



Energy flexibility in buildings – what is the potential and how can it be realized?

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What is energy flexibility?

The Energy Flexibility of a building or neighborhood is the ability to manage its demand and generation according to local climate conditions, user needs and grid requirements.

- *Definition by the IEA EBC Annex 67 "Energy flexible buildings"*

Why do we need it?

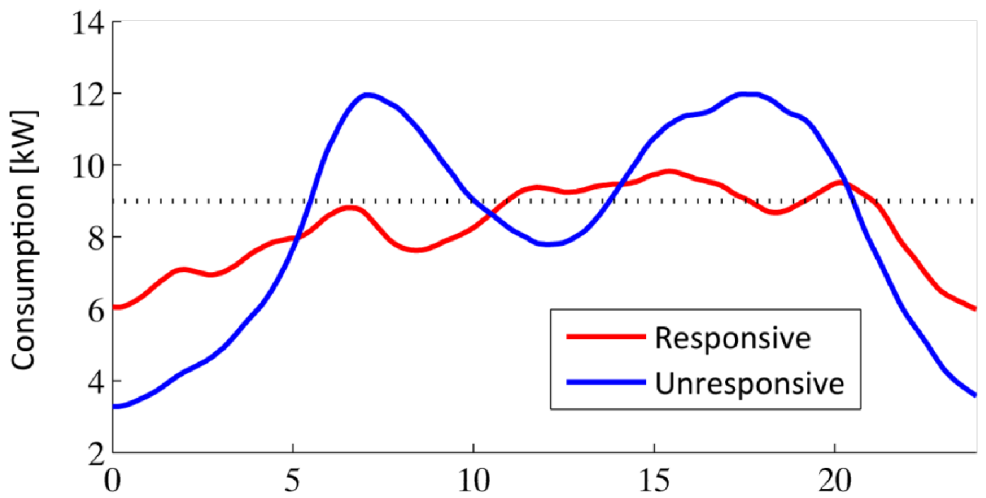
