Balancing urban energy supply and demand through AI and physics-based modelling

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February 7 2020

Energy transition

Energy supply and demand

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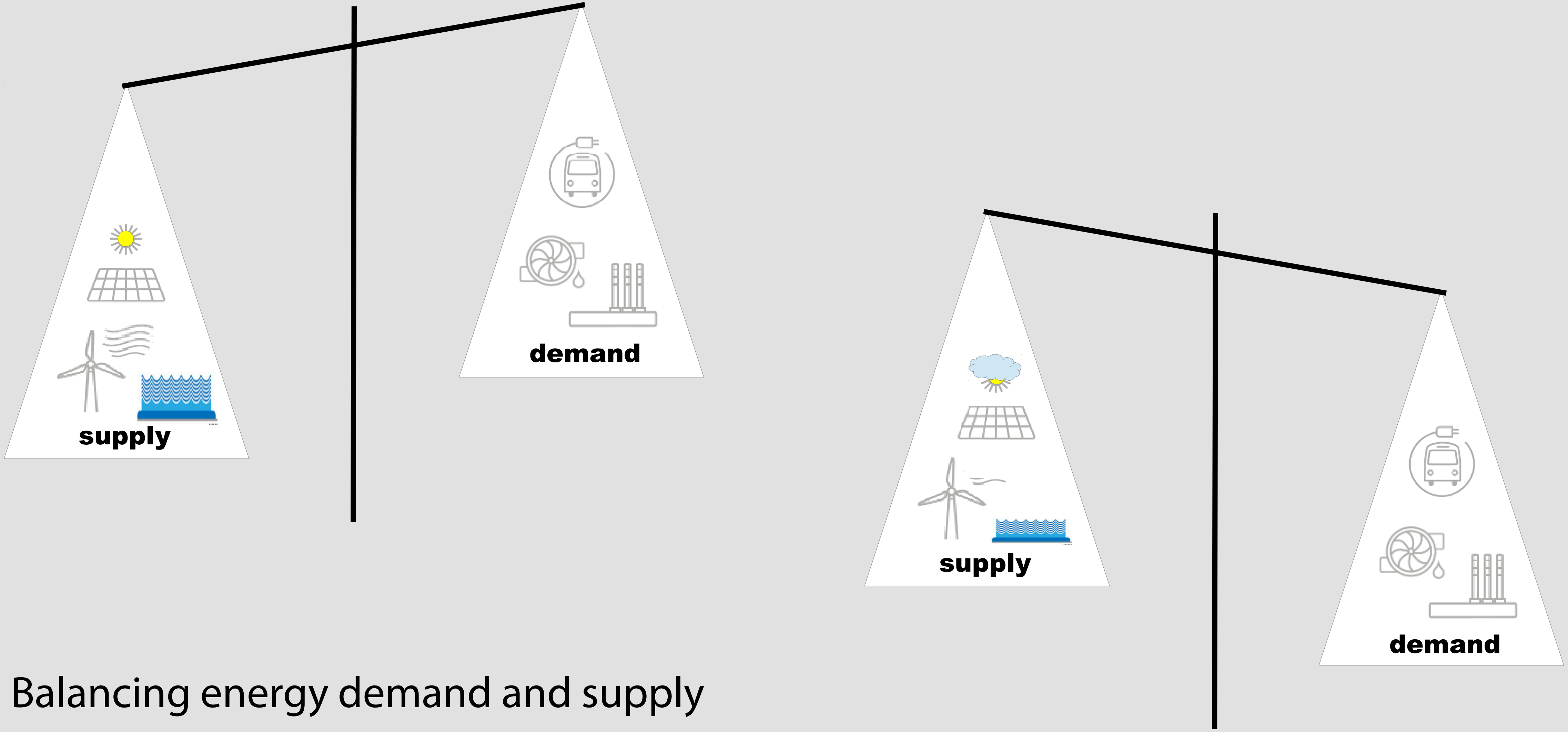


