Unlocking European grid local flexibility through augmented energy conversion capabilities at district-level

Demonstrating Power-to-Heat Flexibility at District Level: Use Cases and Test Platform

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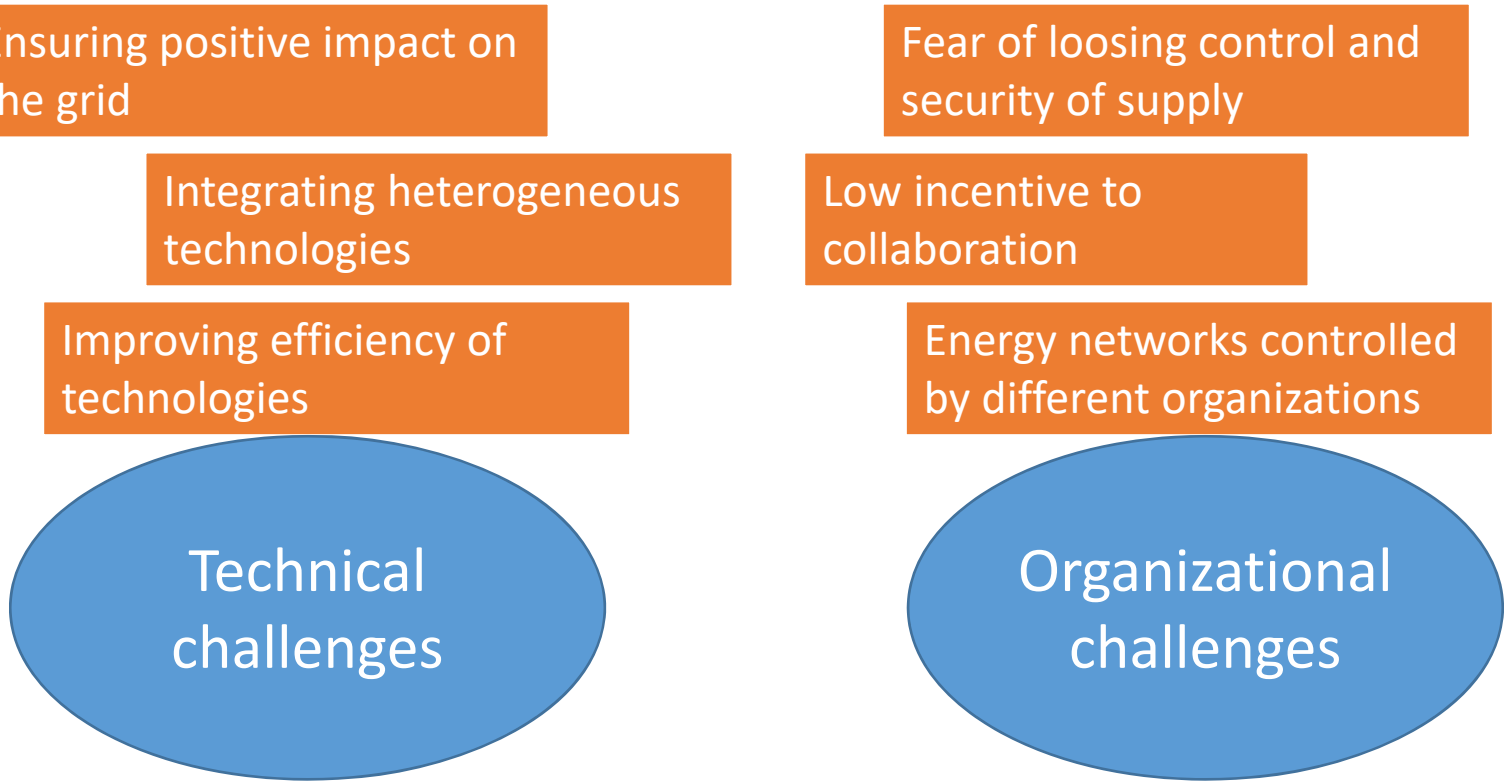
Energetic and economic benefits should be there but …



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Test platform for demonstrating 'live' integration of smart energy systems involving **innovative control/storage/conversion**

energy operators
local authorities
for

Our goal is to **facilitate demonstrations** *not only* of the energetic and economical benefits *but also* the **organizational and technical feasibility** of operating local energy networks in an optimally integrated way.

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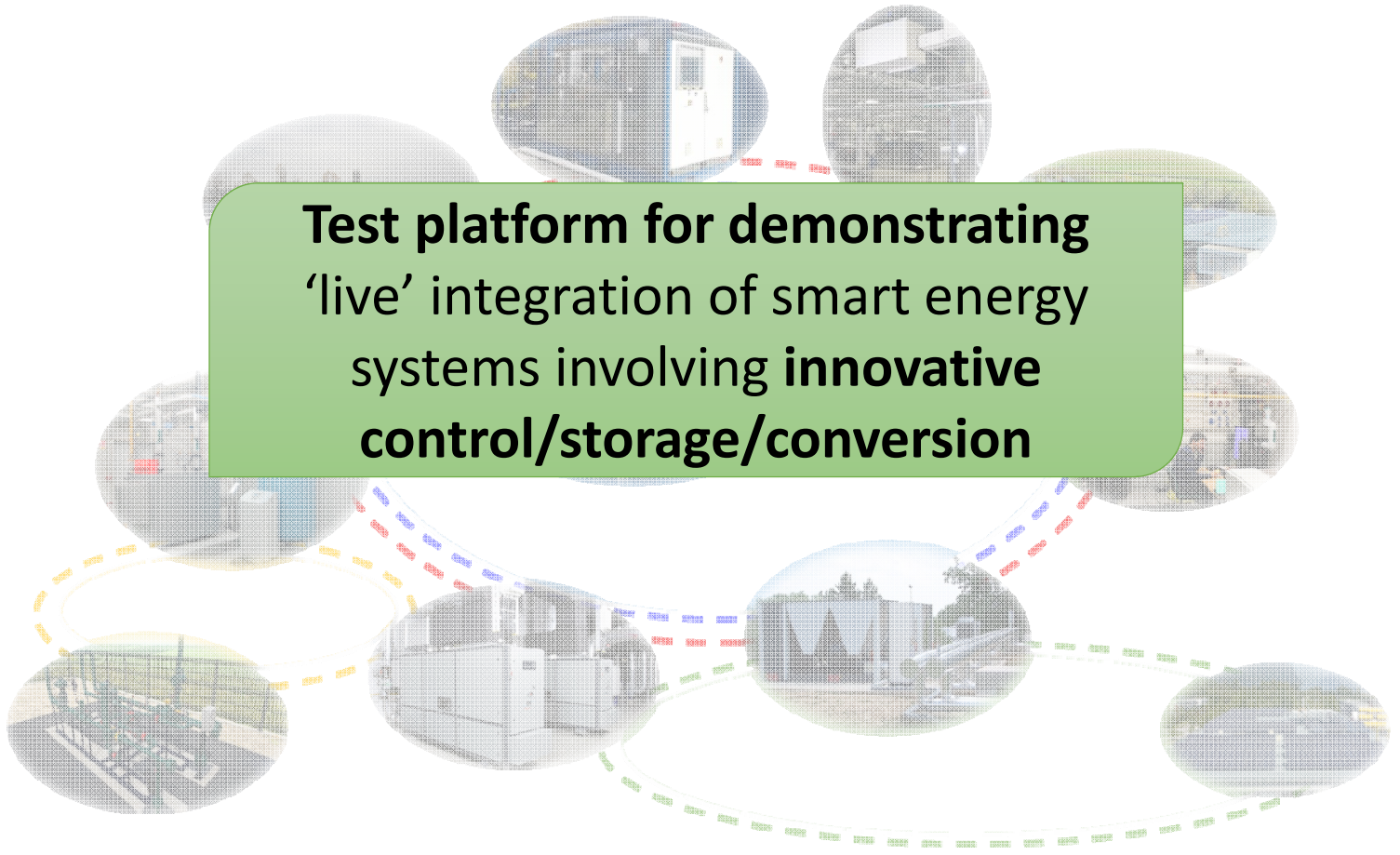

