Determining the feasibility of excess heat utilization in district heating system consisting of natural gas cogeneration and solar thermal

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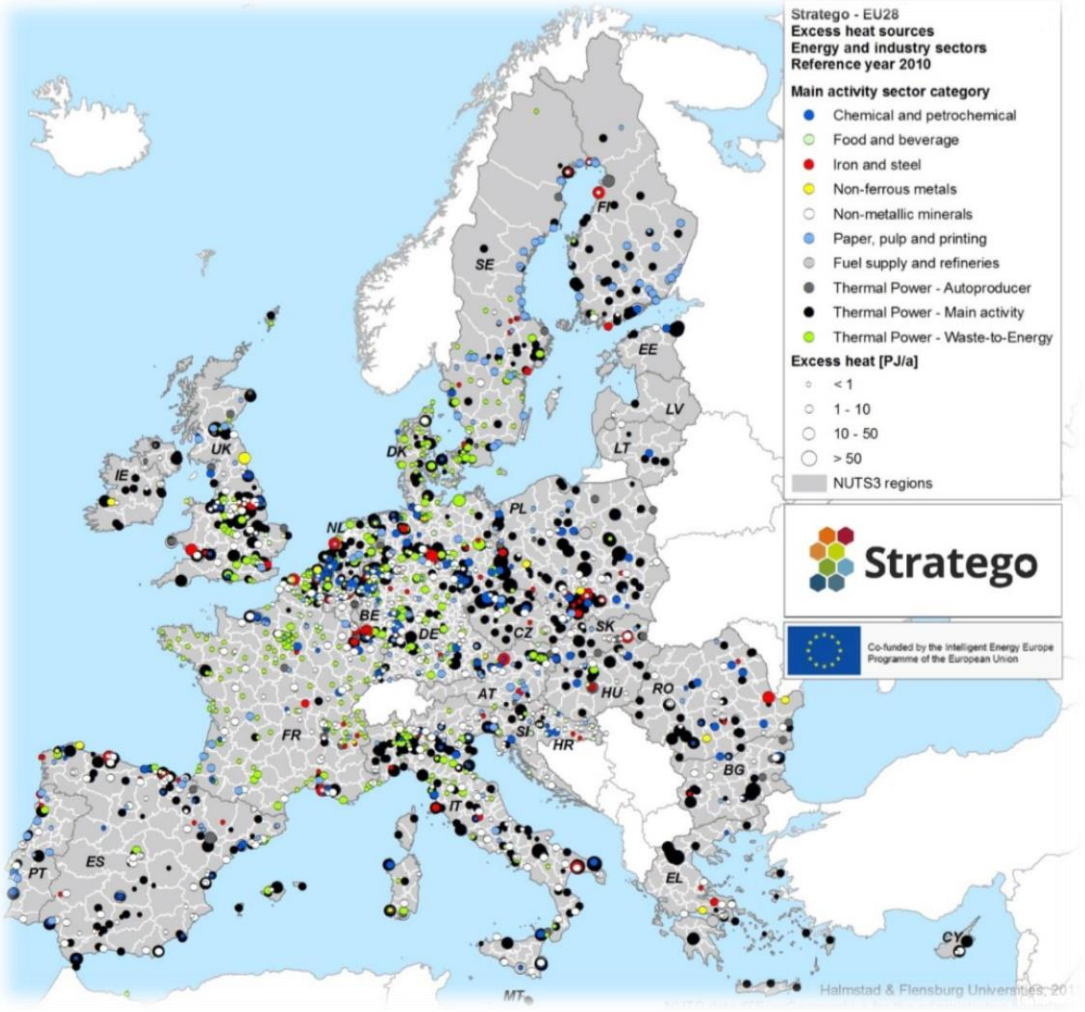
Introduction

- Heating and cooling sector – the most energy intensive sector in the EU
- European Commission – The first heating and cooling strategy recognized the significance of district heating and cooling
- Focus on renewable energy sources and excess heat utilization
- Significant potentials – enough excess heat to cover the demand of all residential and service buildings in Europe



