De Schipjes:

De kracht van het collectief en beyond

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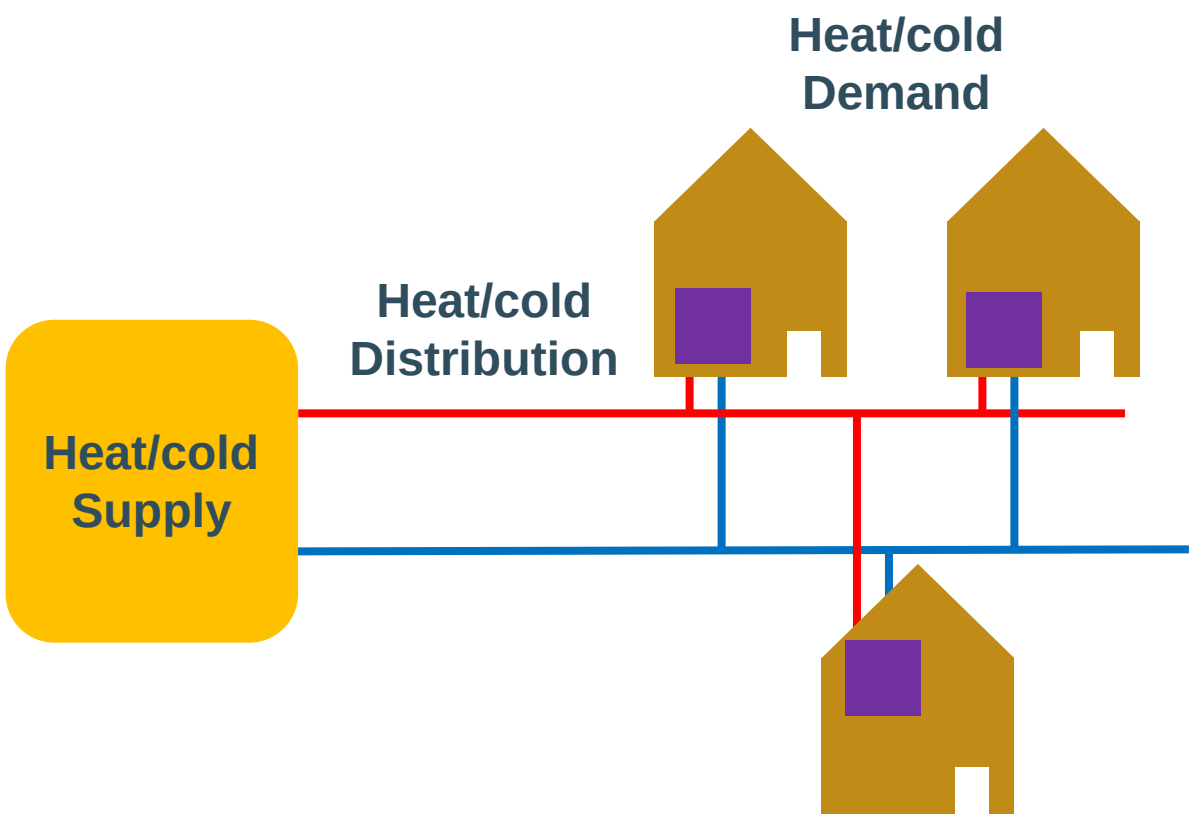
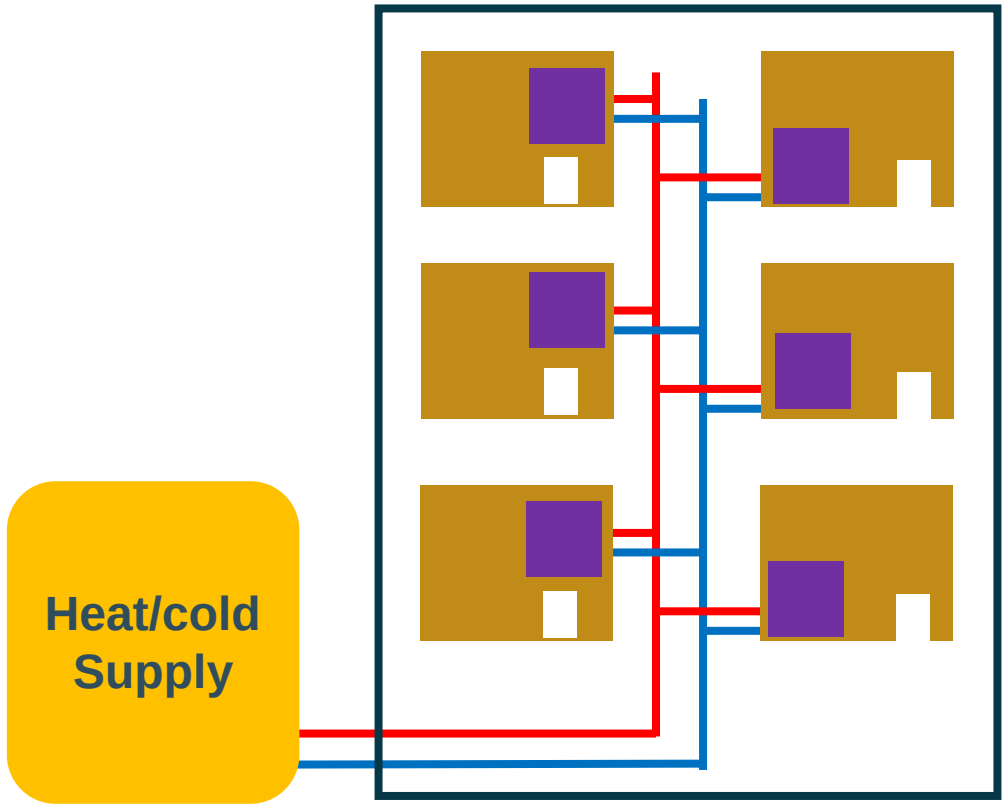
Ann Vandycke (Mintus Brugge)
Lieve Helsen (KU Leuven, Energyville)

Hybrid & Collective Thermal Systems

Horizontal layout



Vertical layout



: HP/HEX/GB

Hybrid & Collective Thermal Systems

FEASIBLE & AFFORDABLE

- Simultaneity < 100%, proper sizing (CAPEX)
- Higher year-round efficiency (OPEX)
  - Lower primary energy use
  - More thermal energy exchange
  - Higher RES share
- Economies of scale
- System integration becomes possible → More flexibility
- Unburden customers
- Less space usage in buildings

Hybrid & Collective Thermal Systems

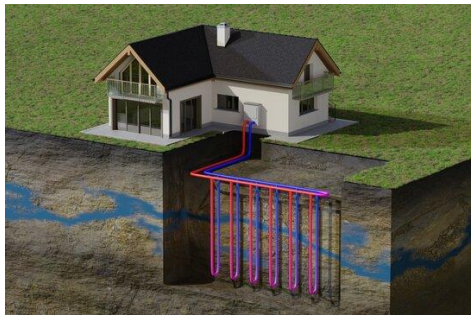
A LOT OF POSSIBILITIES:

Heat/cold supply

Air-source heat pumps

Source: Sunlite Group Ltd

Ground-source heat pumps



(Seasonal) thermal energy storage

Source: Solarthermalworld

Solar thermal collectors

Source: Changzhou Raven Ltd

Heat/cold distribution

4th generation district heating

5th generation district heating and cooling

SYSTEM INTEGRATION IS KEY TO OPTIMALLY LEVERAGE SYNERGIES!

De Schipjes

- Social housing neighborhood
- Classified as heritage
- Renovate with focus on energetic and ecological aspects
- VLAIO Living lab

