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TEMPO

Integrated innovations in the Windsbach DH network– decentralized buffers and CHP optimization

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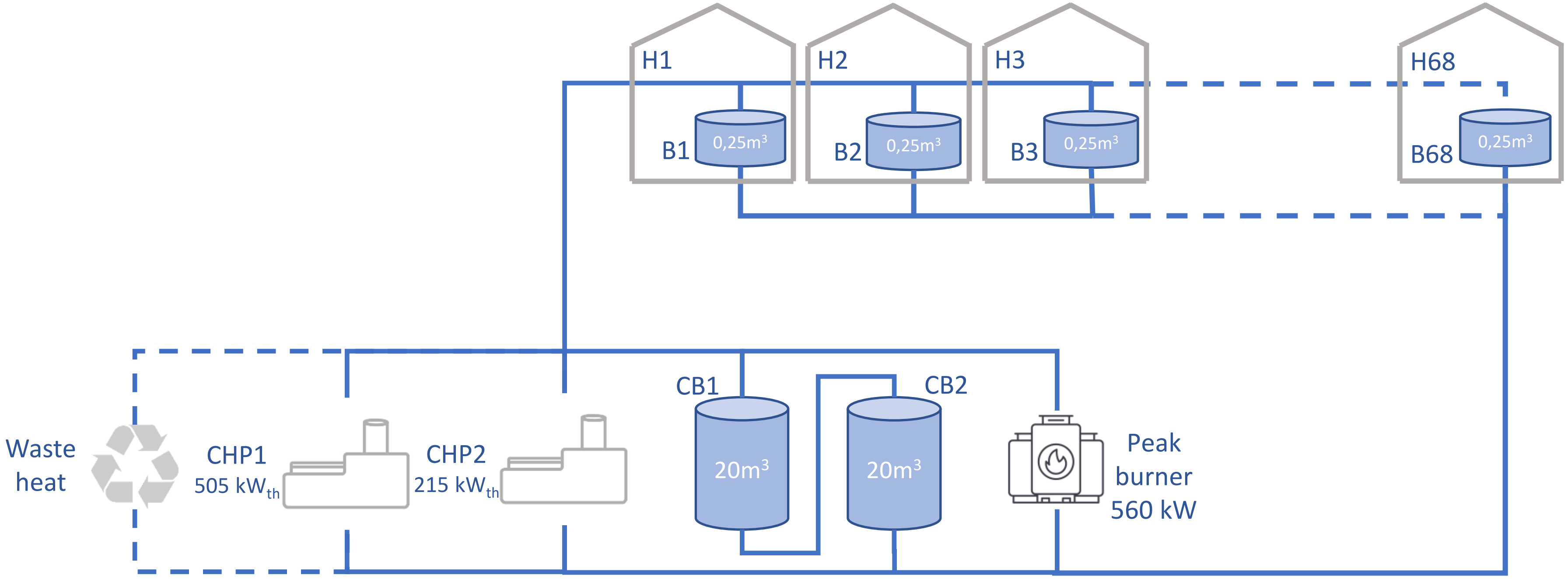
TEMPO workshop

28 January 2021

Enerpipe demonstrator

- DH network overview
- CHP optimization
- Smart charging decentralized buffers
- Conclusion & next steps