Levelized cost of excess heat

- A part of heat production from the natural gas district heating is substituted by **excess heat**
- It is assumed that the temperature level of the available excess heat source is *high enough for direct utilization*
- This scenario includes calculation of the **maximum feasible distan**ce of the potential excess heat source, taking into account **different quantities** of the available excess heat in the area

$$\mathrm{LCOEH} = \frac{I_{HE} \cdot CRF \cdot (1 - TD_{pv})}{8760 \cdot i \cdot (1 - T)} + \frac{O_{HE,total}}{8760 \cdot i} + c_{excess\ heat} \quad [€/\mathrm{kWh}]$$

Levelized cost of excess heat

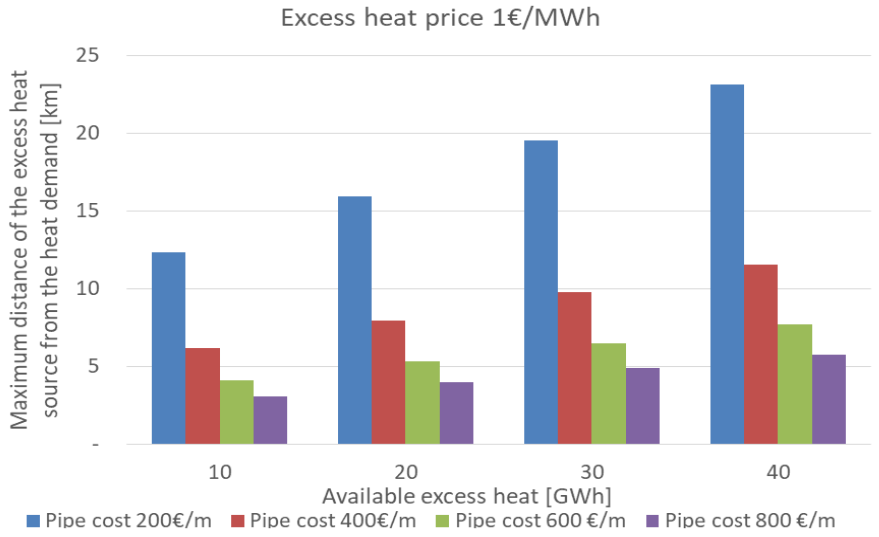
- When calculating LCOEH, the cost for the installation of distribution network is not included in the equation
- Maximum potential distance of the heat source from the demand, i.e. the extra revenue which can be used to finance the construction of the distribution network

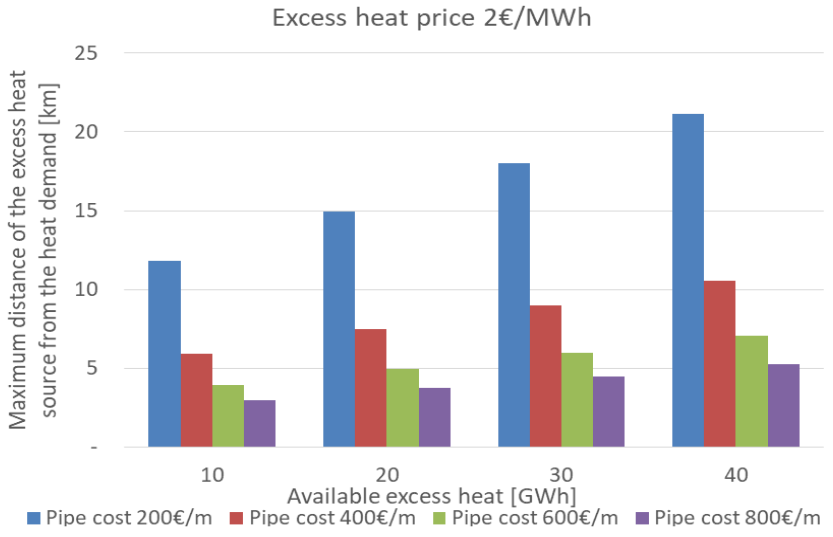
$$\mathrm{R}_{EH} = E_{total} \cdot r_{heat} - (E_{EH} \cdot LCOEH + E_{DH} \cdot LCOH) - l \cdot n \cdot c_{pipes} \quad [€]$$