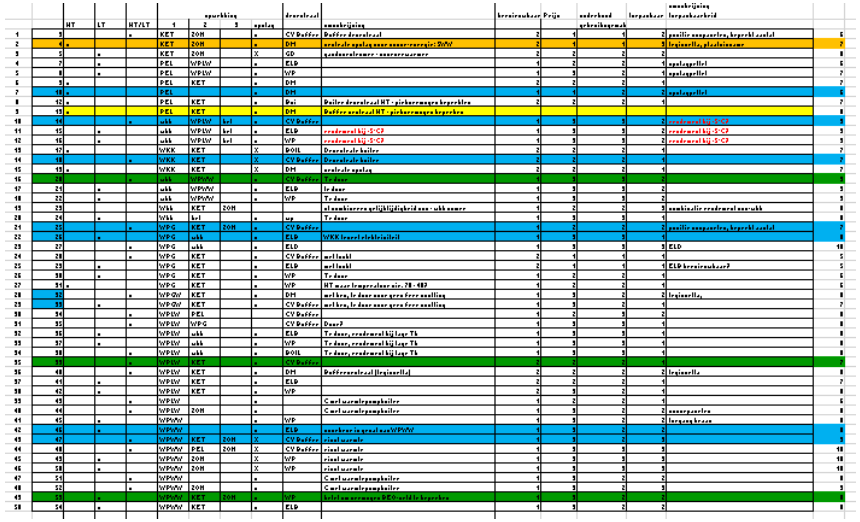
Source: Google Maps

Source: Mintus Brugge

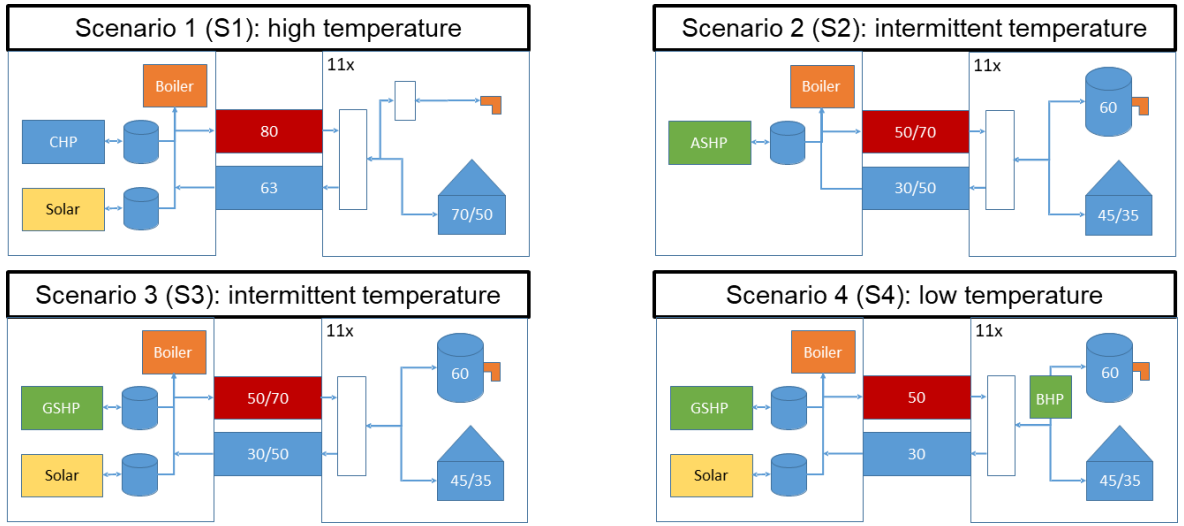
De Schipjes

1. Retrofit buildings → lower heat demand

2. District heating (DH) network

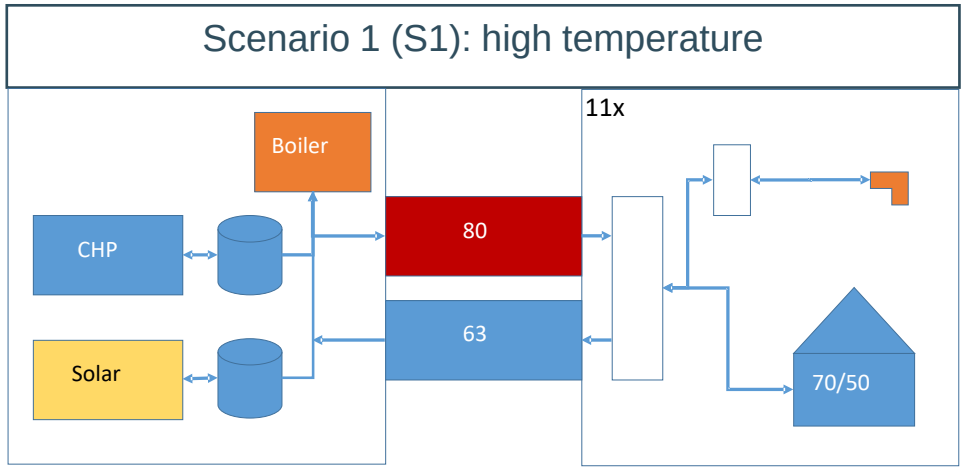


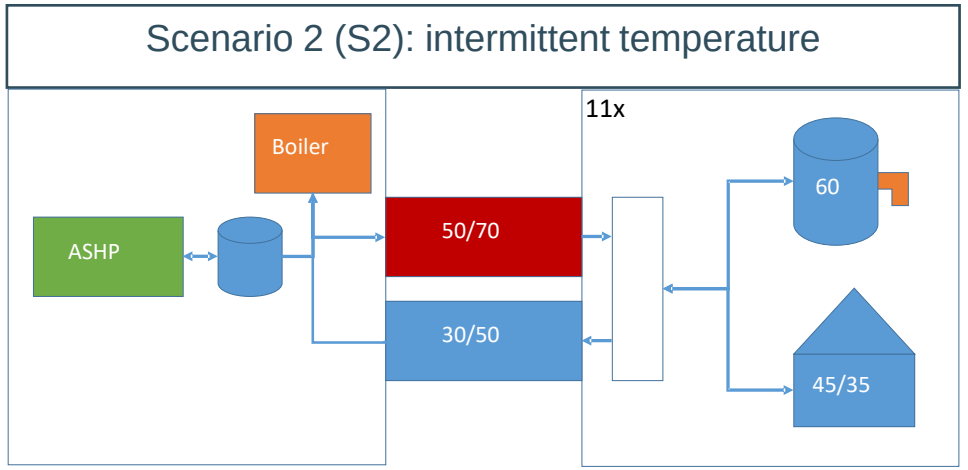