Test platform for demonstrating ‘live’ integration of smart energy systems involving **innovative control/storage/conversion**

Outline

- Overview of use cases
- Multi-vector flexibility management platform
- Small-scale experimental facilities

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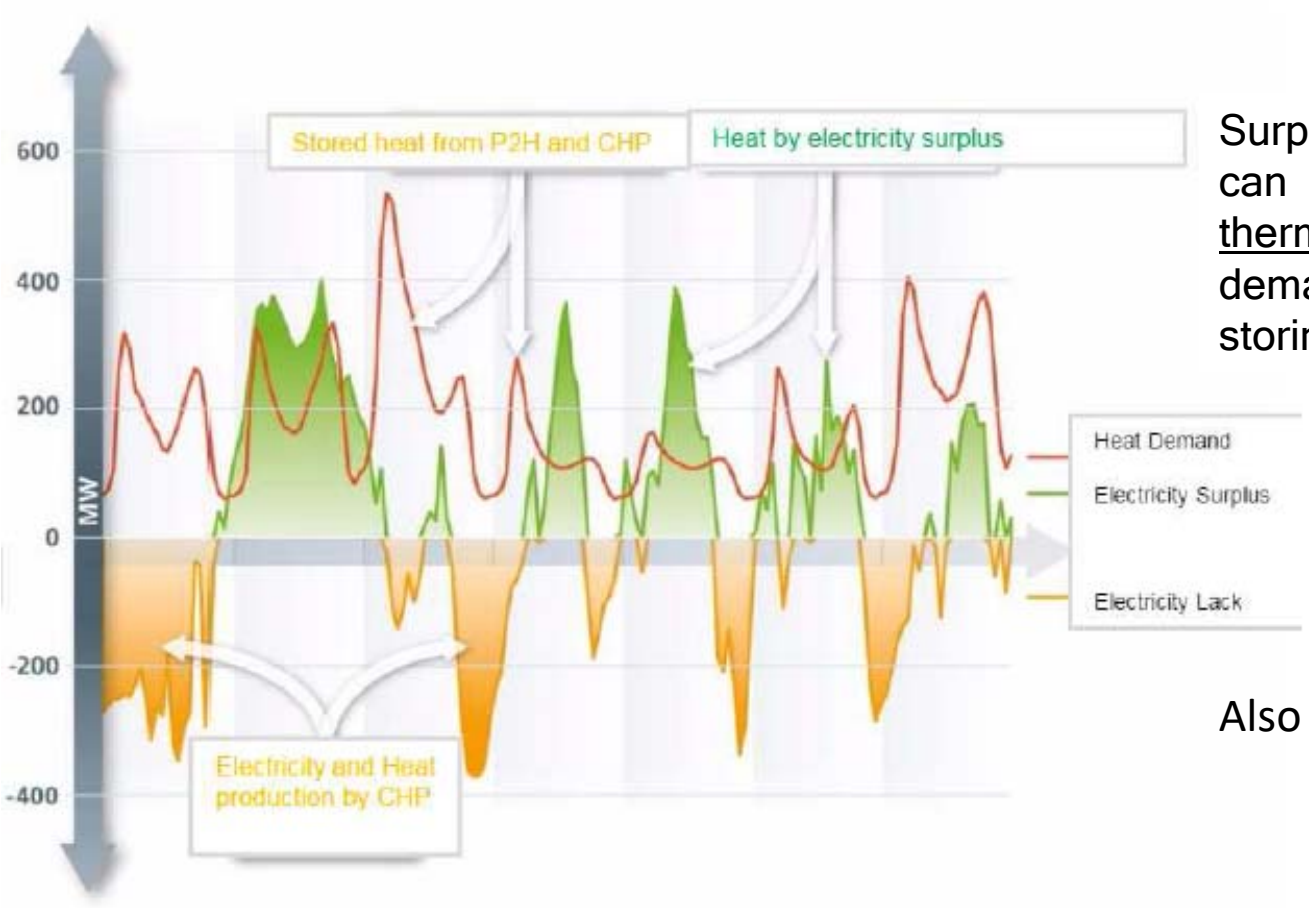
Study of existing eco-districts

- 8 eco-districts in 5 countries

- Common characteristics:
  - **District heating** (DH) networks
  - Biomass or solar thermal heat generation
  - PV (and some wind) electricity production
  - **Low energy coupling**: CHP units, few heat-pumps
- Two distinct configurations (both with DH system):
  - Mainly **residential** with decentralized PV production/storage
  - **Mixed-usage** with centralized power/heat production/storage/conversion
- Central role of **coupling the electric and thermal** networks
  - Power-2-Gas is not yet at the right level of maturity

Details: PENTAGON public deliverable 3.1 *Targeted district configurations and flexibility management platform requirements.*, 06/2017

