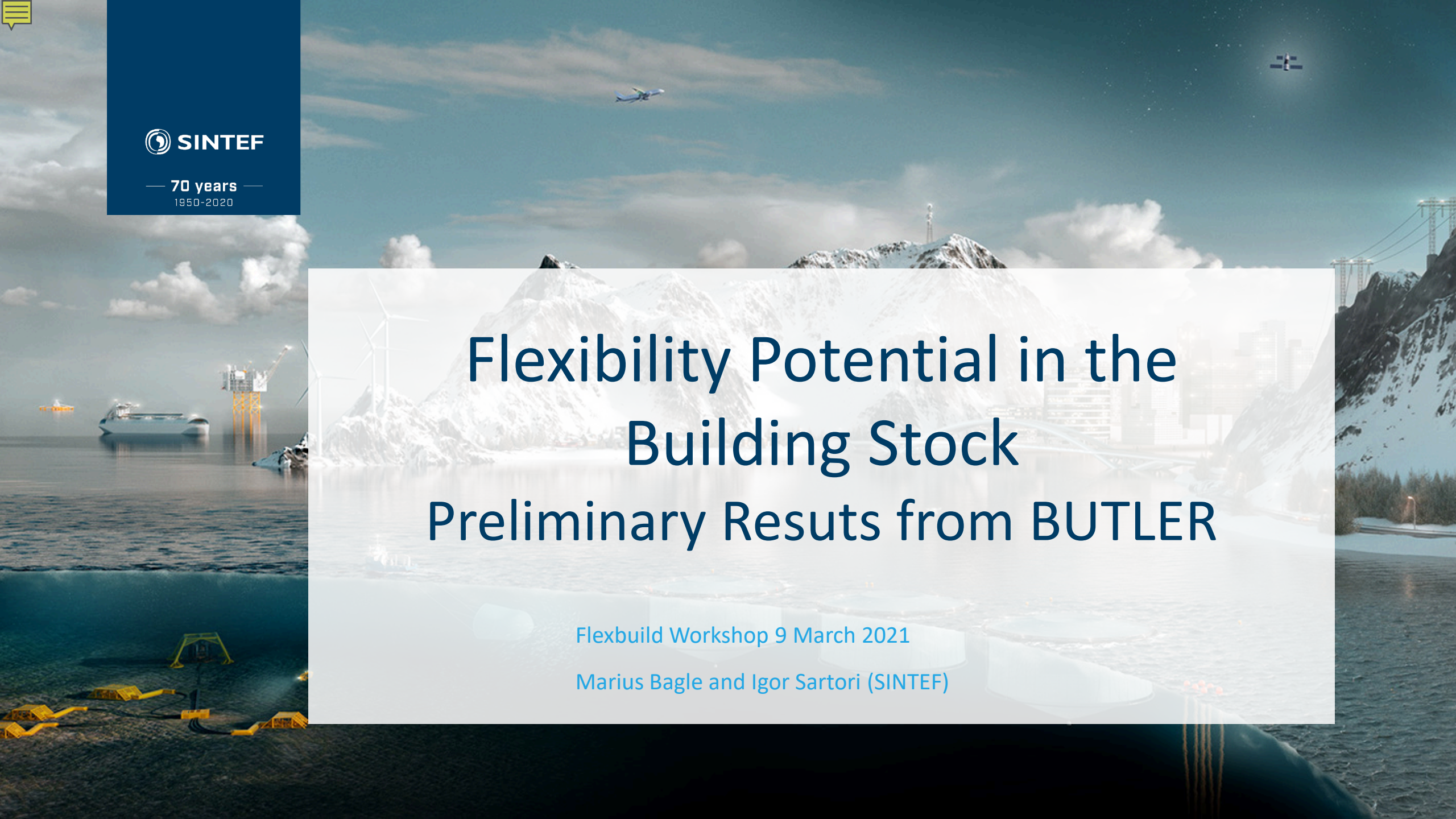

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70 years
1950-2020

Flexibility Potential in the Building Stock

Preliminary Resuts from BUTLER

Flexbuild Workshop 9 March 2021

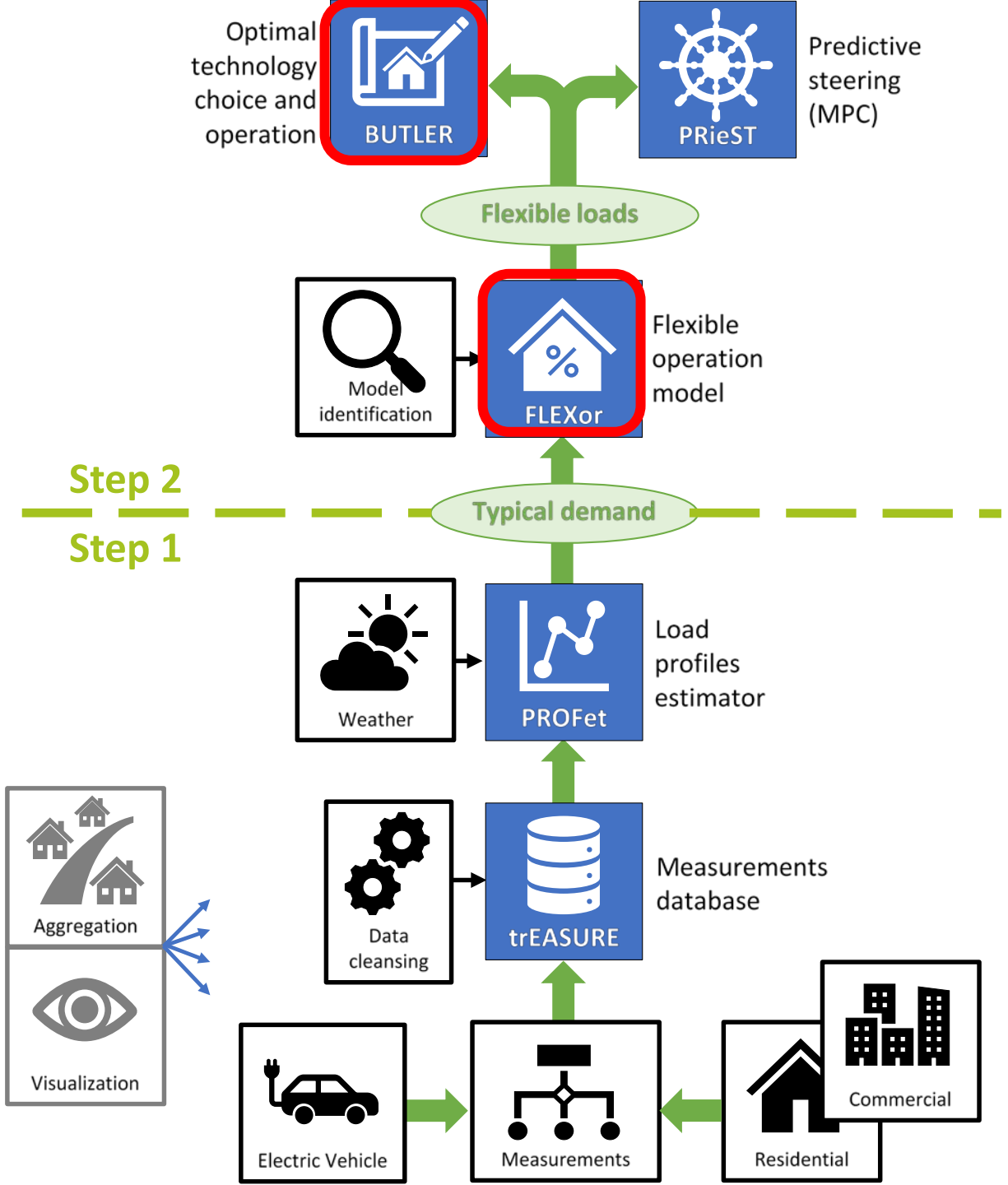
Marius Bagle and Igor Sartori (SINTEF)

