Lessons Learned from Excess Flow Analyses for Various District Heating Systems

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Motivation

- **faulty substations** contribute to **high return temperatures** in existing district heating grids
- **return temperature reduction**:
  - network capacity ↑
  - heat losses ↓
  - pumping energy ↓

  → often prerequisite for supply temperature reduction + integration of renewable energies

- **excess flow method**:
  - identify **substations** with **highest contribution** to return temperature
  - approach for substations with **limited available data** (yearly heat demand and volume flow or return temperature = typical in german district heating networks)

Identification of Faulty Substations

Inspections

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- inspection: visual inspection + reading out data from heat meters
- **Network A:**
  - primary side: mostly setting errors and malfunctions
  - secondary side: mostly design faults
- **Network B:**
  - found faults:
    - 87 % on secondary side (70 % of these unsuitable or incorrect setting of domestic hot water preparation)
    - 65 % of substations need to be retrofitted
- **Network C:**
  - inspection planned next winter

open bypass

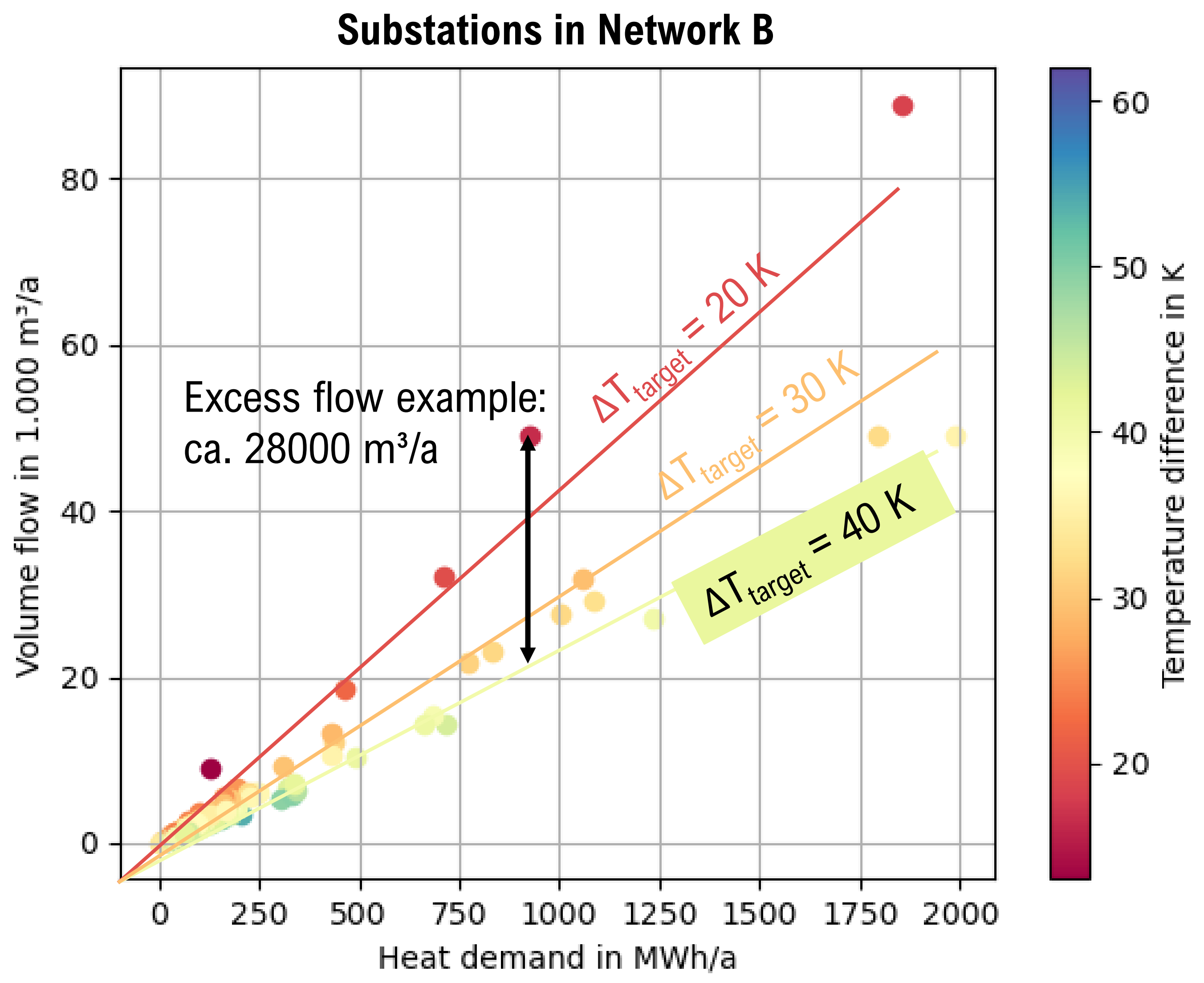
faulty valve

hydraulic separator

- The excess flow method has proven very reliable in detecting faulty substations, in 88 % of the inspected substations, faults could be detected.

Introduction Excess Flow Method

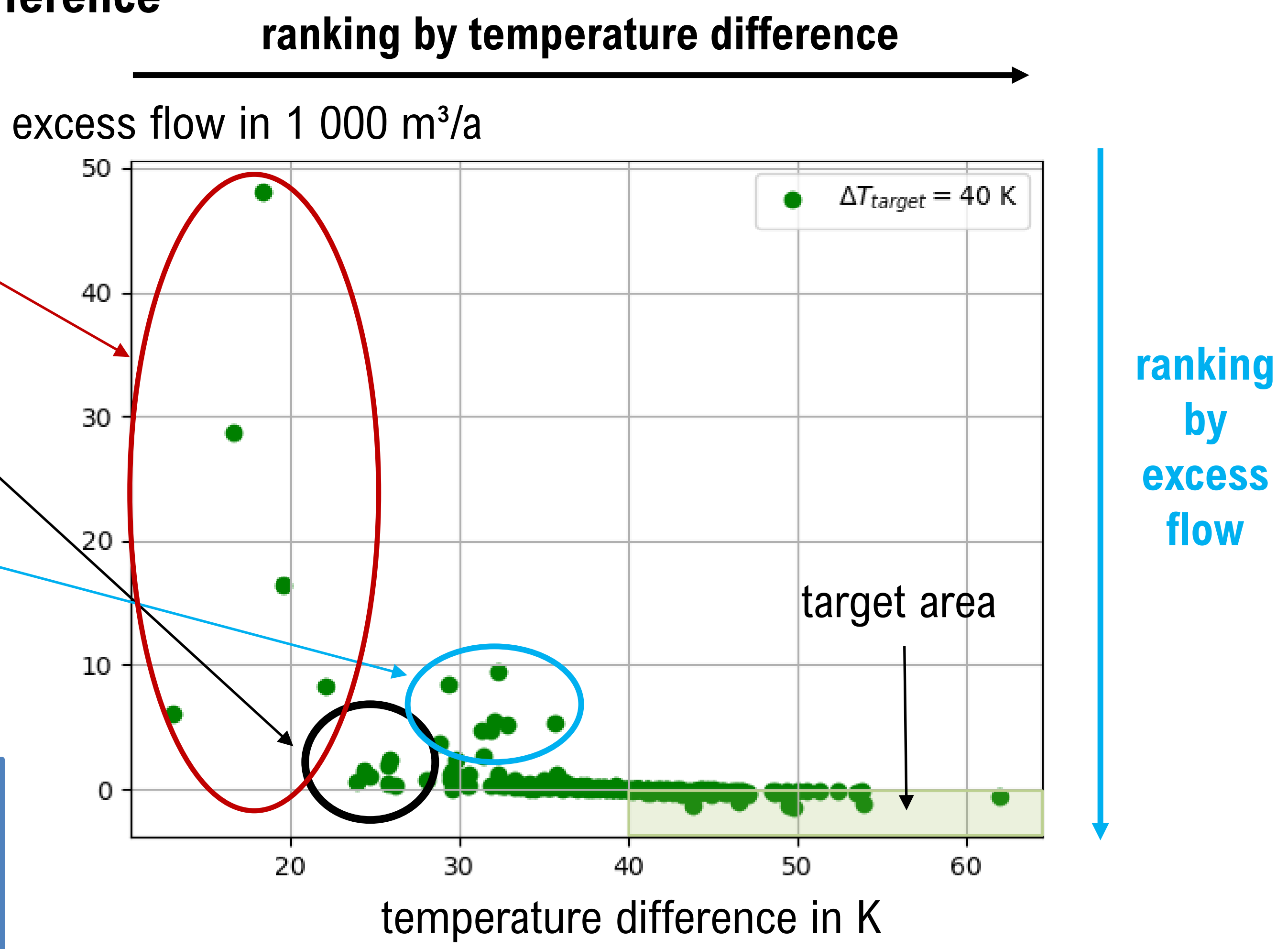
- defined in IEA DHC Annex VII
- $\dot{V}_{excess} = \dot{V}_{actual} - \dot{V}_{target}(\Delta T_{target})$
- volume flow calculated based on the chosen target temperature difference ΔT_{target}
- ΔT_{target} should be realistic temperature difference that can be reached with built-in type of substation