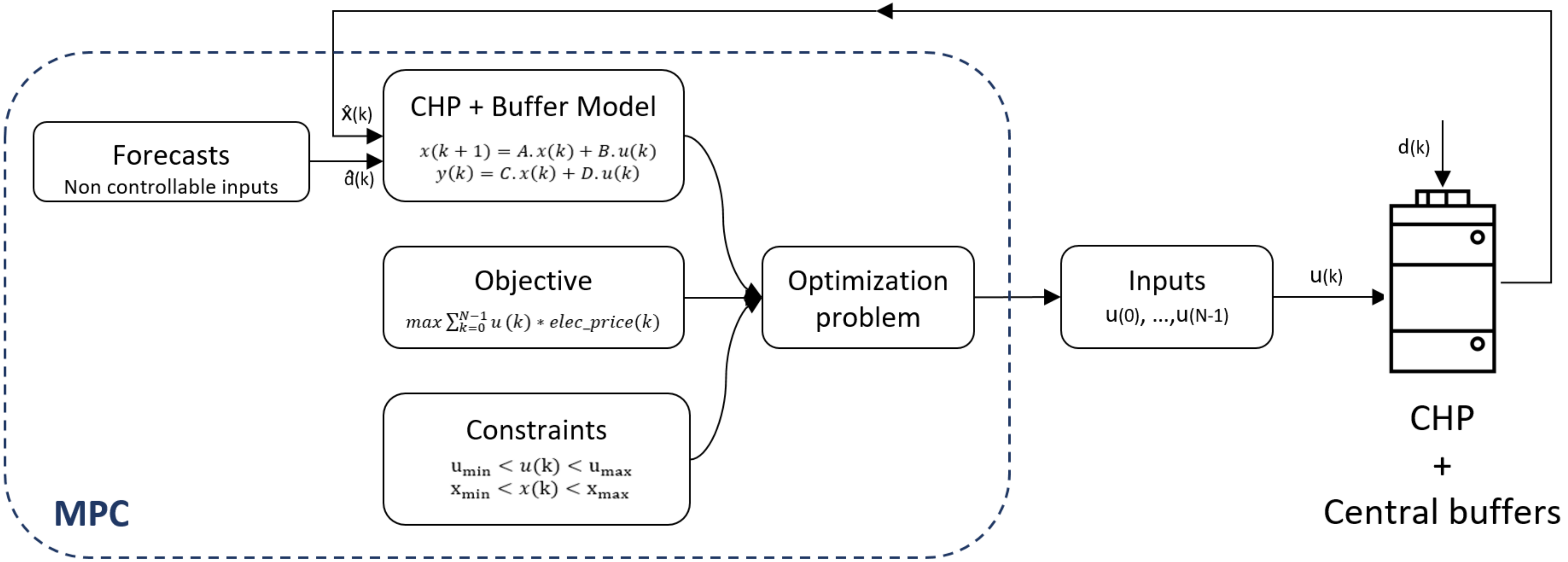
Enerpipe demonstrator



CHP Optimization

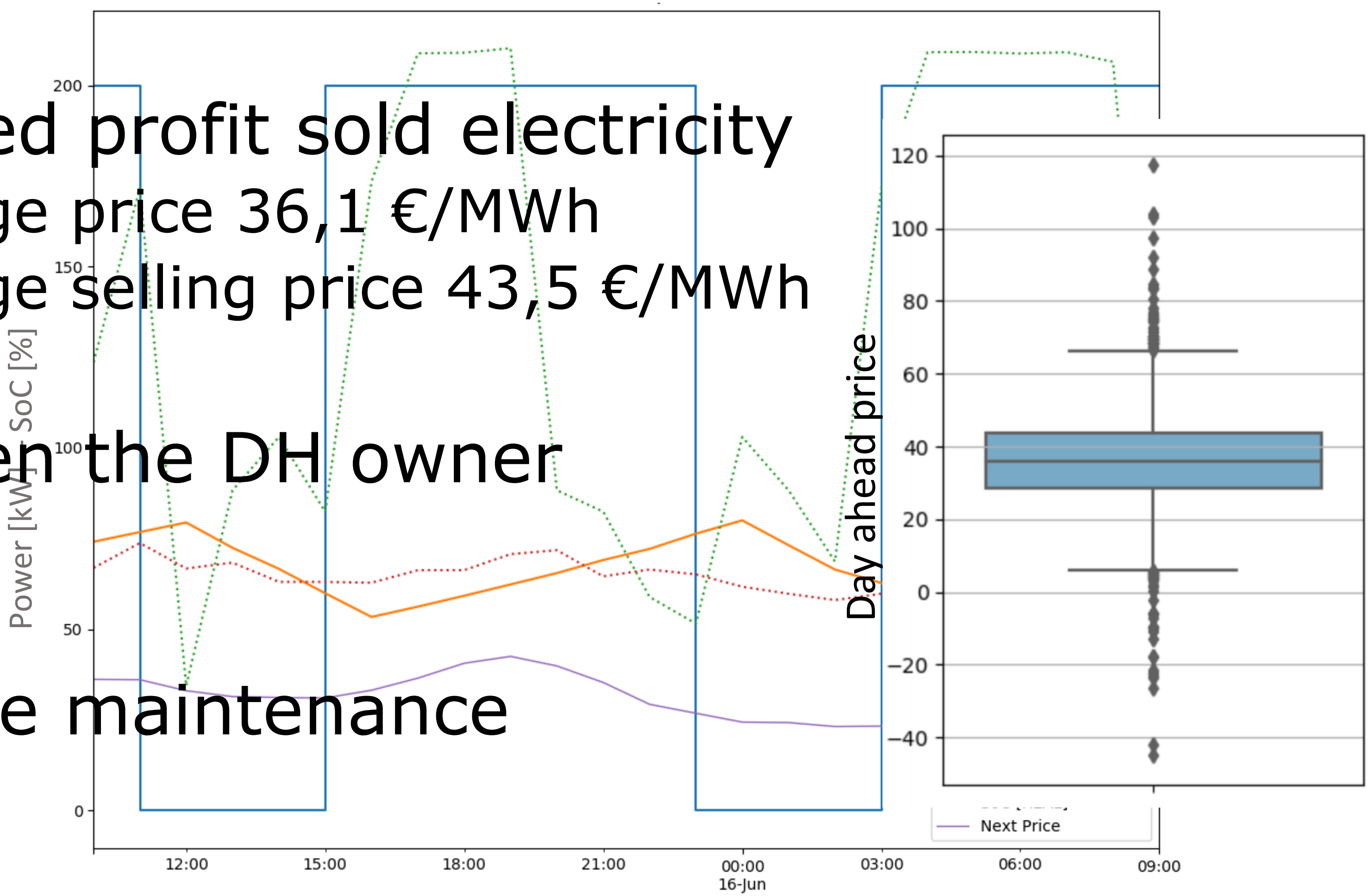
- CHP generates heat and electricity
  - Heat: fixed price
  - Electricity: real-time pricing (RTP)
- Goal
  - Operate CHP when electricity price is high
- How
  - Model predictive control