Main focus in year 2

- BUTLER is under development, work in progress

- PURPOSE: investigate the theoretical flexibility potential in the building stock
  - Optimal control, perfect foresight
  - Minimize cost & keep a "flat" load profile

- SCOPE: limited to Apartment blocks (Regular) in NO1 (Oslo region)



Flexibility Suite

We are developing a ***Flexibility Suite*** of models and tools that enables to study the building loads and how to modify them… in 2 steps:

1. Know today's **typical energy demand** load profiles as well as possible
2. Change tomorrow's demand, obtaining **flexible loads**

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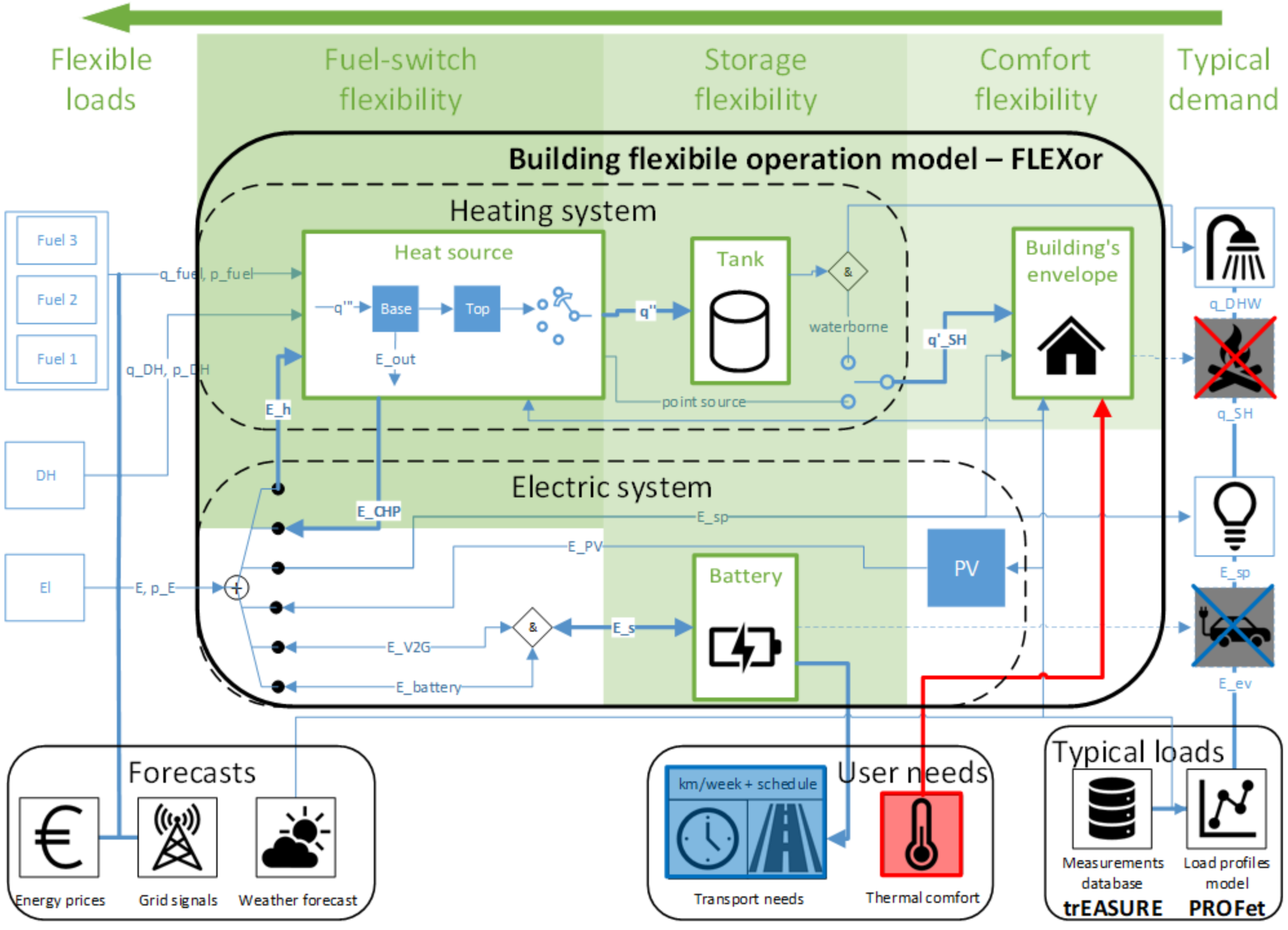
FLEXor

FLEXor considers:

- **user needs**, e.g. indoor temperature
- **interplay between all the elements** in the energy system of a building
- **price and weather forecasts**

→ to make the loads flexible



BUTLER
Optimization: investment & operation

$$minimize: \sum_{time\ steps}^{opt.horizon} \sum_{en.carriers} (Capaci \times Cost) + (Energy \times Price)$$

$subject\ to$:

FLEXor equations

with technologies fixed

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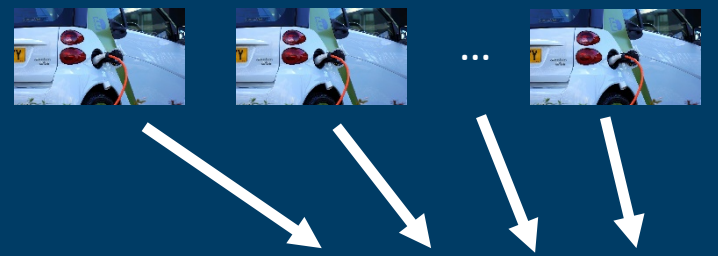
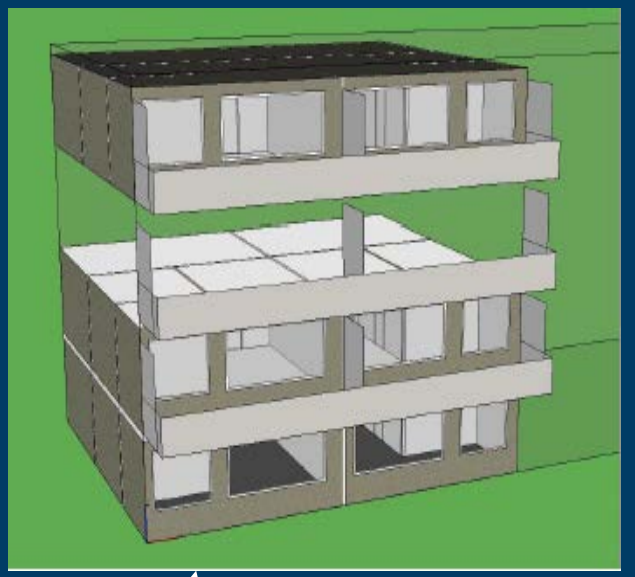
Case description

