AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

fit4power2heat

INVESTIGATING HEAT PUMP POOLING CONCEPTS IN RURAL DISTRICT HEATING NETWORKS IN AUSTRIA

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13.11.2018

4DH
4th Generation District Heating Technologies and Systems

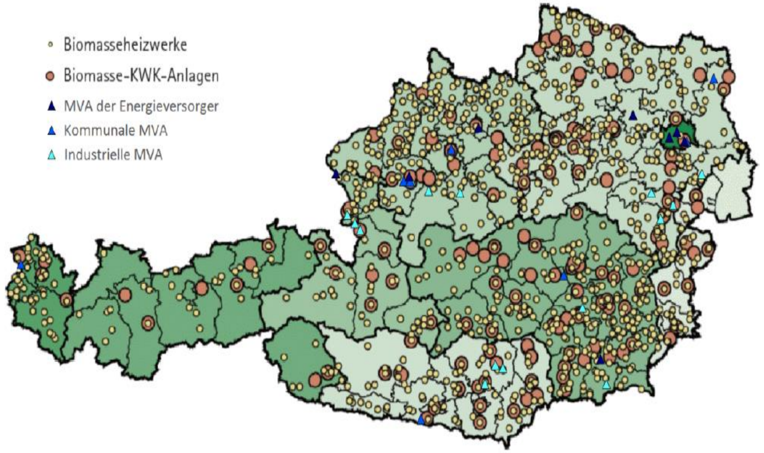
BACKGROUND

BACKGROUND

- Austrian renewable energy targets 2020: 71% of electricity demand from renewable energy sources
  - stochastic generation
  - grid-stabilizing strategies required

- Austrian district heating network settings:
  - 900 biomass heat plants above 1 MW with a total of 2.600 MW_{th}
  - old heat plants operating with low efficiency
  - highly replicable business case

- Power to heat solutions:
  - heat pumps support both electricity and DH networks.