Central role of coupling electricity and heat

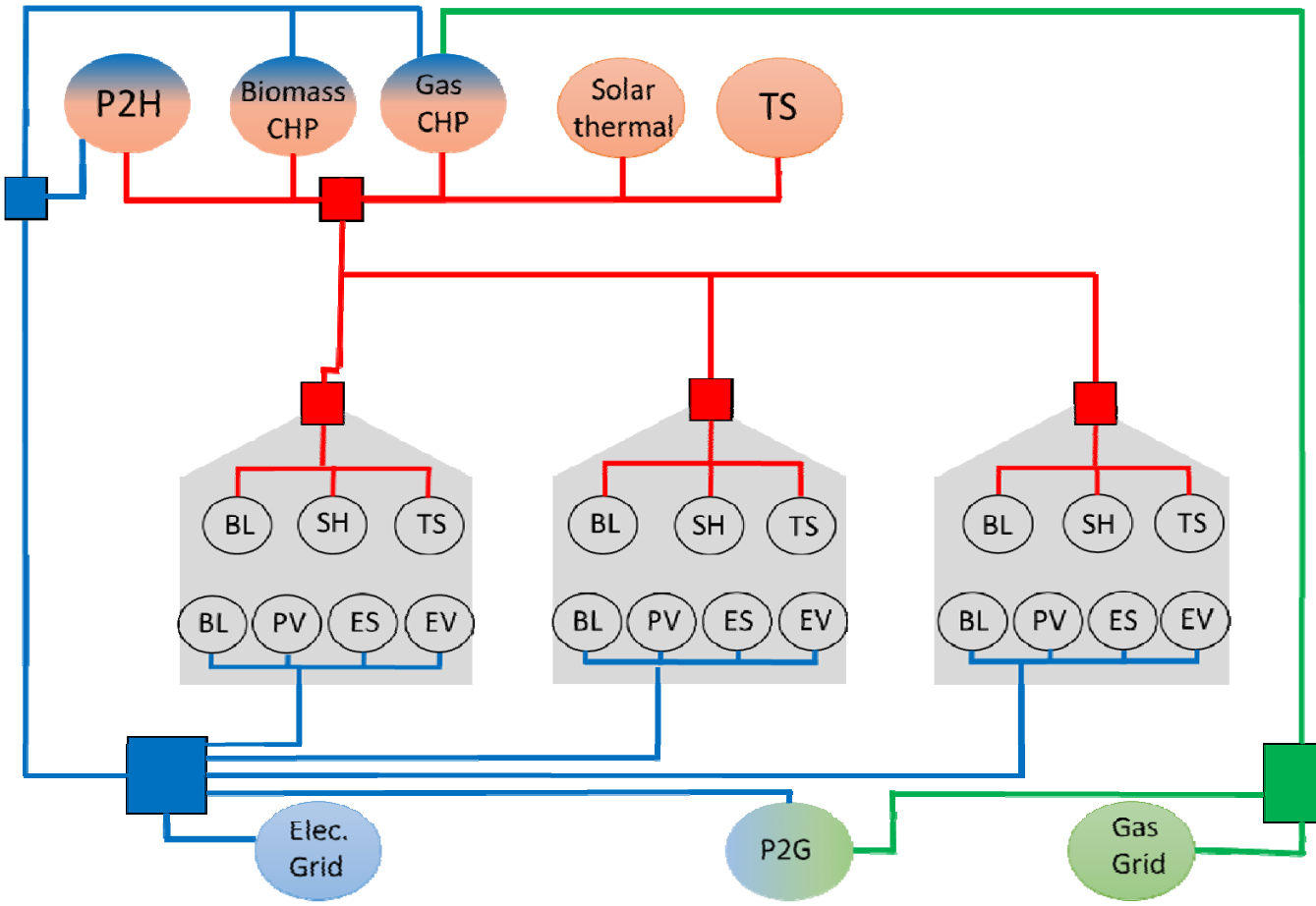


Surplus renewable electricity can be directly stored as thermal energy to meet future demand, at a lower cost than storing electricity.

Also applies to cooling

Source: K. Rohrig & D. Schmidt (2014), *Coupling the electricity and heat sectors – the key to the transformation of the energy system*