Experience-based longlist

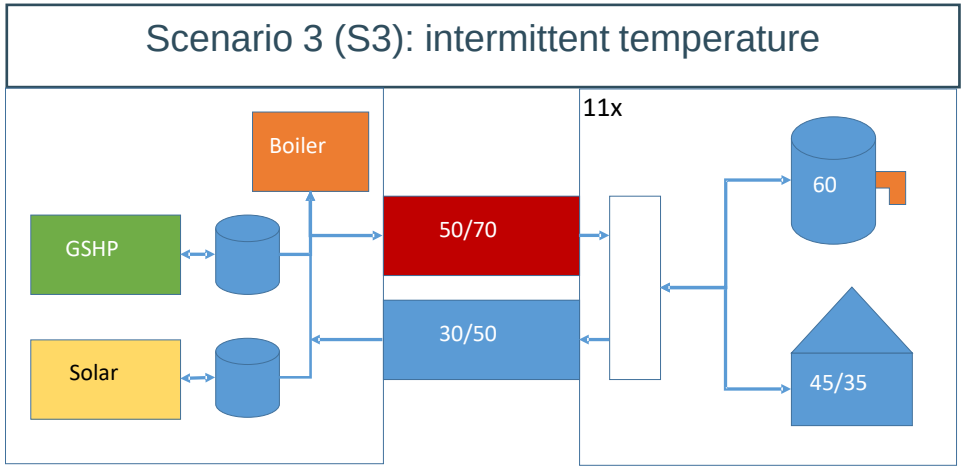


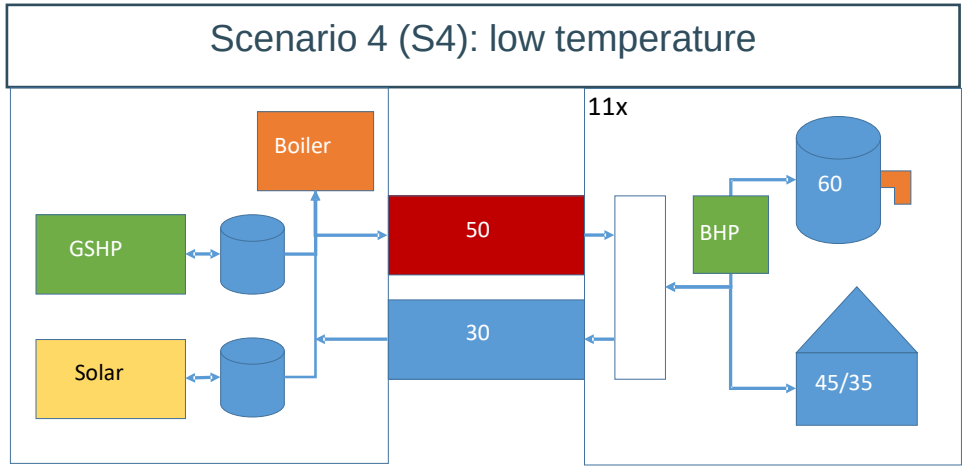
4 promising scenarios

De Schipjes – Scenario Analysis









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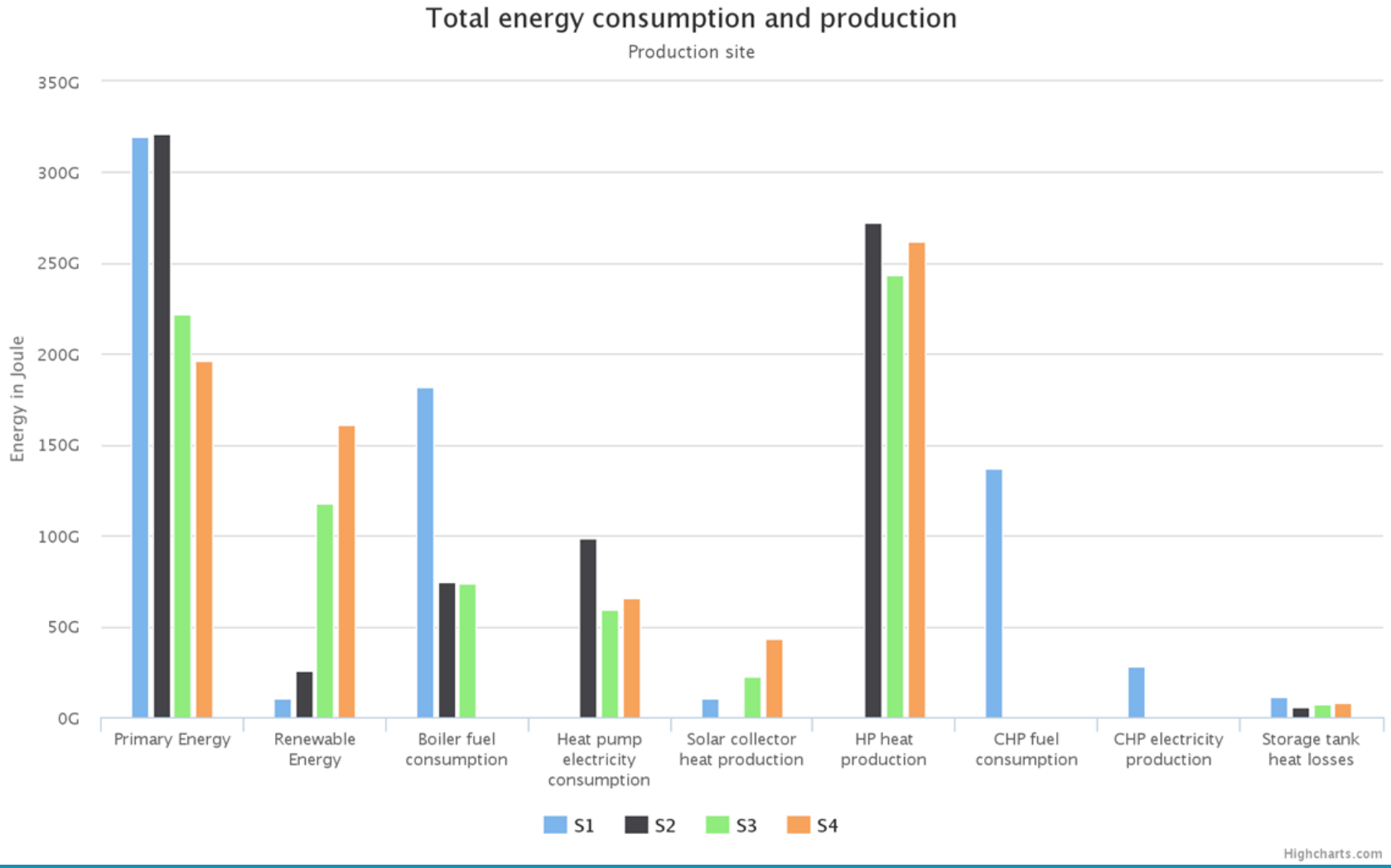
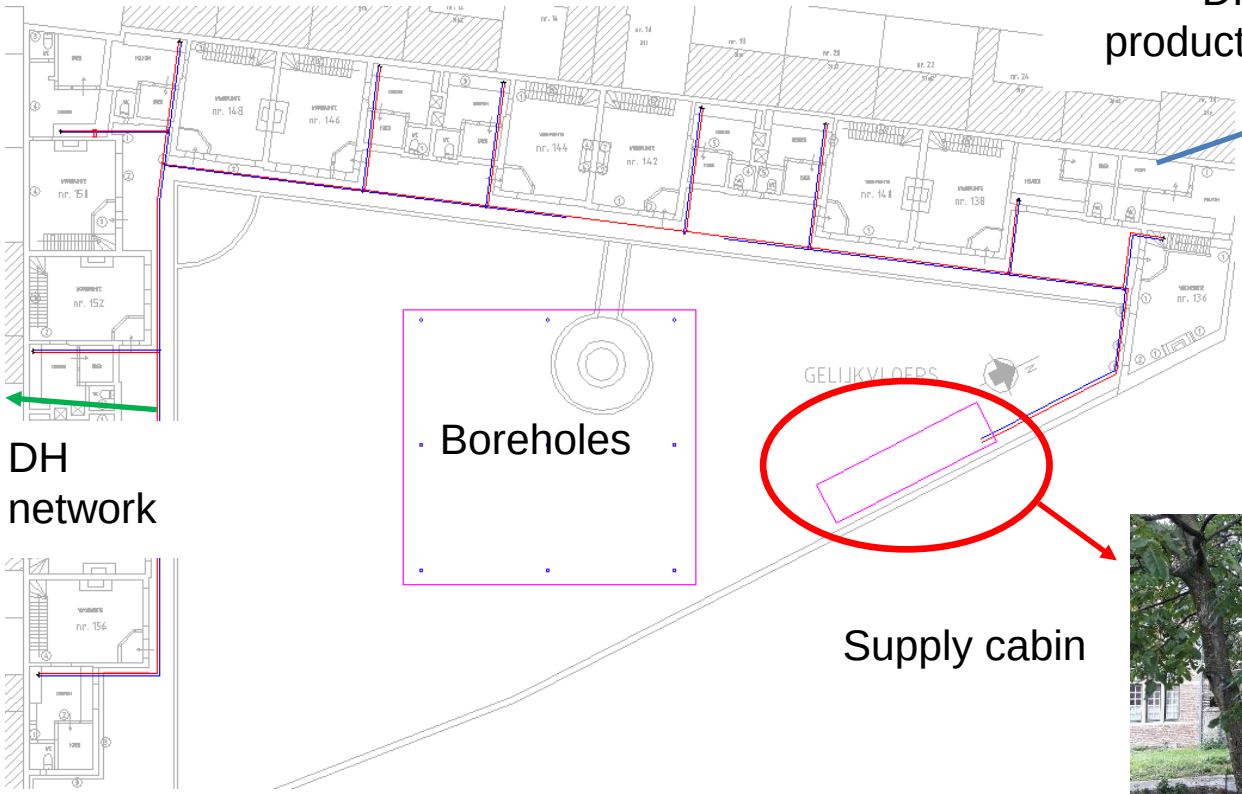