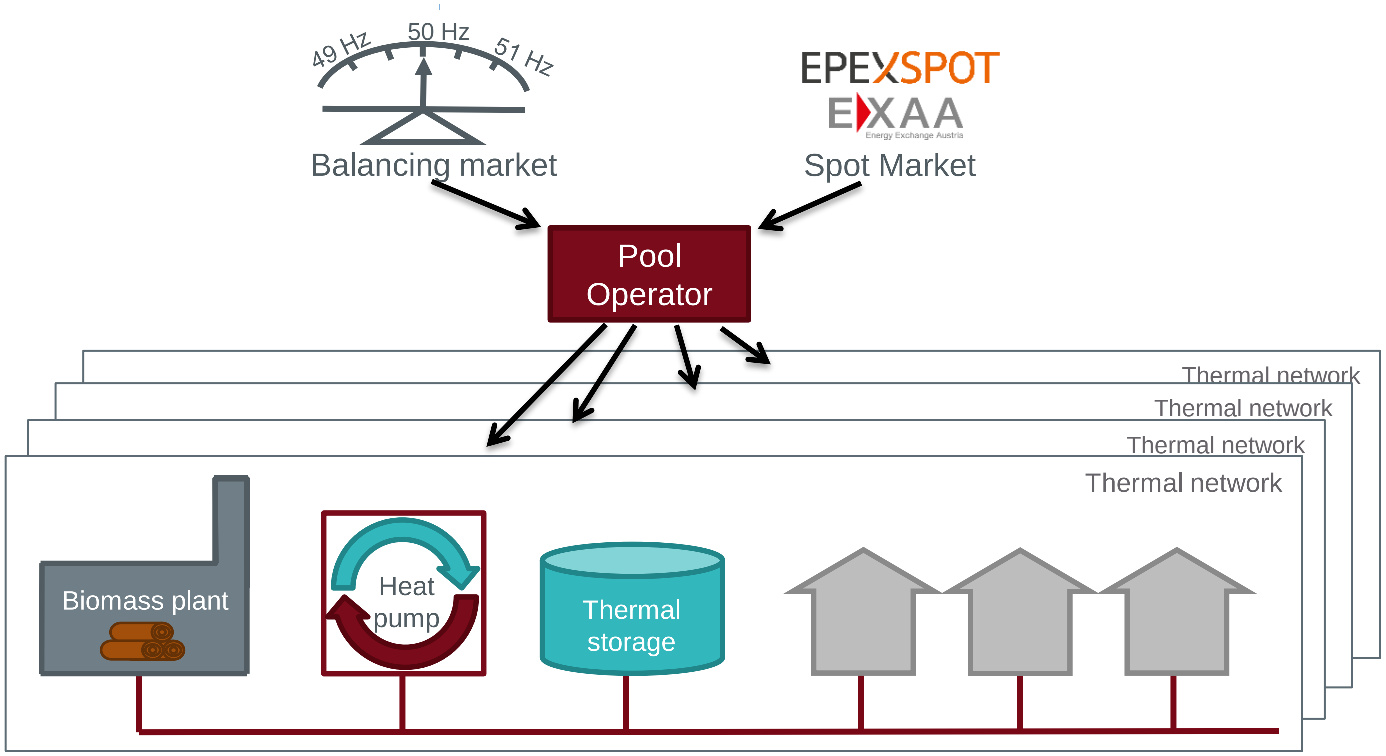


PROJECT CONCEPT

Business models for heat pump pooling in rural district heating networks

- Integration of heat pumps in rural district heating networks.
- Development of feasible use cases and potential business models.

- Synergies between heat and electricity market.
- Participation in the electricity markets:
  - Day-ahead SPOT market.
  - Balancing markets (secondary and tertiary).
- Heat pump pooling over several heating networks.



This project was funded by the Austrian Research Funding Association (FFG) under the scope of the "Stadt der Zukunft" program.

METHODOLOGY & MODEL

METHODOLOGY

1. Analysis of the status quo of the electricity markets and district heating networks in Austria.
1. Definition of scenarios for heat pump integration
1. Techno-economical assessment of the scenarios (optimization model)
1. Development of business models

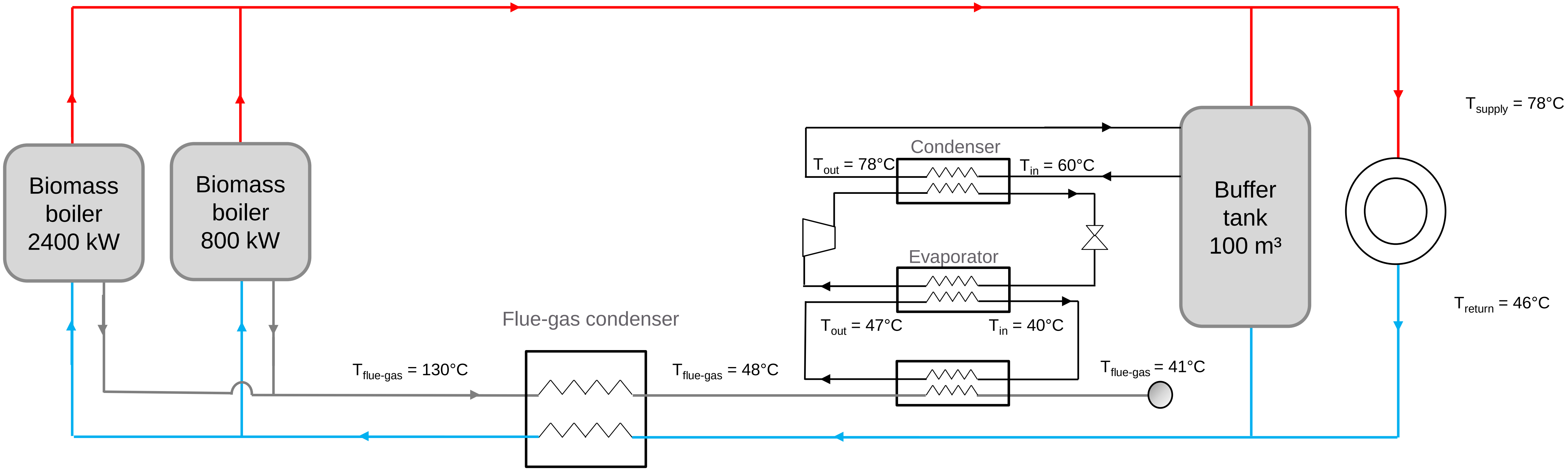
SCENARIOS - VARIATIONS

- **Scenario A**: large district heating network
  - variation 1: flue gas as a source

- **Scenario B:** small district heating network
  - variation 1: flue gas as a source
  - variation 2: sewage water as a source (2 heat pump sizes)