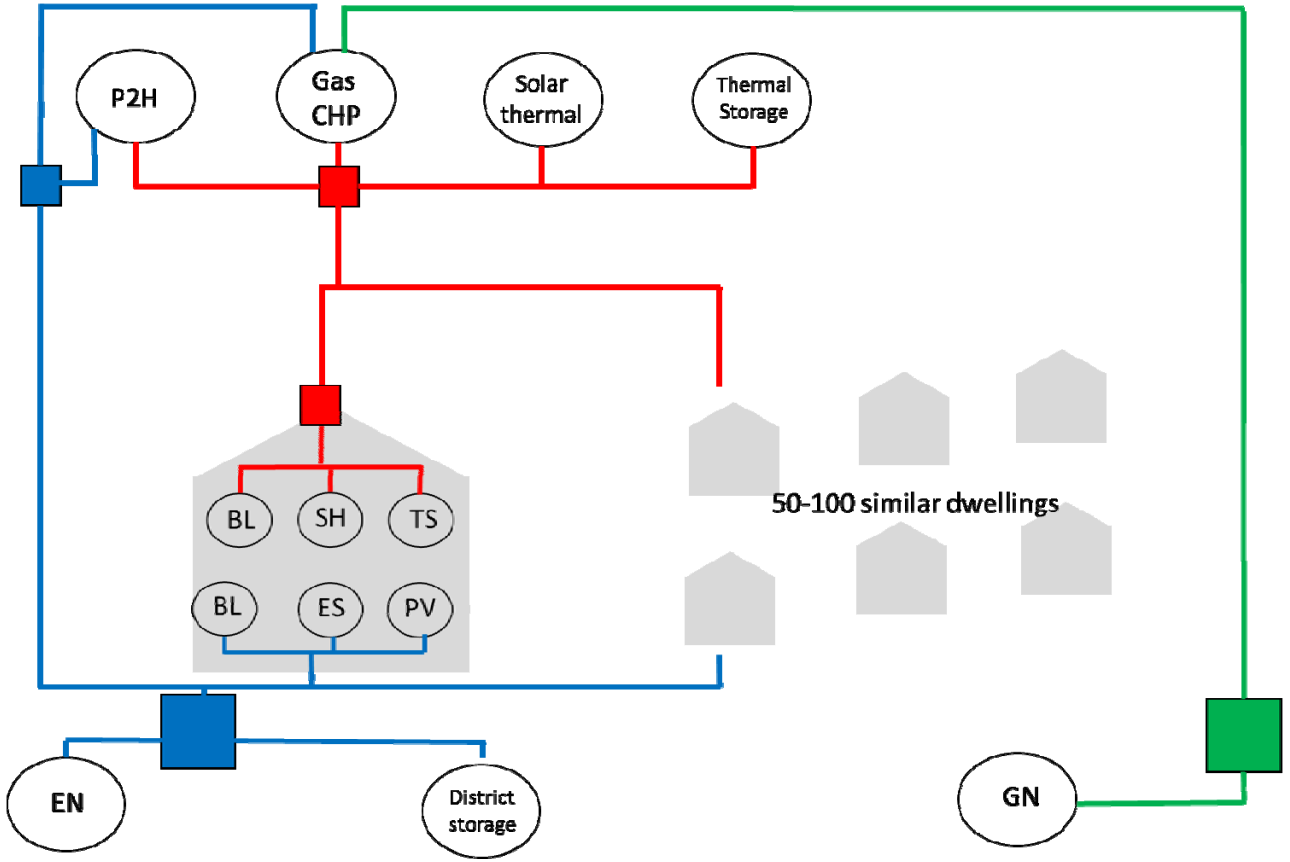
General multi-vector district model



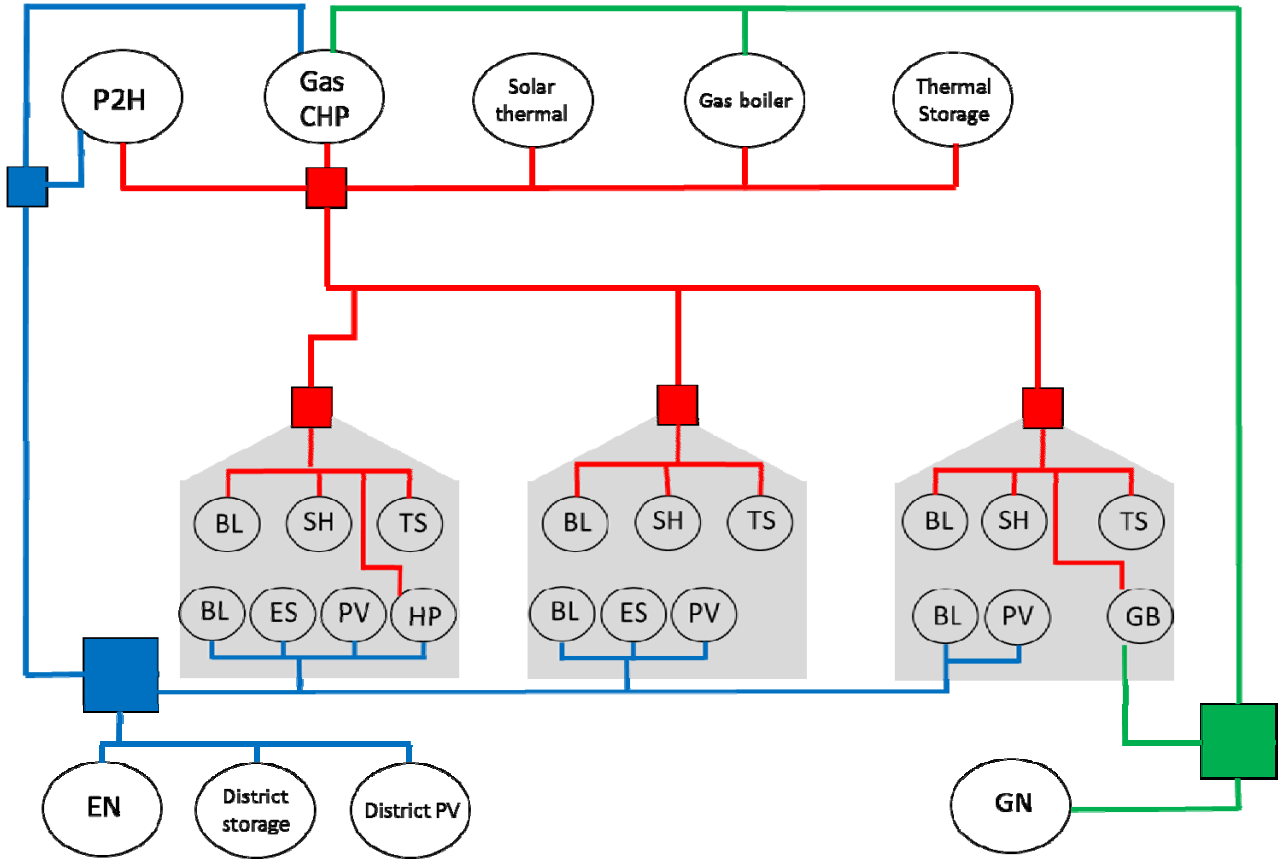
BL	Base load (non flexible)
SH	Space heating
TS	Thermal storage
ES	Electric storage
PV	Photovoltaic
EV	Electric vehicle
GB	Gas boiler
P2G	Power to gas
P2H	Power-to-Heat
CHP	Combined heat and power

Details: PENTAGON public deliverable 3.1 *Targeted district configurations and flexibility management platform requirements.*, 06/2017

Application of the model: residential use case



Application of the model: mixed-usage use case



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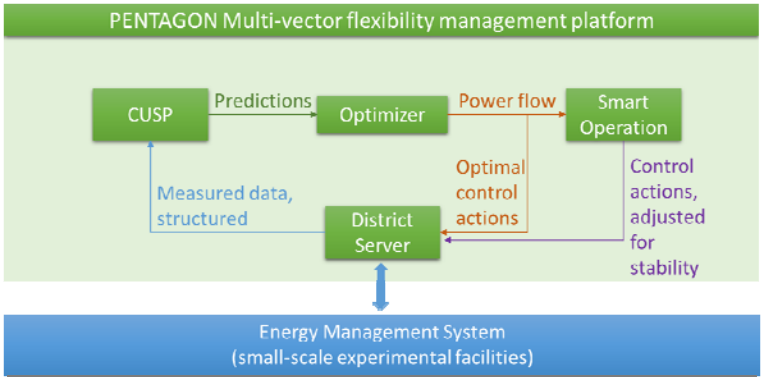
Implementation of the model in the test platform

