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GENETIC ALGORITHM TECHNIQUE TO OPTIMIZE THE CONFIGURATION OF HEAT STORAGE IN DH NETWORK

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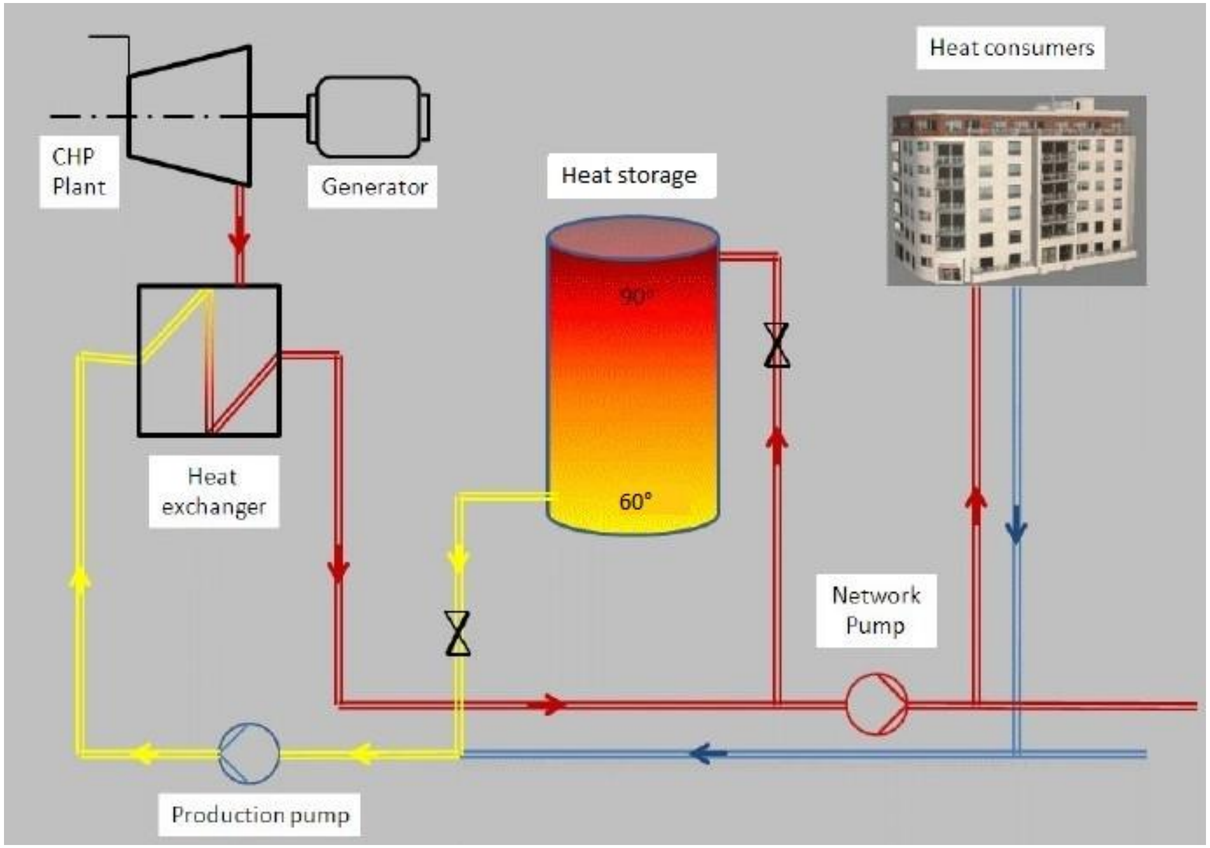
Introduction



✓ Heat storage integrated in a DH system*

*source: Martin & Thornley, Tyndall Centre for Climate Change Research

Outline

1. DH Network Configuration, Topology & Modeling (Graph Model)
2. Calculation of heat costumer load profile
3. Determining heat storage layout and volumes
4. Generating cost function
5. Optimization with Genetic Algorithm
6. Result and Discussion
7. Summary and outlook