- **Scenario C:** hotel
  - variation 1: flue gas as a source

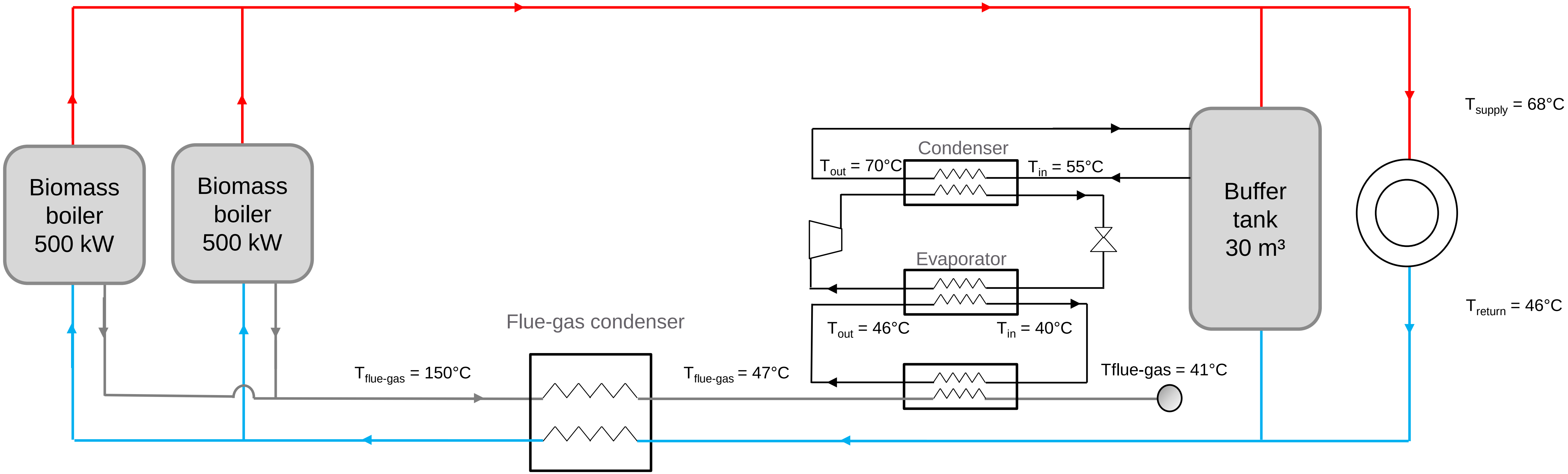
SCENARIO A – VARIATION 1: FLUE-GAS AS A SOURCE



Heat demand: 6.5 GWh

Heat pump
COP = 5.4
Capacity = 224 kWth

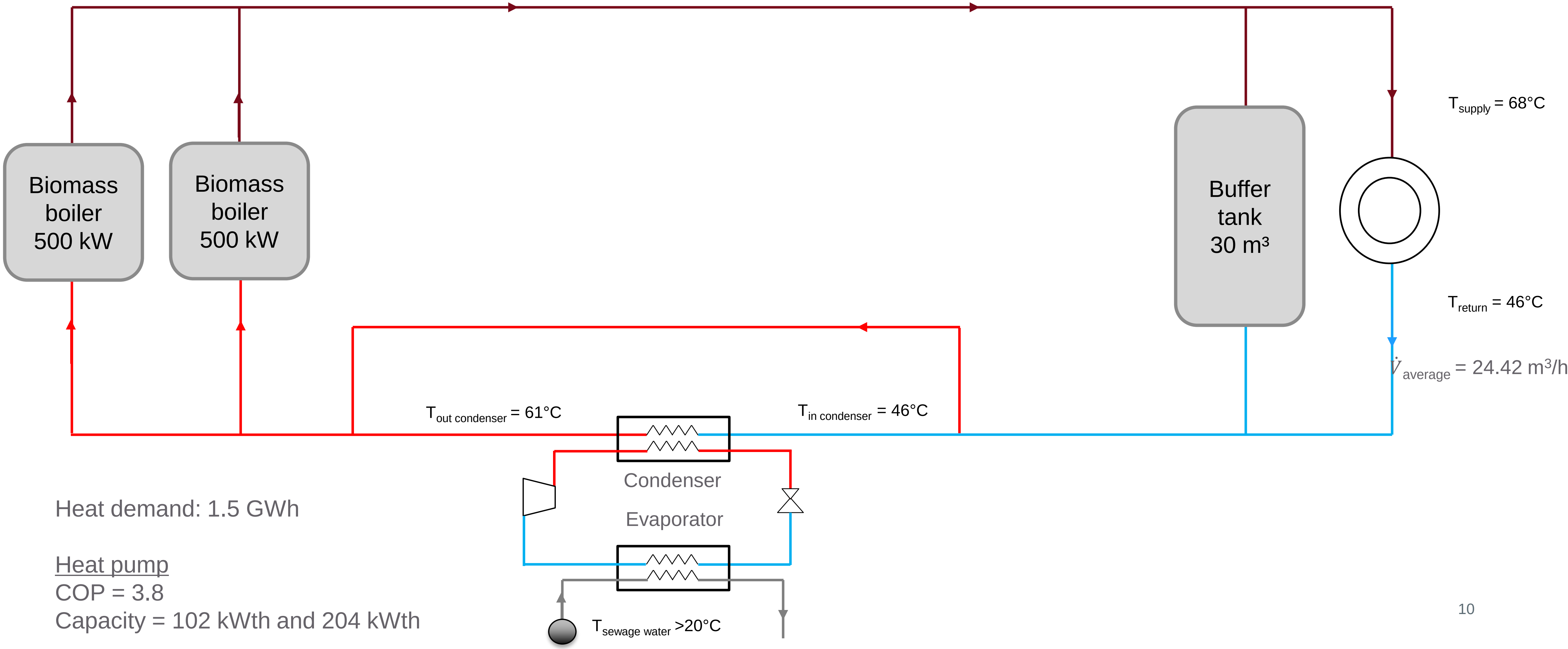
SCENARIO B – VARIATION 1: FLUE-GAS AS A SOURCE