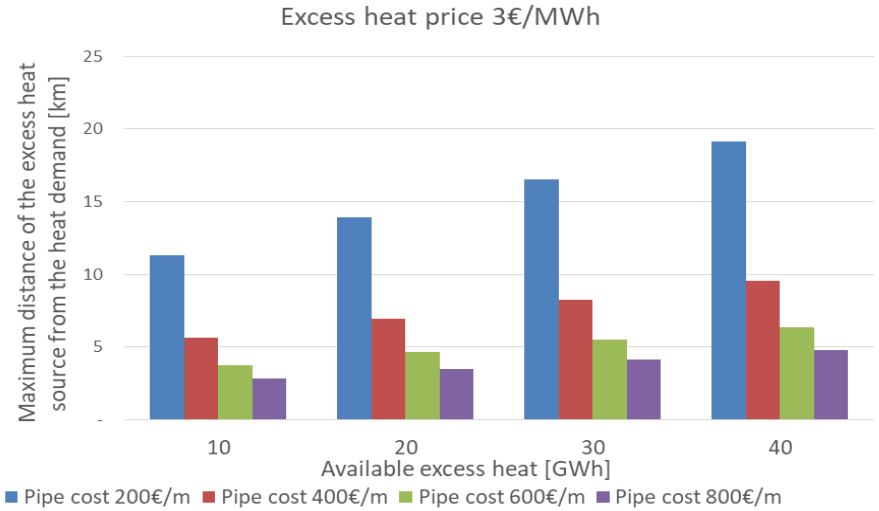
- The *sensitivity analysis* has been made by changing the values of **available excess heat, costs of pipes and the cost of excess heat**

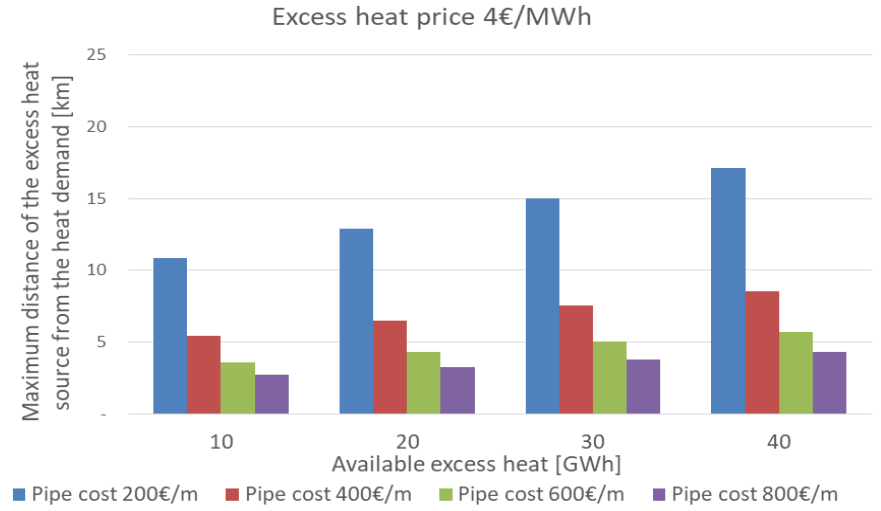
Excess heat price [€/MWh]	Cost of distribution pipes [€/m]	Available excess heat supply [GWh]
1	200	10
2	400	20
3	600	30
4	800	40