DH Network Configuration, Topology & Modeling (Graph Model)

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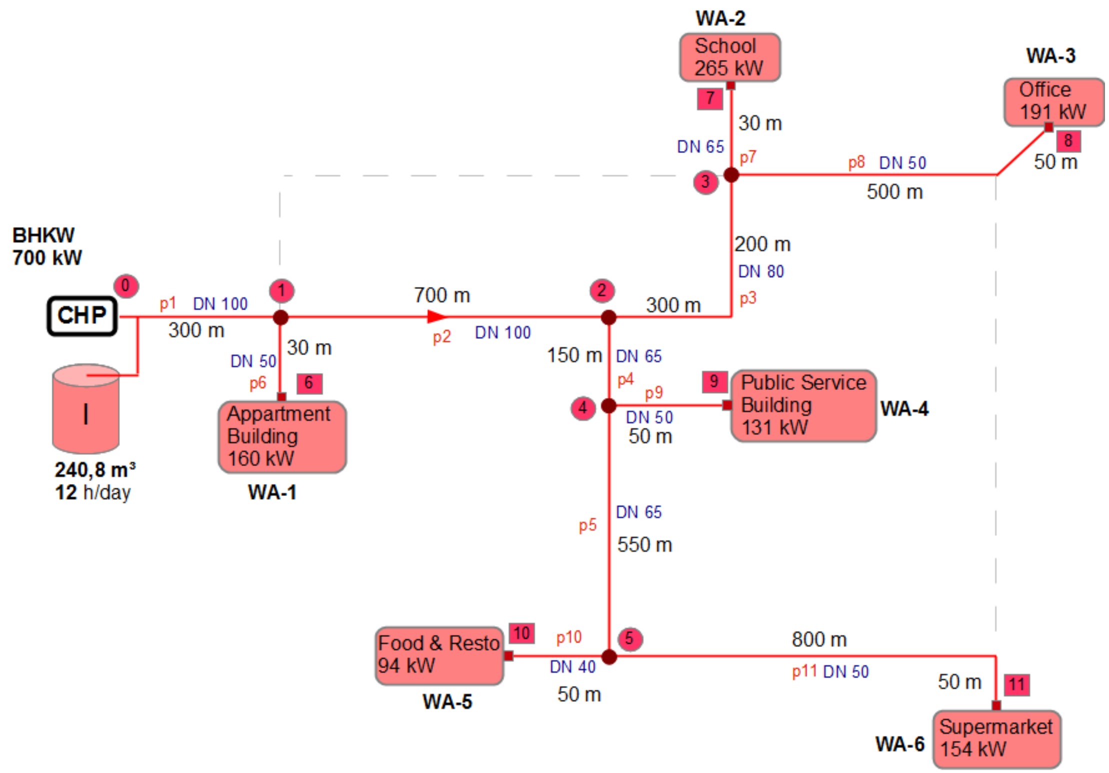
Network Modeling
(3 Scenarios)

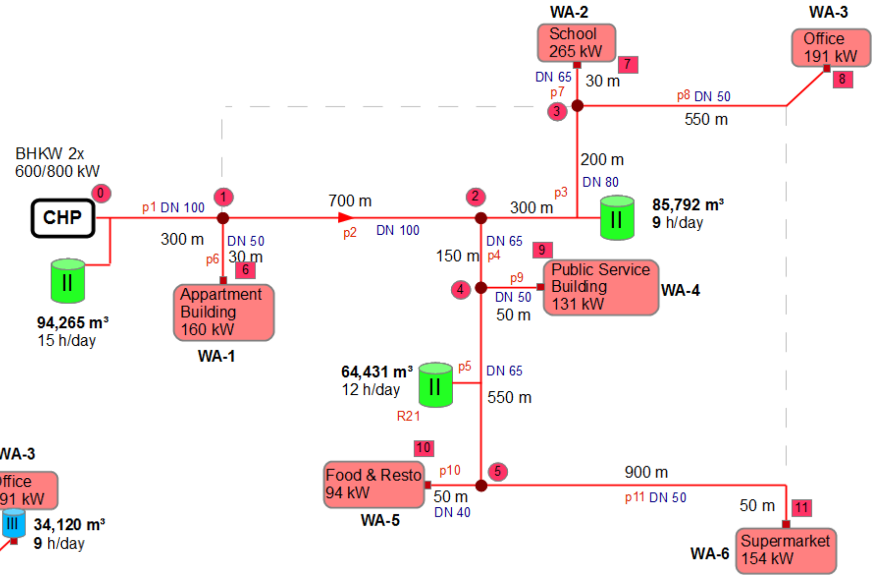
1. **Centralized**
2. **Semi decentralized**
3. **Full decentralized**

