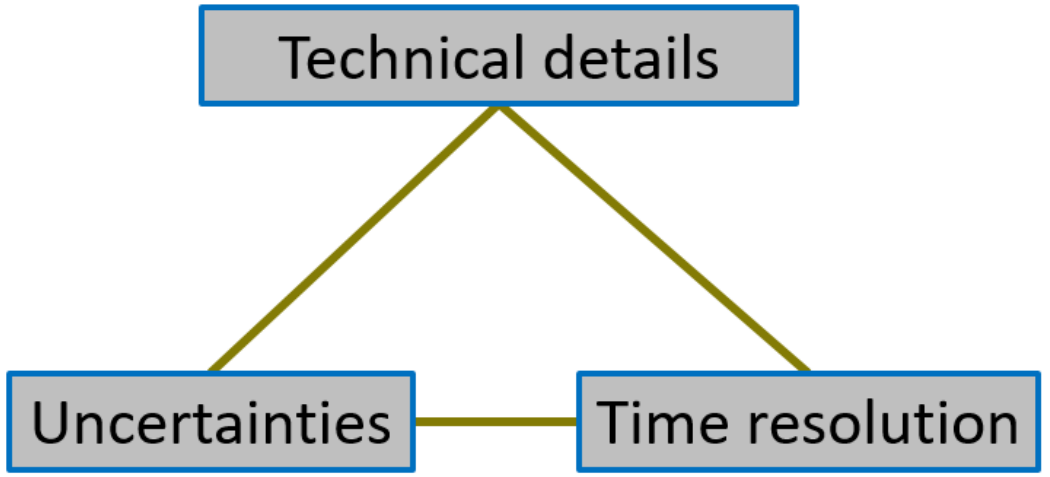
Low-load week

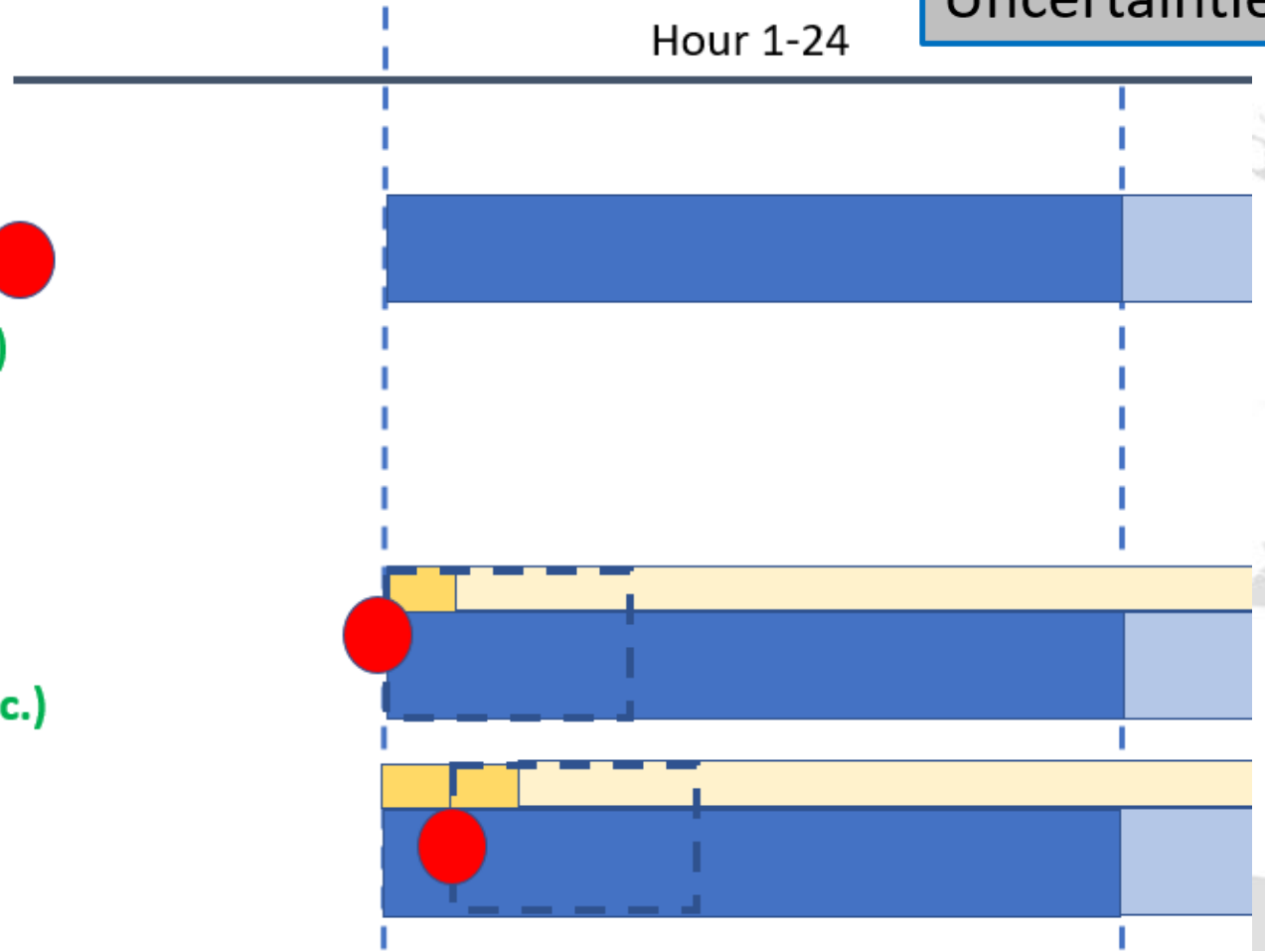


Low-load week



Future Work





