technische universität dortmund

control and cyberphysical systems

Sustainable and Reliable Predictive Control Schemes for Geothermal Systems

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Motivation

- Reducing carbon footprint of building climate systems
- Using natural and ubiquitous presence of heat and cold in e.g.: European climate zone

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- Deploying underground thermal energy storage with large heat capacity saving heat of summer for winter and vice versa

Aim

- Physically Informed Neural Networks
- Covering high-inertia effects with frequency domain
- Focus of control scheme:
  - Sustainable and dynamic exploitation of underground
  - Reducing redundant action of classical building climate systems

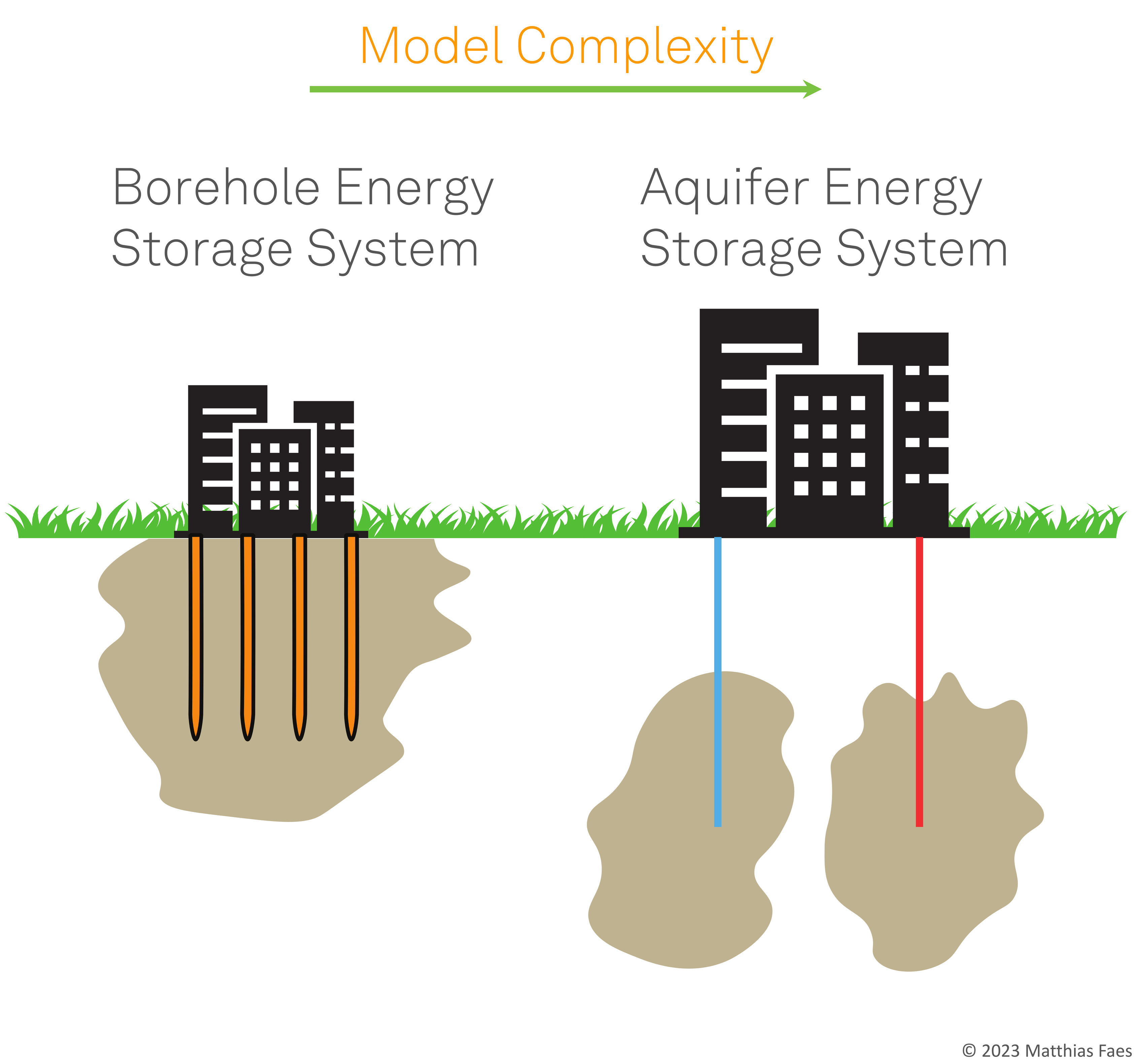
Underground Thermal Energy Storage Systems

Borehole Thermal Energy Storage

- Closed water circle / no groundwater pumped
- U-Shaped piping in boreholes
- Depths: up to $15m$
- Heat exchange process: Conduction

Aquifer Thermal Energy Storage

- Open water circle
- Seasonal injection and extraction of groundwater
- Depths: up to $200m$
- Heat exchange process: Advection



Challenges

- Data Scarcity & Uncertainty Quantification of Underground Temperature Distribution
- Robust / Stochastic Nonlinear Mixed-Integer Programming

$$\min J(x,u,d)$$
$$\text{s.t.: } x(t+1) = \begin{cases} f_1(x,u,d) & \text{if } \delta_1(t) = 1 \\ \vdots & \\ f_n(x,u,d) & \text{if } \delta_n(t) = 1 \end{cases}$$
$$\delta_i(t) \in \mathbb{Z}, x(t) \in \mathbb{X}, u(t) \in \mathcal{U}$$