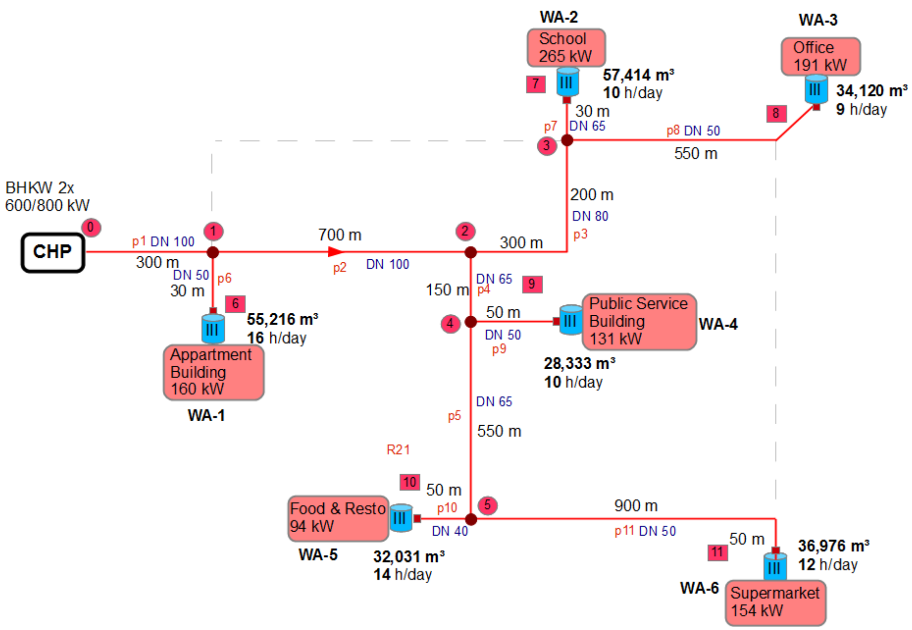


- ➢ Network parameter dimensioning (length, pipe diameter, consumer heat load)
- ➢ Network simulation (thermohydraulic, heat loss)

DH Network Configuration, Topology, & Modeling (Graph Model)