Introduction Excess Flow Method

Ranking Excess Flow Method vs. Temperature Difference

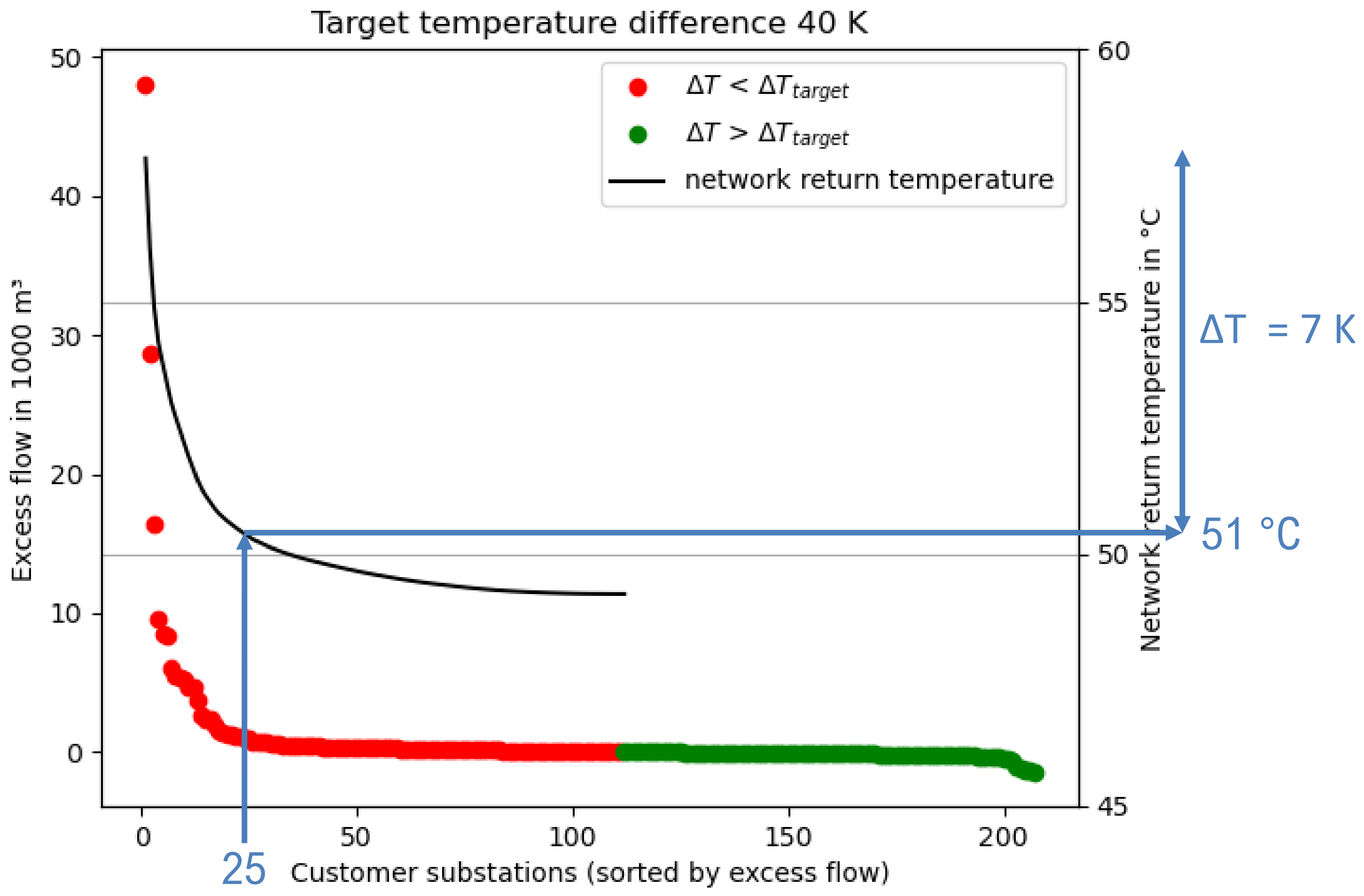
- **most problematic stations** show up in both rankings
- **low impact** on return temperature
- **high impact** on return temperature