Heat demand: 1.5 GWh

<u>Heat pump</u>
COP = 5.1
Capacity = 102 kWth

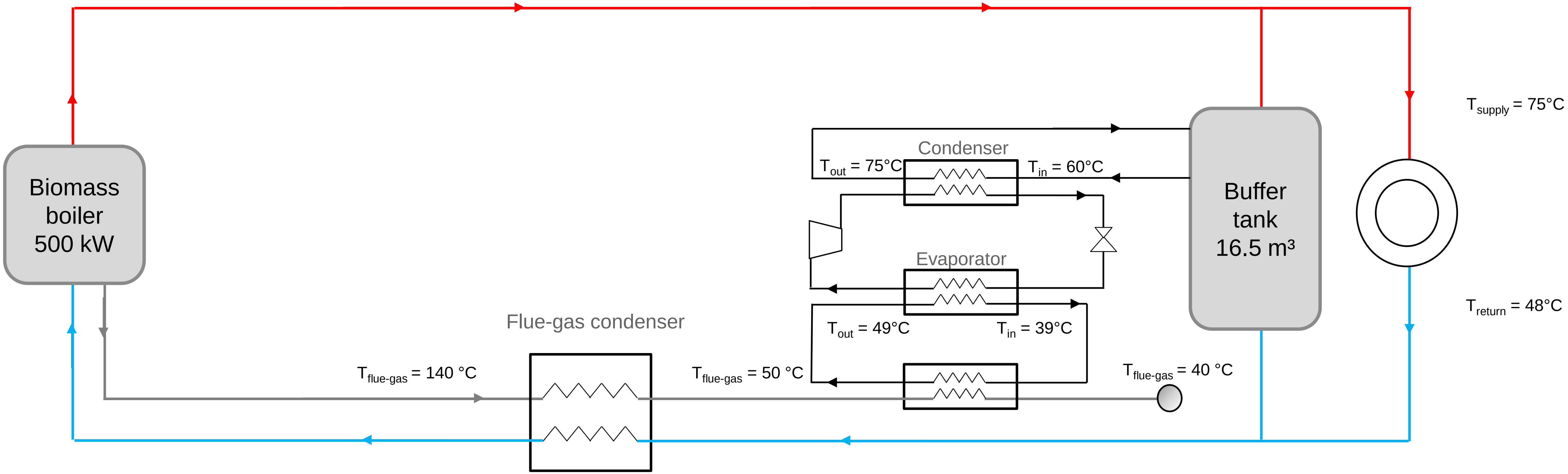
SCENARIO B – VARIATION 2: SEWAGE WATER AS A SOURCE