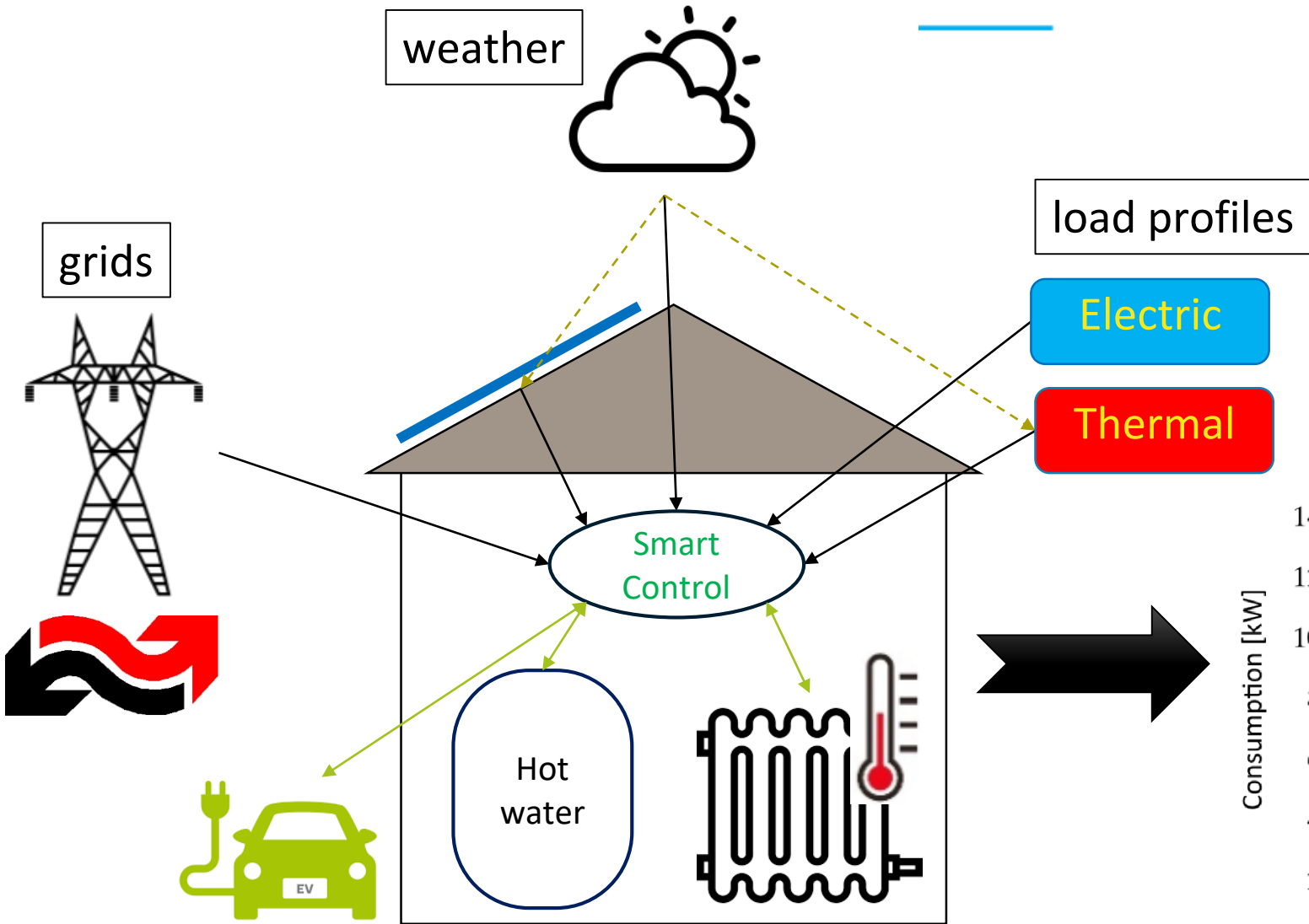
- Energy system, especially power system, traditionally with a supply side dominated by controllable energy sources (e.g. fossil fuels) and a demand side mostly inflexible, driven by user needs only
- As the supply becomes increasingly based on intermittent renewable sources (e.g. wind and solar), energy demand should become more flexible/controllable in order to "optimize" the overall energy system... with the help of digitalization