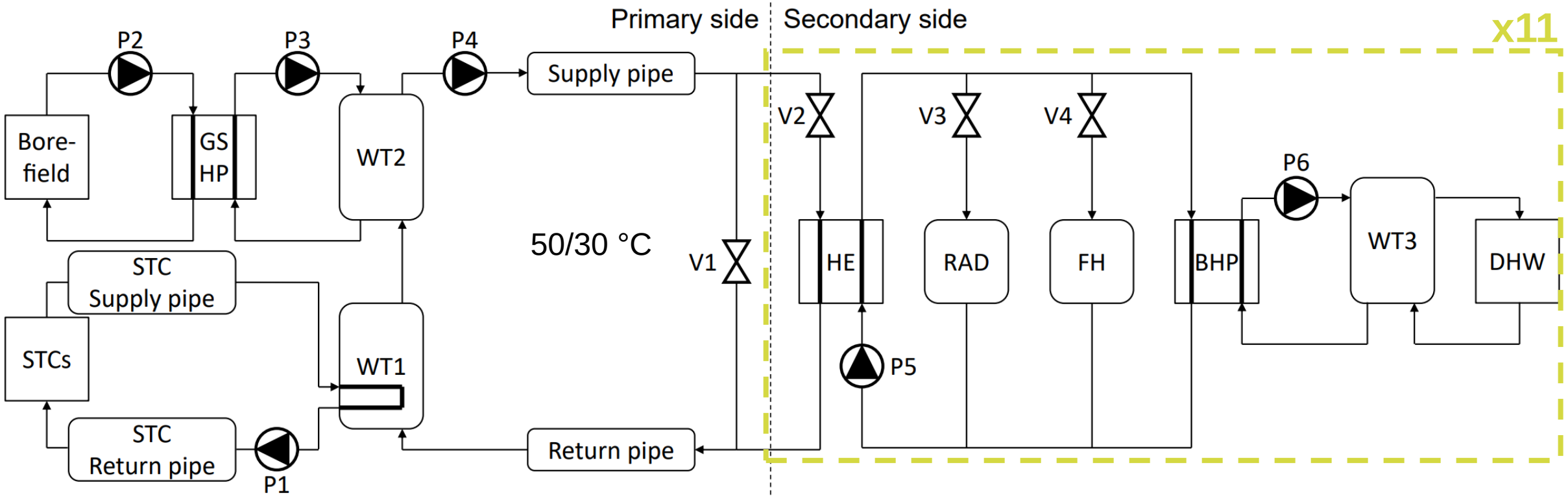
De Schipjes



DHW
production

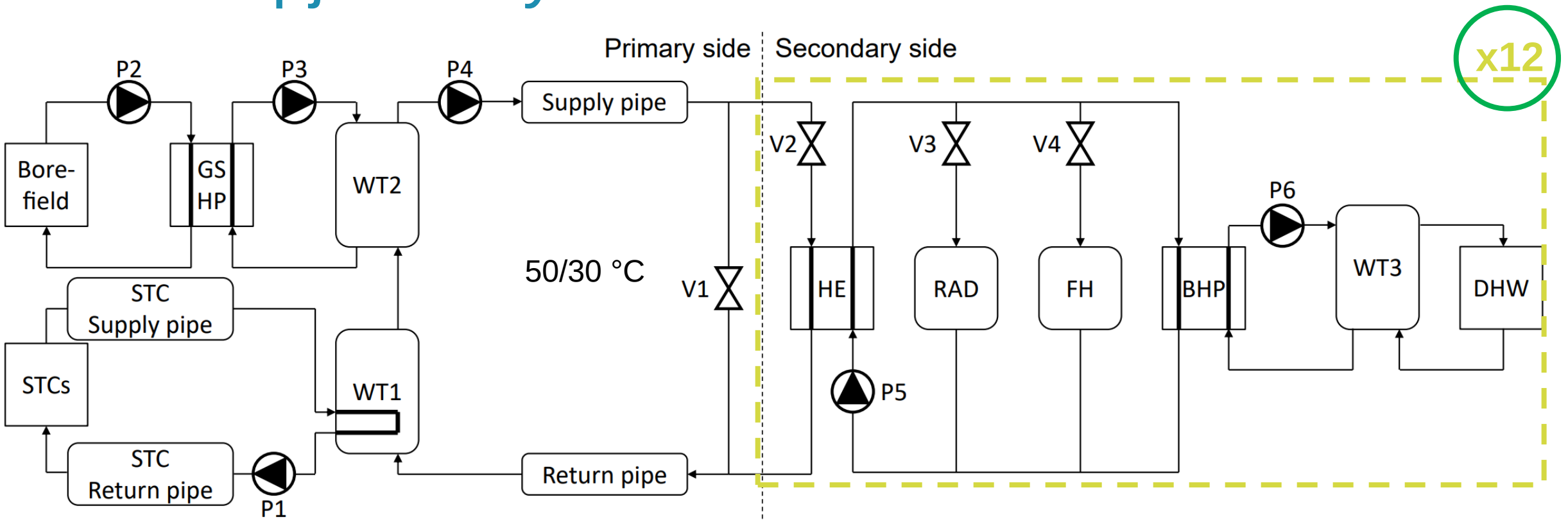
Source: Boydens engineering part of Sweco

De Schipjes – Hydraulic Scheme



BHP: Booster heat pump	RAD: Radiators
FH: Floor heating	GSHP: Ground sourced heat pump
STC: Solar thermal collector	HE: Heat exchanger
WT: Water tank	DHW: Domestic Hot Water
P: Pump	V: Valve

De Schipjes – Hydraulic Scheme



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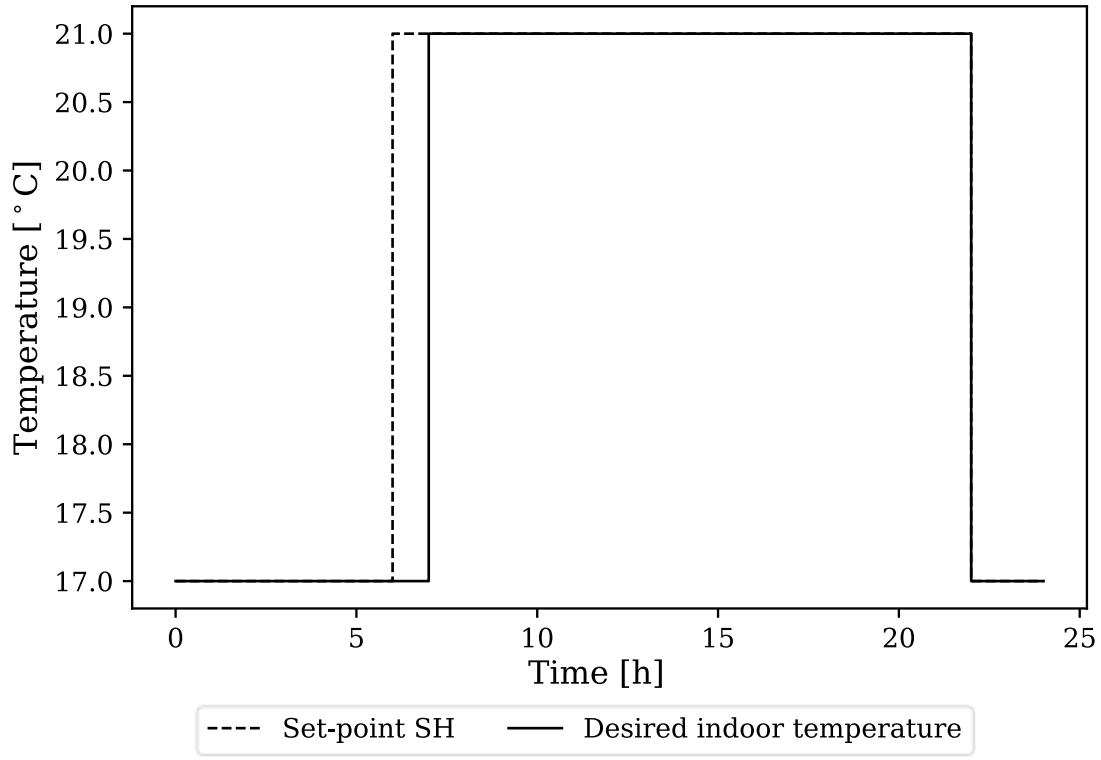
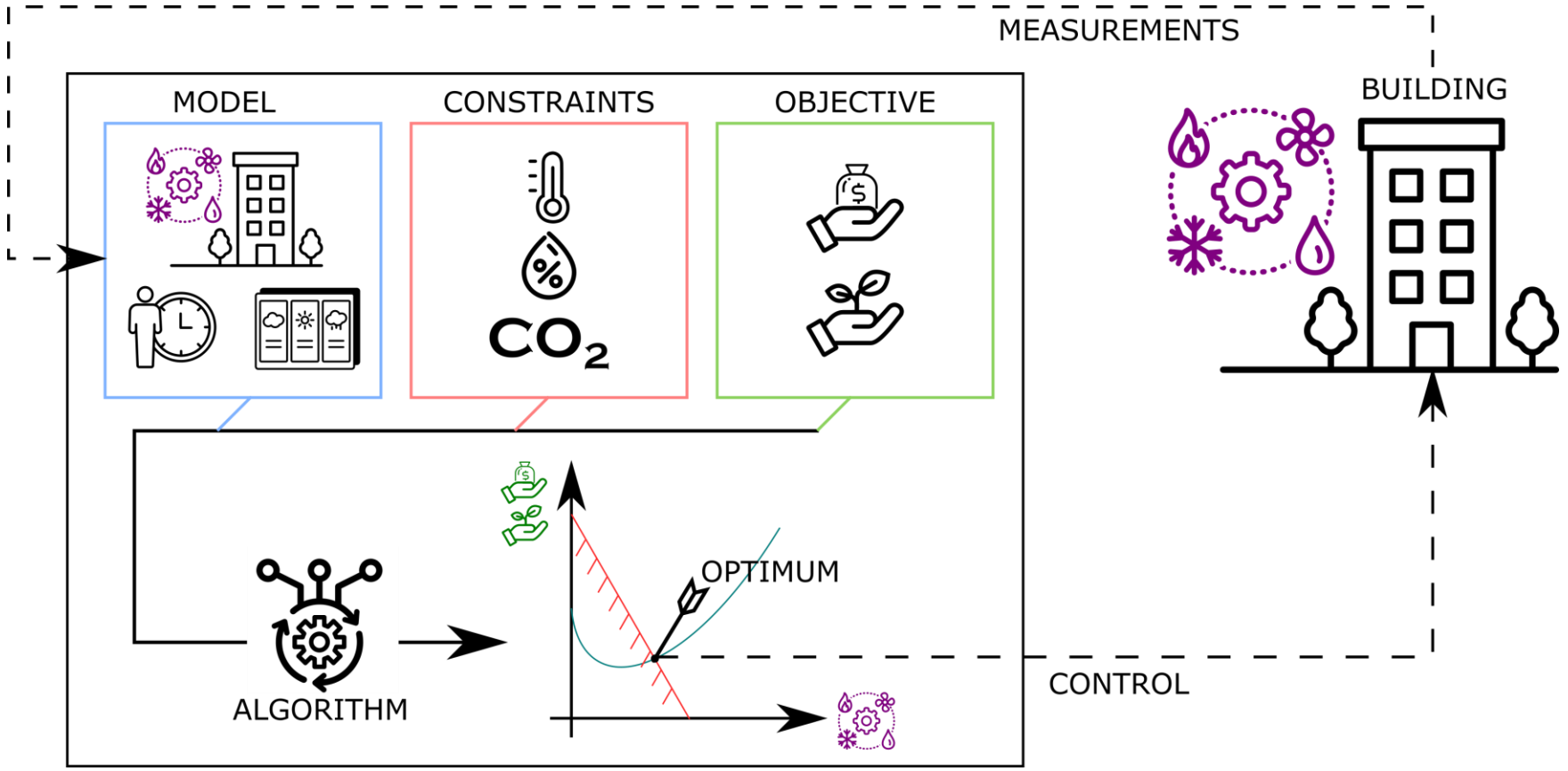
Initial Control