Heat demand: 1.5 GWh

Heat pump
COP = 3.8
Capacity = 102 kWth and 204 kWth

SCENARIO C – VARIATION 1: FLUE-GAS AS A SOURCE

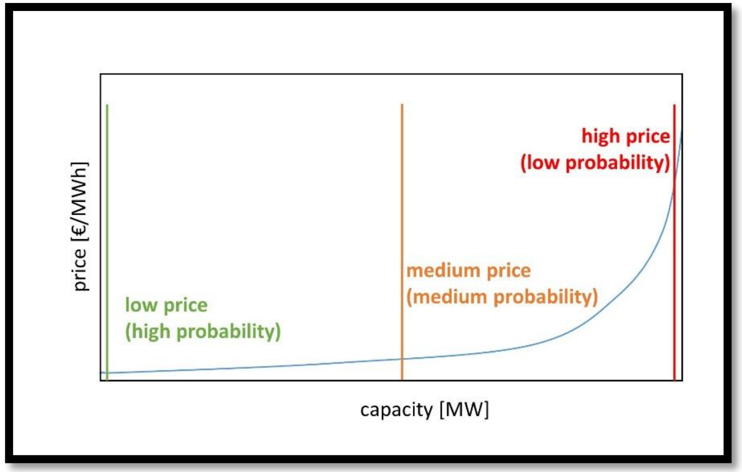


Heat demand: 2.2 GWh

<u>Heat pump</u>
COP = 5.1
Capacity = 102 kW

OPTIMISATION MODEL - VARIATIONS

- Based on the mixed integer linear programming (MILP) method.
- Implemented in Python.
- Objective function: minimisation of the operation costs.



Heating grid

- **Demand type**
  - A) DH grid
  - B) Heating grid
  - C) Hotel facility

Heat pumps

- **Source**
  - 1) Flue gas
  - 2) Sewage water

Electricity grid

- **Market**
  - Day-ahead SPOT (EPEX)
  - Secondary balancing market
  - Tertiary balancing market
- **Merit order**
  - Low rev. / High prob.
  - Med. rev. / Med. prob
  - High rev. / Low prob.

OPTIMISATION MODEL - STRUCTURE

Input

- Heat demand profiles
- Heat plant parametrisation (boilers & heat pump)
- Storage parametrisation
- Day ahead prices
- Balancing market prices (energy & power)
- Balancing market probabilities (call & acceptance)

Model

- MILP method
- Optimisation time: 2day
- Time step: 15min
- Constraints included (flow lim.)
- Objective function: minimisation of operational costs