Balancing energy demand and supply

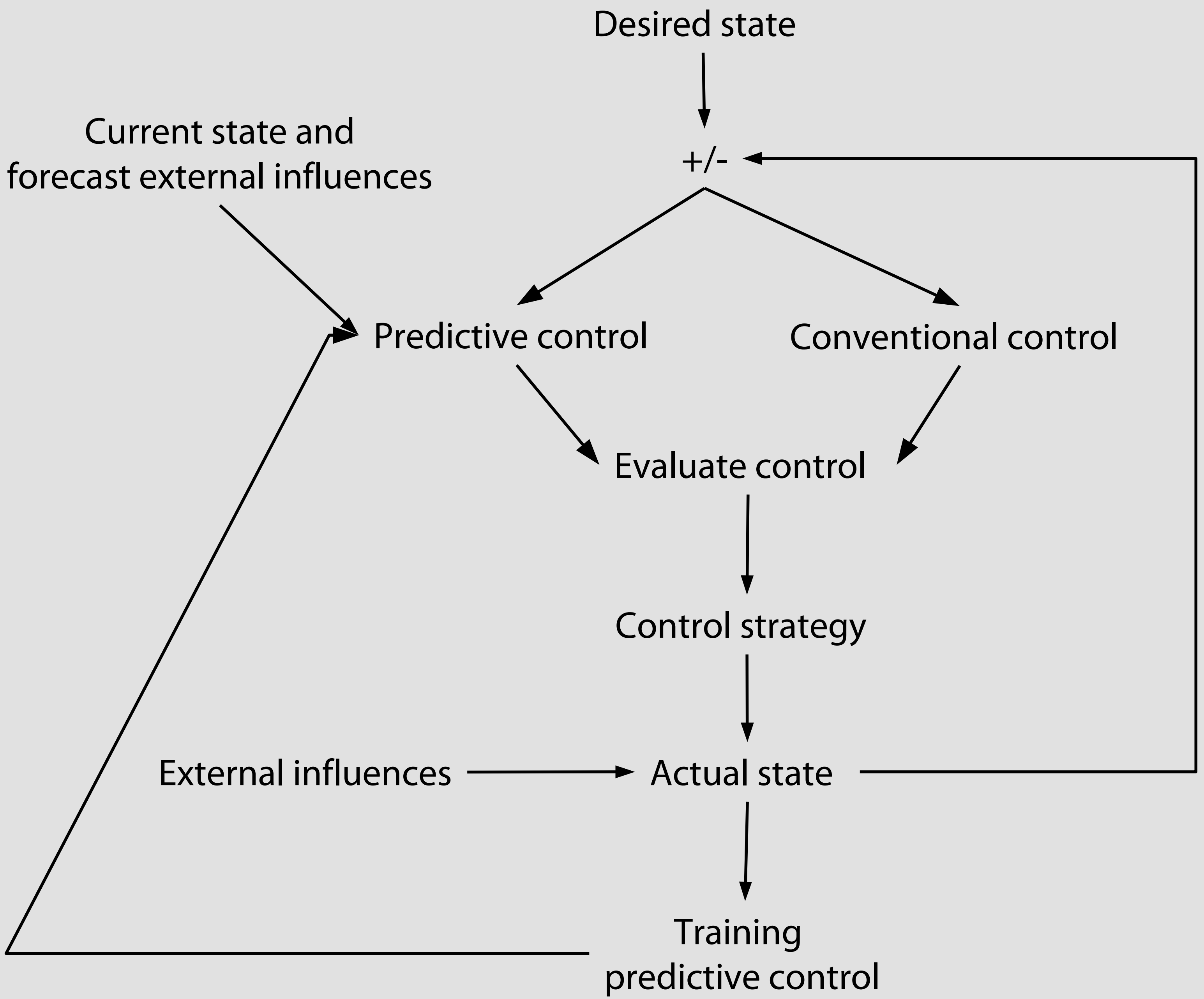
→ optimization problem

Optimization through anticipation

Control strategies based on predicted supply and demand

Data availability

→ physics-based models



Illustrative example: simulation of a residential application