- Apartment block, 24 apts, 1672 m^2
- Flexibility sources:
  - Building envelope
  - DHW tanks
  - 10 EVs → 0.4 EV per household
- Heating technologies mix as from 2020 calibration:
  - District Heating
  - Ground Source Heat Pump
  - Electric Boiler
  - Electric panels

} Waterborne heating





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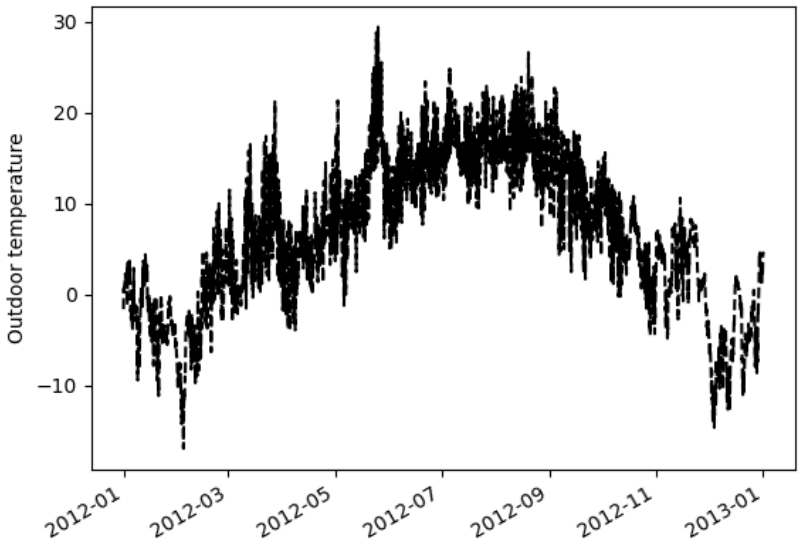
Input data

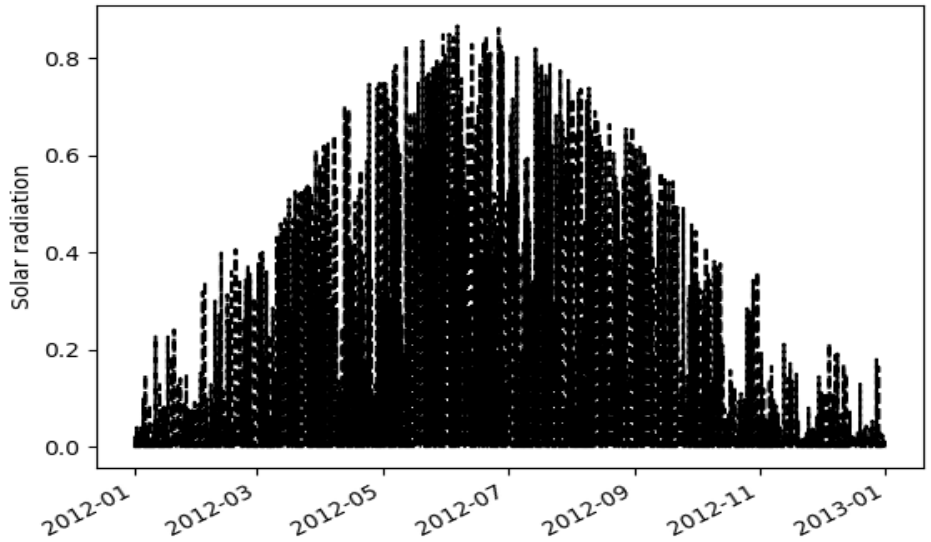
- Year 2012
- Historical year, for consistency between climate and energy prices
- It is an "average" year but with significant peaks
- Spot price as the "price signal" to follow*

* Households have a flat grid tariff

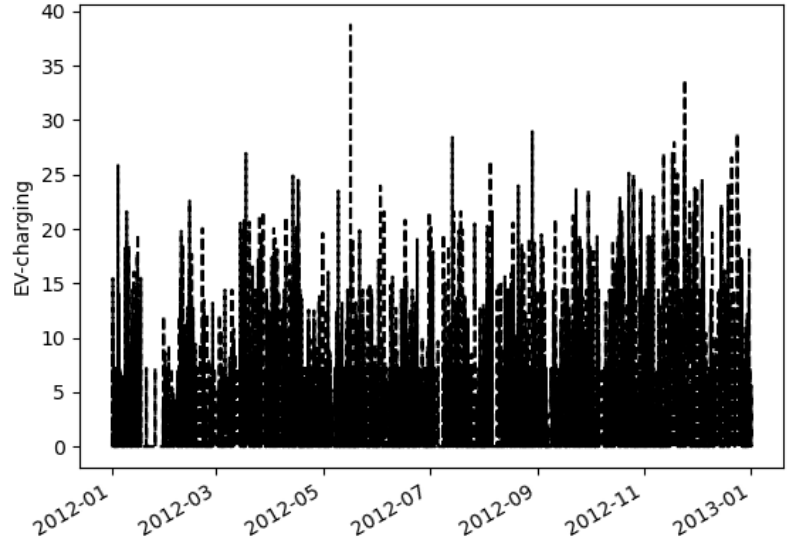
Outdoor temperature



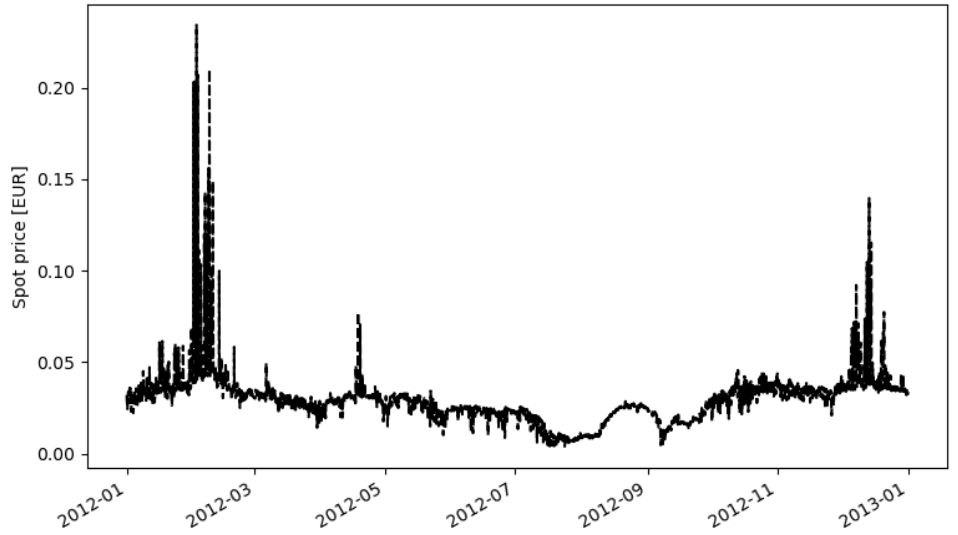
Solar radiation



EV charging (from measurements)

