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TEMPO

The rural low-temperature district heating network and innovations, findings in Windsbach

Manfred Abt, ENERPIPE

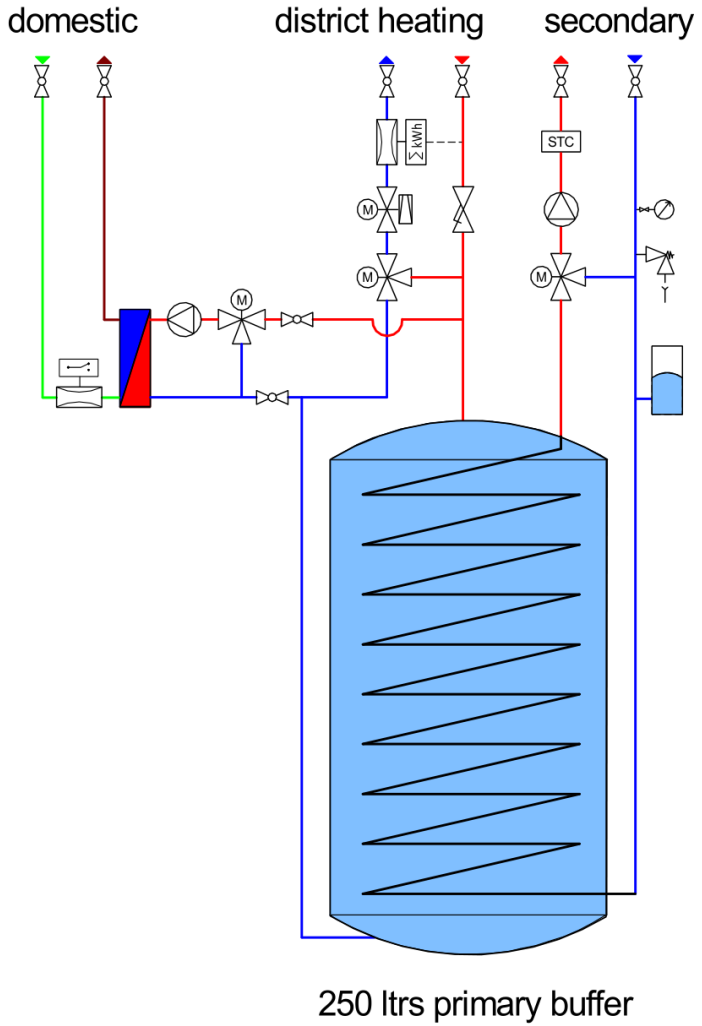
Davy Geysen, VITO / EnergyVille

Windsbach: A rural low-temp district heating network

Lean & efficient network through:

- Decentralized primary buffers
- Superior control for
  - Fault detection & optimization of consumers
  - Smart charging
- CHP Optimization