- Air-to-water heat pump

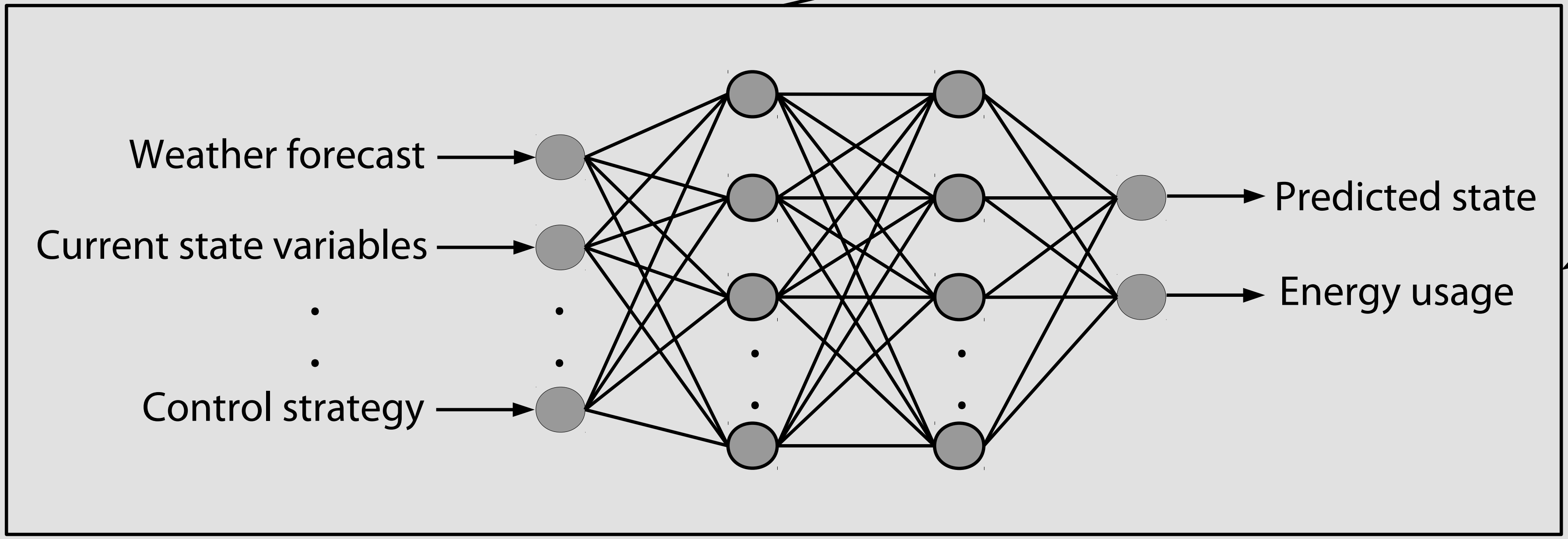
  air temperature → heat supply

- Floor heating system

  mass → inertial effect on demand

Dynamic energy model (TRNSYS/TRNFlow)

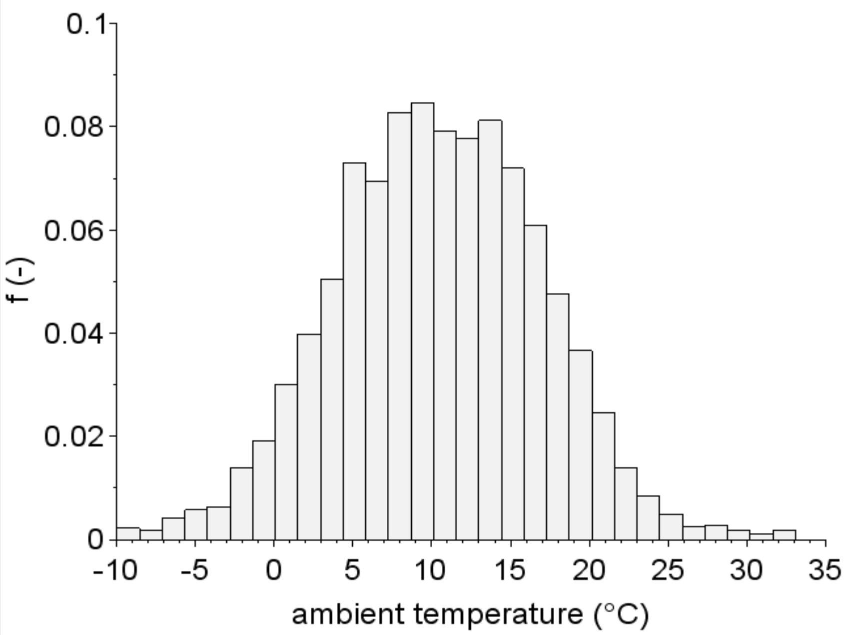
dwelling with heat pump and floor heating system and semi-stochastic user behaviour