Recommendation:
Use the excess flow method rather than looking only at the temperature difference at substations!

Introduction Excess Flow Method

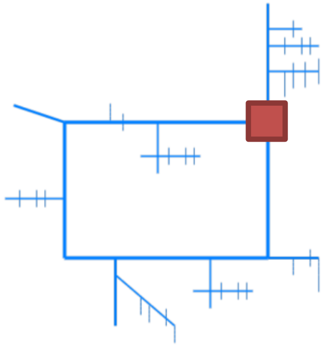
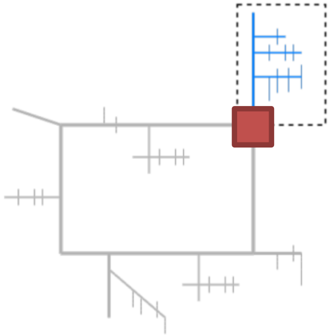
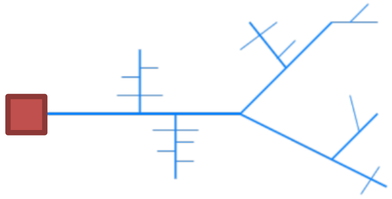
Typical Results from the Excess Flow Analysis



Ranking	Return temperature	Excess-Flow
1	72,0	48 063
2	73,7	28 650
3	70,7	16 381
4	58,1	9 513
5	61,0	8 499
6	68,2	8 294
7	77,3	5 994
8	54,1	5 437
9	54,6	5 292
10	57,5	5 229
11	58,5	4 700
12	59,0	4 698
13	61,5	3 691
14	59,0	2 658
15	64,5	2 384
16	60,5	2 353

25 inspected substations can lower the network return temperature by 7 K

Overview Evaluated Networks

	Network A	Network B	Network C
Network type	Large urban network, complete	Large urban network, subgrid	Rural network
Network structure			

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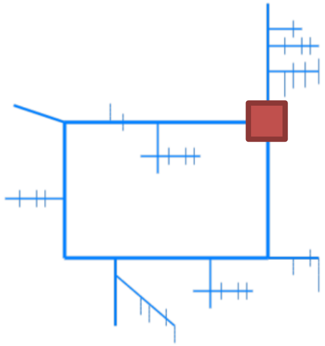
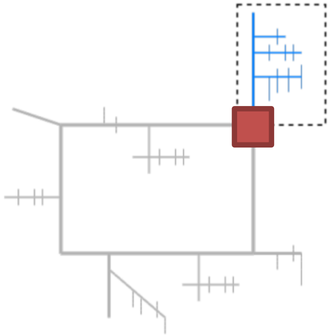
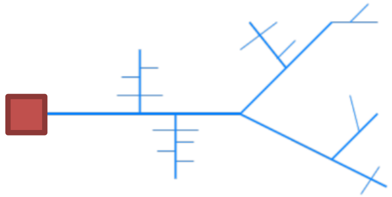
Network structure			
Supply/Return temperature	110…90/58 °C	120…90/58 °C	70/60 °C
Total annual heat demand	≈ 450 GWh/a	≈ 35 GWh/a	≈ 25 GWh/a