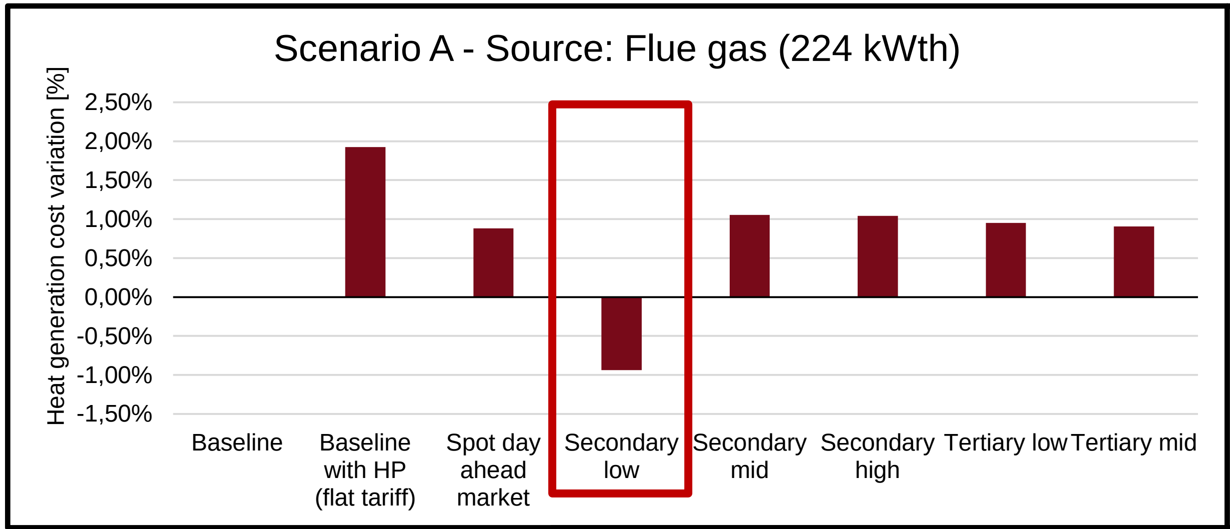
Output

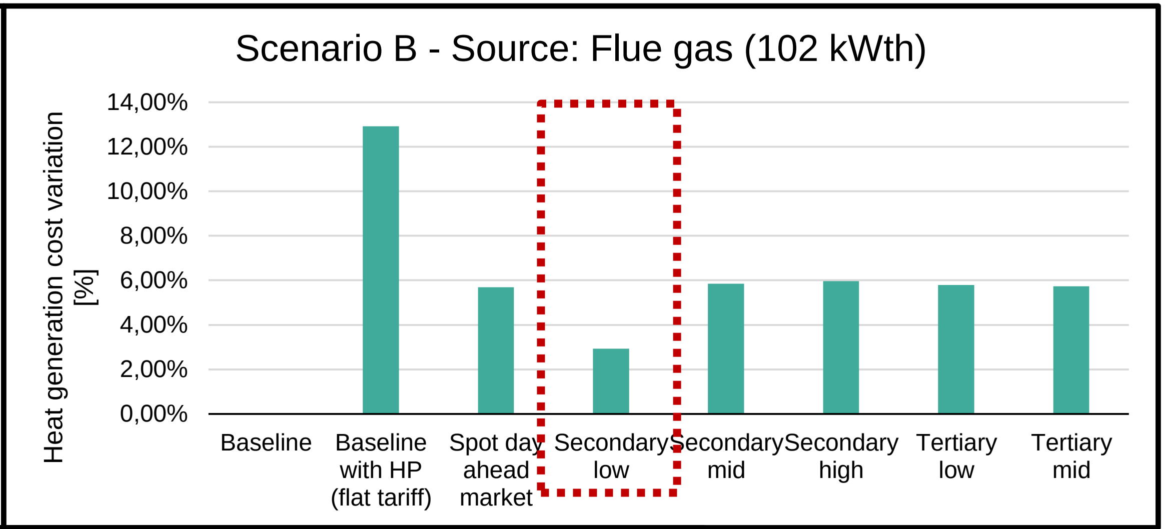
- Heat generation costs
- Annual operational costs
- Heat production (for each plant)
- Storage operation (load, charging/discharging)
- Balancing energy offered (positive & negative)
- Energy bought on the spot market

BUSINESS MODELS

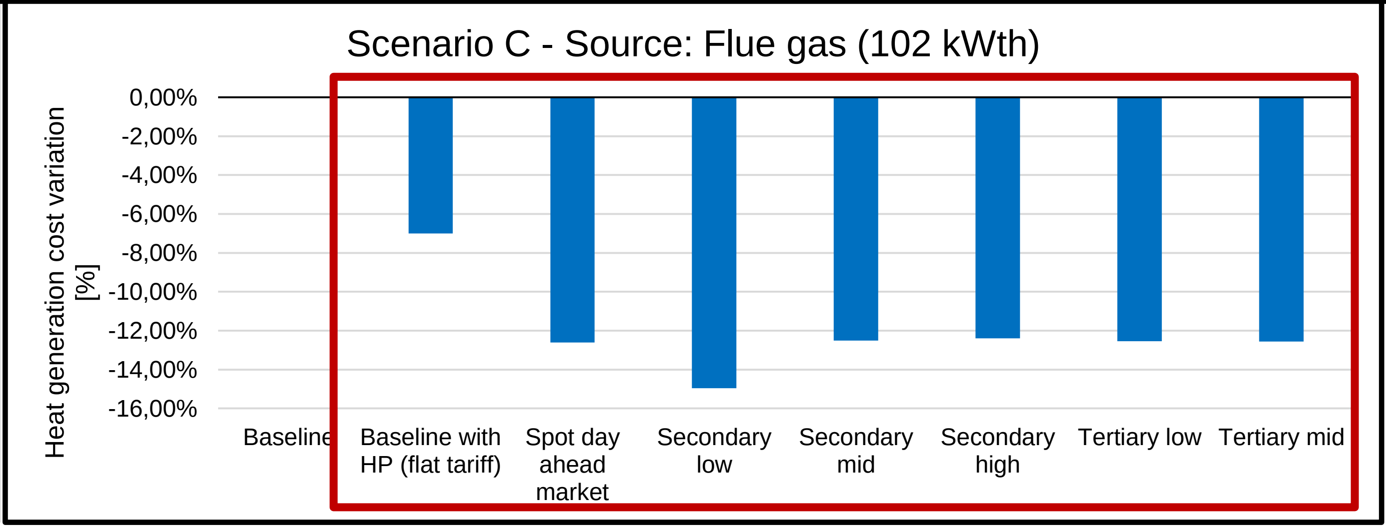
ECONOMIC EVALUATION – BUSINESS MODELS

Heat generation cost variation [€/MWh]