1. Centralized
2. Semi decentralized
3. Full decentralized

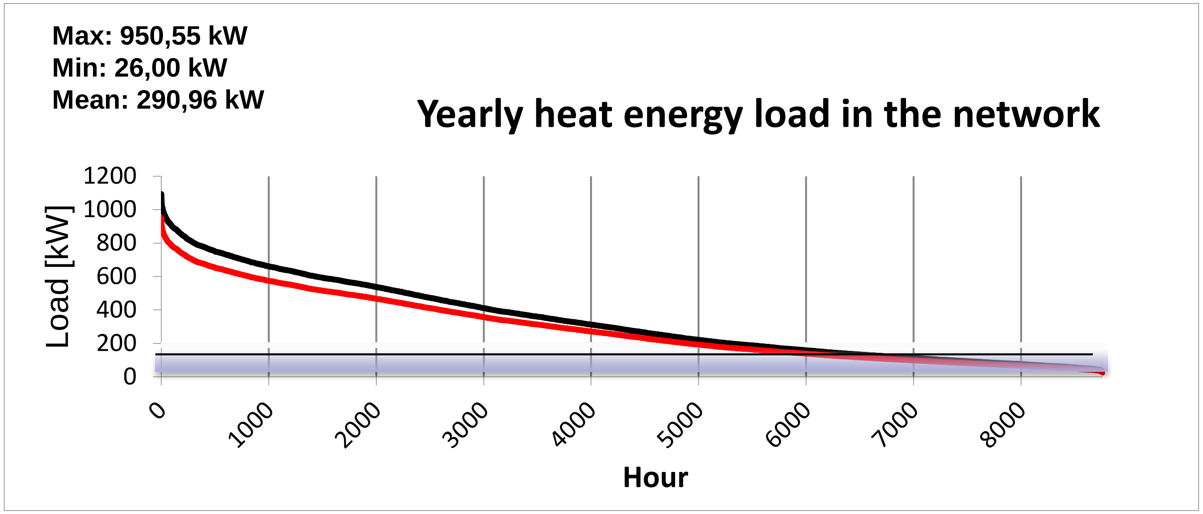


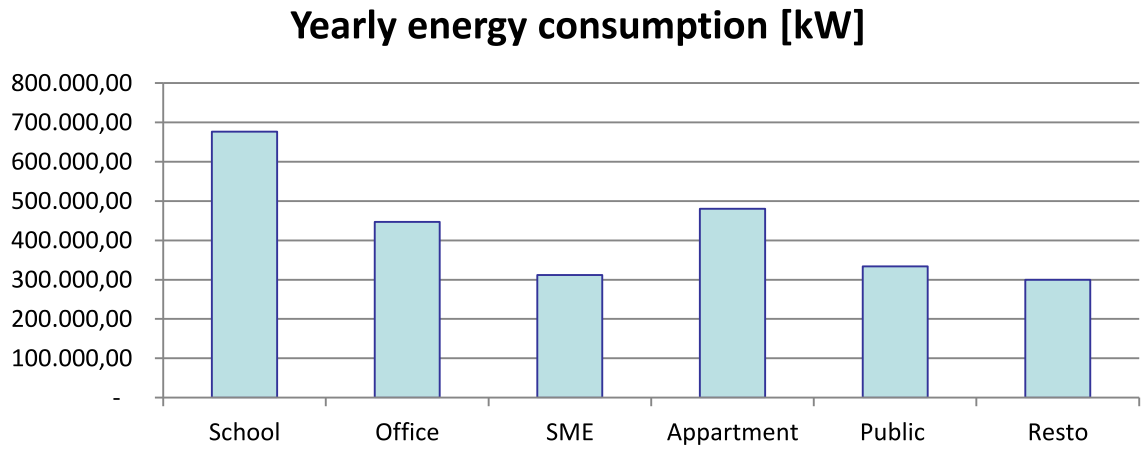


Calculation of Heat Consumer Load Profile

Calculating

- Consumer Standard Load Profile
- Data processing for every hour during a year using outer temperature data, building type, week factor and hour factor
- Reference: BGW