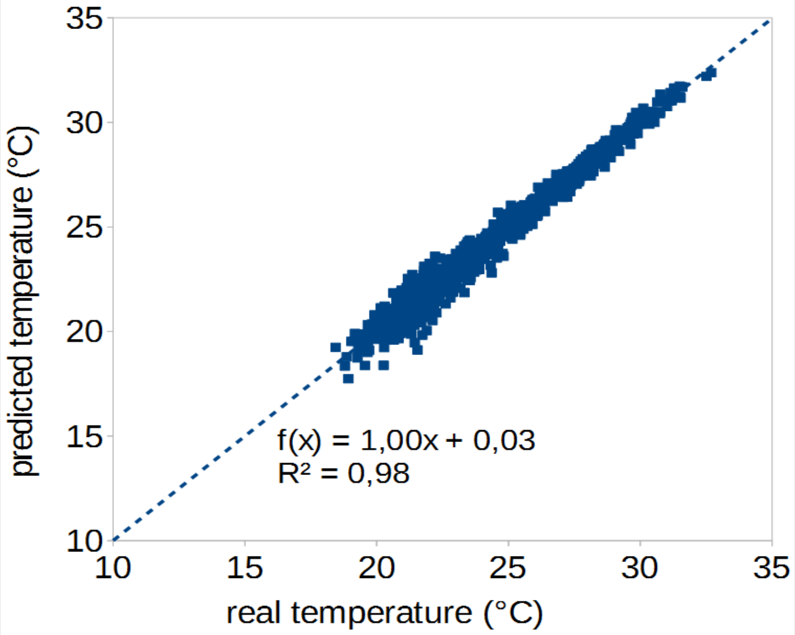


Simulation test case 1

Balancing supply and demand of heat through predictive control using a neural network

→ predicting the effect of a strategy



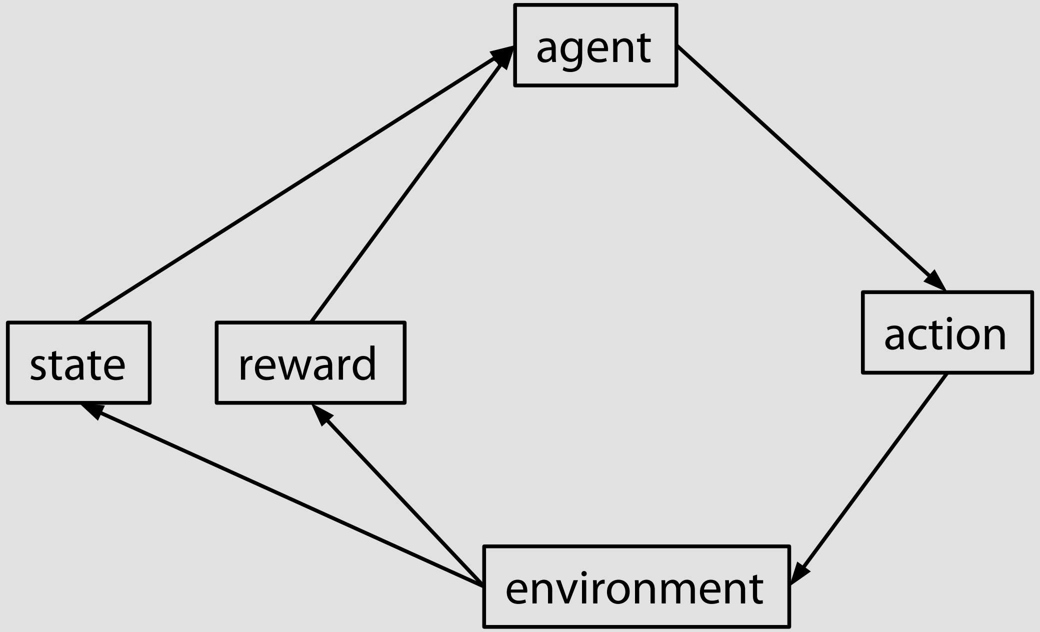


Type of control	Time control	Time control	Constant	Self learning
Power	100% P_0	40% P_0	40% P_0	40% P_0
Energy usage (w.r.t. 100% P_0)	100 %	78 %	93 %	**83 %**
Probability of fall below set point	6 %	12 %	6 %	**6 %**
Average fall below set point	0.7 °C	1.1 °C	0.6 °C	**0.6 °C**
Maximum fall below set point	3.7 °C	5.1 °C	2.9 °C	**2.9 °C**