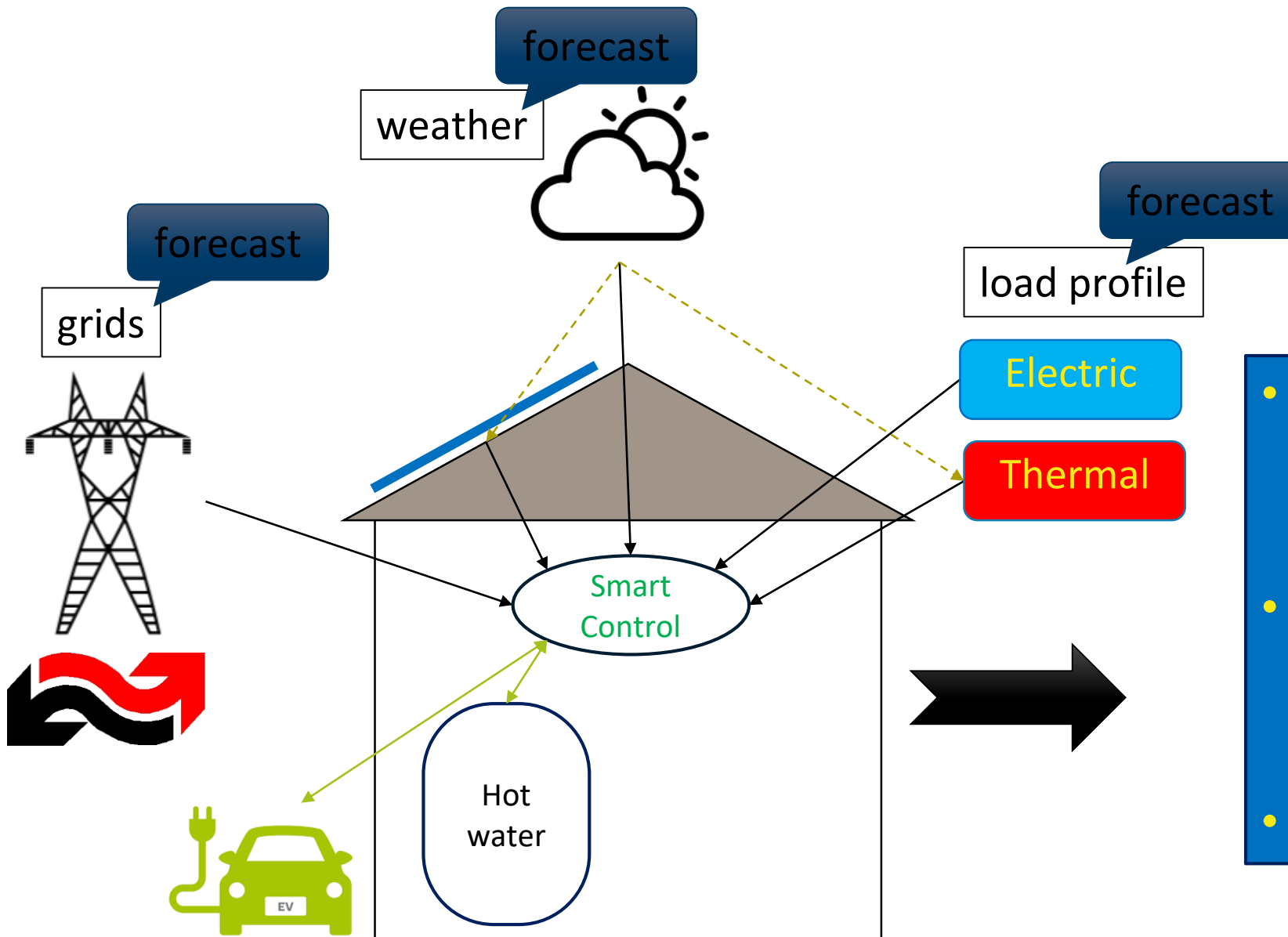
"Optimize" what?