$$Q_{sp} = m\ Cp\ \Delta T$$

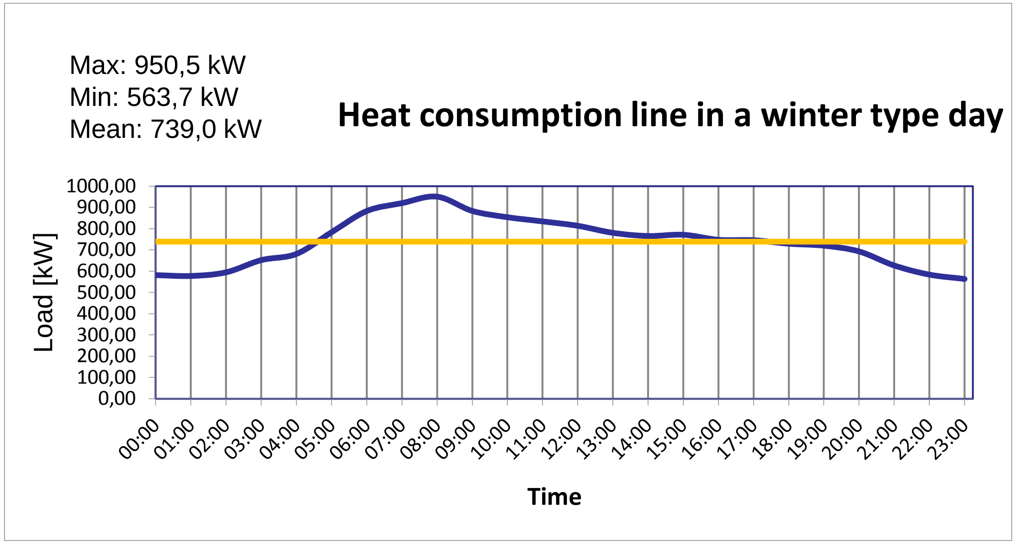
Determining heat storage layout and volumes

Determining heat storage layout in the network & volume for every scenario,

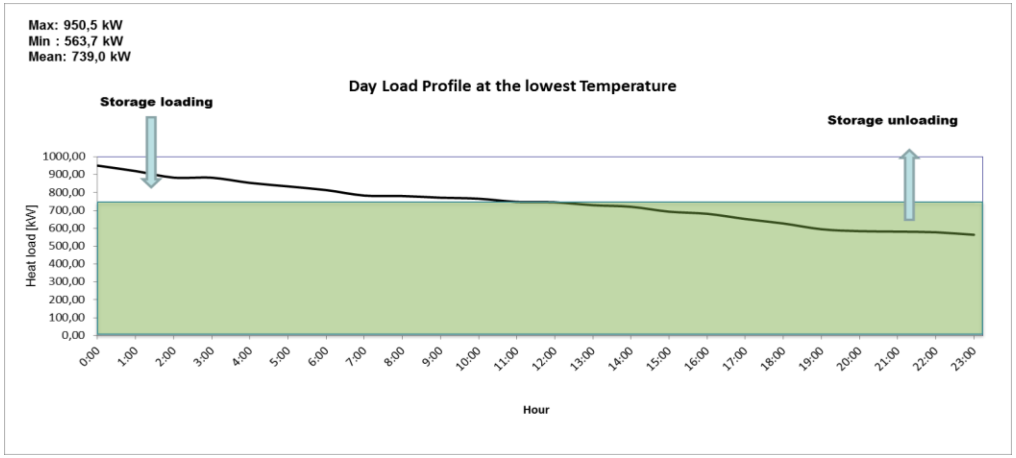
In daily basis according to Load profile,

Calculate integral
∫ Q dt of the curve-> numerical integration

Using Excel table



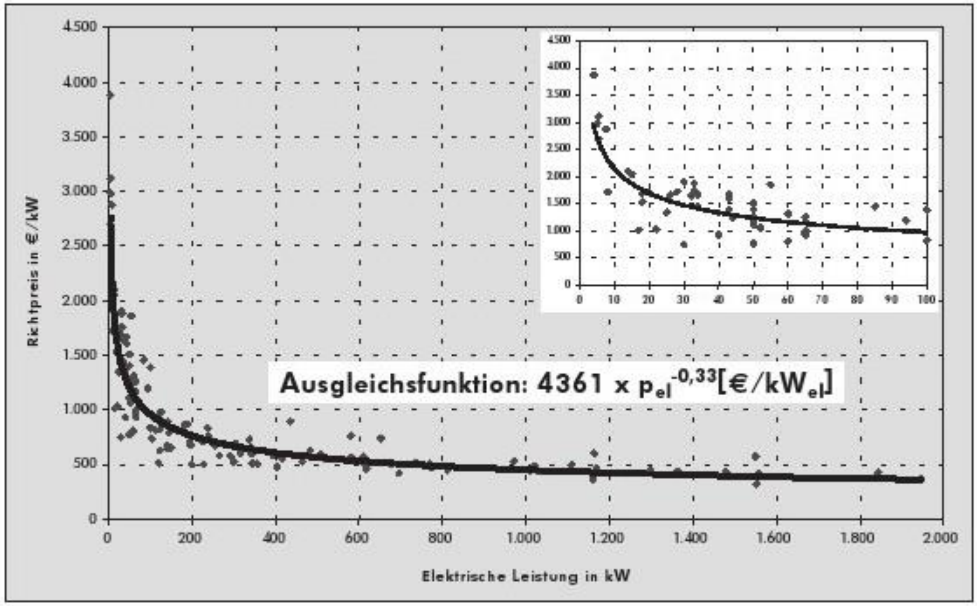
$Q_{sp}= M_{sp}\ Cp_{sp}\ dT_{sp}=V_{sp}\ \rho_{sp}\ cp_{sp}\ (T_{1sp}-T_{2sp})$