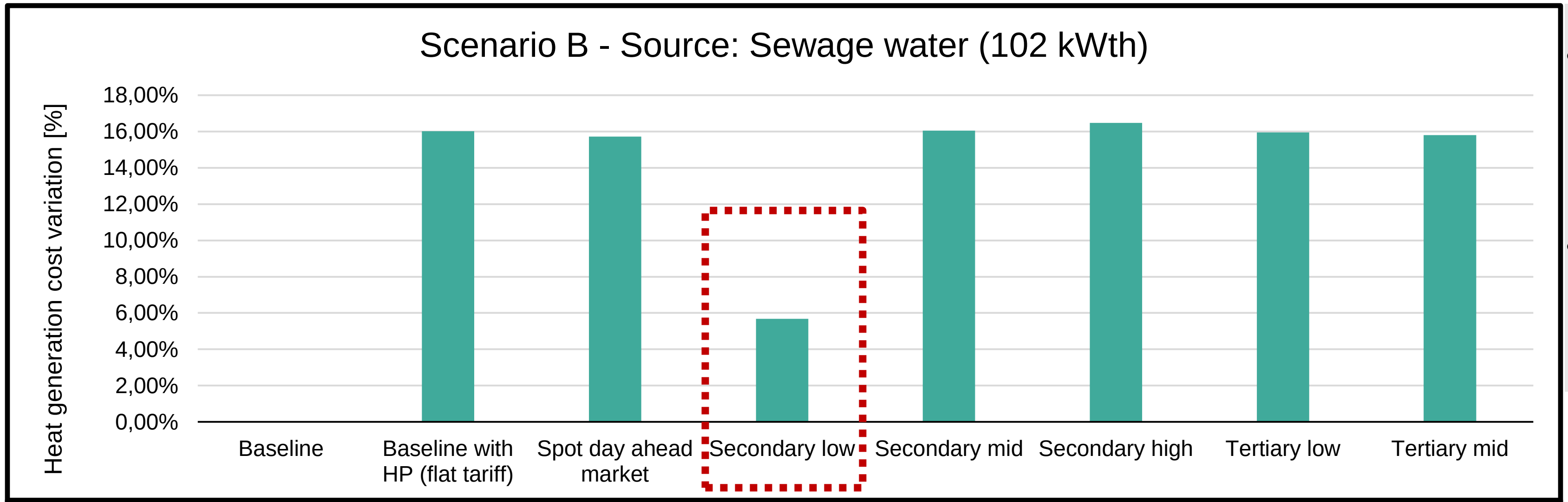


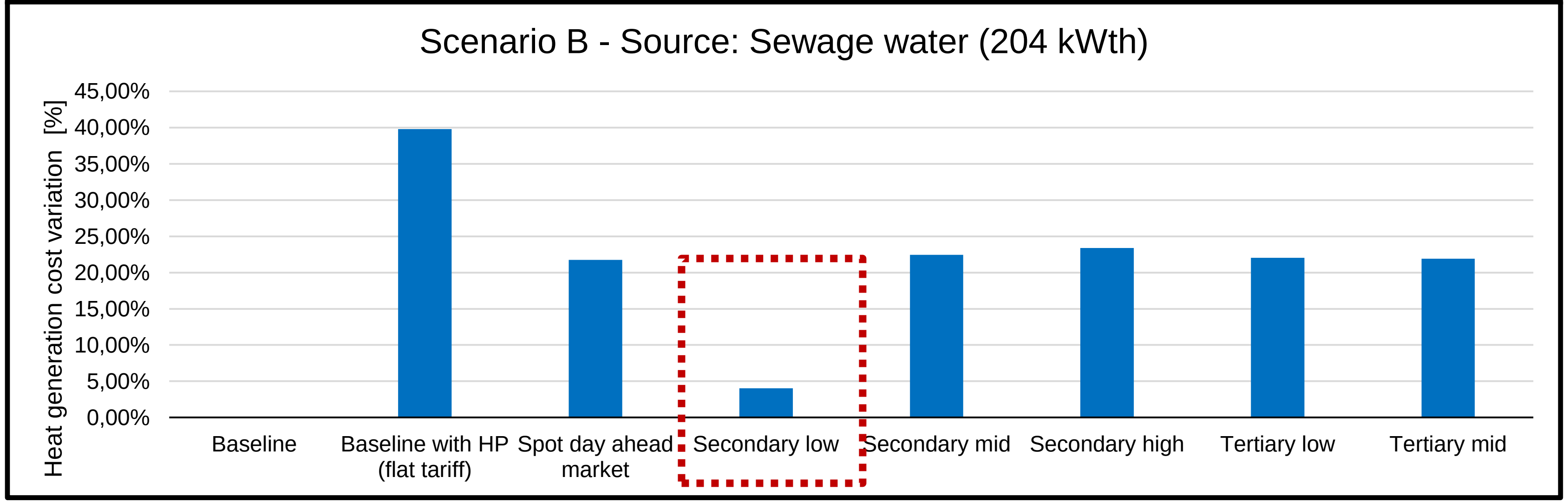
- Existing heating network with biomass boilers and storage.
- Investment in a heat pump (source: flue gas)