Different goals, each contributing to a sustainable energy system:

- ❑ Better match between supply and demand allows:
 - Integrate more renewables, such as wind and solar
 - Minimize need for large scale storage
- ❑ Better utilization of infrastructure (grid):
 - Reduce peak load and congestion problems
 - Free capacity for other uses, such as EV or export
 - Avoid, reduce or postpone costly grid reinforcement
- ❑ Maximise self-consumption of local generation, such as PV

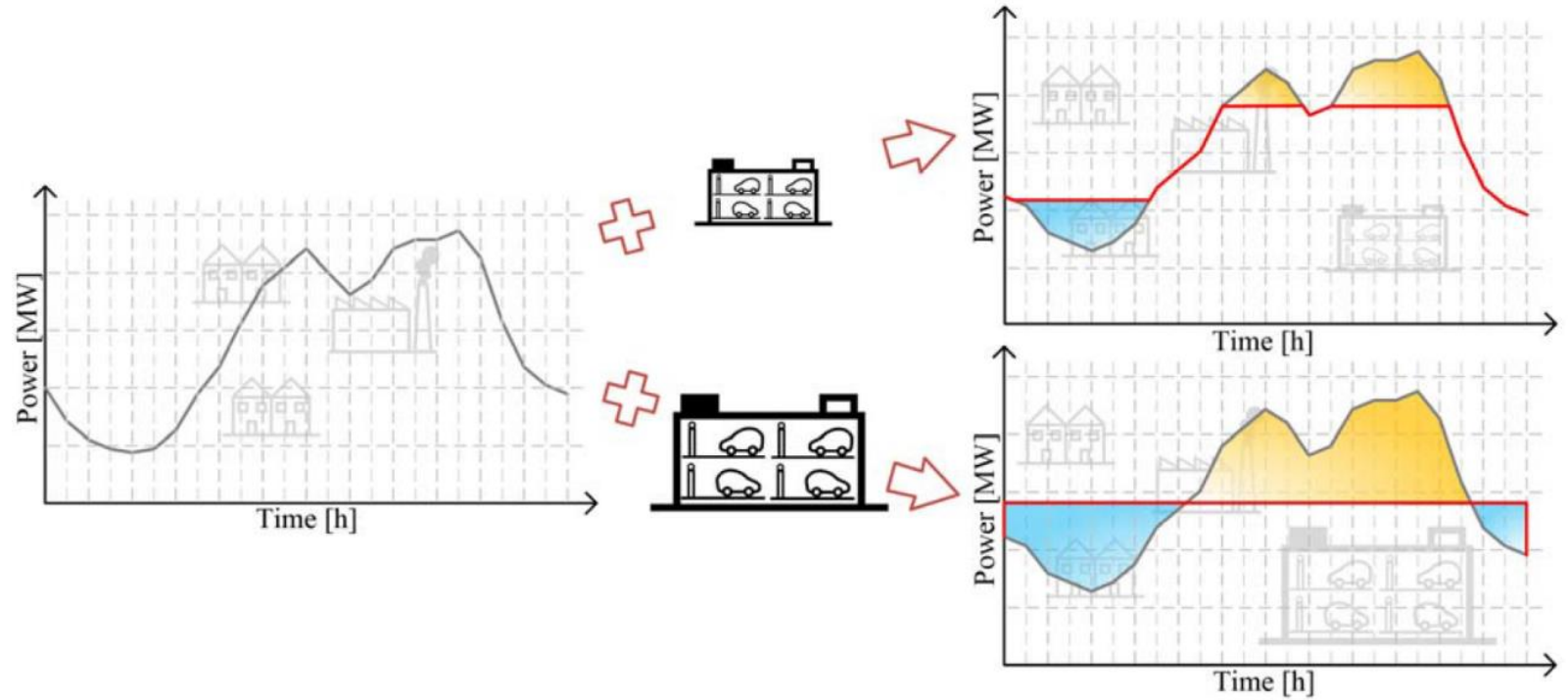
Energy flexibility in buildings



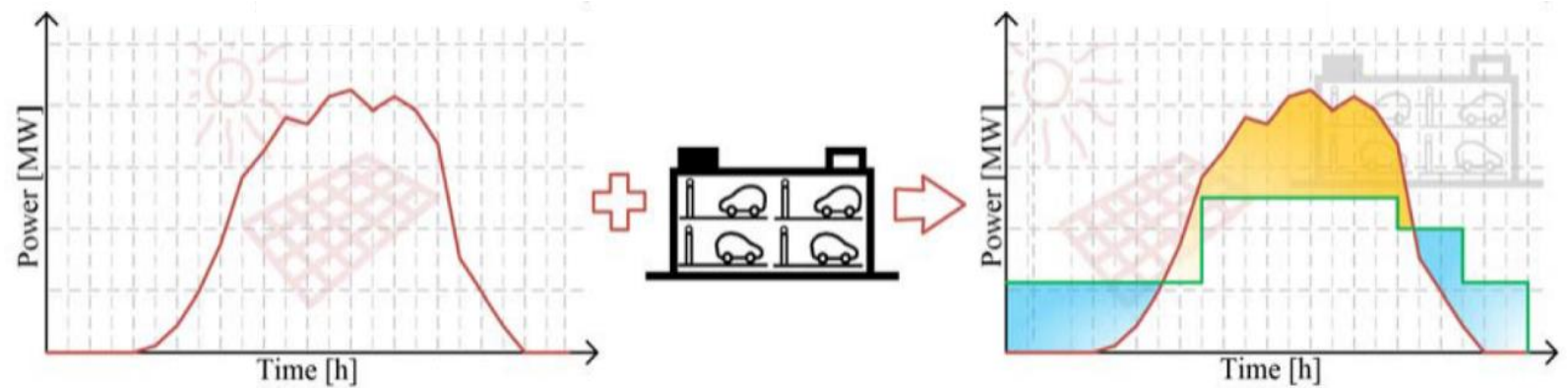


- If the flexible resource is independent of the building's load profile
- Load can be forecasted based on past observations and external factors, e.g. weather
- Control is affected by forecast