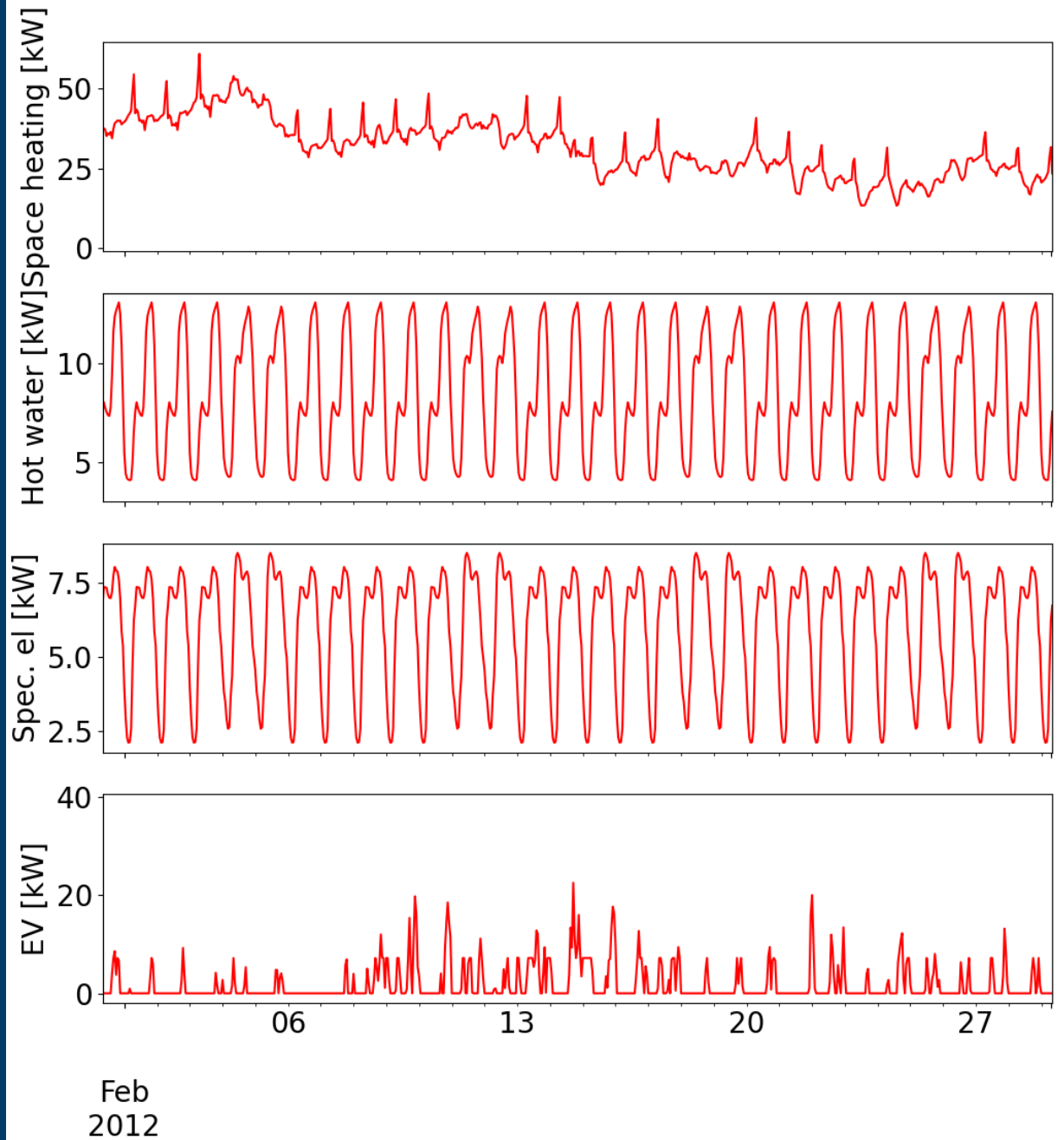


Spot price

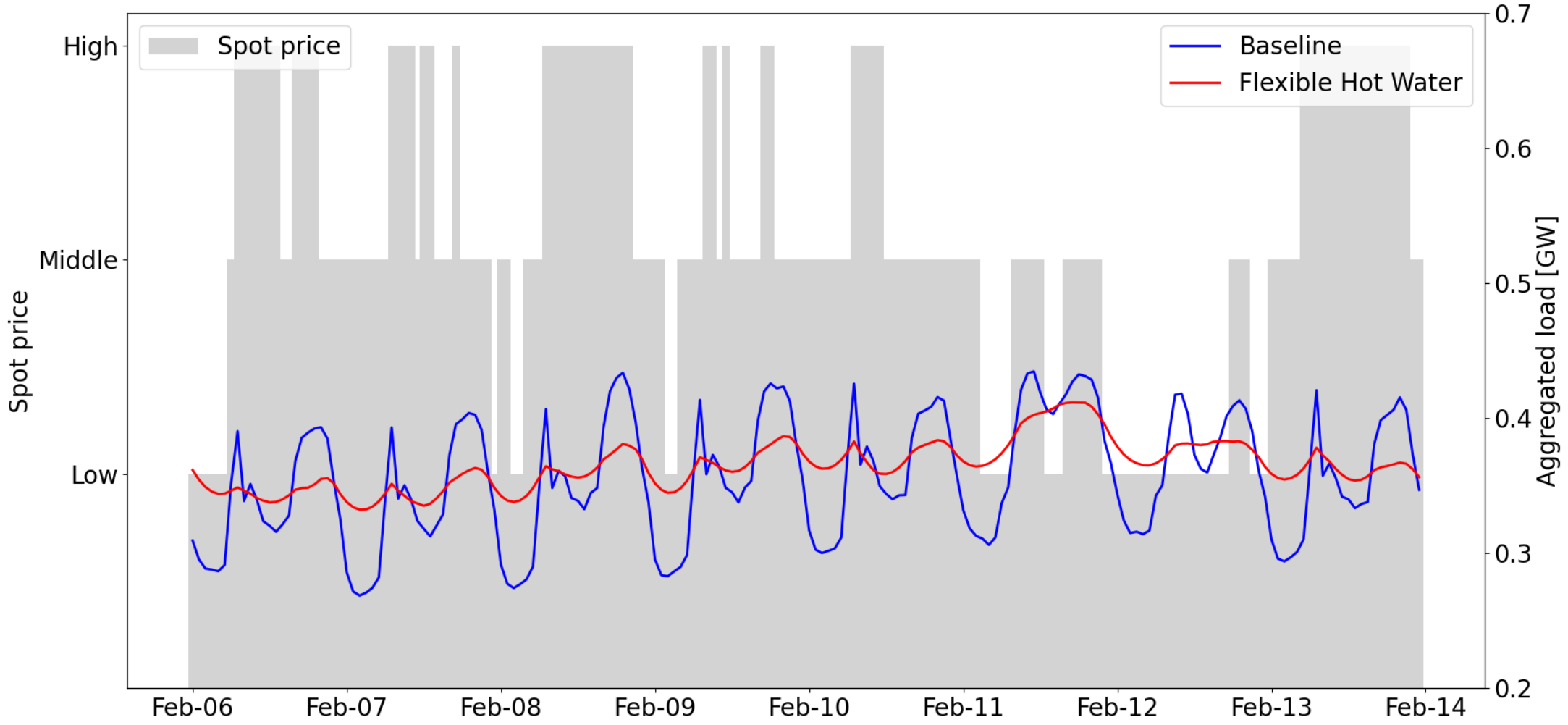


Energy demand

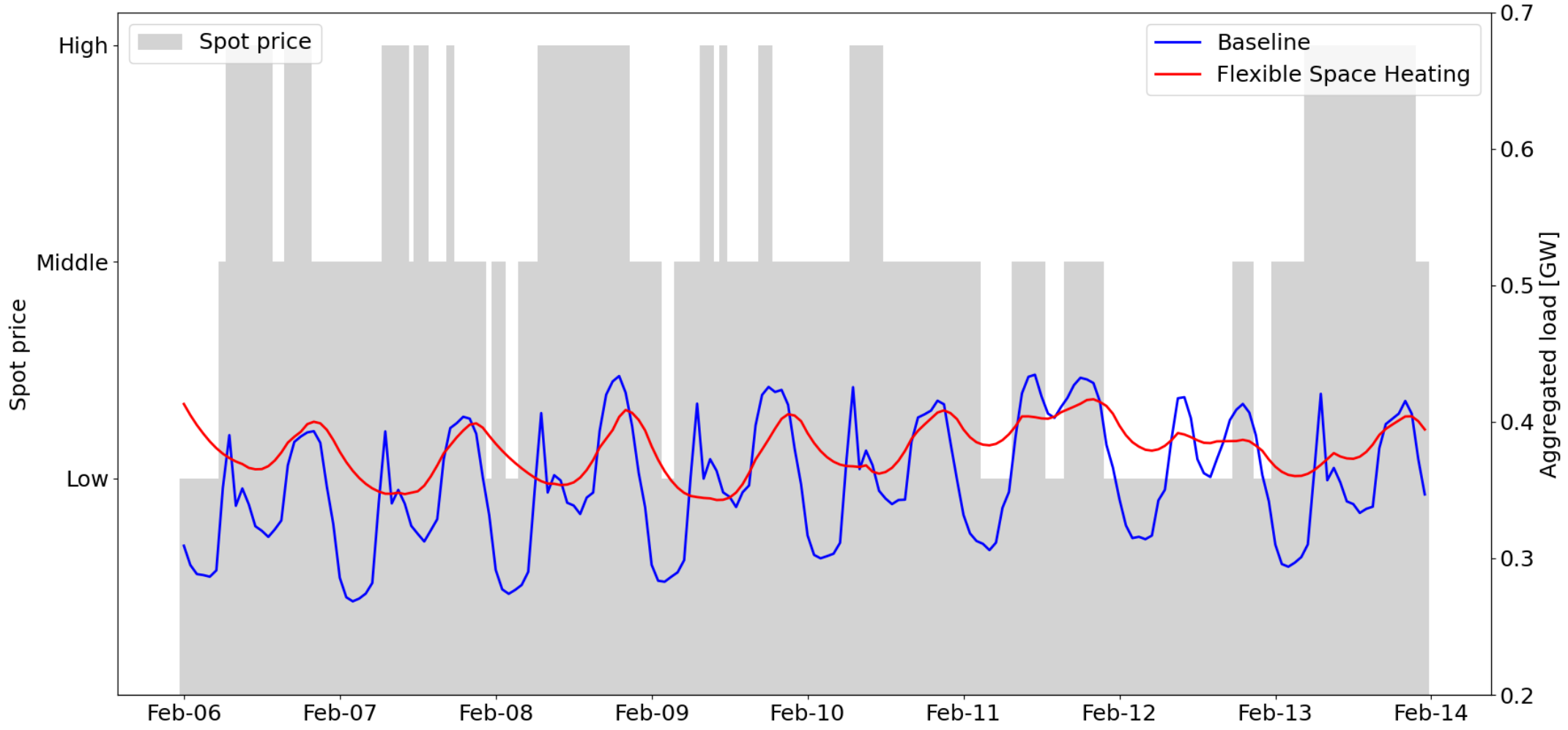
- Space Heating
- Hot Water
- Electric Specific load
- EV charging