Decentralized primary buffer



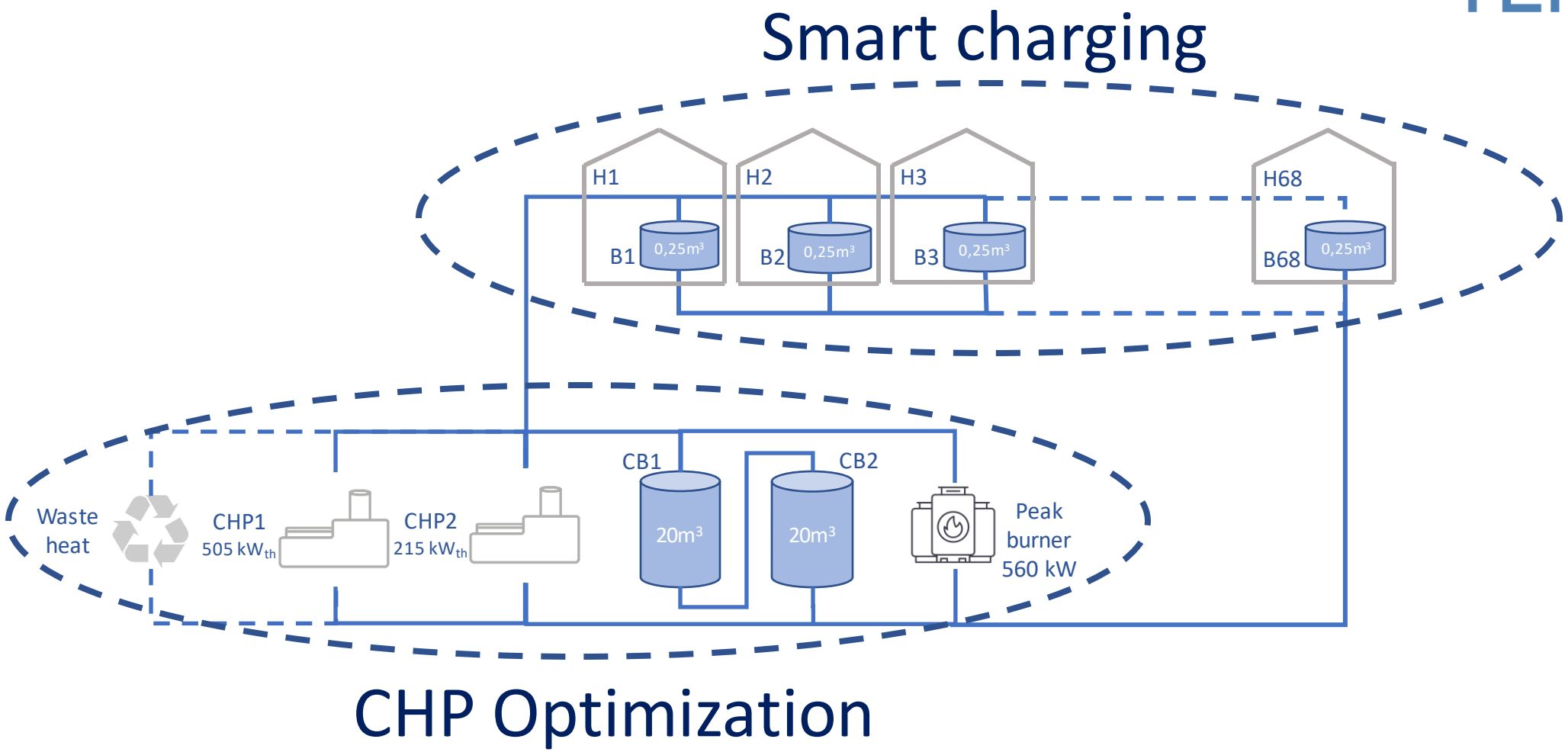
- Buffer allows peak shaving
  - Leaner network design
- No consecutive heat exchangers: primary buffer
  - Lower flow temperature sufficient
  - Lower return temperature possible

CaldoTherm: Layout

Findings regarding buffers

1. Building installation is key
2. Network return temperatures <40°C ☑
3. Useful for low- and medium-temperature networks (60-95°C)
   Thus usable with many renewable heat sources
4. Ideally installed in a visualized network for remote optimization
5. CaldoTherm as practical solution for modern single-family homes: Functional, compact, pre-assembled, wide range of accessories