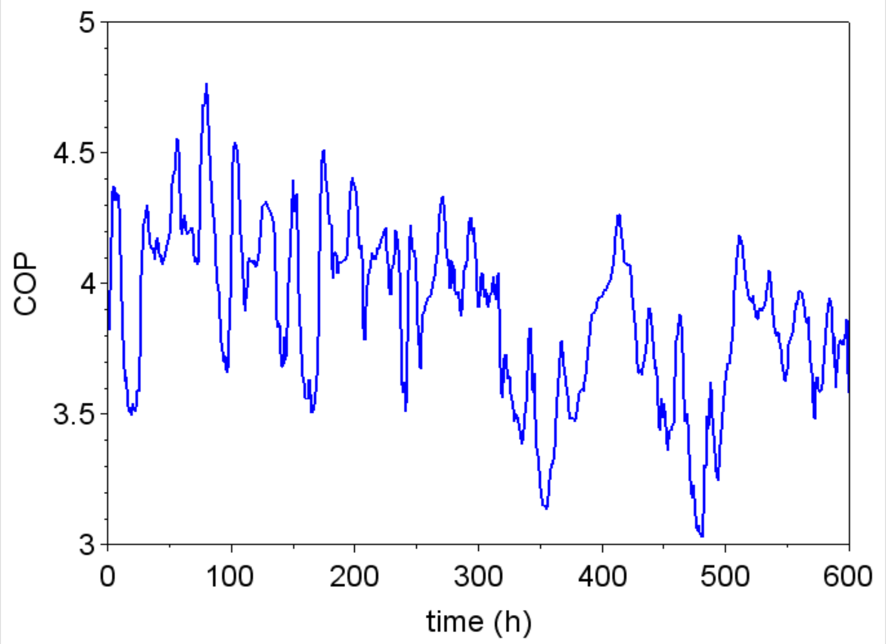
Simulation test case 2

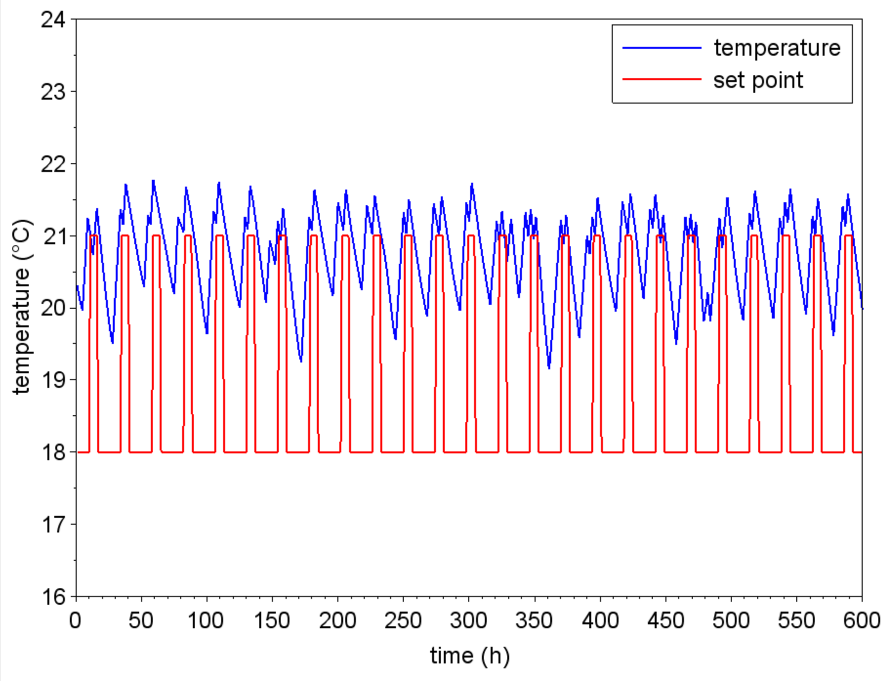
Balancing supply and demand of heat through predictive control using Q-learning