- Rule-Based Control (RBC)
  - On/off control GSHP
  - Heating system buildings
    - Heating Curve
    - Night set-back
  - On/off control BHP (45/60°C)



System Integration through **smart control**

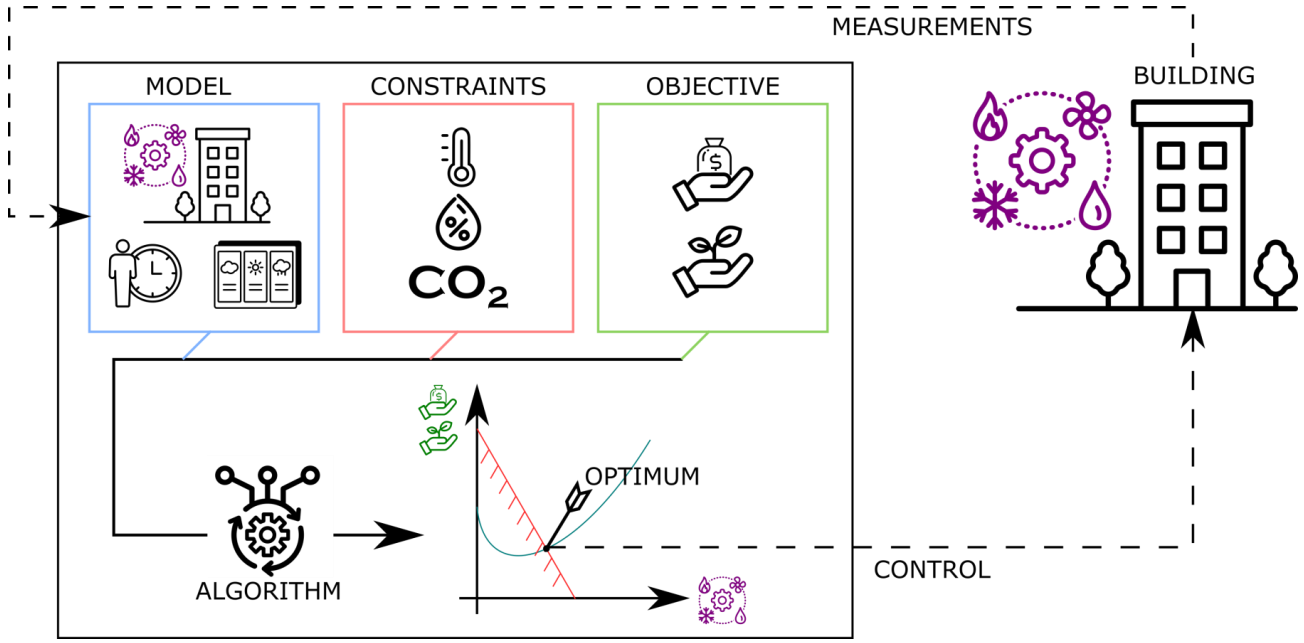
Model Predictive Control (MPC)

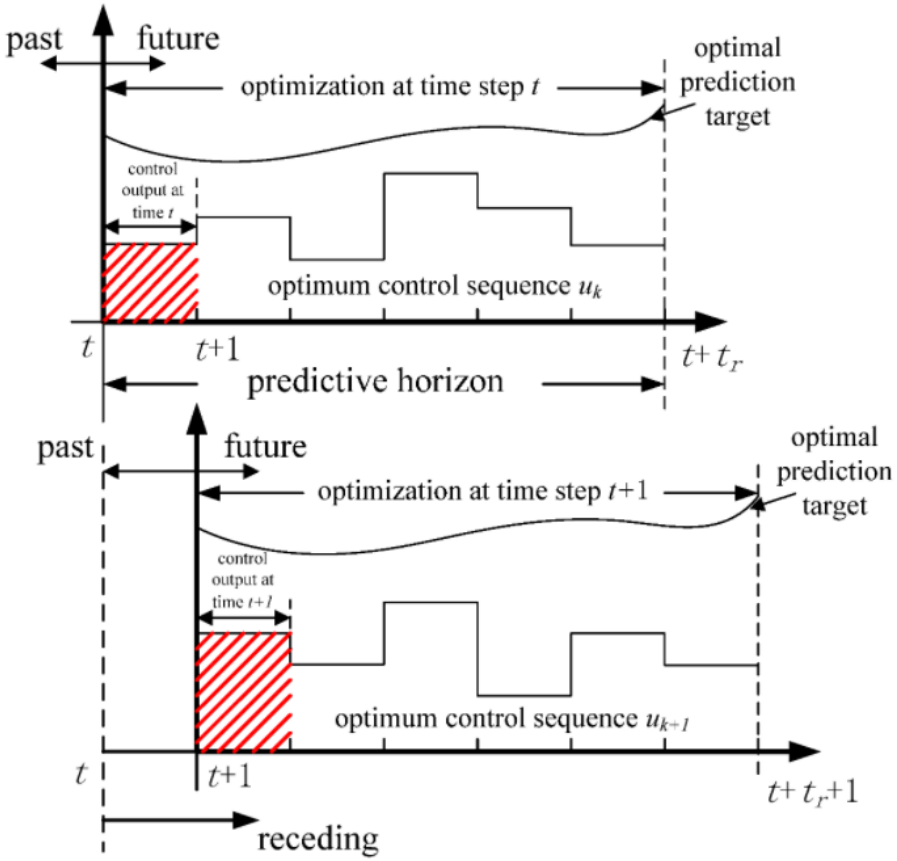


F. Jorissen & D. Picard

Model Predictive Control (MPC)