Model Predictive Control



Results

- Increased profit sold electricity
  - Average price 36,1 €/MWh
  - Average selling price 43,5 €/MWh
- Unburden the DH owner
- Decrease maintenance

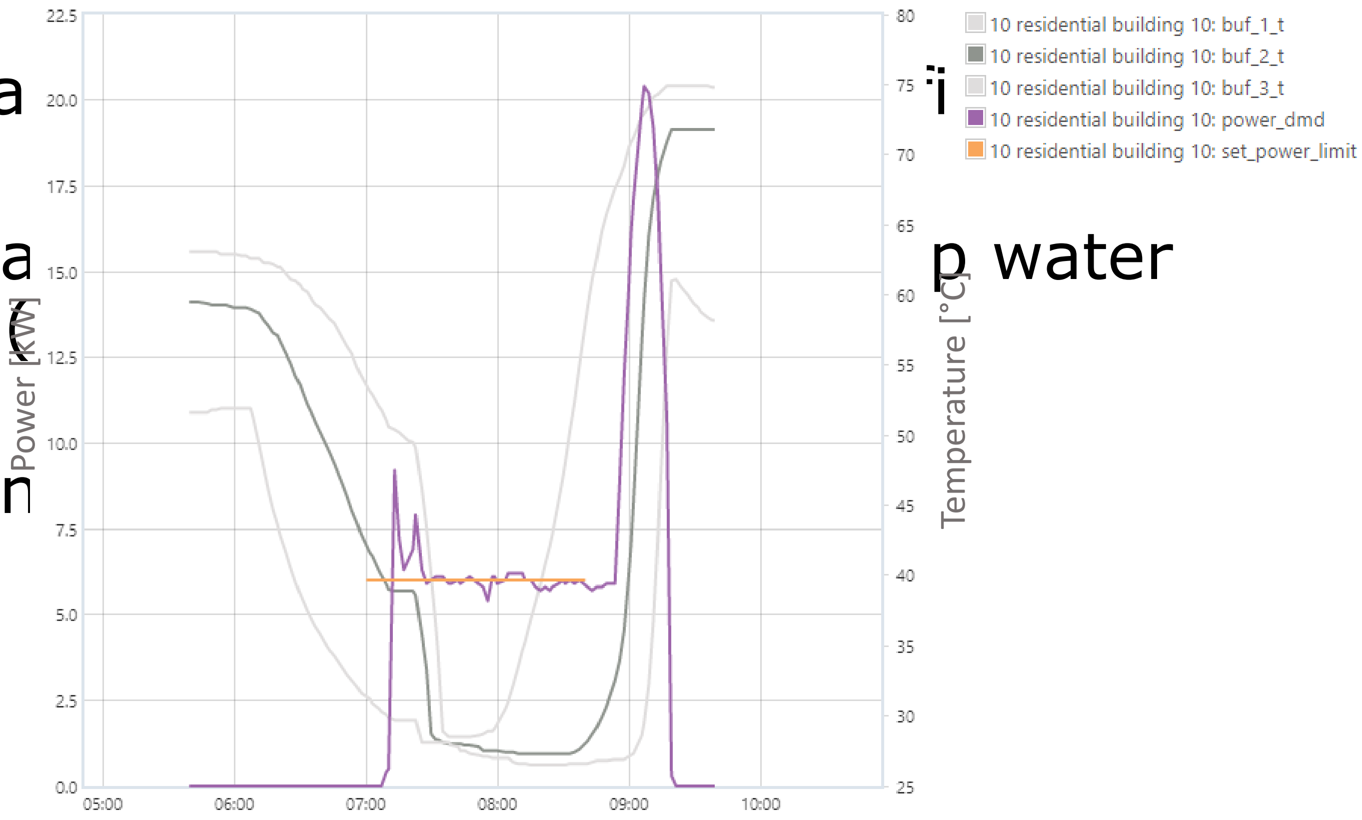


Smart buffer charging

- Conventional charging based on temperatures
  - Peak demand simultaneous charging
- Goal
  - Smart charging to reduce peak load
- How
  - Reinforcement learning approach (data-driven)