→ learning the optimal strategy



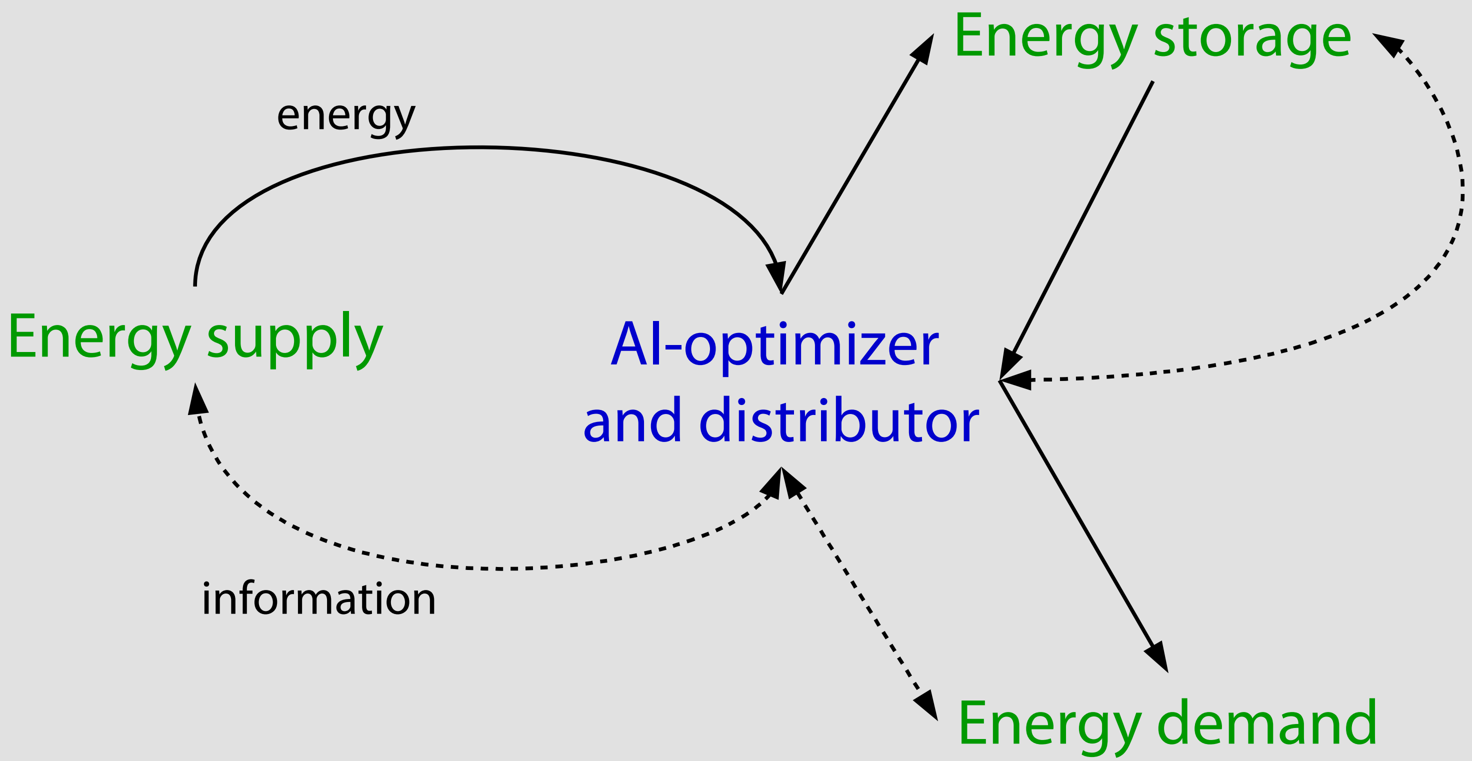
$$Q(S,A) \leftarrow Q(S,A) + \alpha\left(R + \gamma \max_{a'} Q(S',a') - Q(S,A)\right)$$