Levelized cost of excess heat - results

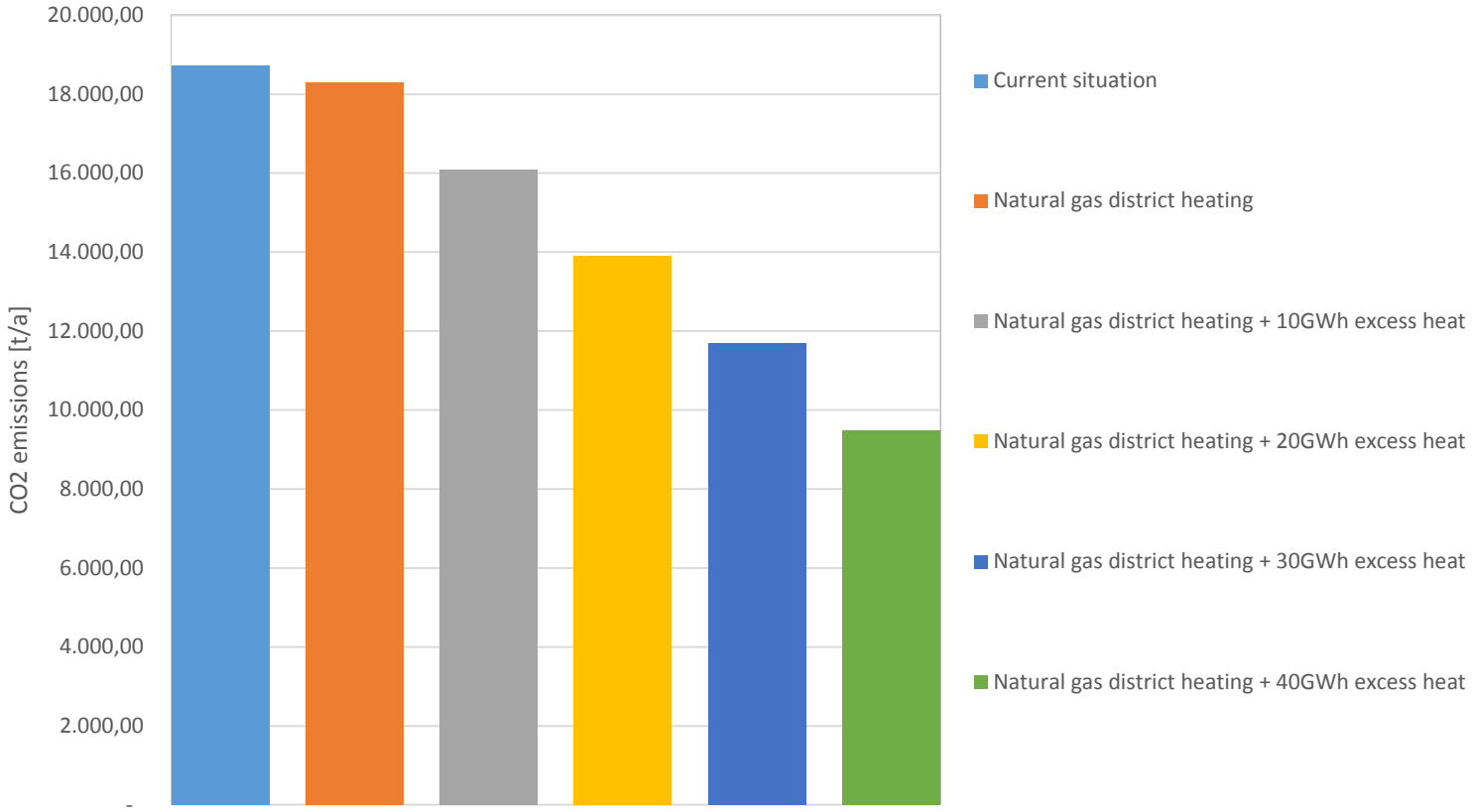








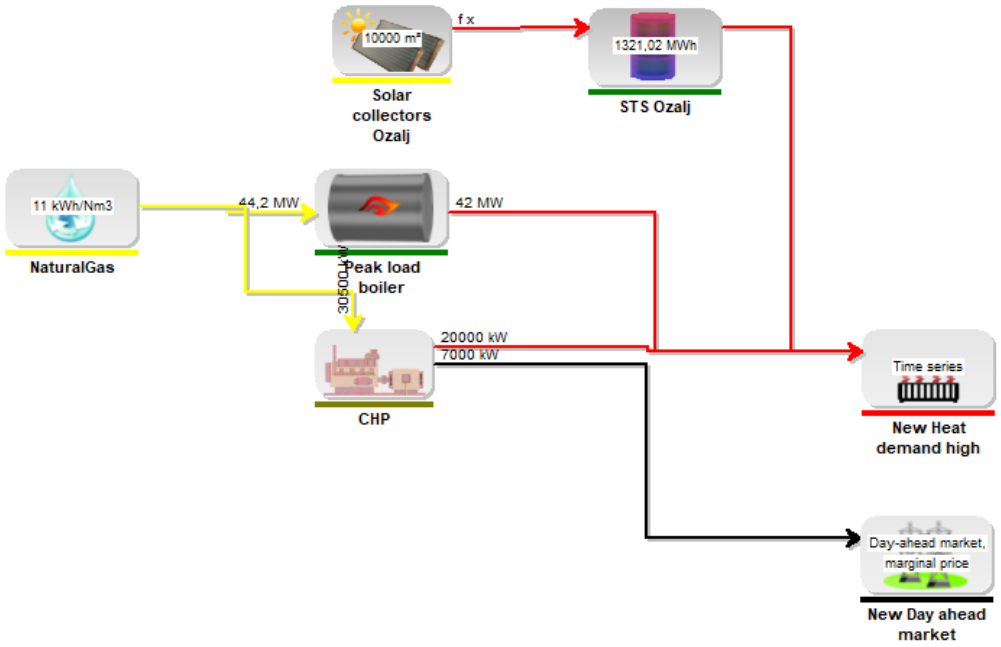
Environmental impact analysis - results



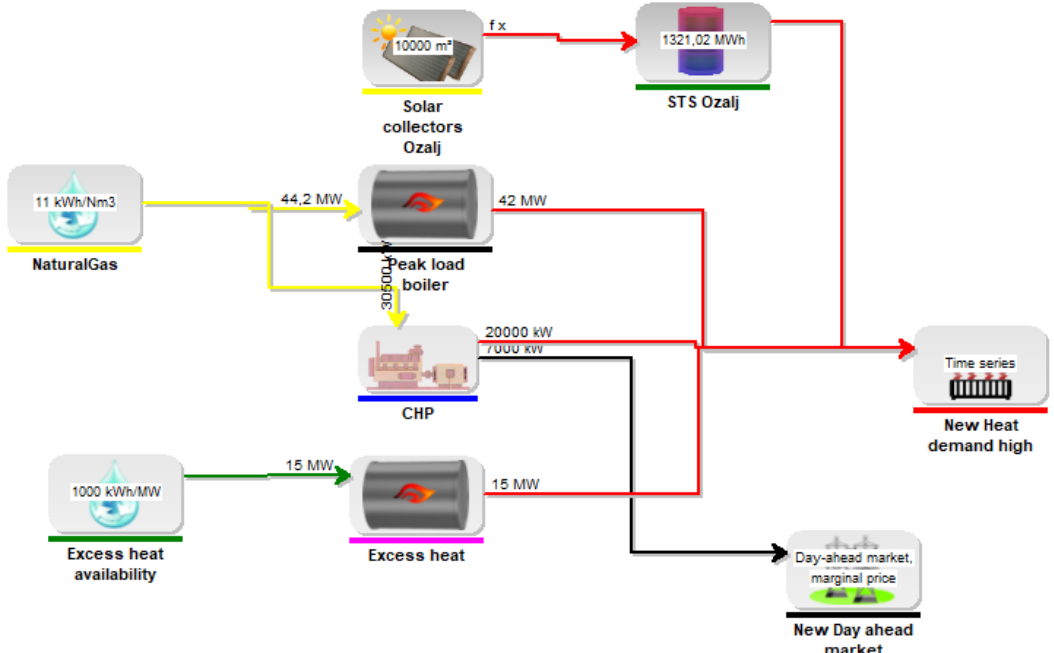
	Current situation	Natural gas district heating	Natural gas district heating + 40 GWh excess heat