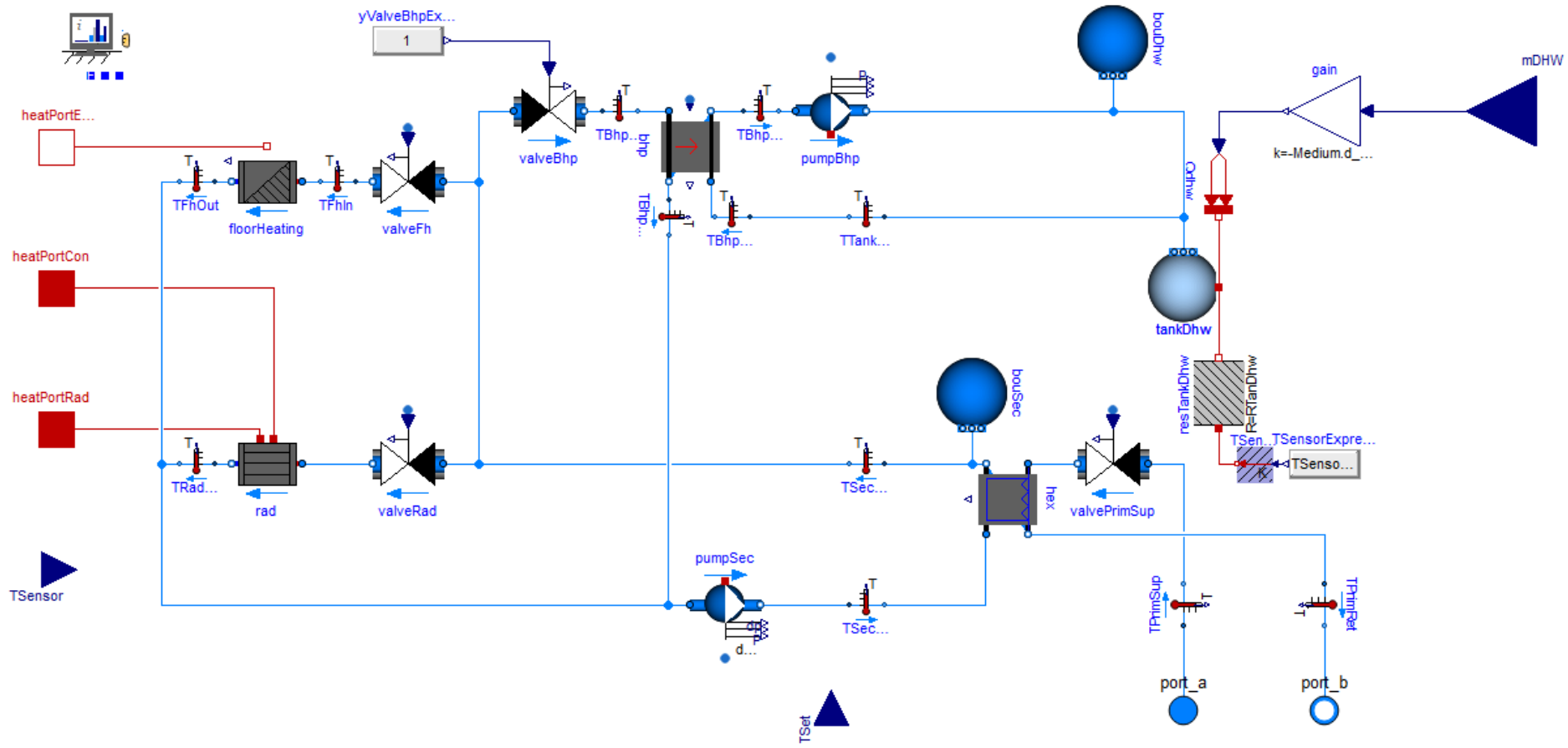
Prediction horizon





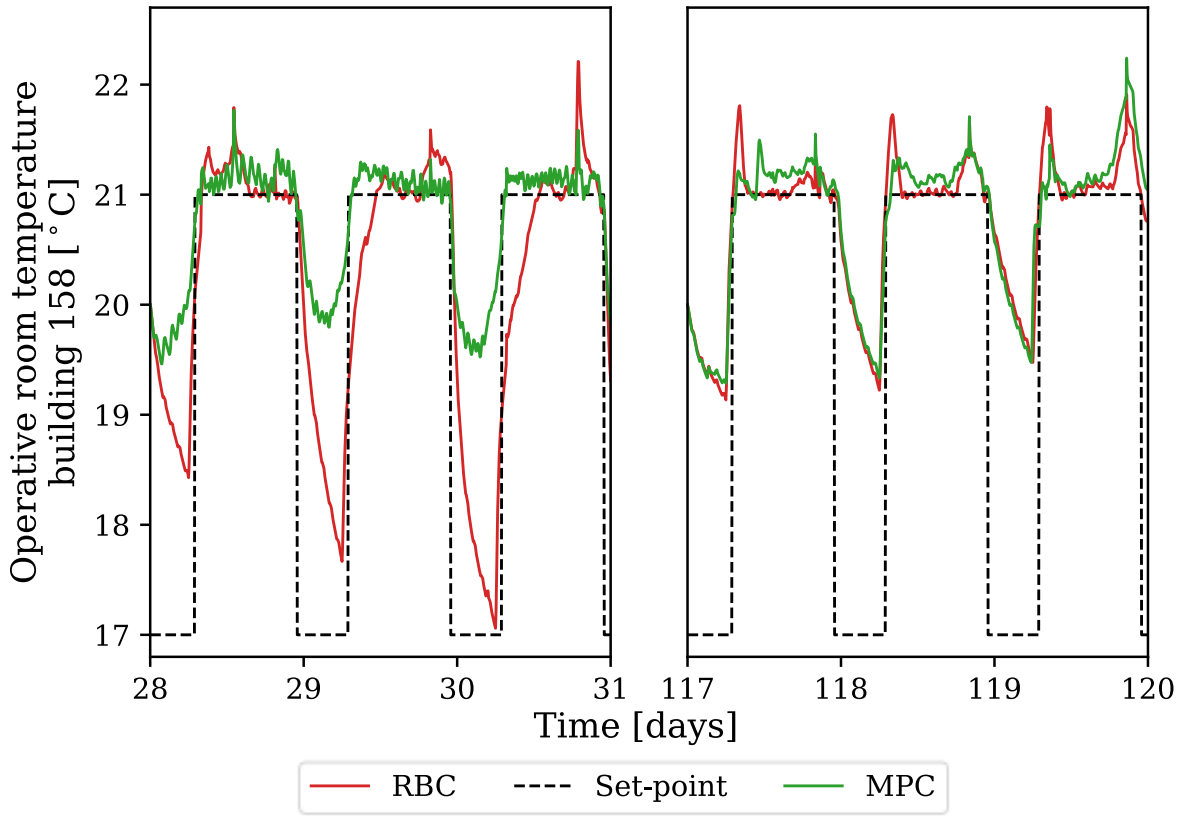
Model Predictive Control

White-box approach



MPC vs RBC

Indoor temperature



MPC vs RBC

District heating temperature

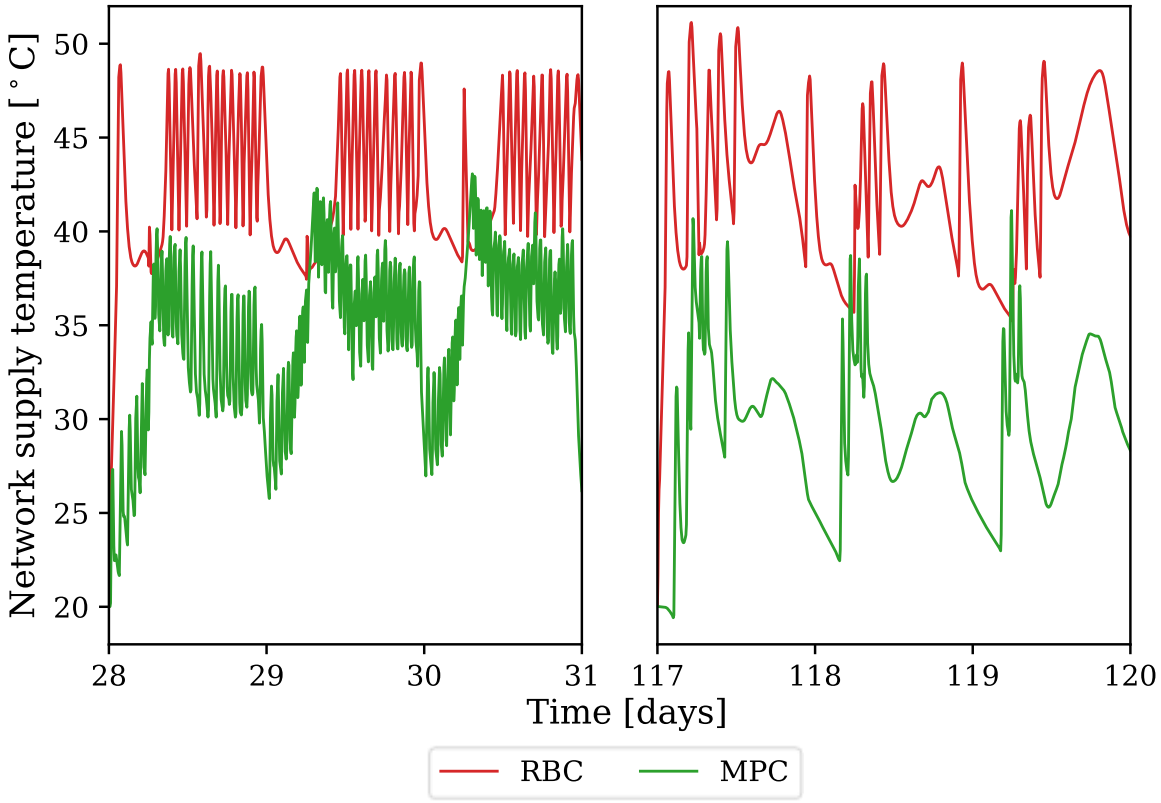
GSHP SCOP [-]:

Winter period (28-31 januari) :

RBC: 3.3
MPC: 3.9 +17%

Spring period (27-30 april):

