Hourly optimization model for district heating systems including building retrofit – case study for the city of Velika Gorica

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Content

- Why optimization of DH systems?
- Method
- Input data
- Scenarios
- Results
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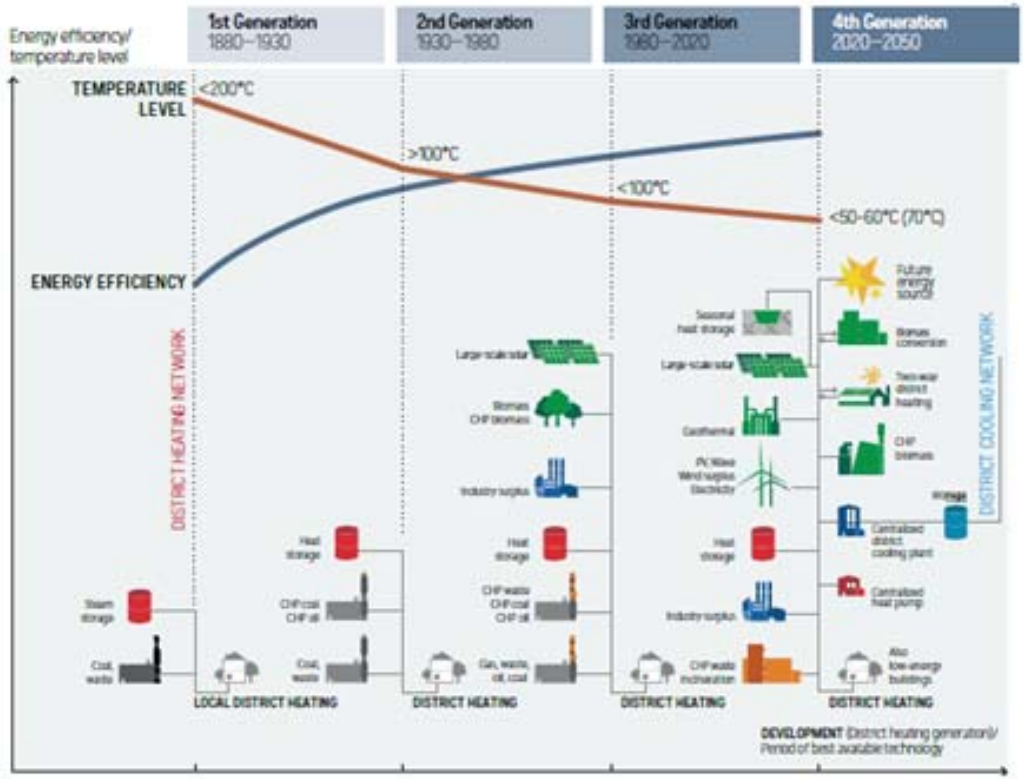
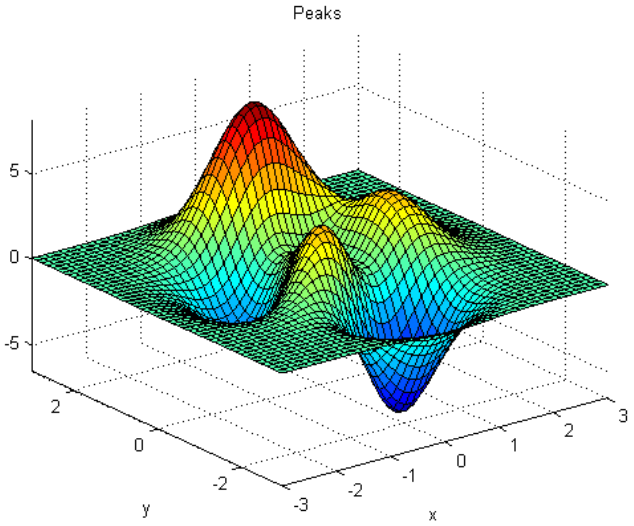
- Road to 4DH
- Many technologies, energy and mass streams will be involved

Finding the optimal solution presents a great challenge



Optimization of DH systems

- Satisfy demand
- Investment and yearly O&M expenses
- Analyse GHG emissions



H2RES - Energy system simulation/optimization

- MATLAB+OPTI Toolbox (SCIP)
- Mixed integer linear optimization
- DH systems
- Technology capacity and operation of supply
- Minimize investment