ECONOMIC EVALUATION – BUSINESS MODELS

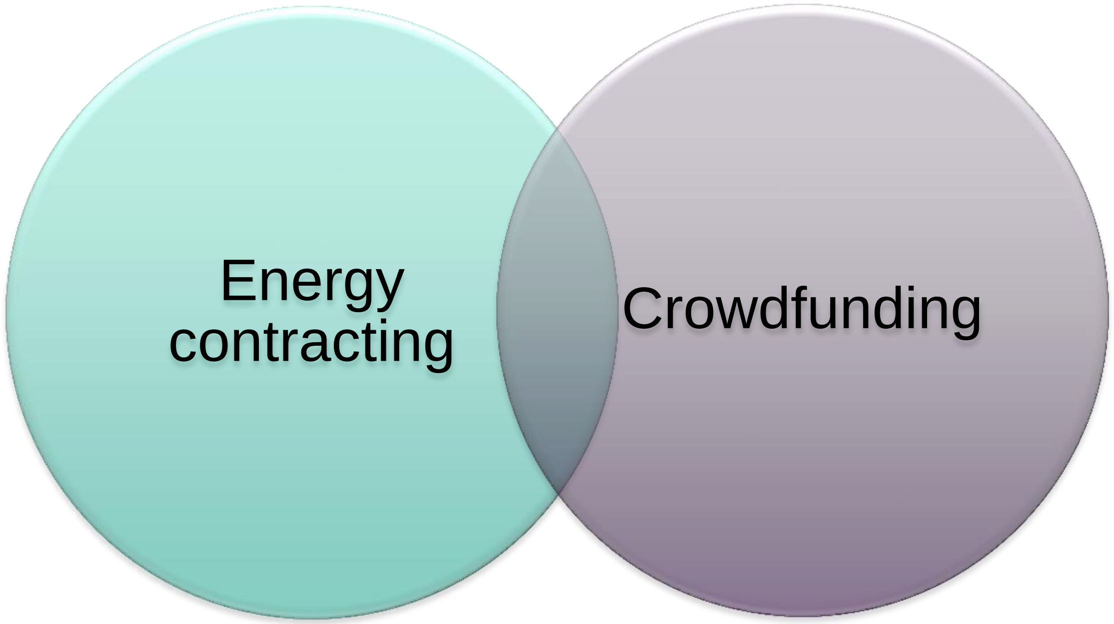
Heat generation cost variation [€/MWh]





- Existing heating network with biomass boilers and storage.
- Investment in a heat pump and sewage water heat exchanger.

ECONOMIC EVALUATION – OTHER BUSINESS MODELS



CONCLUSIONS

OUTCOME

The integration of heat pumps in the scenarios analysed shows feasible results for many variations:

- **Scenario C** presents the most attractive results:
  - Heat generation cost reduction up to 15% (12600€/year)

- In **scenario A, B** and **C** variation “**secondary low**” presents the best results.
- In all scenarios, the **sewage water variation** is not attractive enough due to the high investment costs.
- The **market participation** is the most attractive option for the heat pump in comparison to a flat electricity tariff.
- **Increase of revenues** due to the participation in the balancing markets (up to 2600€).
- The results for the current scenarios are **not highly influenced by the future** development of biomass/electricity prices and call probabilities. The scenarios are **feasible** under future conditions.

The integration of heat pumps provides additionally the following benefits:

- **Capacity increase** in the district heating network.
- **Prolongation of the lifetime** of the existing old boilers.
- **Counteract the high costs** associated with the expansion of the electricity grids.

This project was funded by the Austrian Research Funding Association (FFG) under the scope of the “Stadt der Zukunft” program.

We gratefully acknowledge funding and support by the Climate and Energy Funds.

THANK YOU FOR YOUR ATTENTION

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