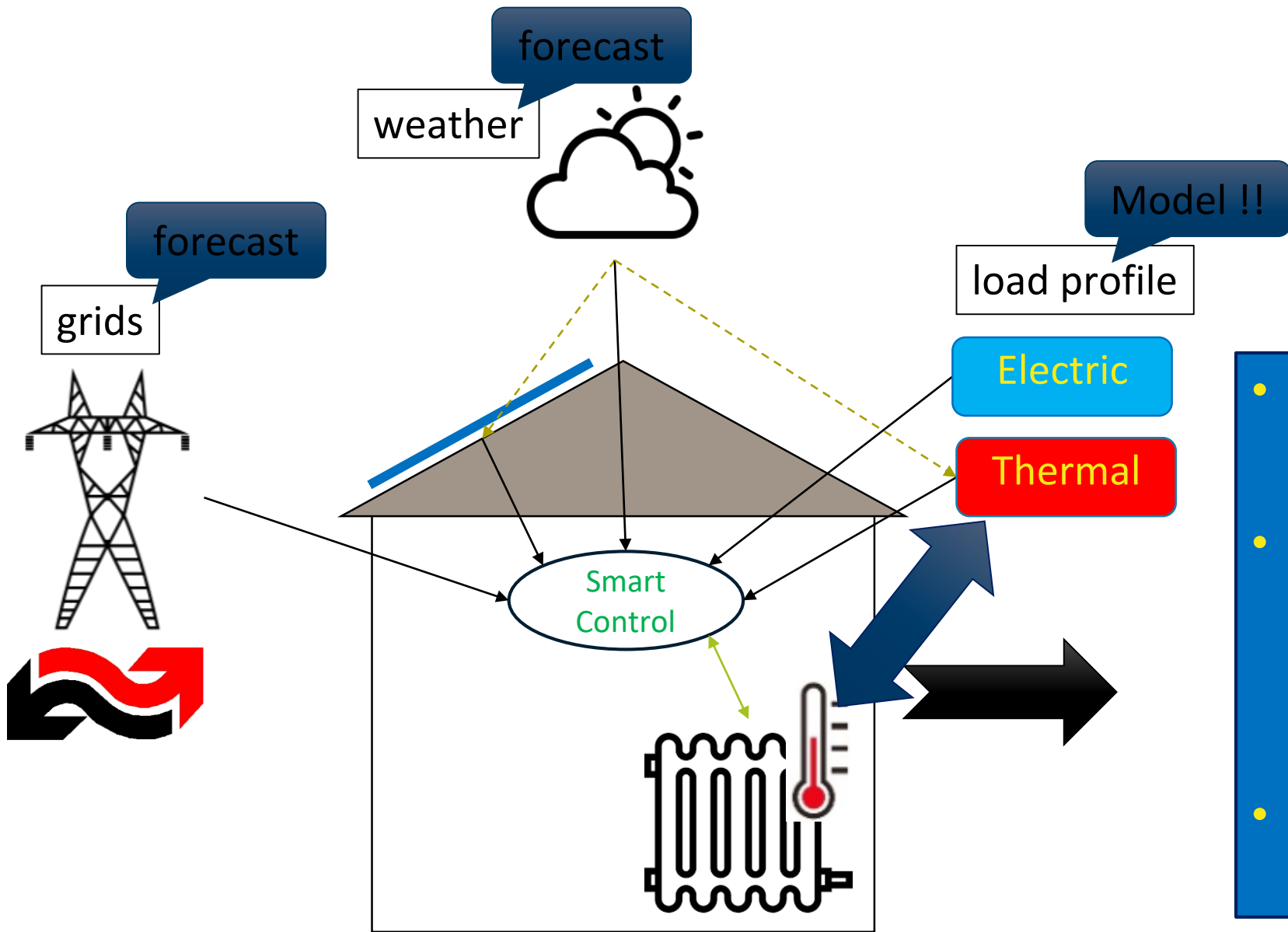
Consumption



Onsite generation



Source: Damiano A. et al. (2018) Vehicle-to-Grid Technology: State-of-the-Art and Future Scenarios, *Journal of Energy and Power Engineering*



- If the flexible resource is the building's load profile itself
- Load must be modelled together with building's internal "states", e.g. indoor temperature
- Control is affected by forecast & model used!