- To be included in the PLANHEAT tool

Objective function

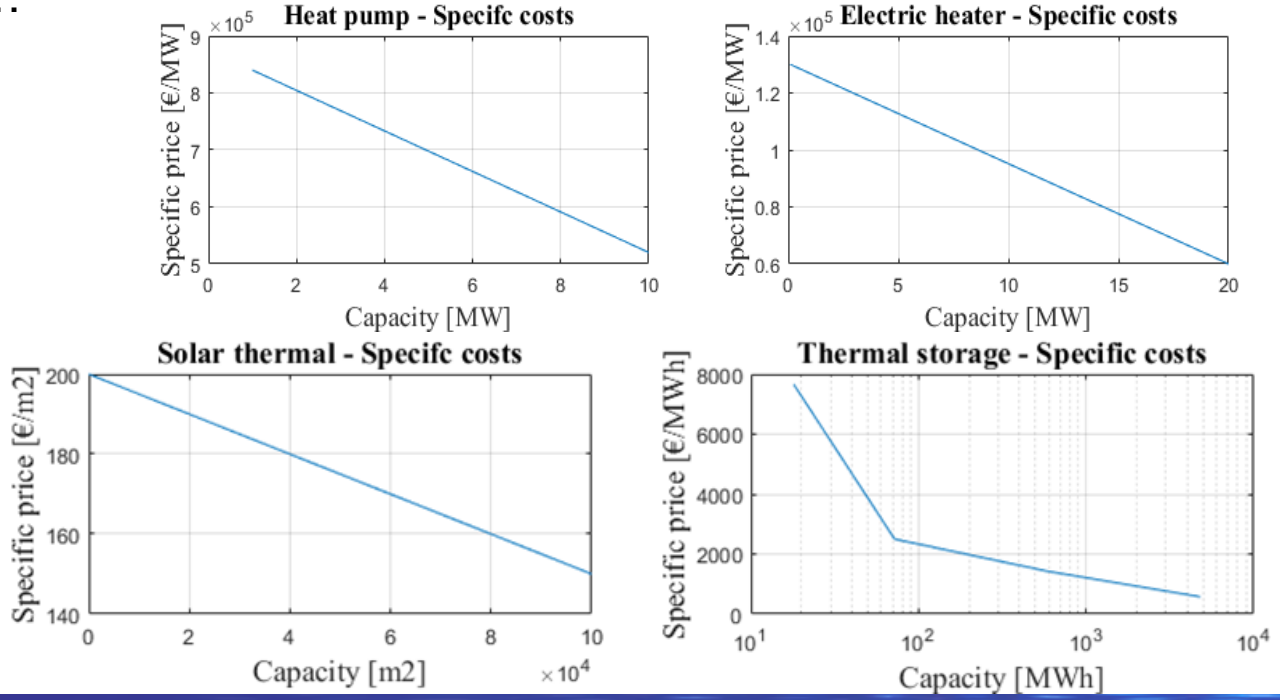
- Investment and operation cost

$$\min(Cost) = \sum_{i=1}^{n} Investment_{technology,i} + \sum_{i=1}^{n} O\&M_{technology,i} - \sum_{i=1}^{n} Aditional\ income_{technology,i}$$

- $Investment = f(technology,\ capacity, specific\ price, demand)$
- $O\&M = f(technology,\ fuel,\ capacity,\ specific\ prices,\ demand)$
- $Aditional\ income = f(technology,\ specific\ prices,\ etc.)$

Input data

- Technology: CHP, heat-only boiler, heat pump, electrical heater, solar thermal, thermal storage (seasonal and daily), including buidling retrofit
- Min and max possible capacities
- Other…



Output data

- **Optimal** unit's capacities and thermal energy production distribution with minimal overall cost
- Total cost of investment and O&M
- Levelised cost of heat (LCOH)
- Total emissions of CO_2