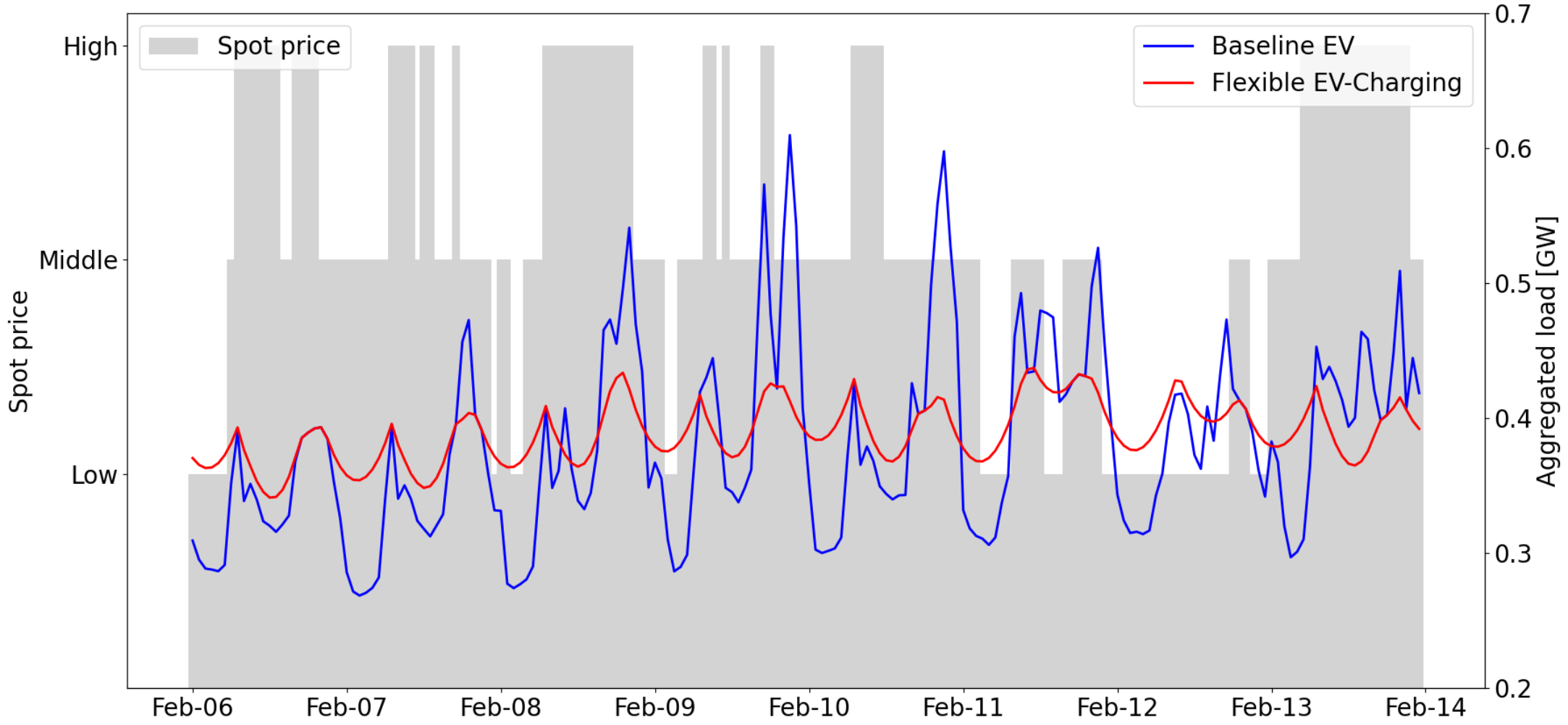
Results – Flexible Hot Water



Results – Flexible Space Heating



Results – Flexible EV-charging

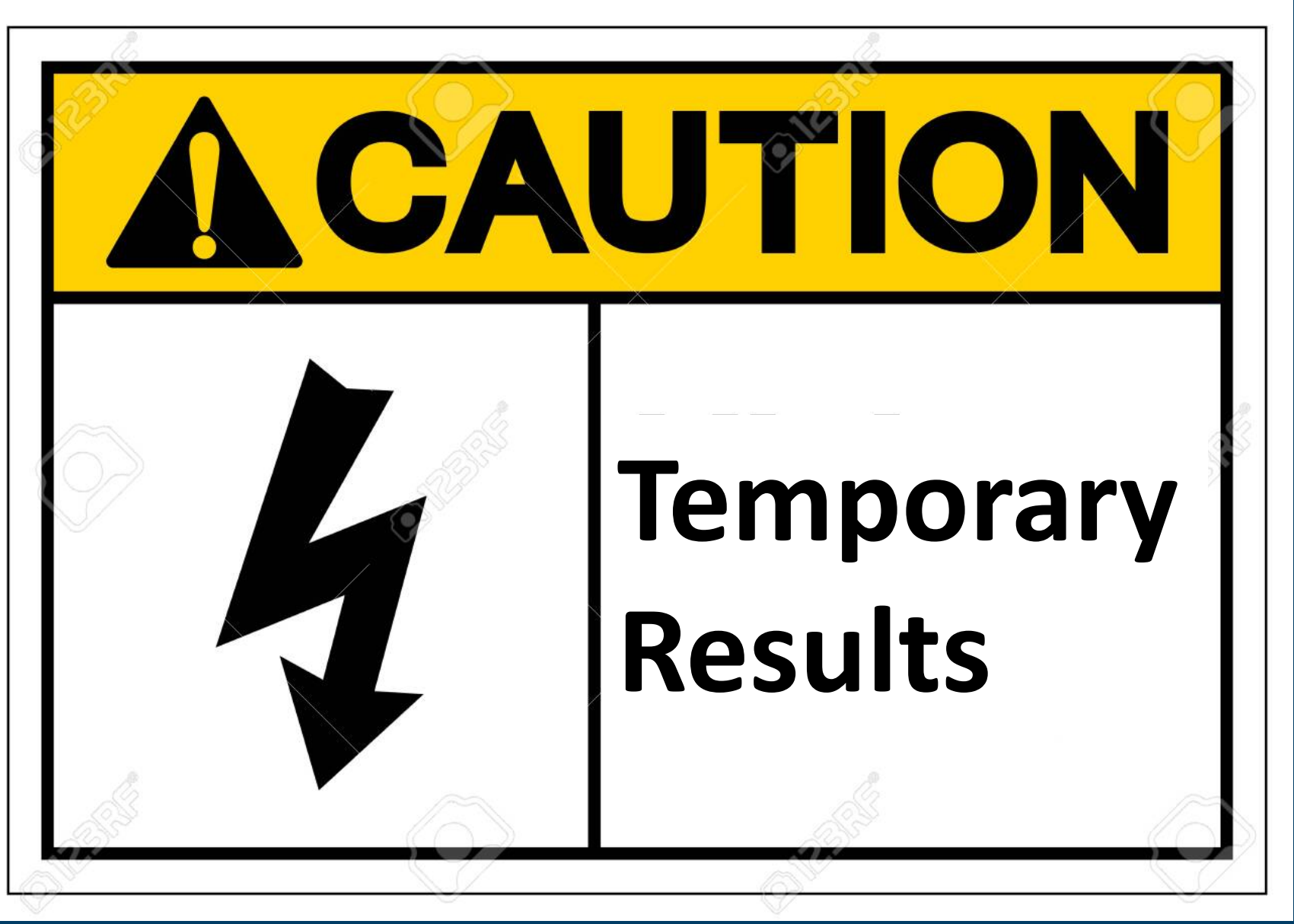


KPIs (Key Performance Indicators)

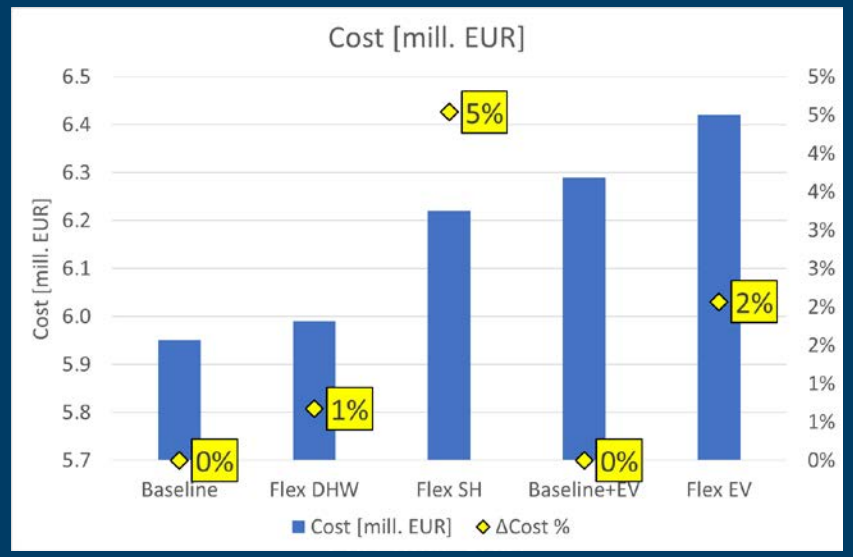
- Cost of energy (for the end-user)
- Energy use
- Peak load