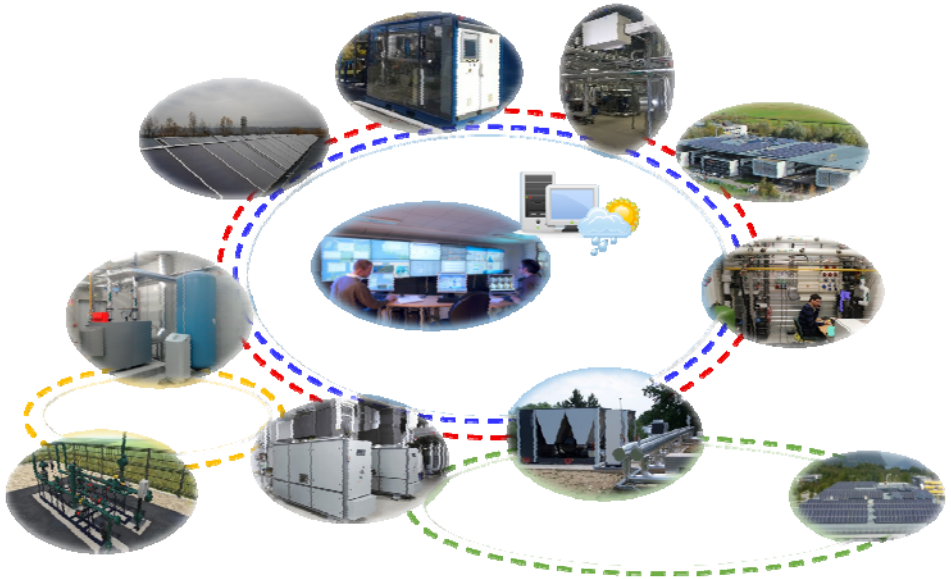
Software

Multi-vector flexibility management platform



Hardware

Small-scale experimental facilities



Missing:

- Electric vehicles (EV) not included in software platform
- Power-to-gas (P2G) not included in hardware platform

Outline

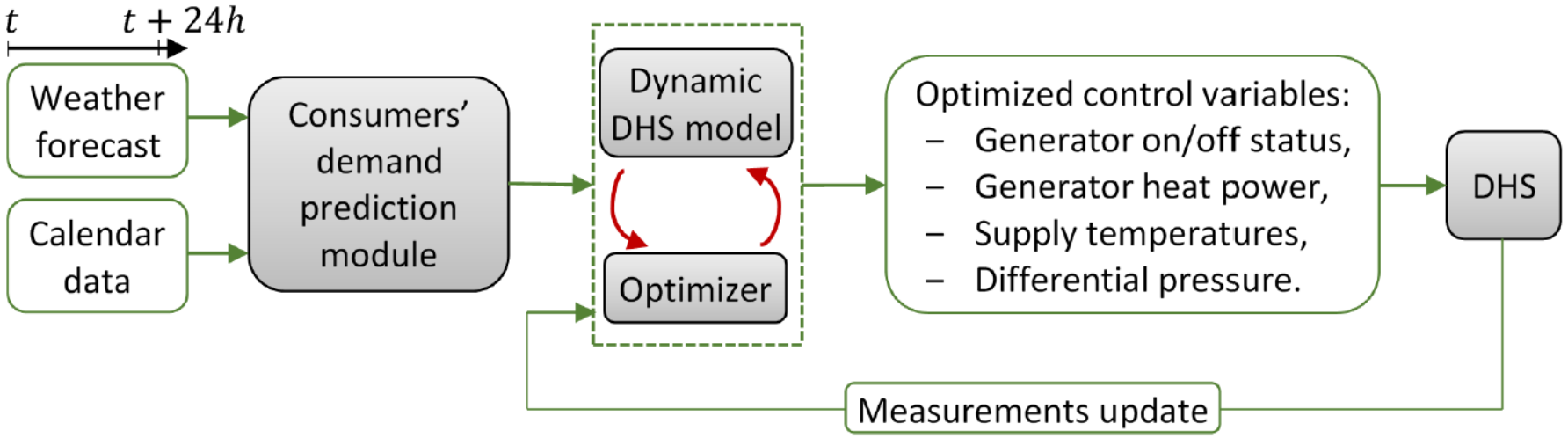
- Use cases and challenges
- **Multi-vector flexibility management platform**
- Small-scale experimental facilities

Flexibility and flexibility management

Ability of the system to react to the changes in supply and demand	
Supply side	Demand side
Ability to balance the changes in energy consumption and fluctuation in renewable generation	Ability of the demand side to deviate consumption from a plan or reference state

- ***Optimal operation algorithms (e.g. Model-Predictive Control)*** significantly increase the efficiency of flexibility measures
- **Not taking into account predictions** on the future production / demand could even hinder the benefits of storage and conversion

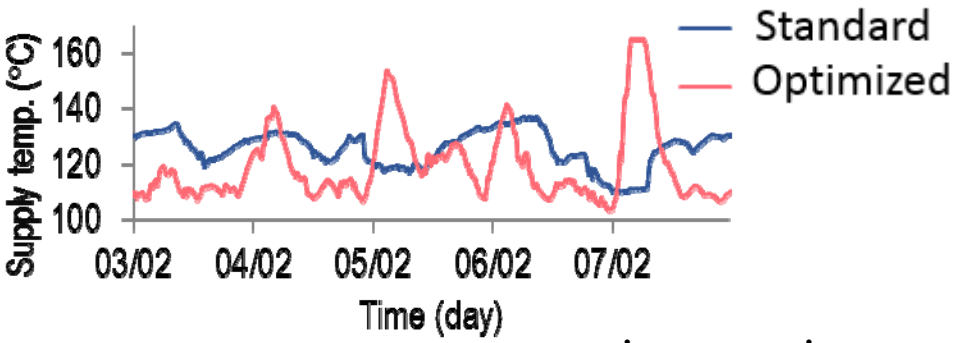
Model-predictive control for supply side flexibility

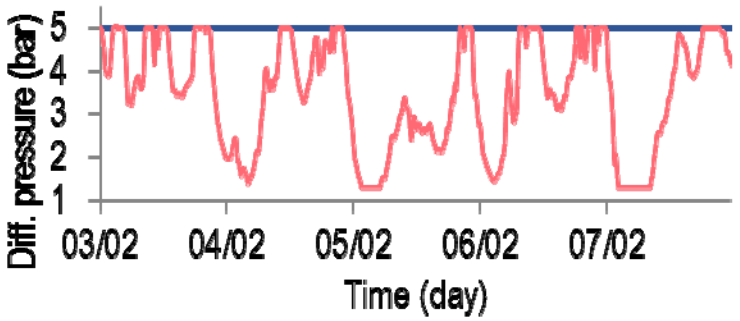


Giraud et al. *Recent Advances in Modelling Simulation and Operational Optimization of DH Systems*, Euroheat and Power, 2016