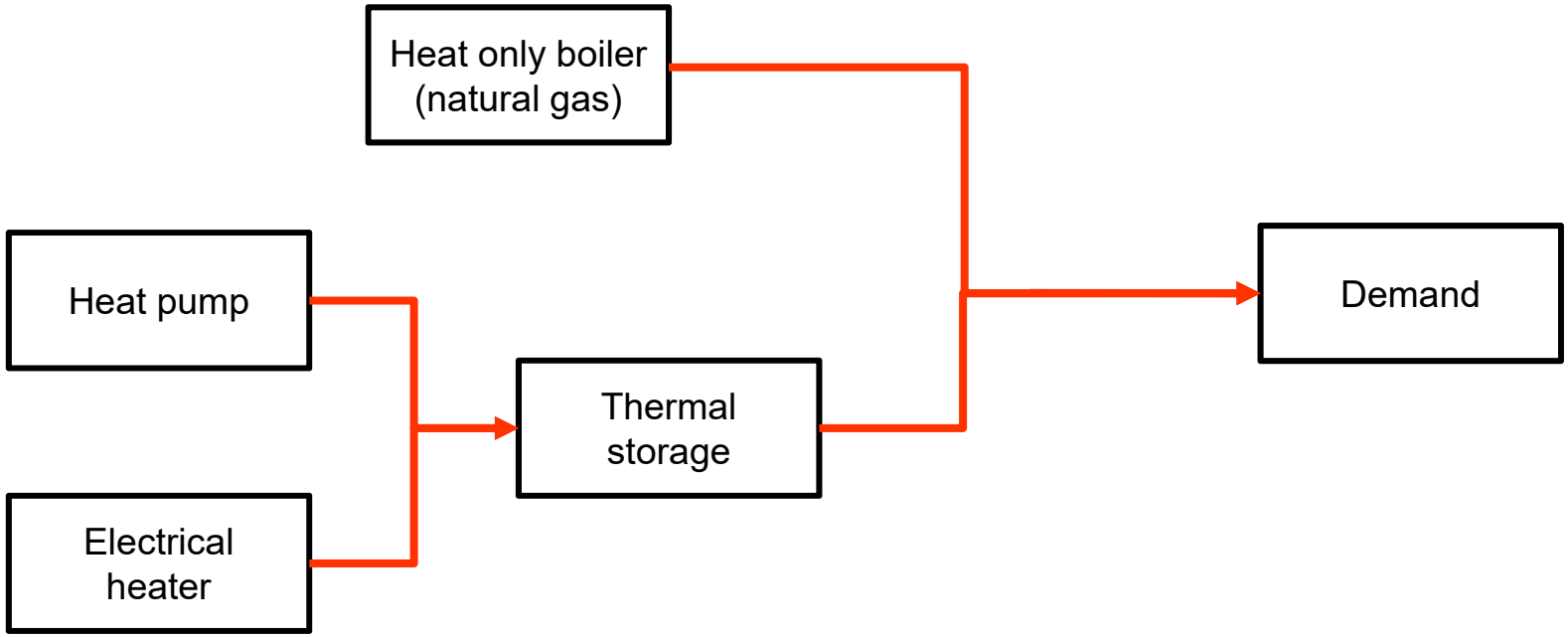
Scenario analysis

- Scenario 1 – reference scenario

- Scenario 2

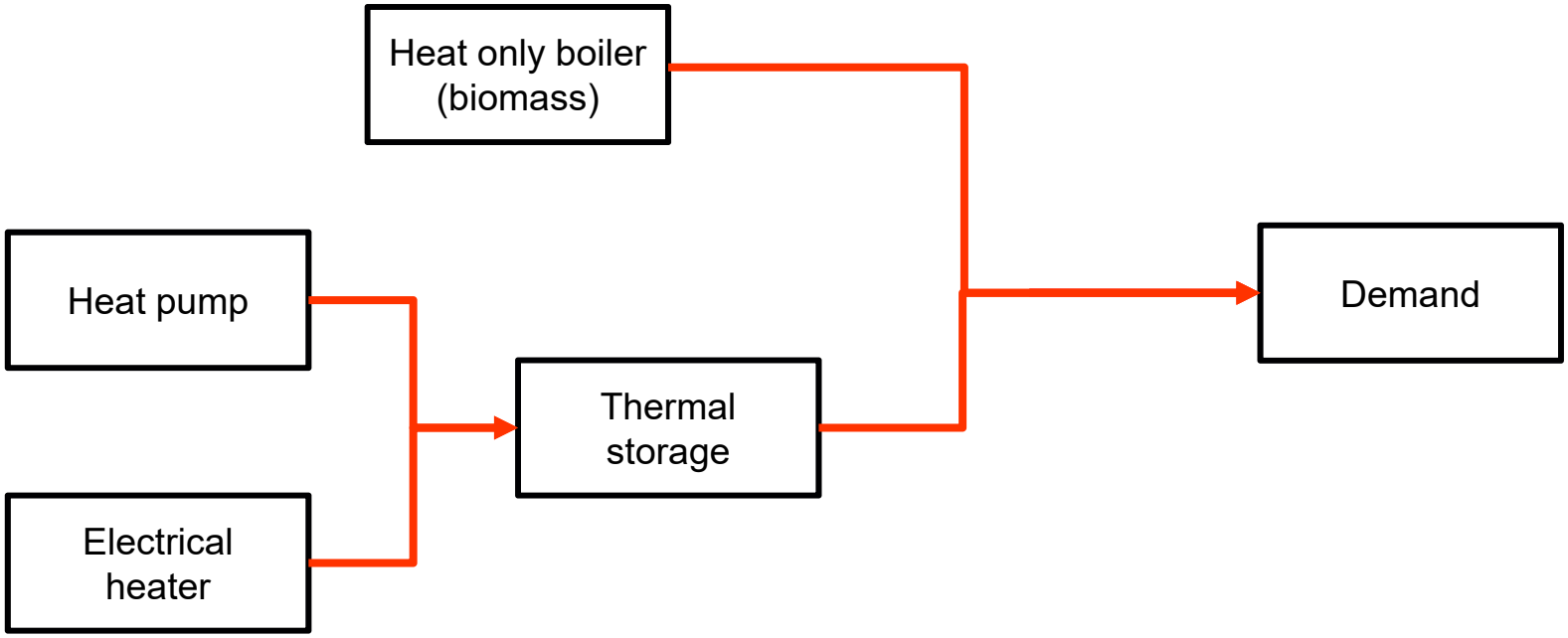
Scenario analysis

- Scenario 3



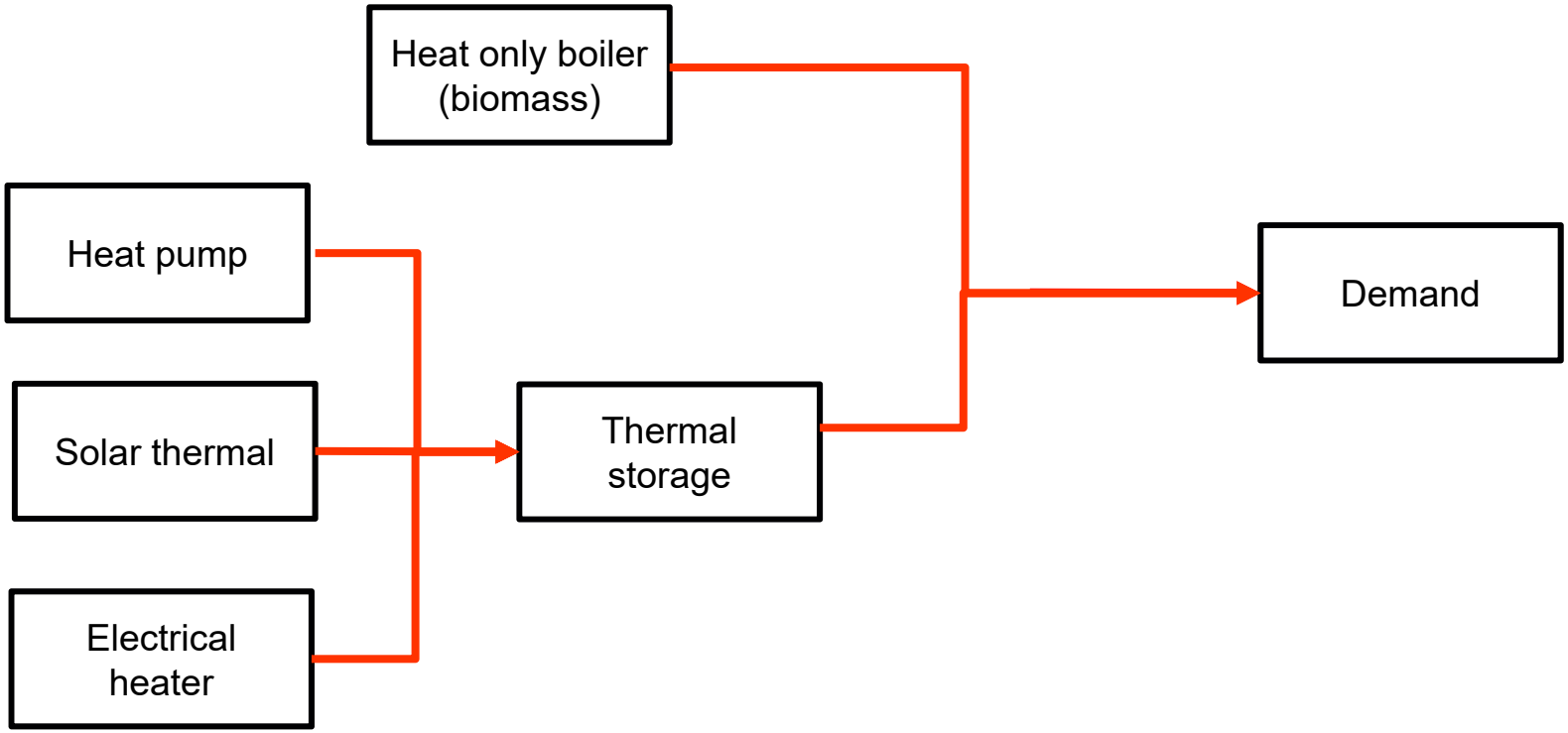
Scenario analysis

- Scenario 4