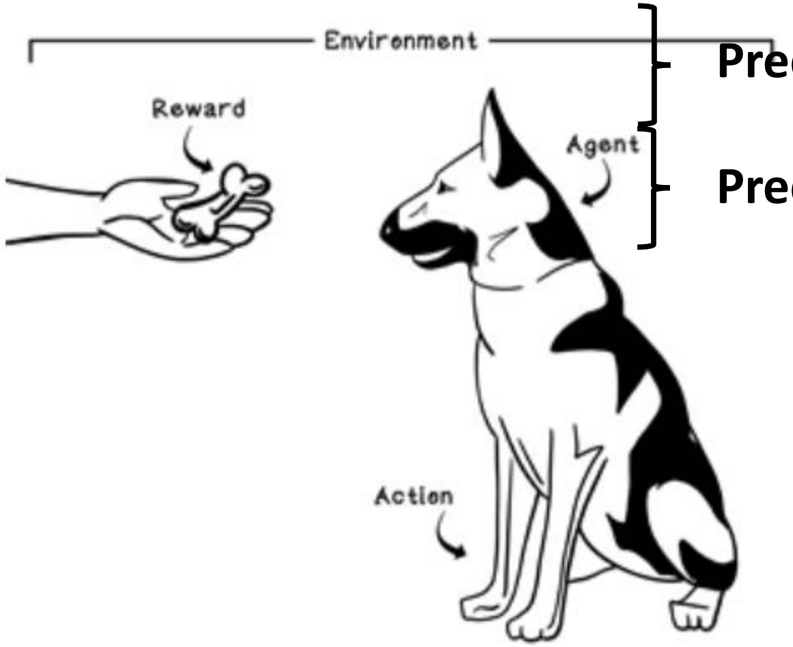
Challenges

- Response test results
  - Buffer is not a ... i
  - Charging beha... p water consumption (
  - High uncertain



Reinforcement learning

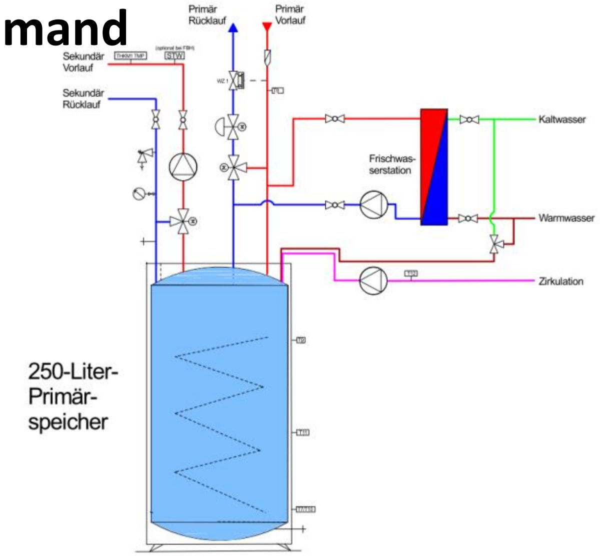
- State space
    - 3 x N (3 tem
    - Historical se
    - Historical po
    - Time since l
- Action space
    - Activation: 0/
- Reward functi
    - Peak shaving
        - Squared power demand + penalty for backup controller override



source: Hurbans R., Grokking Artificial Intelligence Algorithms, July 2020

Predict dynamics

Predict power demand



Reinforcement learning

- Policy-iteration
  - Initialize policy (π) as do-nothing policy
  - While not V*
    1. Evaluate given policy by calculating value function for all states
    $$V_\pi(s) = E[R(s, \pi(s), s') + \gamma V(s')]$$
    2. Improve policy: find better action for state s
    $$\pi_1(s) = \arg\max_{a \in A} E[R(s, \pi(s), s') + \gamma V(s')]$$

$$\pi_0 \xrightarrow{\text{E}} V^{\pi_0} \xrightarrow{\text{I}} \pi_1 \xrightarrow{\text{E}} V^{\pi_1} \xrightarrow{\text{I}} \pi_2 \xrightarrow{\text{E}} \dots \xrightarrow{\text{I}} \pi^* \xrightarrow{\text{E}} V^*$$

- Practical hurdles
  - Huge state space
    - Pruning by limiting to historical states
  - Huge action space dimensionality
    - Pruning by limiting number of simultaneous activations

Conclusion & next steps

- Increasing number of connections
  - Learning data not representative
  - Difficult to forecast
  - Data interruptions
- CHP optimization
  - Unforeseen events difficult to forecast
  - Extend MPC with 2nd CHP
    - Add extra operational constraints
  - Automate application of control plan
- Smart buffer charging
  - Limited flexibility
    - 250 l buffer
    - Backup controller
    - Bypass valve
  - Test reinforcement learning approach

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Thank you for your attention!

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