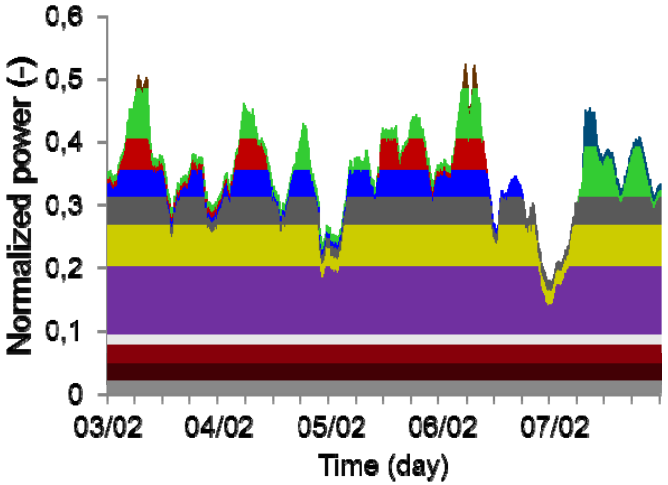
Model-predictive control for supply side flexibility

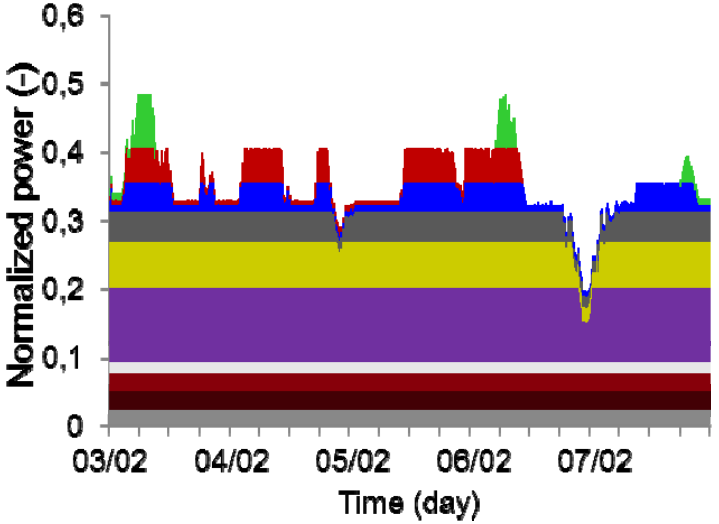
Optimization of distribution variables $(T, \Delta P)$