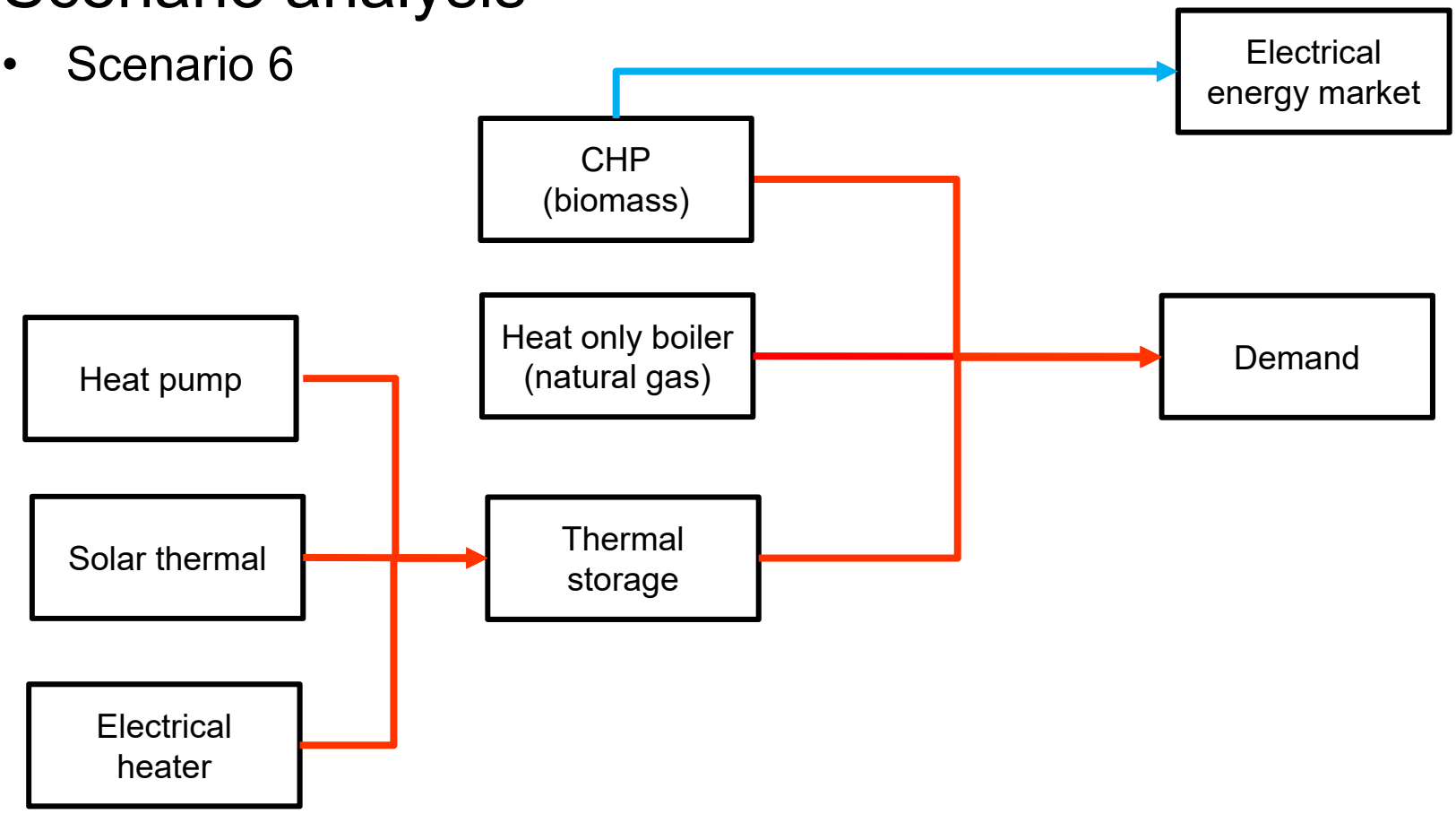
Scenario analysis

- Scenario 5



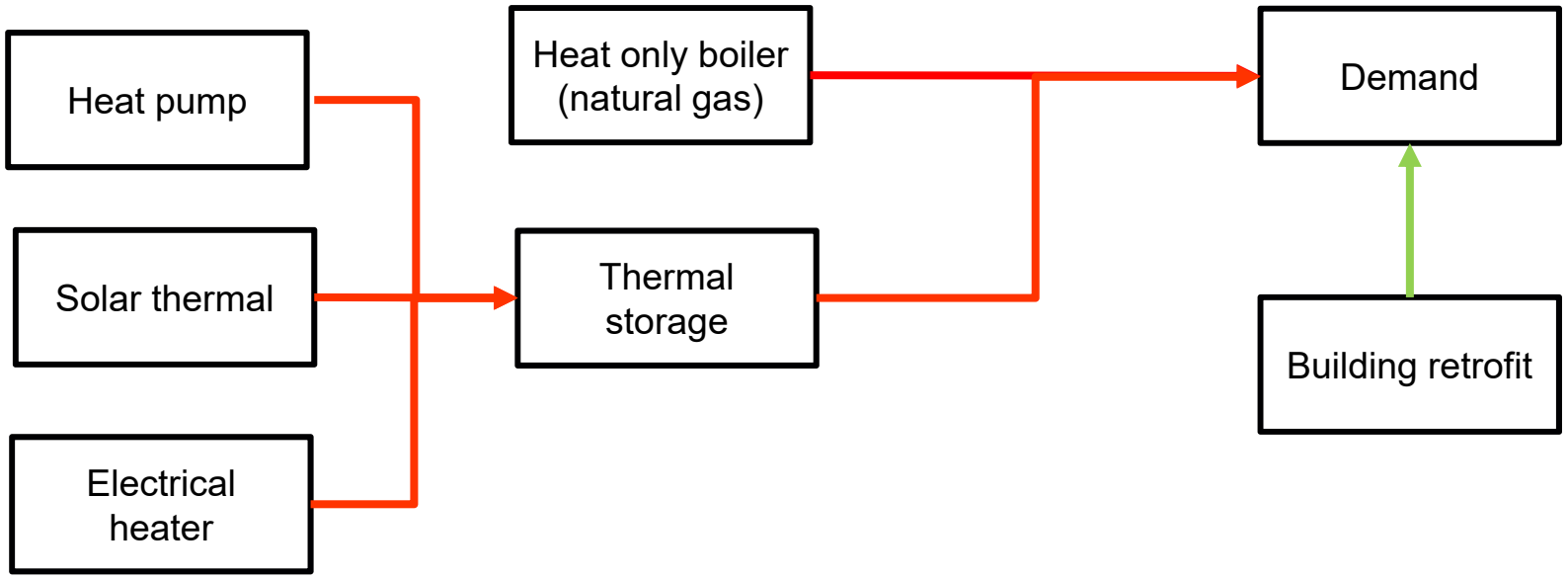
Scenario analysis

- Scenario 6



Scenario analysis

- Scenario 7



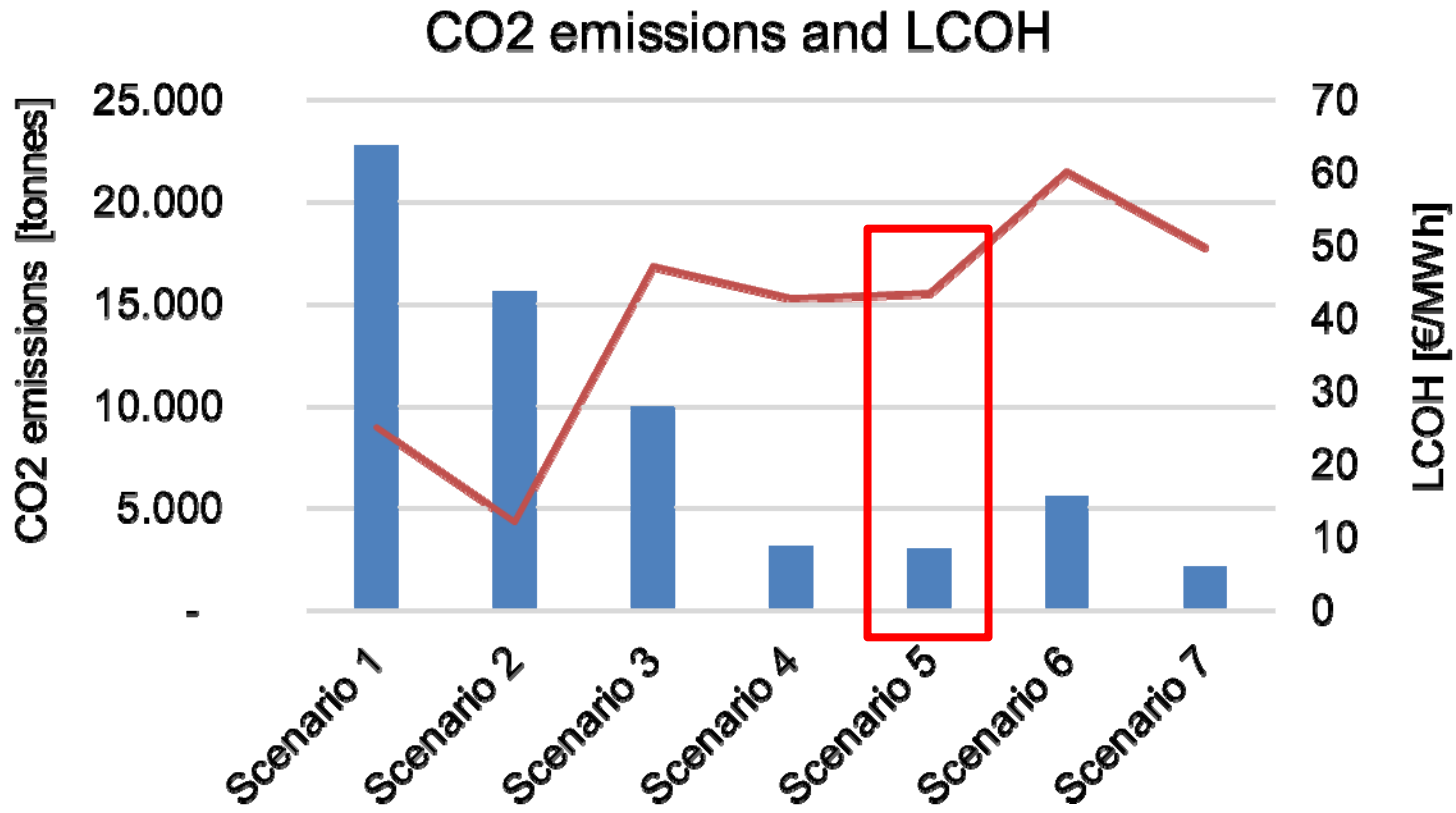
Input

Scenario number	Heat only boiler (min/max) [MW]	Electrical heater (min/max) [MW]	Heat pump (min/max) [MW]	Solar thermal collectors (min/max) [m^2]	CHP (min/max) [MW]	Storage (min/max) [MWh]	Building retrofit (min/max) [%]
Scenario 1	40/40 (heating oil)	-	-	-	-	-	-
Scenario 2	40/40 (natural gas)	-	-	-	-	-	-
Scenario 3	0/40 (natural gas)	0,5/20	0/2,5	-	-	0/200	-
Scenario 4	0/40 (biomass)	0,5/20	0/2,5	-	-	0/200	-
Scenario 5	0/40 (biomass)	0,5/20	0/2,5	10000/50000	-	0/12000	-
Scenario 6	0/30 (biomass)	0,5/20	0/2,5	2000/10000	20/20	0/12000	-
Scenario 7	0/40 (biomass)	0,5/20	0/2,5	10000/50000	-	0/12000	0/50%