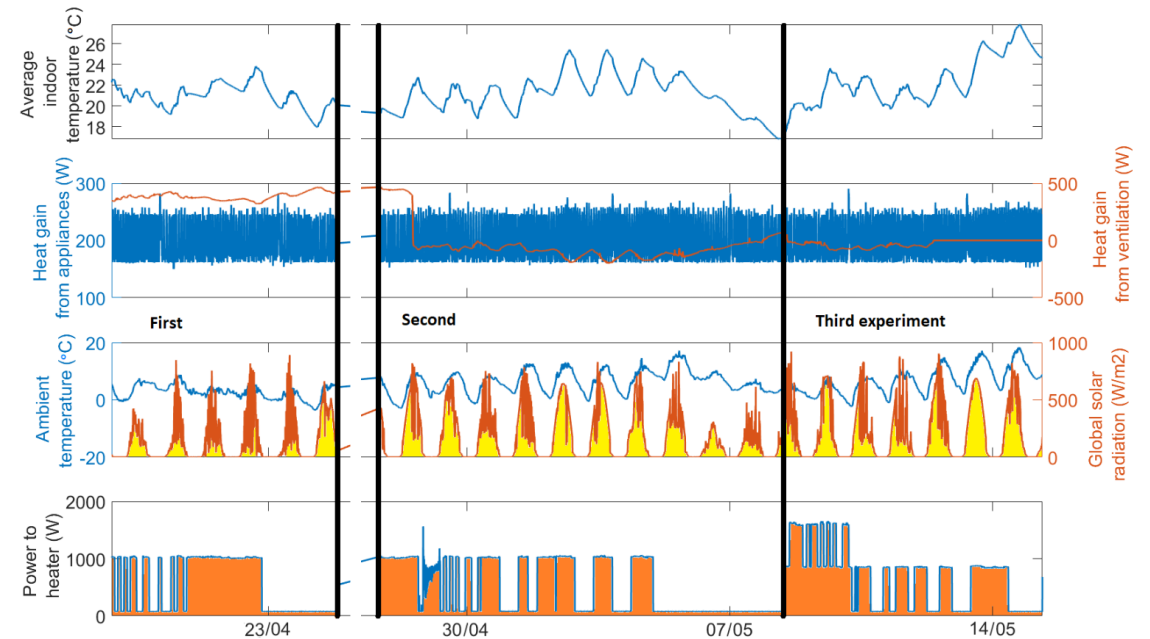
Zero Emission Building – Living Lab

Passive house, PV, sensors, people

Trondheim, Mid-Norway



Control-oriented modeling is acknowledged as the most demanding part in the design of a Model Predictive Control (MPC)



Source: Vogler-Finck P. *et al.* (2017) A dataset to support dynamical modelling of the thermal dynamics of a super-insulated building.

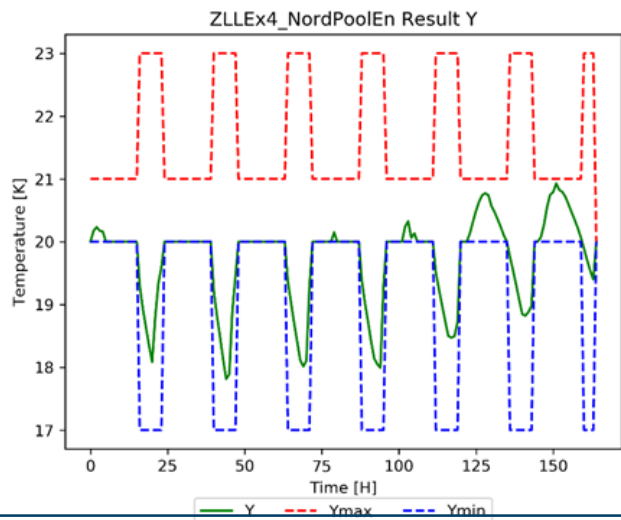
<http://dx.doi.org/10.5281/zenodo.1034819>

First experiments with MPC

Control driven by temperature "comfort range"...