Windsbach: DHS

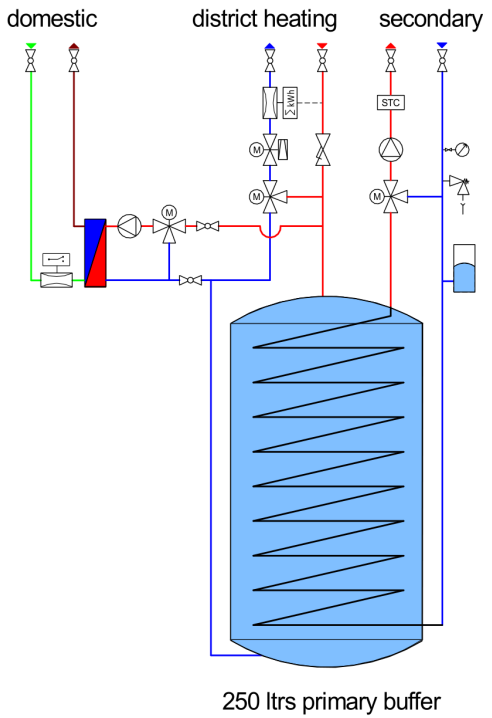


Windsbach: smart charging

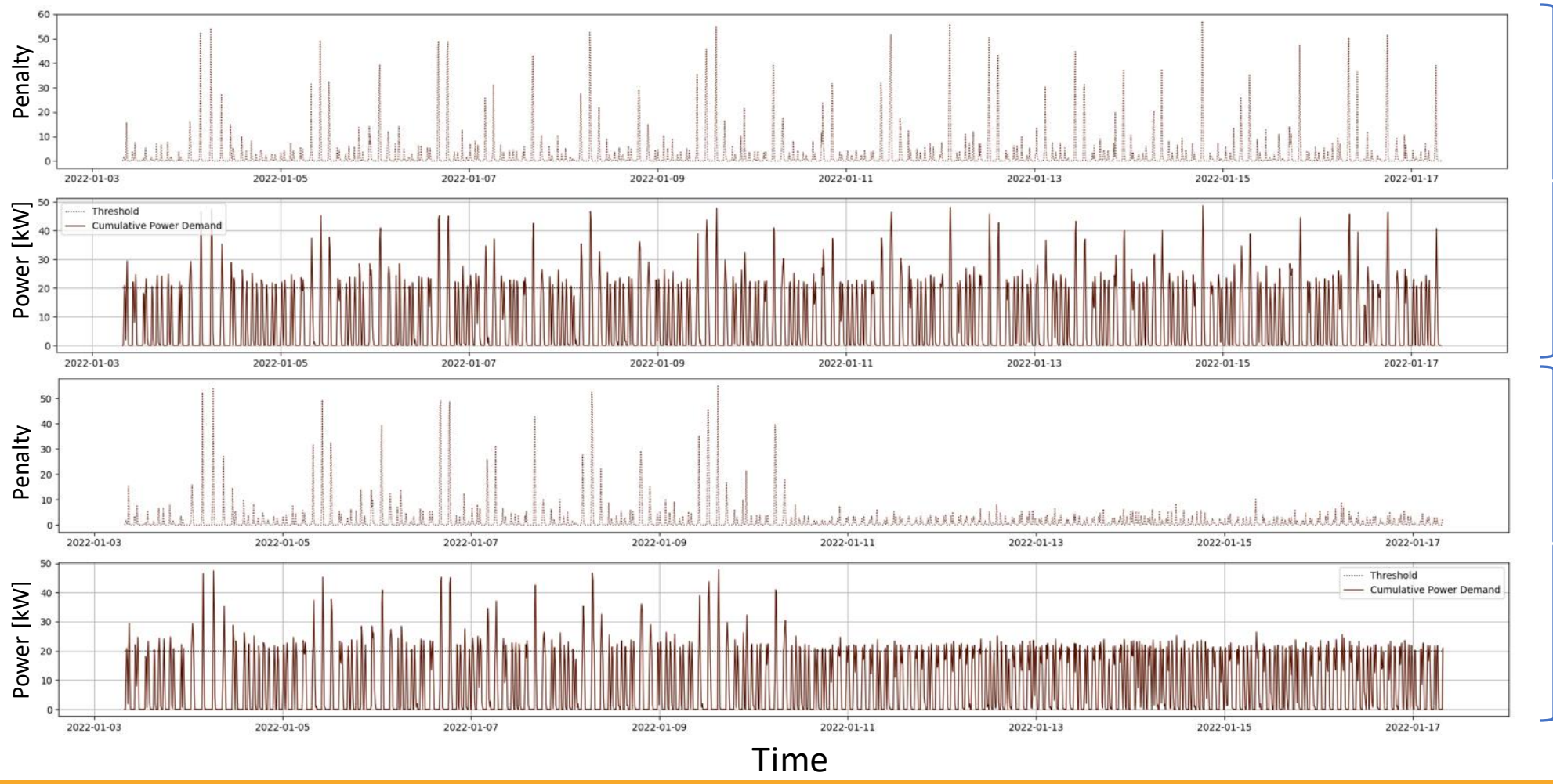
- Conventional charging based on temperatures
  - Peak demand simultaneous charging
- Goal
  - Smart charging to further reduce peak load in winter
- How
  - Reinforcement learning (RL) approach (data-driven)

Smart charging: RL

- Machine learning training method
  - rewarding desired behaviors
  - punishing undesired ones
- Action
  - Start charging
- Reward function
  - Peak shaving
    - Squared power demand
    - Penalty for backup controller override



Smart charging: 2 buffers



No control

With control

Smart charging: numbers

- 2 buffers
  - Peak training : 47,8 kW
  - Peak control : 30,4 kW
  - Peak reduction : 36 %

- 9 buffers
  - Peak training : 107,8 kW
  - Peak control : 67,3 kW
  - Peak reduction : 37 %

Time

Smart charging: pilot findings

- Increasing number of connections
  - Learning data not representative
- Highly stochastic DHW consumption
- Limited flexibility
  - 250 l buffer
  - Temperature limits for forced charging
- Limited response to control signal