NO_x emissions (kg/a)	25,783.24	3,292.07	1,707.62
PM emissions (kg/a)	1,331,938.62	29.93	15.52
CO emissions (kg/a)	2,153,771.65	70,013.02	36,316.36

Scenarios

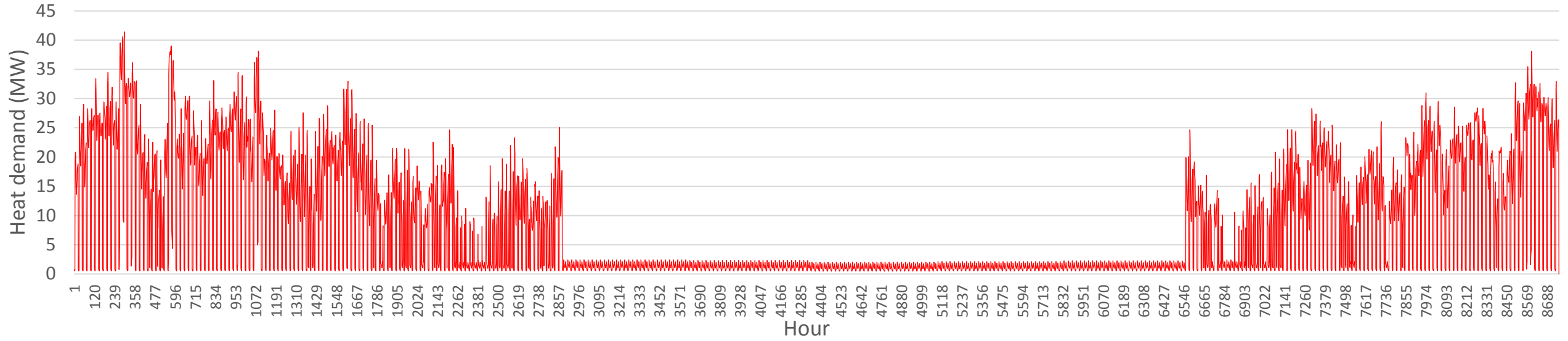
- Scenario 1
  - ➢20 MW_{th} natural gas CHP
  - ➢30 MW_{th} natural gas peak boiler
  - ➢10,000 m2 solar collectors
  - ➢1,321 MWh thermal storage