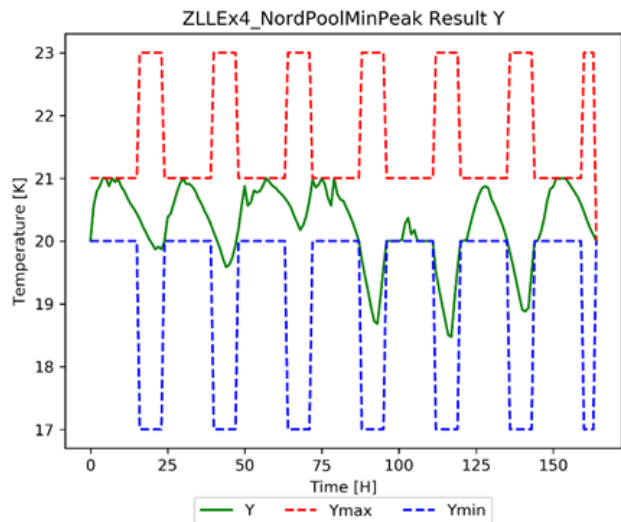
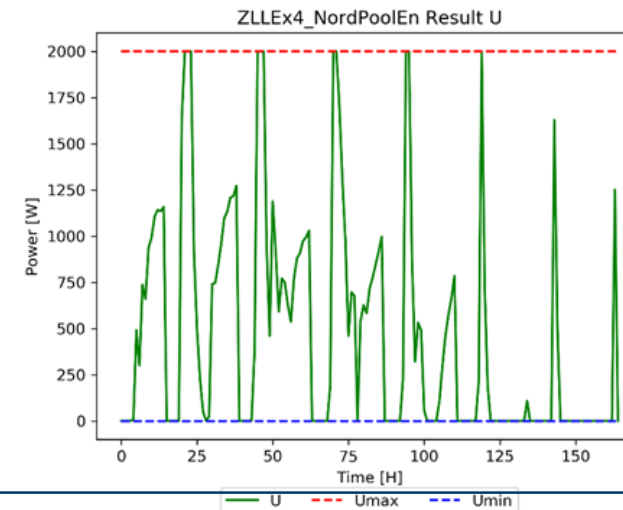


...leads to changes in energy demand profile

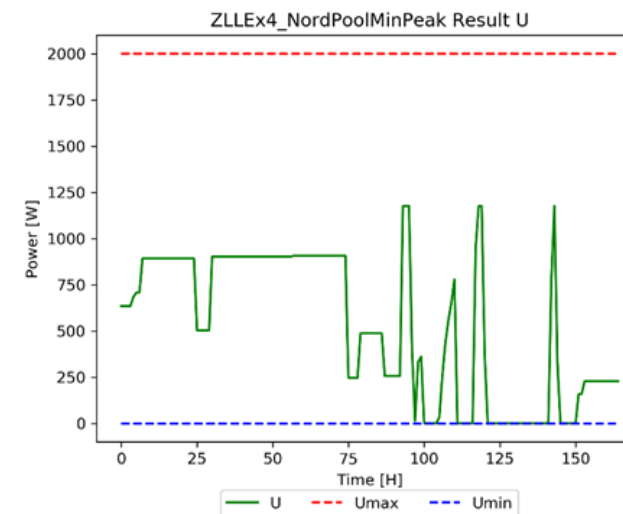


MPC target

Example 1:
Minimize energy



Example 2:
Minimize peak power



Source: Work in progress (Walnum H.T., SINTEF)

Flexibility in a smart energy system

Source: Madsen H. *et al.* (2015) Integrated energy systems; aggregation, forecasting, and control, *DTU International Energy Report*