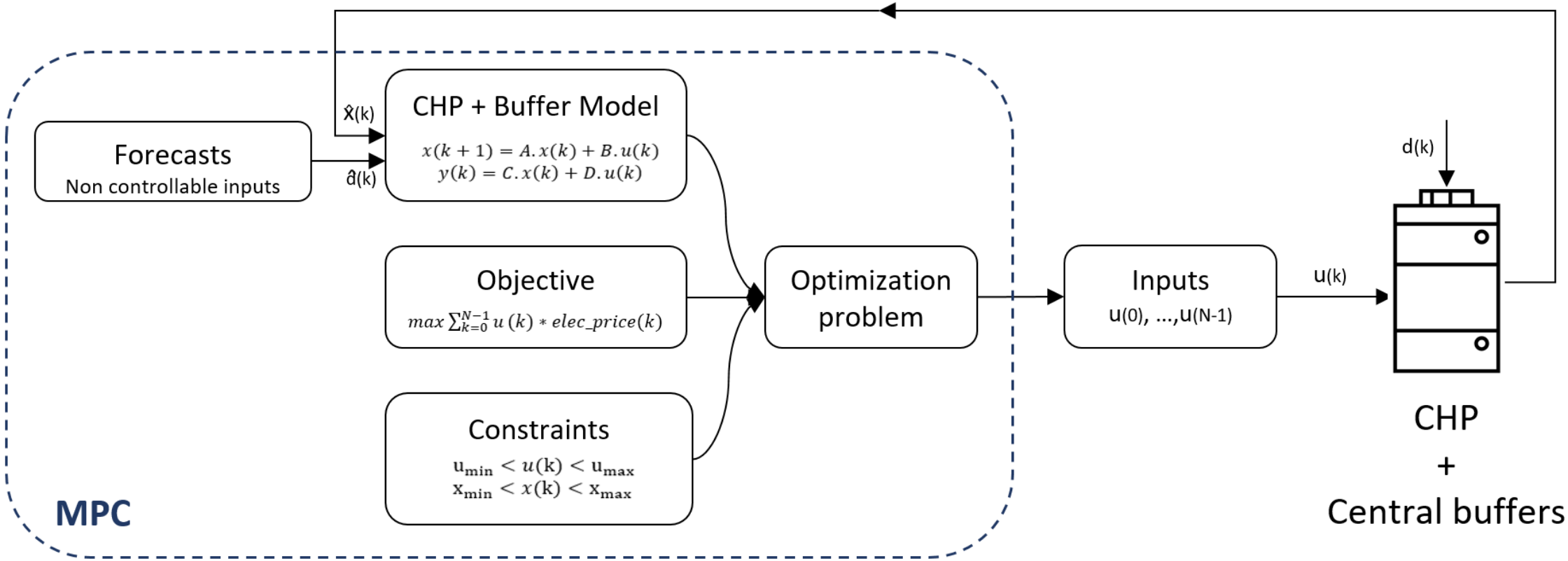
Windsbach: CHP optimization

- CHP generates heat and electricity
  - Heat: fixed price
  - Electricity: real-time pricing (RTP)

- Goal
  - Optimize revenues and operate when share of renewables in the grid is low