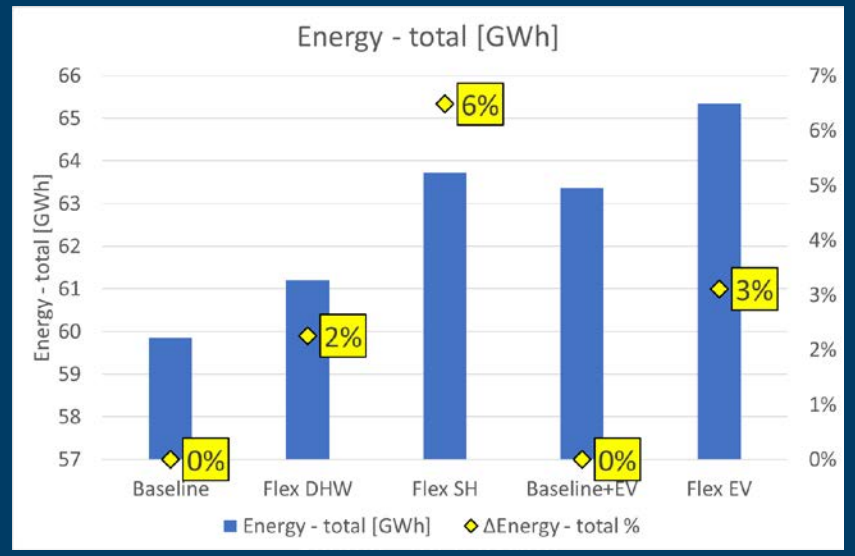
Energy price is assumed a good indicator of the "system stress" in general (combination of scarce/costly production + high demand + transmission/distribution bottlenecks), therefore the following should be good indicators of how much buildings (single and aggregated) contribute to the overall stress of the power system:

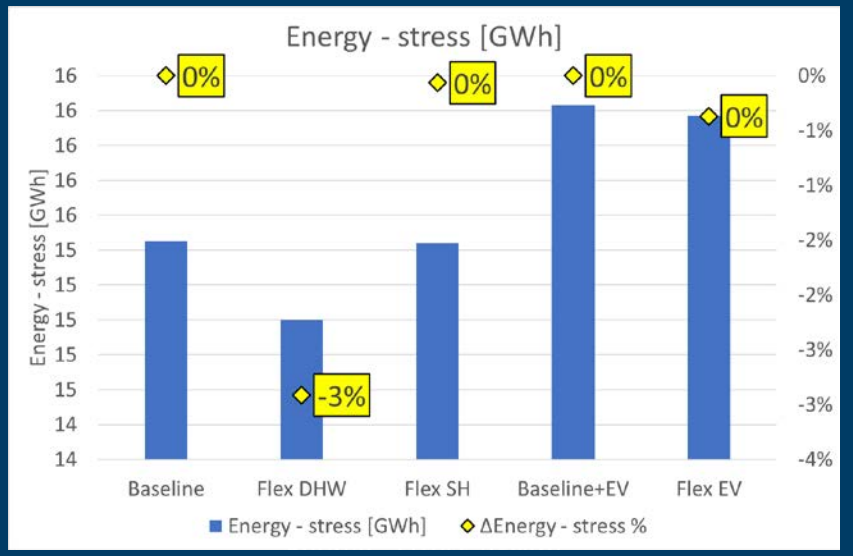
- Energy use during high-price hours
- Peak load during high-price hours