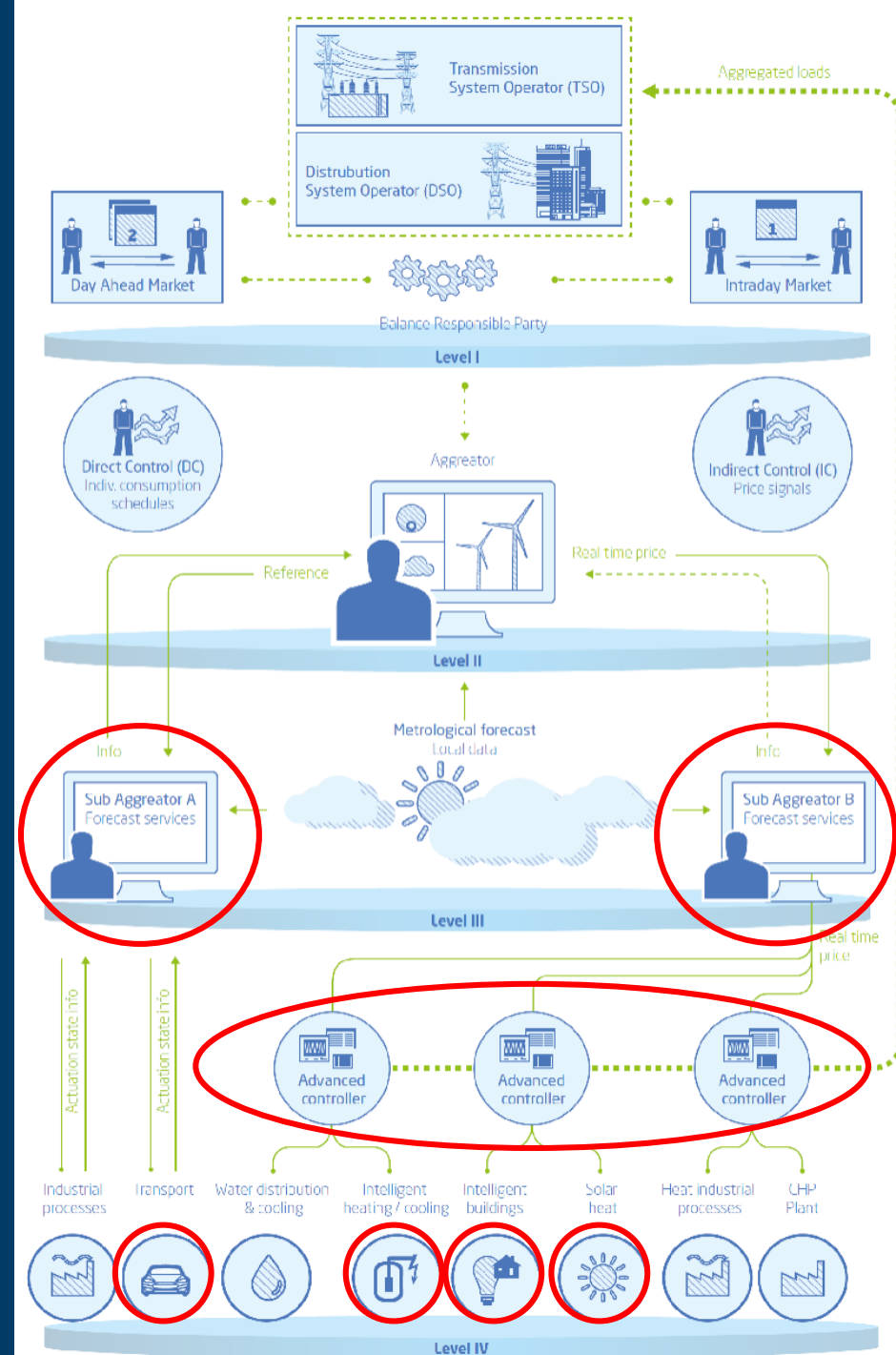
Market →

Aggregator(s)
Market pooling →

Sub-Aggregator(s)
Area specific →

Requires adequate
modeling and control

Distributed Energy Resources →





Technology for a better society