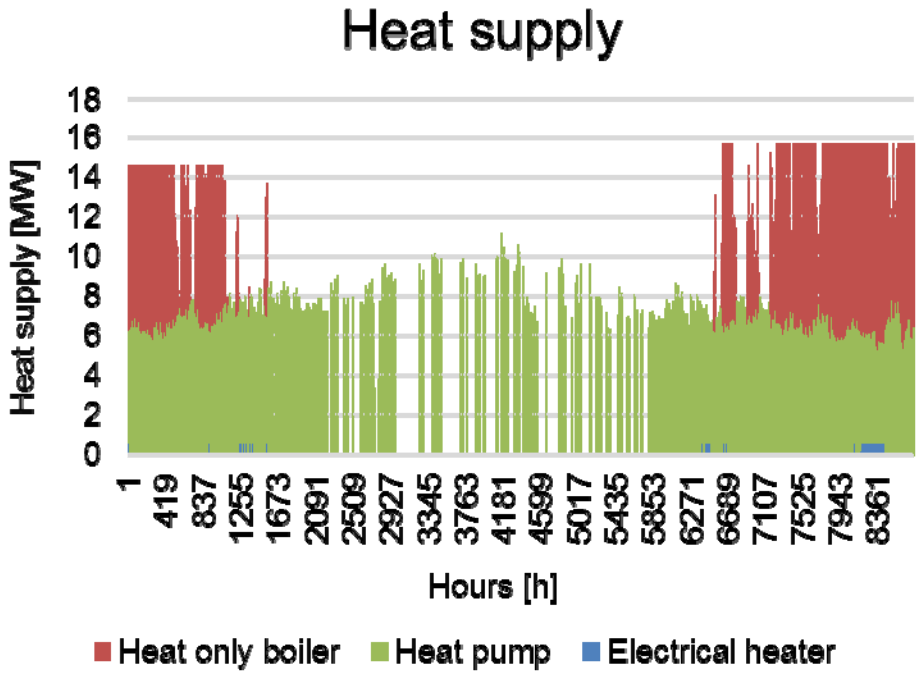
Results – unit's capacities

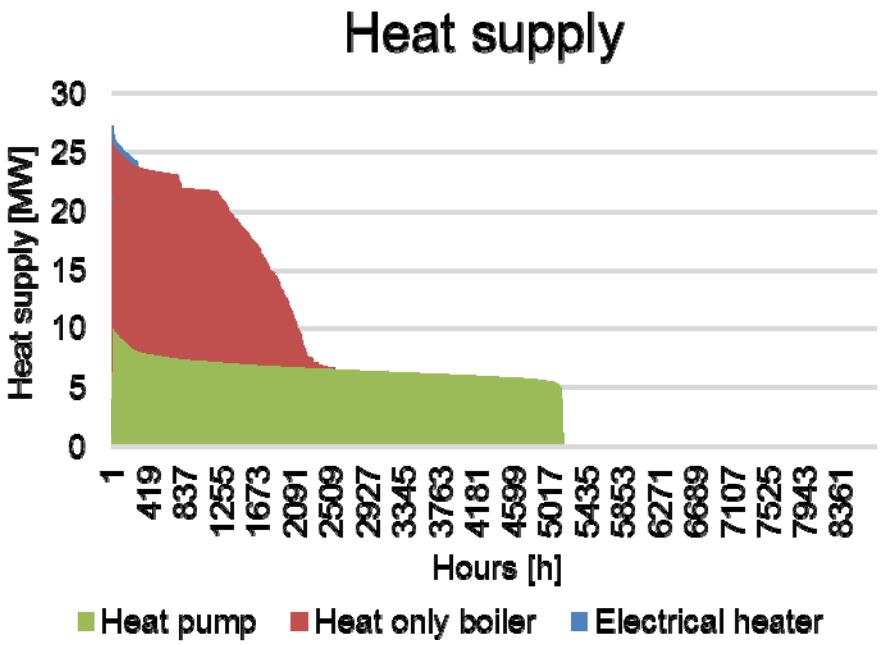
Scenario number	Heat only boiler [MW]	Electrical heater [MW]	Heat pump [MW]	Solar thermal collectors [m^2]	CHP [MW]	Storage [MWh]	Building retrofit [%]
Scenario 1	40	-	-	-	-	-	-
Scenario 2	40	-	-	-	-	-	-
Scenario 3	20,3	0,5	2,5	-	-	200	-
Scenario 4	20,35	0,5	2,5	-	-	200	-
Scenario 5	15,67	0,5	2,5	10.000	-	600	-
Scenario 6	0	0,5	2	2000	20	72	-
Scenario 7	2,7	0,5	2	10.000	-	4800	50%

Results - LCOH and CO_2 emissions