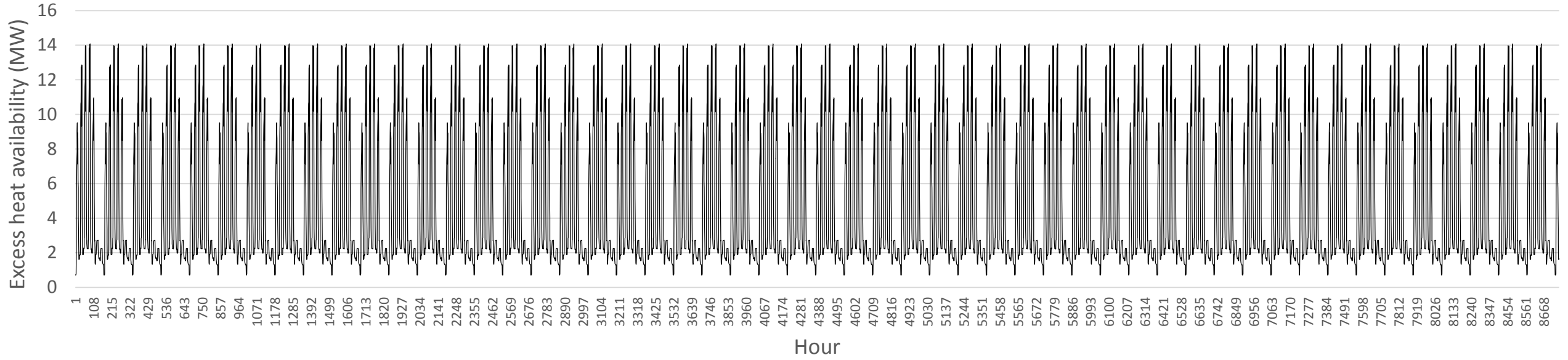


- Scenario 2
  - ➢20 MW_{th} natural gas CHP
  - ➢30 MW_{th} natural gas peak boiler
  - ➢10,000 m2 solar collectors
  - ➢1,321 MWh thermal storage
  - ➢40 GWh excess heat