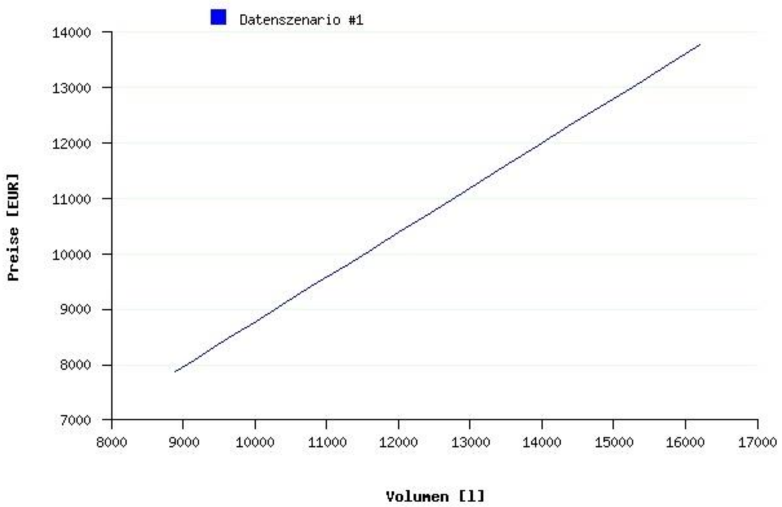


Q_{sp}[J] : heat capacity of the storage
M_{sp} [kg] : mass of the storage
Cp_{sp}[J/kgK] : specific heat of storage media (water)
dT_{sp}[K] : temperature difference in storage
V_{sp}[m³] : volume of the storage
ρ_{sp}[kg/m³] : density of storage media
T_{1sp}[°C] :temperature of loaded storage
T_{1sp}[°C] : temperature of unloaded storage

Generating Cost function, interpolation

Generating non linear cost function (Network, CHP, Storage) F(d), F(Vol), F(kW), interpolation