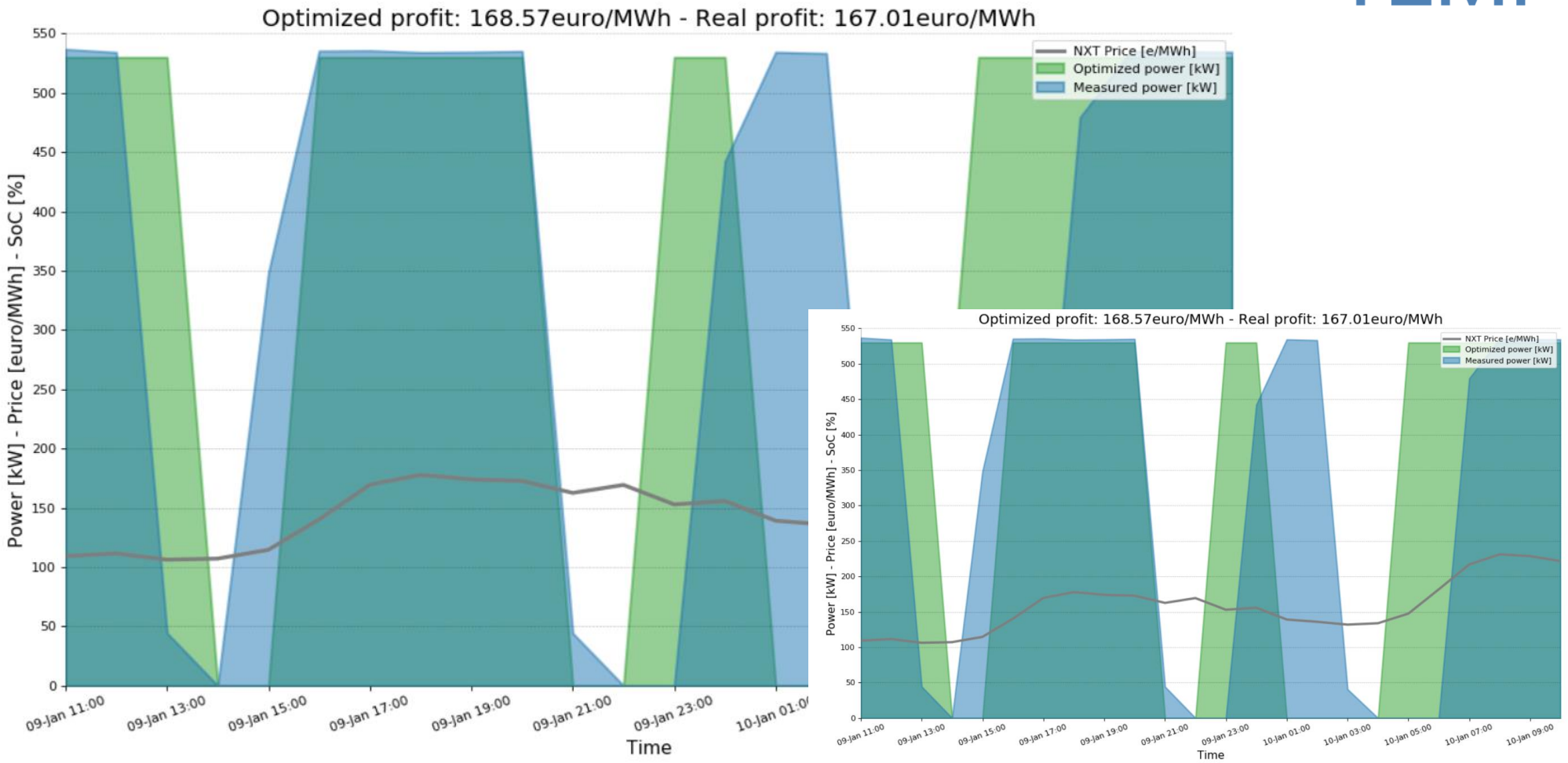
- How
  - Model predictive control (MPC)

CHP Optimization: MPC



CHP Optimization: results

- Incr
  - Av
  - Av
- Unbu
- Decr



CHP optimization: pilot findings

- Unforeseen events difficult to forecast
  - Maintenance
  - Input from satellite site
  - New connections: heating up the screed
- Access to real-time price updates
- Automate application of control plan
  - Advice not equal to executed plan
  - Network owner not part of the project

Summary: results

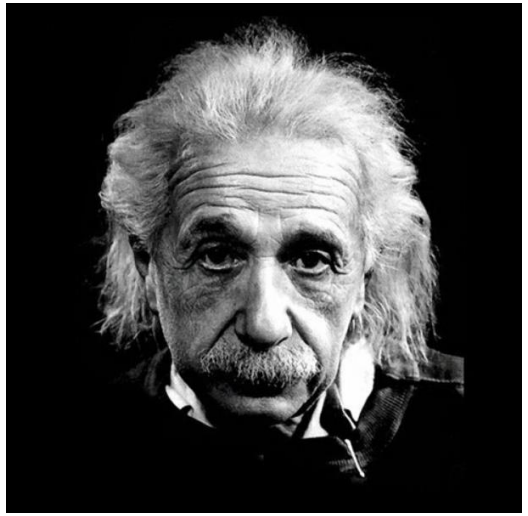
- Decentralized buffers
  - Peak shaving + low return temperatures (< 40°C)
- CaldoTherm
  - Integration with renewable energy sources at low temperature
  - Practical solution for a modern SFH
    - Functional, compact, pre-assembled, easy installation
- Smart buffer control
    - 35% peak reduction (ideal world)
    - 25% peak reduction (real operation)
- CHP optimization
  - Increased profit (10%)
  - Ruling out manual operations

Summary: lessons learned

- Smart control
  - Take into account at design phase
- Include all stakeholders in the project
- Knowledge spread over different stakeholders
  - Challenge to get the complete overview

“In theory, theory and practice are the same. In practice they are not.”

Albert Einstein



Thank you!

Manfred Abt, ENERPIPE
manfred.abt@enerpipe.de
Davy Geysen VITO/EnergyVille
davy.geysen@vito.be