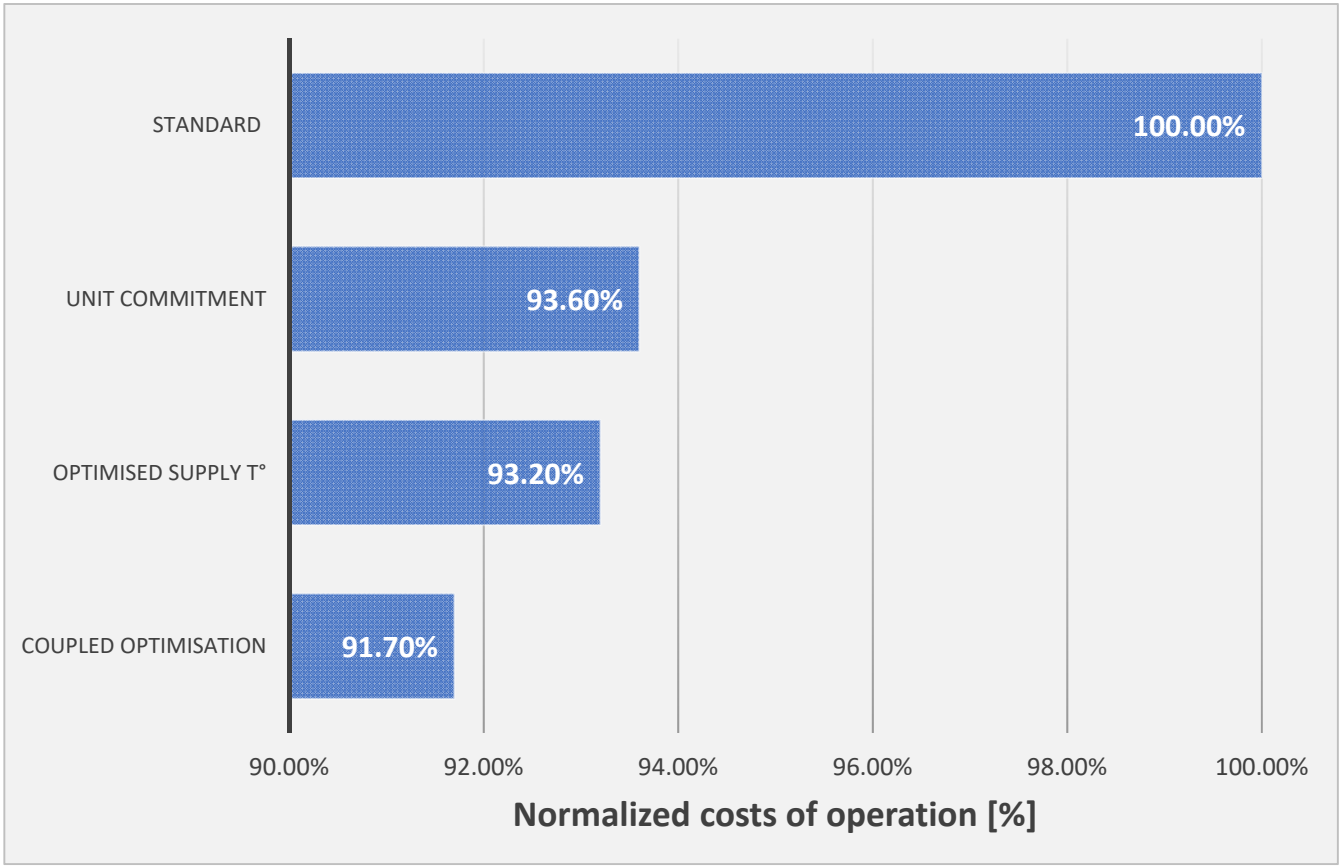


Optimization of generators $(\dot{Q}_{tot} = \sum \dot{Q}_g)$



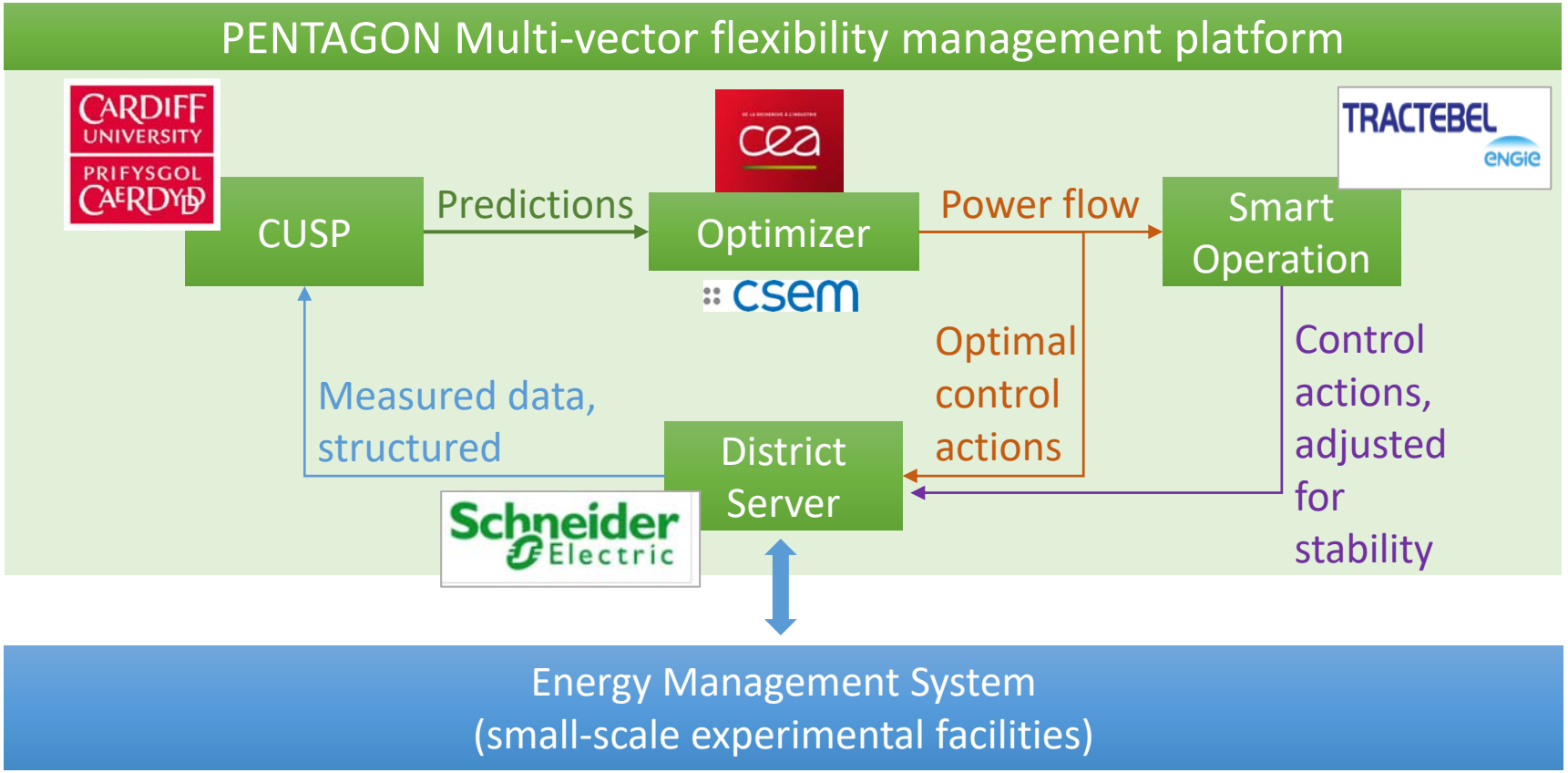


Model-predictive control for supply side flexibility



Giraud et al., *Optimal Control of District Heating Systems Using Dynamic Simulation and Mixed Integer Linear Programming*, Modelica 2017

Generalized multi-vector flexibility management platform



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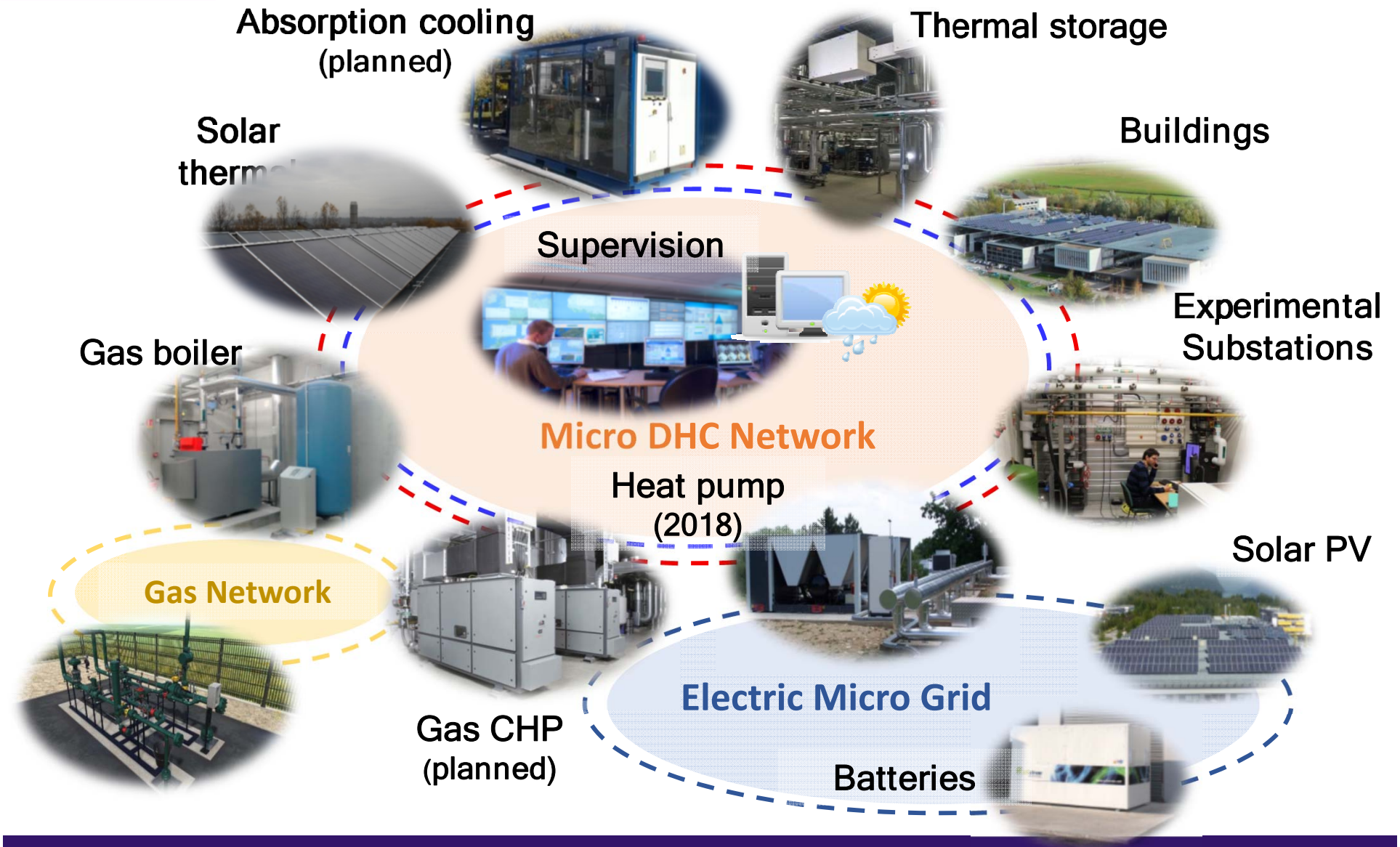