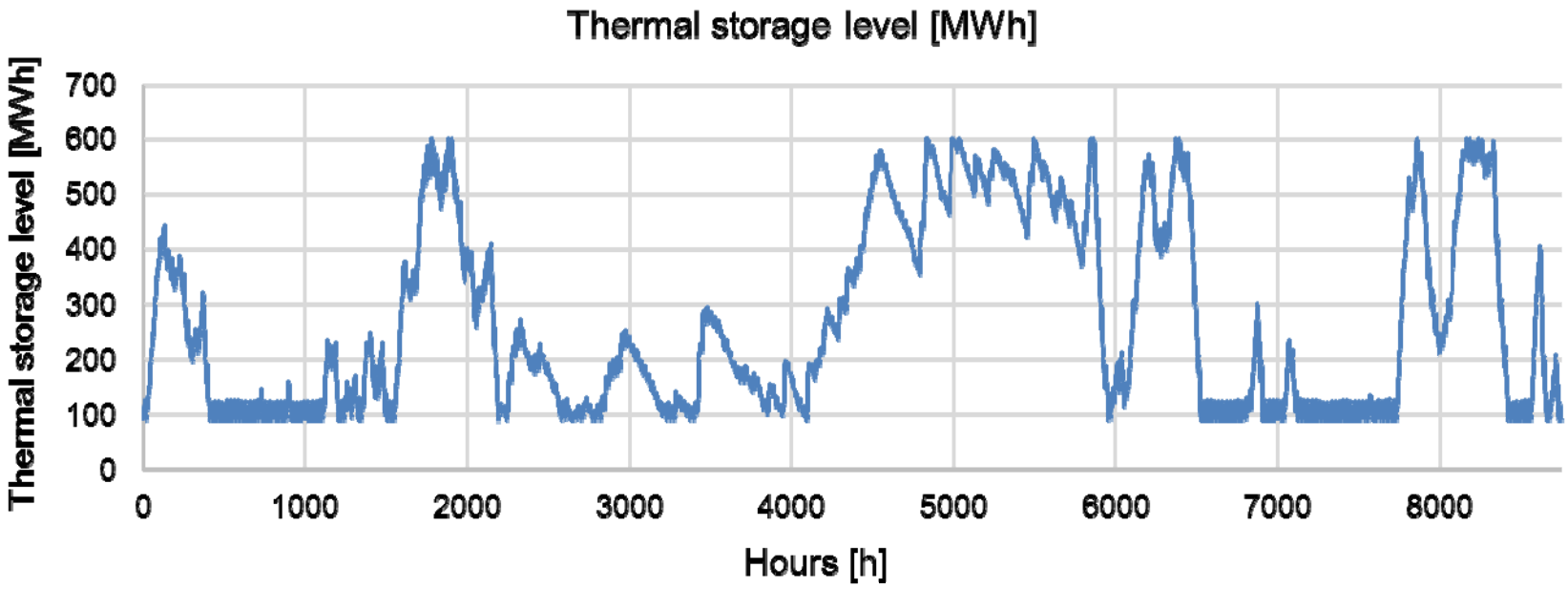


Heat supply distribution





Thermal energy storage



Conclusion

- DH system optimization has been shown, including building retrofit
- Due to low electrical energy prices, heat pumps are excessively used
- CHP and solar thermal aren't included in the optimal solution due to their high investment cost
- Building retrofit combined with solar thermal provides the lowest CO_2 emissions

Thank you for your attention

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