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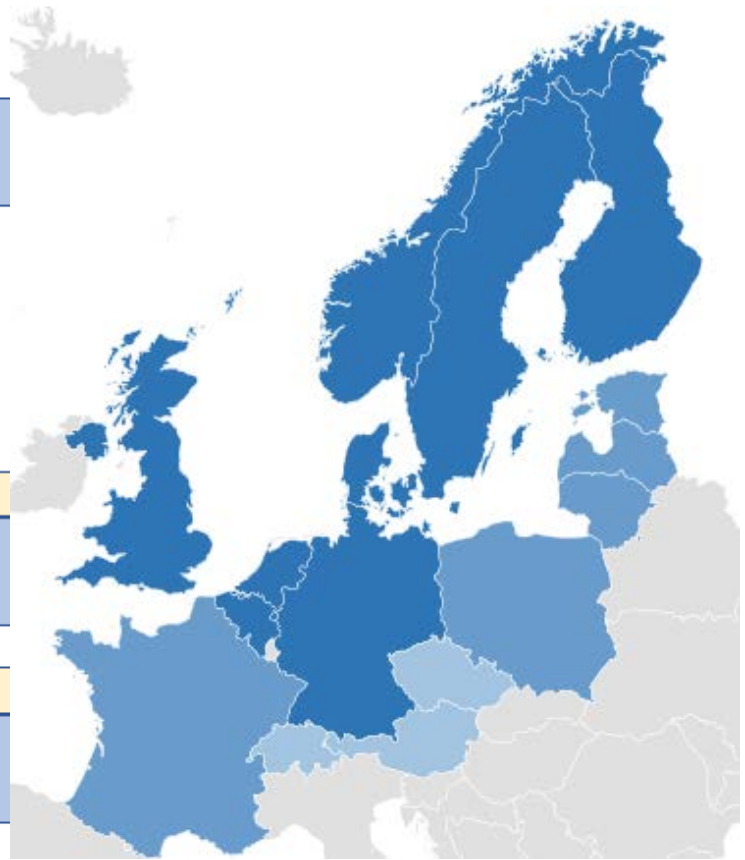

Research Projects Timeline