$$\sum \quad f(CHP) + f(DHS) + f(Heat\ Storage)$$

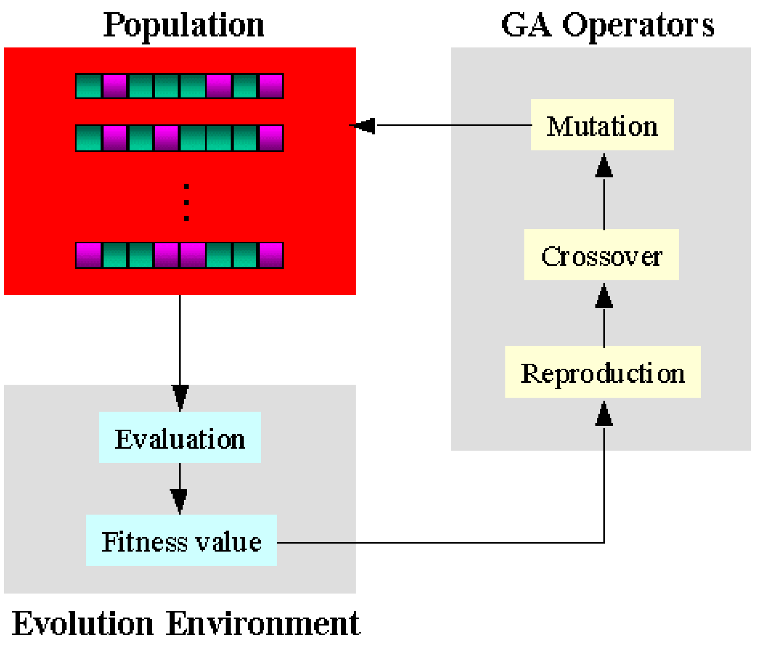
Optimization with Genetic Algorithm

Summary of GA method

Optimization steps using Genetic Algorithm

Objective function → cost function (non linear)
Constraints:
- Capacity of CHP
- Capacity of heat storage

Upper bound
Lower bound

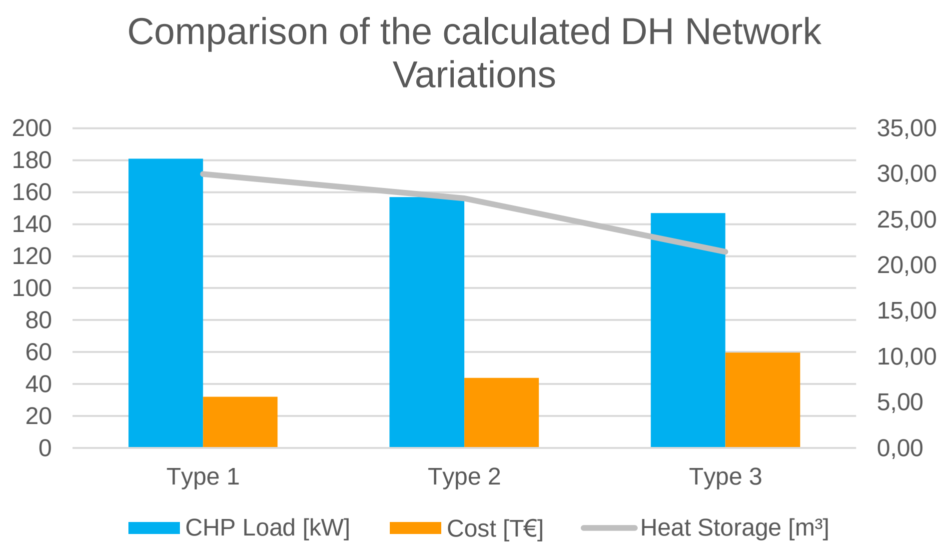


Genetic Algorithm Evolution Flow

Result and Discussion

Results & Analysis

- Network type 1 has the lowest investition cost but require more heat energy
- The energy efficiency reached by network type 3, but it needs higher initial investment.
- Network of type 2 has medium efficiency of cost and energy, depends on the installation volume of the heat storage and its location as well.
- Network type 3 requires higher cost, but it offers higher heat supply security



Summary & Outlook

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- Detail calculation of storage volume by utilizing learning algorithm
- Control on heat customer side (demand side management) increases efficiency of the heat production
- Combination of heat sources (solar cell, geothermal, etc.) in the network is possible using the same method
- Other layout combinations (close loop, more heat sources) should be investigated as well.
- Comparing the result with operational data of the heat production plant with optimization, data integration and performance testing.

Reference

1. BGW Praxisinformation P2007/13 Gastransport/Betriebswirtschaft, Abwicklung von Standardlastprofilen
2. ASUE (Arbeitsgemeinschaft für Sparsamen und Umweltfreundlichen Energieverbrauch e.V.), BHKW-Kenndaten 2005
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4. Optimization in Scilab, The Scilab Consortium, July 2010.
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Thank you very much

Questions?