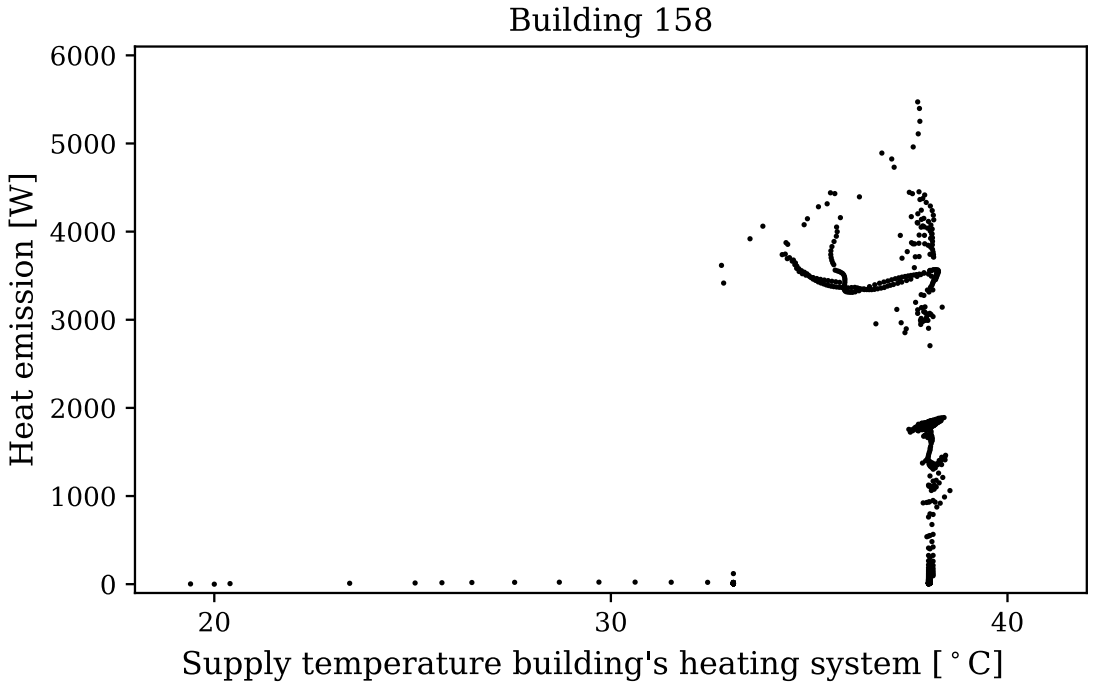
RBC: 3.6
MPC: 4.4 +21%



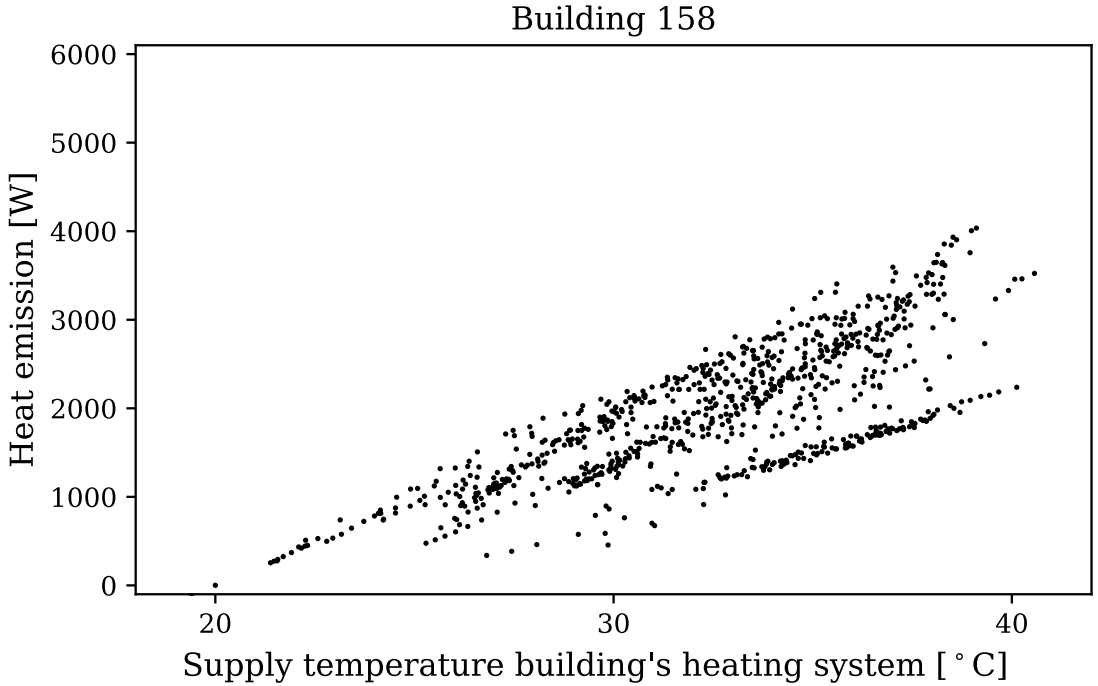
MPC vs RBC

Space heating

RBC



MPC



MPC vs RBC

Conclusion

MPC outperforms RBC in electricity use and thermal comfort (winter)

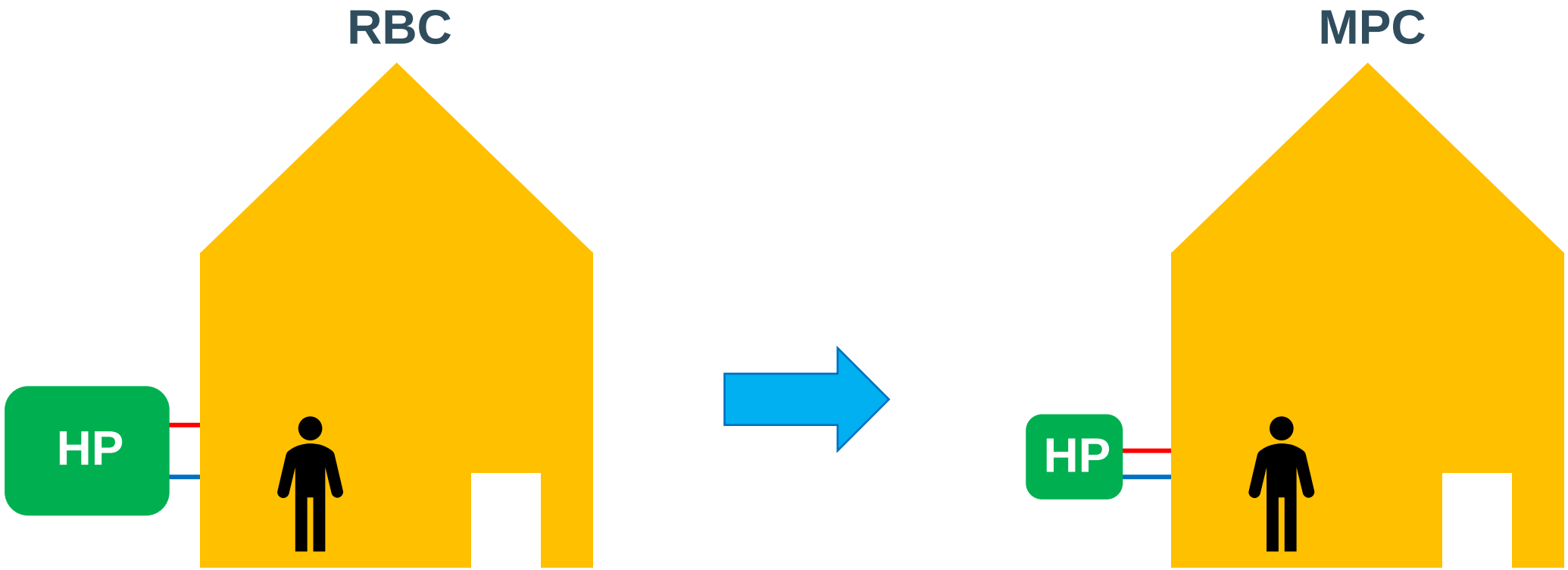
- Heating during the night ➔ use of building's thermal mass (flexibility)
- Lower network temperatures ➔ higher SCOP GSHP
- Uses predictions ➔ anticipates

➔ Use of predictive and anticipative optimal control leads to large gains!

System Integration through **integrated optimal design and control**

Interplay design and control - Example

Goal: Thermal comfort



Interplay design and control

Goal: Thermal comfort

HP size:

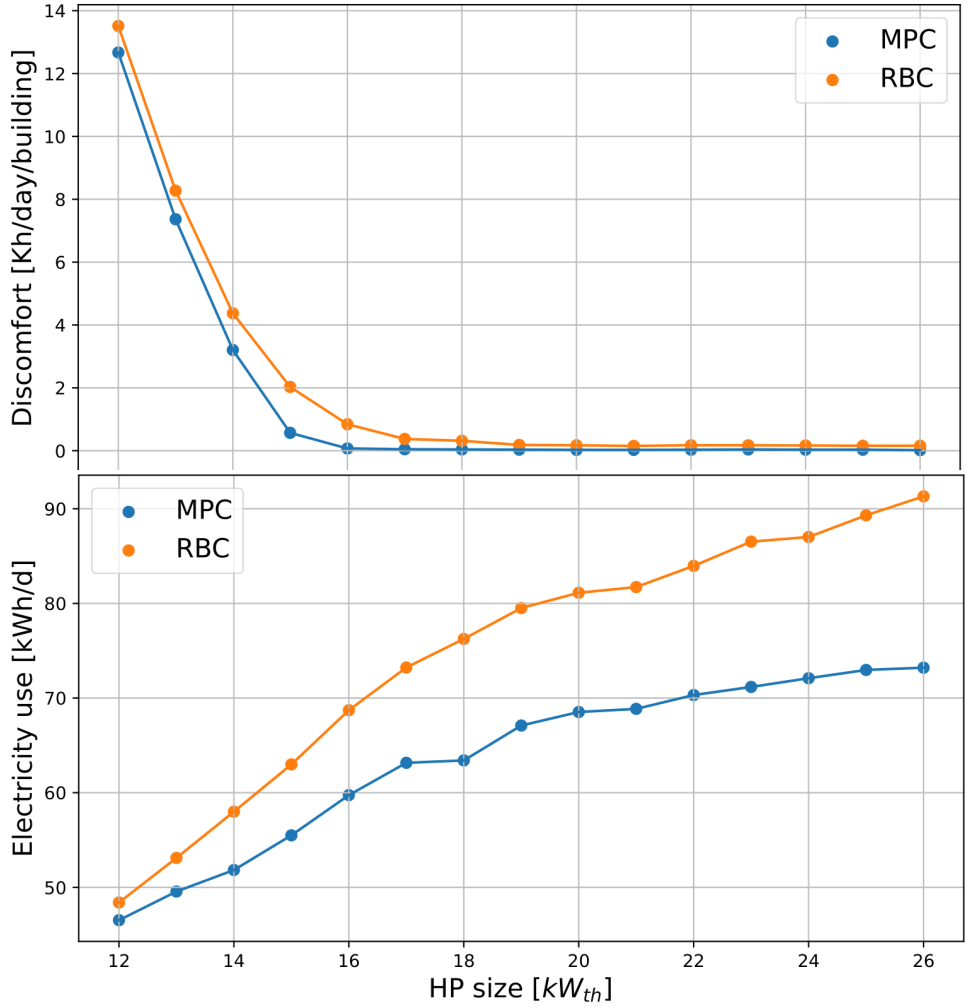
RBC:	16.9 kW	-9.5%
MPC:	15.3 kW	

OPEX:

RBC:	€24 450	-22%
MPC:	€19 060	

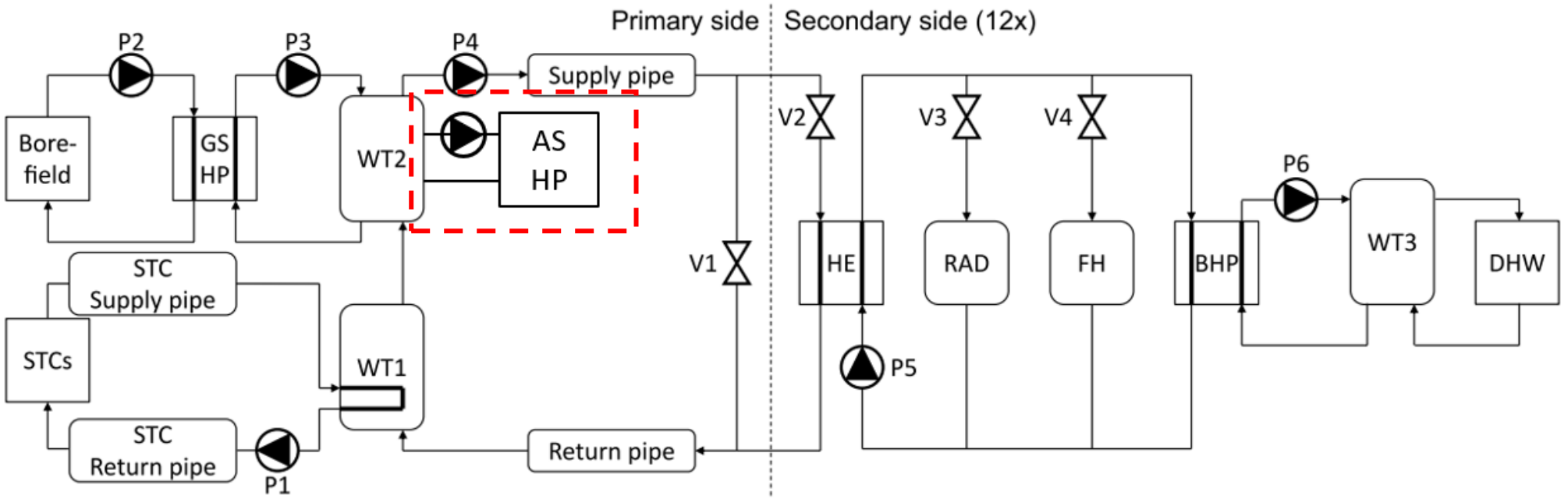
CAPEX:

RBC:	€10 080	-5%
MPC:	€ 9 590	



De Schipjes – Hybridization

Addition of ASHP to increase flexibility



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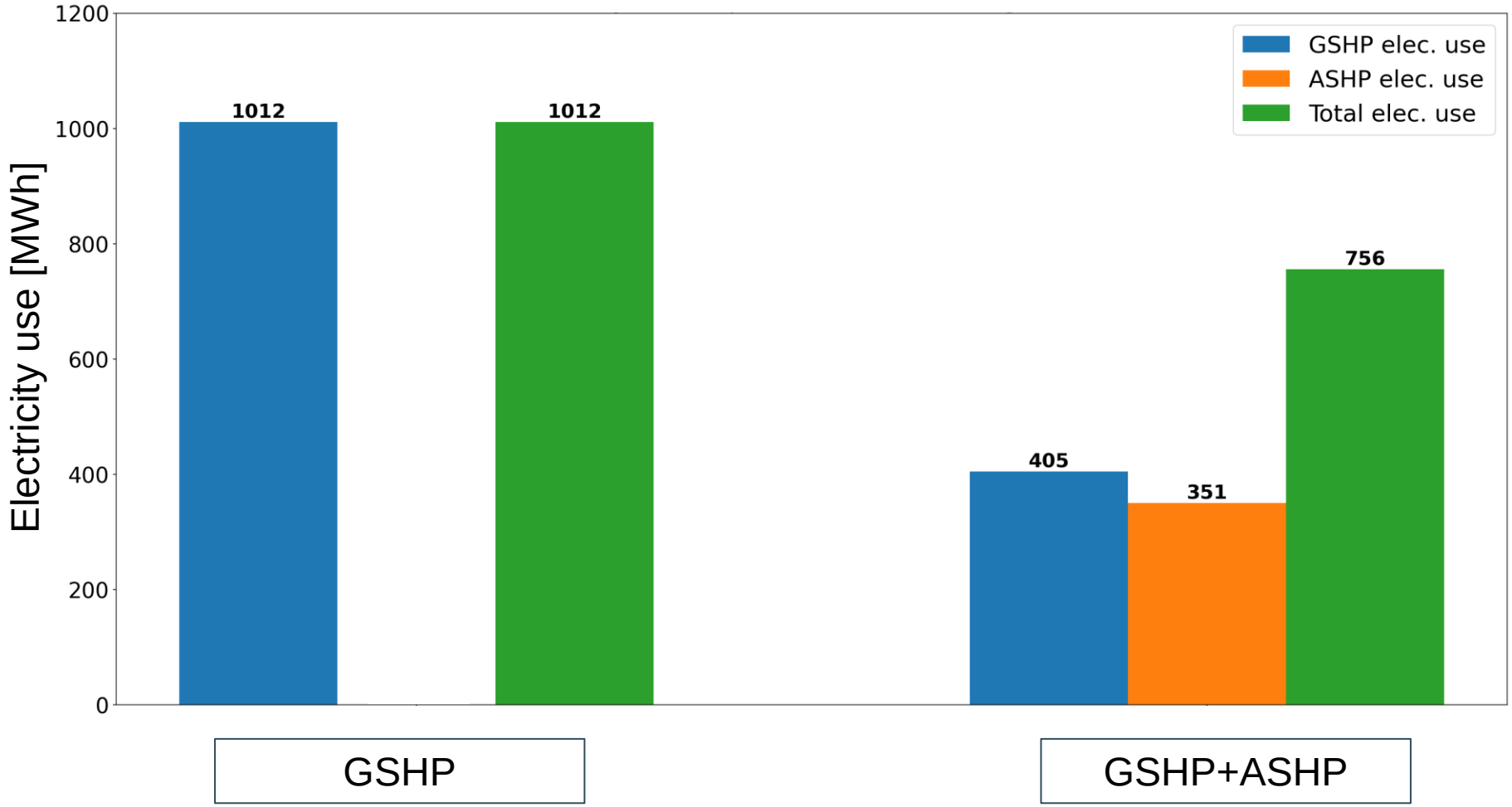
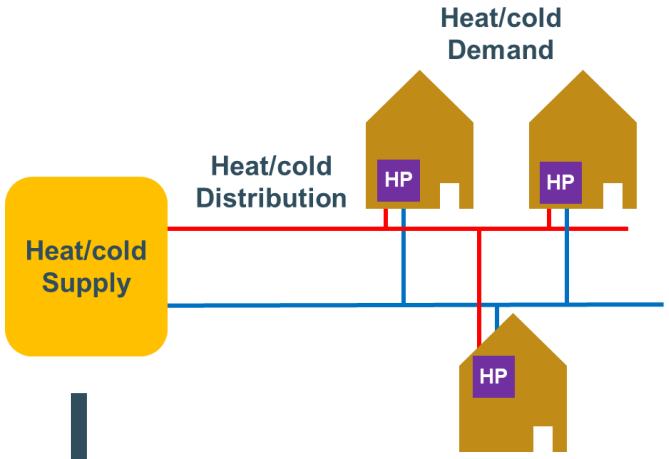


Integrated optimal design and control



AS HP Size?

GS HP Size?

BEO Size?

TANK Size?

→ Integrated optimal design and control

→ Minimize OPEX
Minimize CAPEX
Minimize CO_2-emissions
Guarantee comfort

Integrated optimal design and control

Conclusion

- All technologies are integrated and work together efficiently
  - Available flexibility maximally exploited
- CAPEX and OPEX are minimized together
- White-box approach allows for one single toolchain:
  - Actual eventual smart control taken into account
  - Development of MPC model from day 1

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