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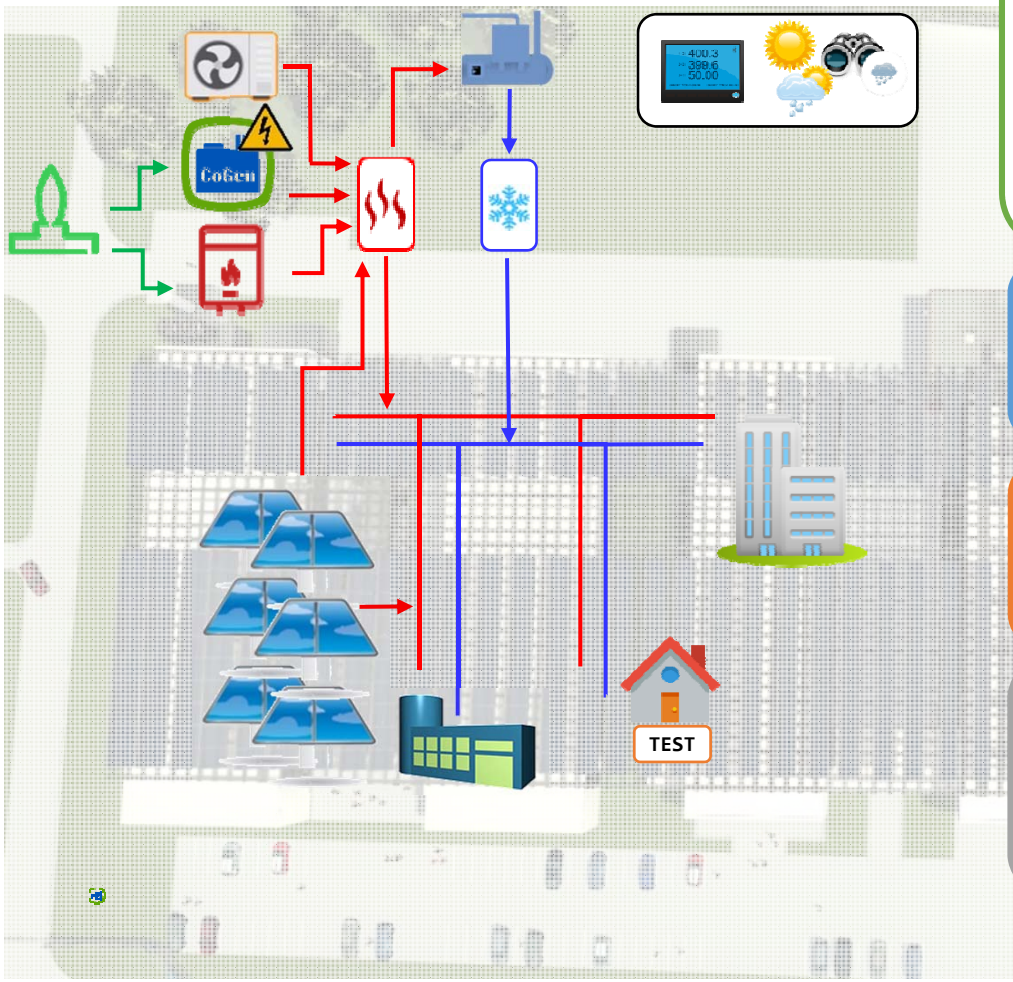

Production :

- Condensing gas boiler - 280 kW
- Solar thermal- 300m² ~ 210 kW
- Power-to-heat - 50 kW
- Combined Heat and Power (planned)
- Absorption cooling - 100kW

Thermal storage:

- Hot - 40 m^3
- Cold - 5 m^3

Distribution network:

- Hot- 2 pipes (70 – 50°C)
- Cold - 2 pipes (7 - 12°C)

Consumers:

- Office and industrial buildings
- Thermal load emulation (semi-virtual dynamic testbed) – 75 kW

Monitoring:

- SCADA

SUMMARY

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Summary

- Demonstrating organizational and technical feasibility of Smart Energy Systems at district level

- Setting up a versatile demonstration infrastructure
  - Multi-vector flexibility management platform
  - Small-scale experimental facilities

- Welcoming contributions for additional use cases and/or experimental studies :
  - Conversion technologies
  - Storage technologies
  - Control algorithms

Questions are welcome

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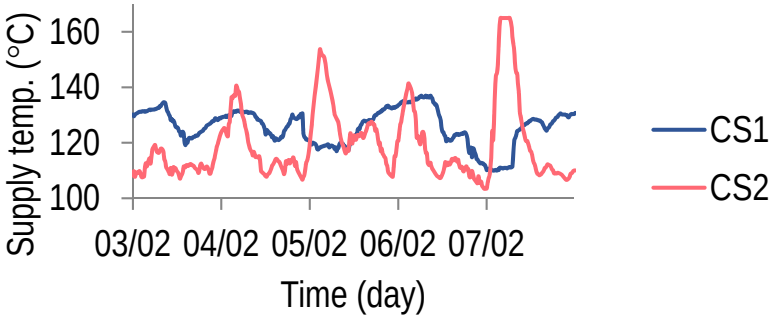

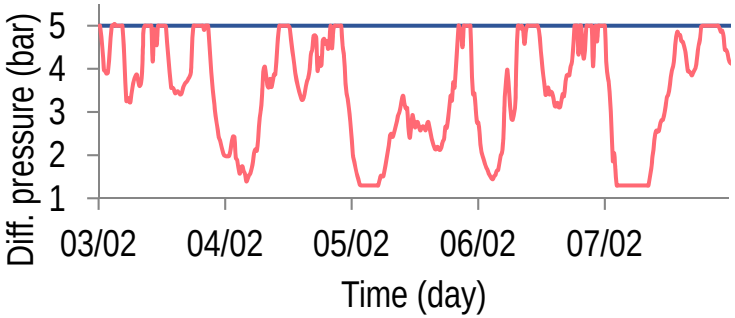

Standard
Optimized