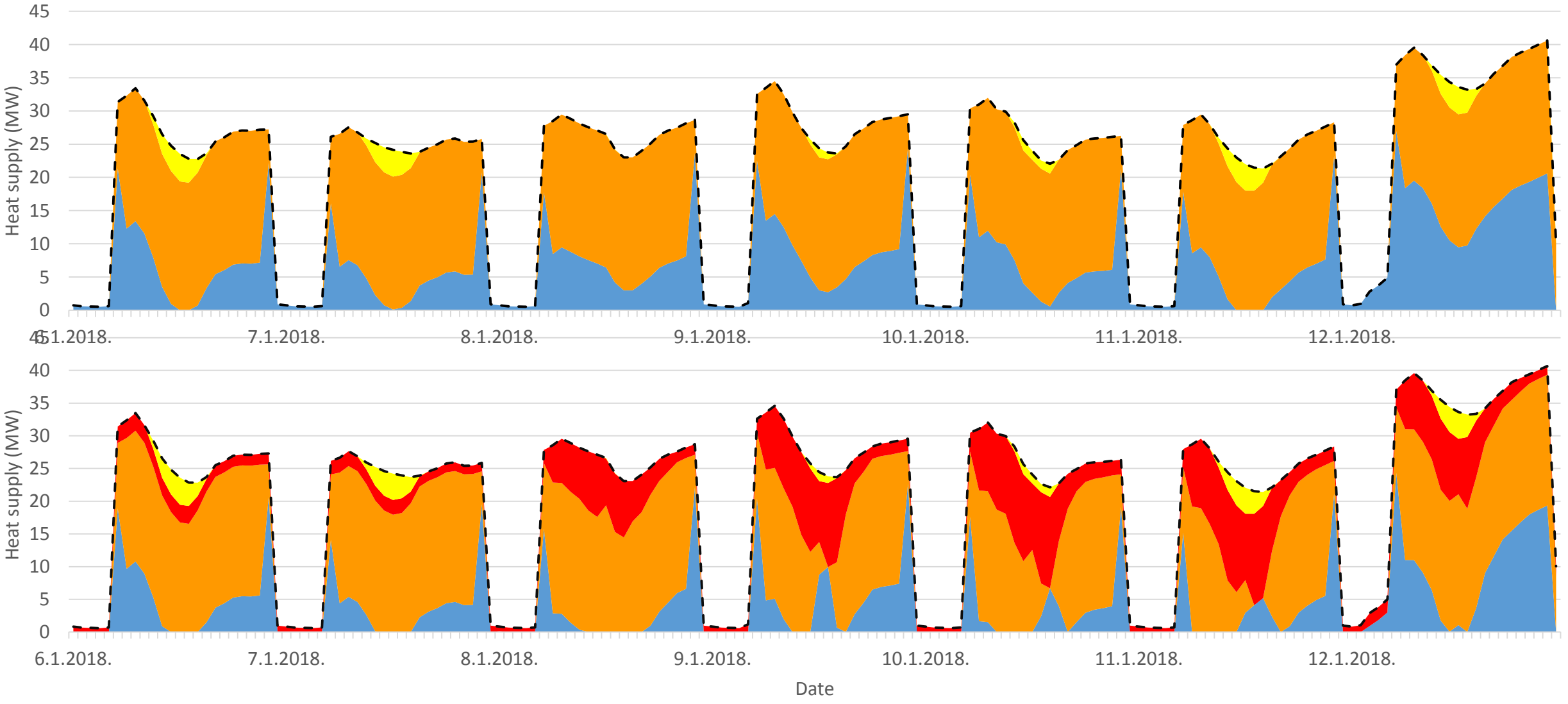


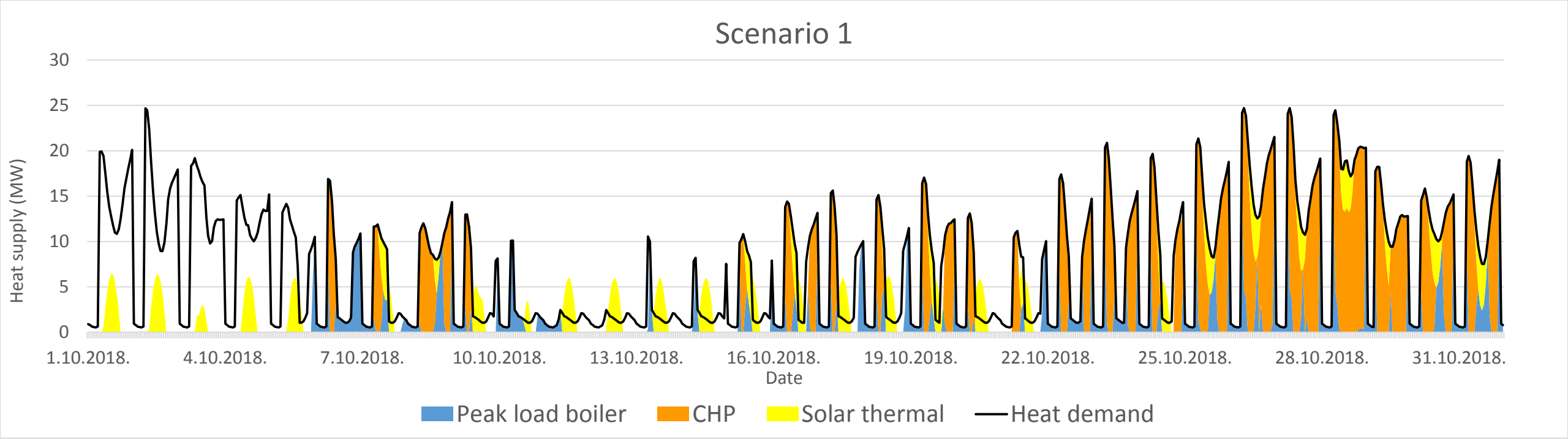
Analysis on an hourly level

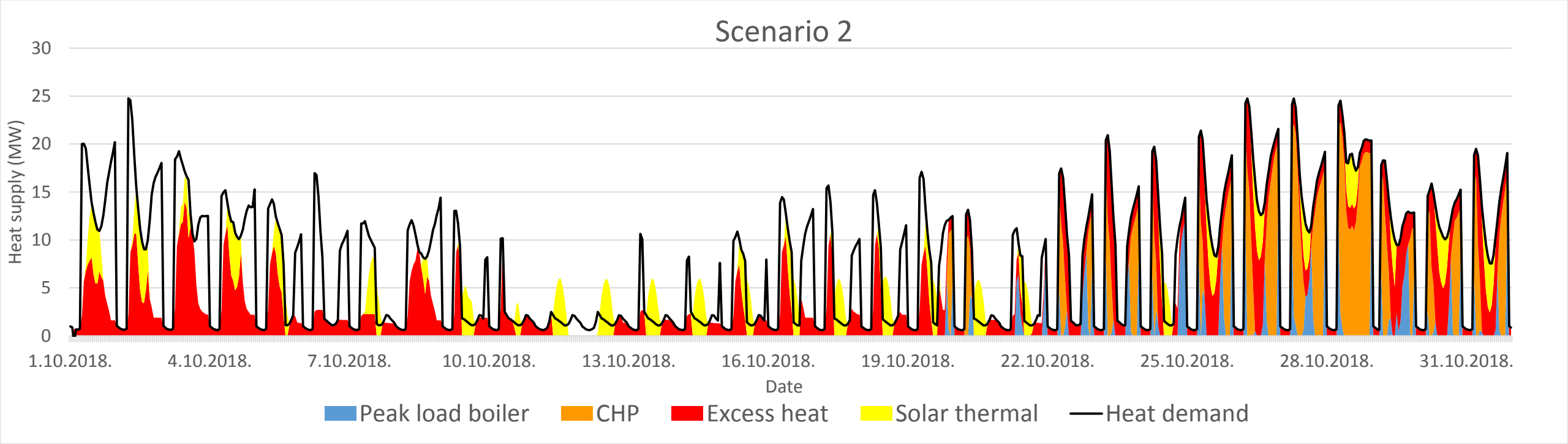




Results


Heat supply (MW)
45
40
35
30
25
20
15
10
5
0
6.1.2018.
7.1.2018.
8.1.2018.
9.1.2018.
10.1.2018.
11.1.2018.
12.1.2018.
Heat supply (MW)
40
35
30
25
20
15
10
5
0
6.1.2018.
7.1.2018.
8.1.2018.
9.1.2018.
10.1.2018.
11.1.2018.
12.1.2018.
Date
Peak load boiler
CHP
Excess heat
Solar thermal
Heat demand


Scenario 1
Heat supply (MW)
30
25
20
15
10
5
0
1.10.2018.
4.10.2018.
7.10.2018.
10.10.2018.
13.10.2018.
16.10.2018.
19.10.2018.
22.10.2018.
25.10.2018.
28.10.2018.
31.10.2018.
Date
Peak load boiler
CHP
Solar thermal
Heat demand


Scenario 2
Heat supply (MW)
30
25
20
15
10
5
0
1.10.2018.
4.10.2018.
7.10.2018.
10.10.2018.
13.10.2018.
16.10.2018.
19.10.2018.
22.10.2018.
25.10.2018.
28.10.2018.
31.10.2018.
Date
Peak load boiler
CHP
Excess heat
Solar thermal
Heat demand

Conclusions

- Needed peak load boiler capacity reduced by 3 MW
- Peak load boiler operation reduced by 29.3 %
- Production units start operation 13 days later in autumn with EH
- Solar collector production remains the same
- 17,847 MWh excess heat utilized – 44.6% of available amount
- Storage needed

Thank you for your attention!

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