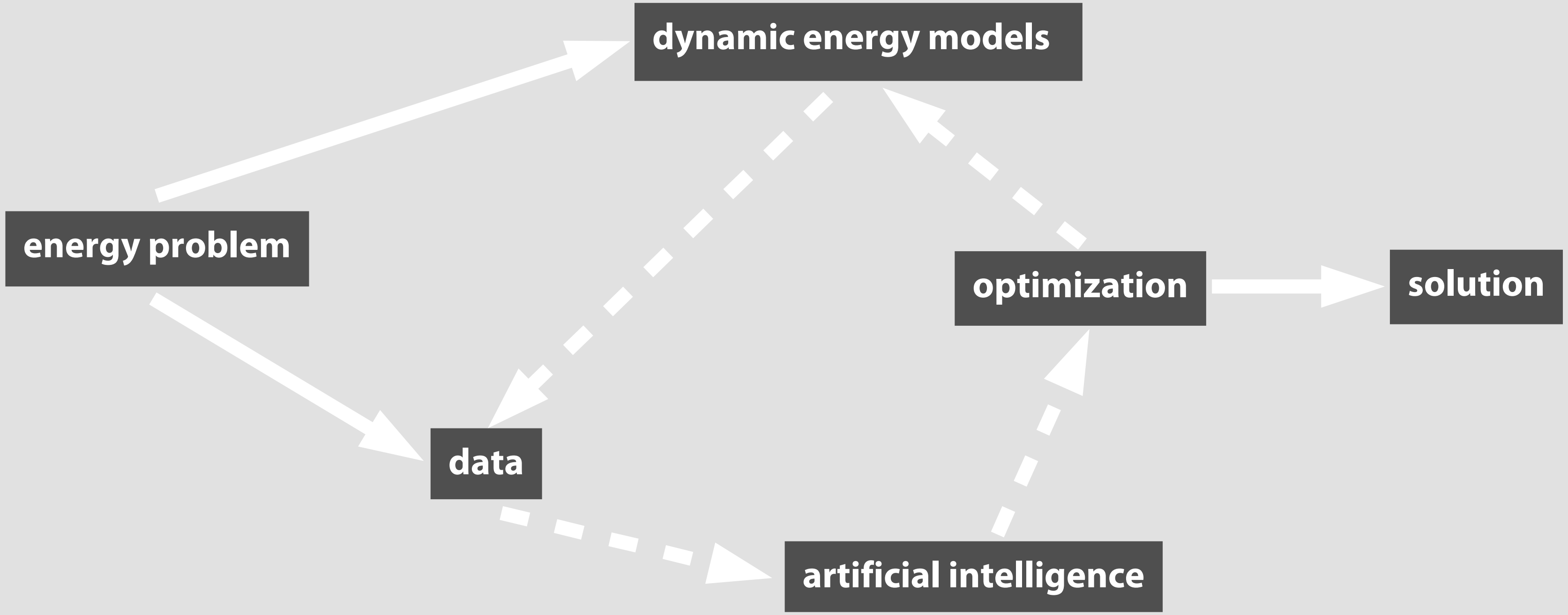
At urban scale

- Heat/cold storage
- Batteries
- Scheduling of demand
- ...



Hybrid approach

- Data availability
- Physics-based models
  - Filling in the gaps
  - Validation with available data
- Interpretability of data through physics



Summary

- AI-control algorithms can be used to balance energy supply and demand
    - Artificial neural networks
    - Q-learning
- Physics-based models can be used to develop and test AI-control algorithms
- Physics-based models are very useful when data availability is lacking or incomplete

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The solid reputation of Peutz is based on the quality of its consultancy work, with the use of advanced measuring and computing techniques and the availability of its own laboratories. Peutz' main clients are found in various industries, government agencies, and institutions in the cultural, health care and the education sectors.

Peutz operates laboratories for acoustics, building physics, wind technology and fire safety. These laboratories are used for specific project-related research as well as fundamental research studies. Moreover the laboratories are accredited for various standardised measurements. Customised solutions are created by linking laboratory research, field measurements, numerical simulations, data science and AI and expert knowledge. From the simple but efficient to the distinctive, daring and innovative.

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