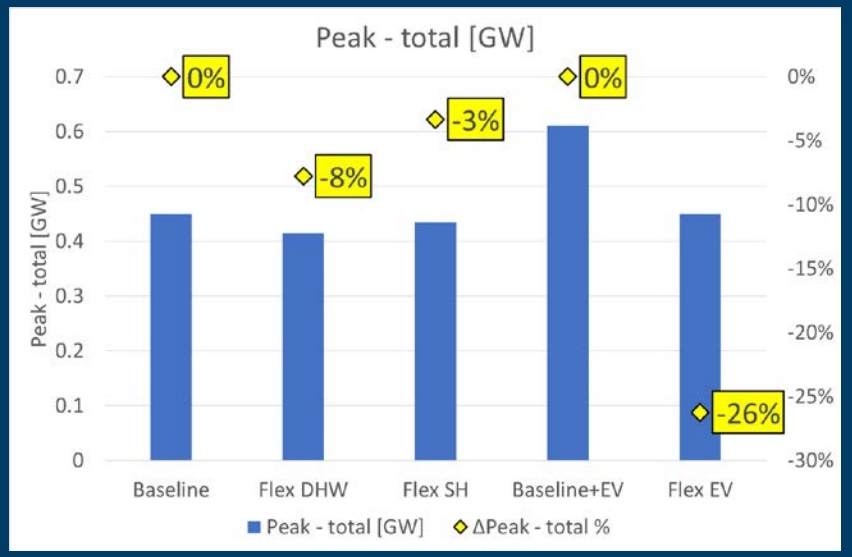

CAUTION
Temporary
Results

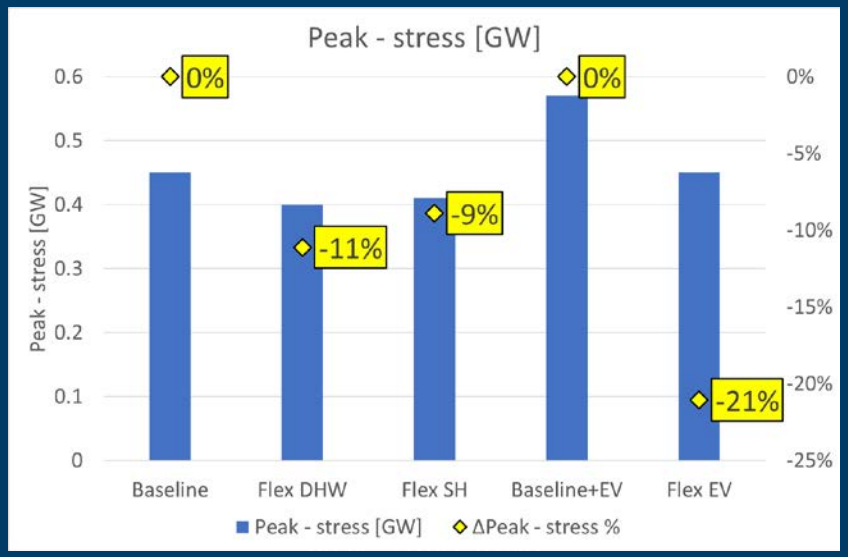
Results – KPIs cold week











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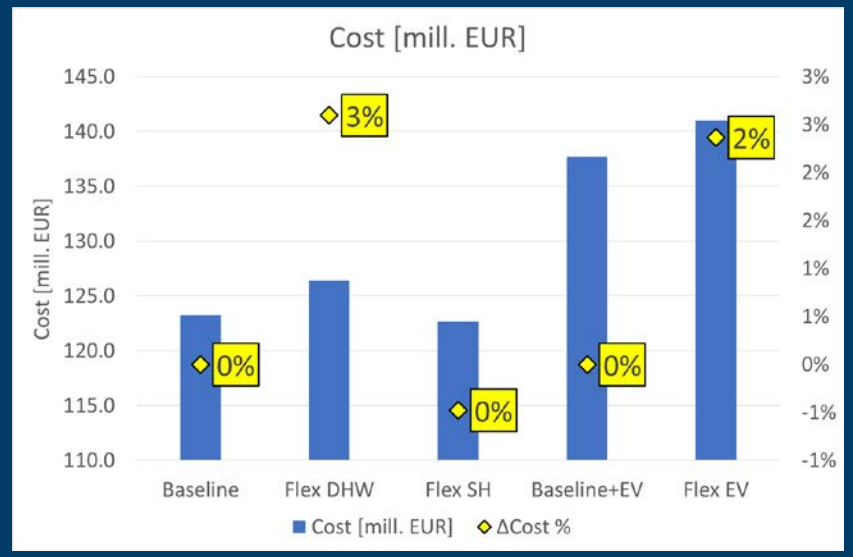
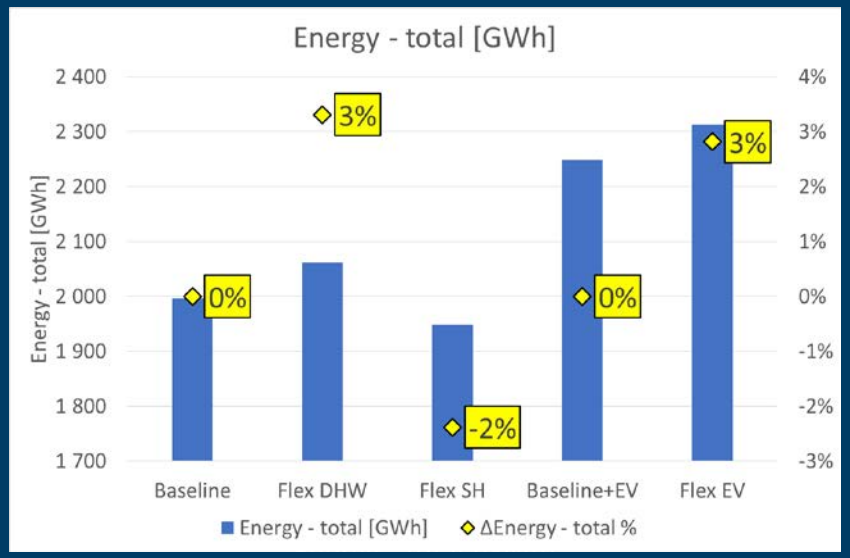
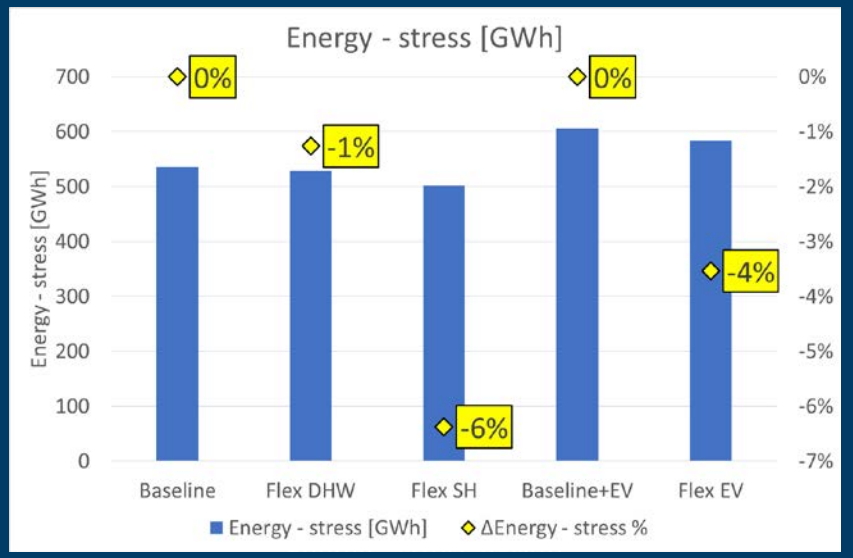
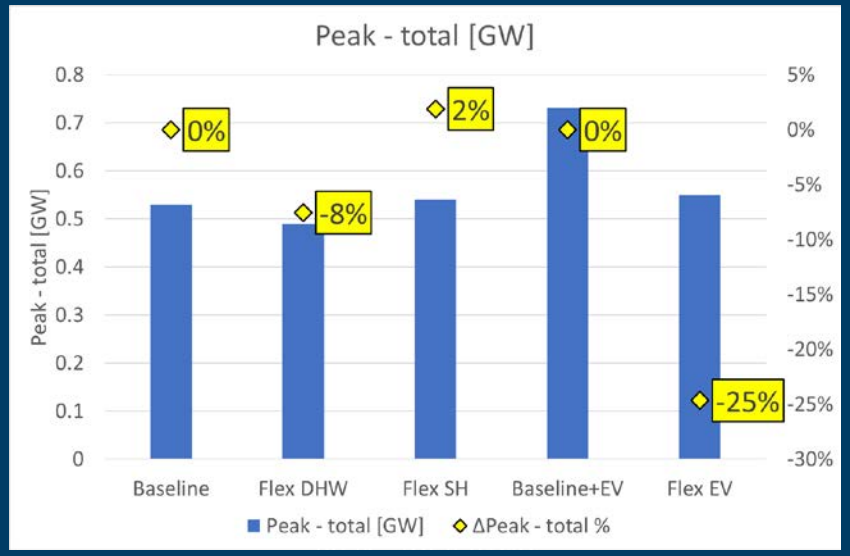
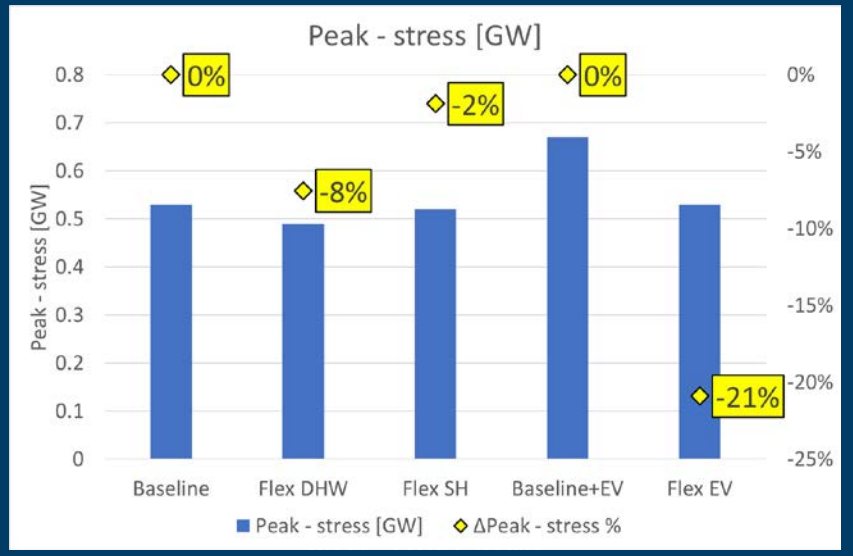
Results – KPIs year











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Conclusions and Questions to partners

CONCLUSIONS:

- Work in progress, results to be verified
- Peak reduction during "stress hours" always achieved BUT
- With higher energy use and cost
- Potential: EV (in large quantities) > DHW > Space Heating → surprise!

QUESTIONS TO PARTNERS:

1. What should flexibility be used for? → what "price signal" to follow?
2. How do we measure its effect? → what KPIs?

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70 år

1950-2020

Teknologi for et bedre samfunn