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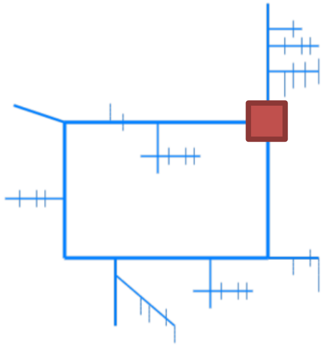
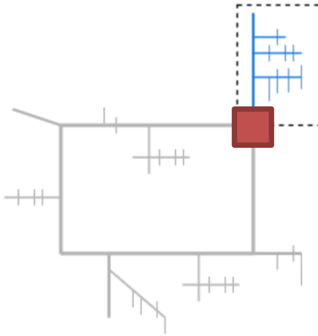
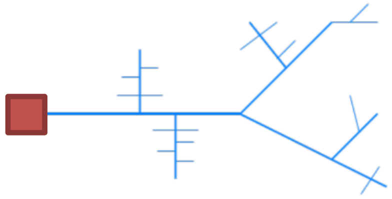
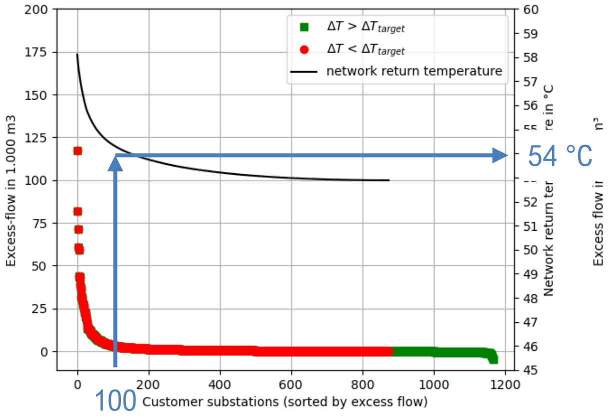
Network structure			
Supply/Return temperature	110…90/58 °C	120…90/58 °C	70/60 °C
Total annual heat demand	≈ 450 GWh/a	≈ 35 GWh/a	≈ 25 GWh/a
Number of substations included in excess flow analysis	≈ 1200 (60 % of substations)	≈ 200 (85 % of substations in subgrid)	≈ 70 (100 % of substations)
On-site inspection	24 selected substations	17 selected substations	Planned in winter

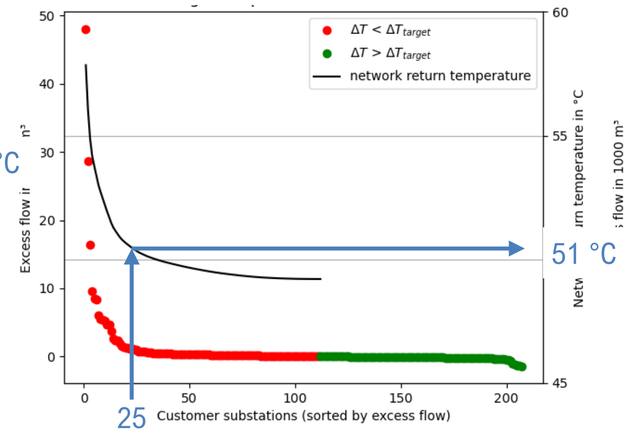
Comparison Excess Flow Analyses of Evaluated Networks

Excess flow ranking

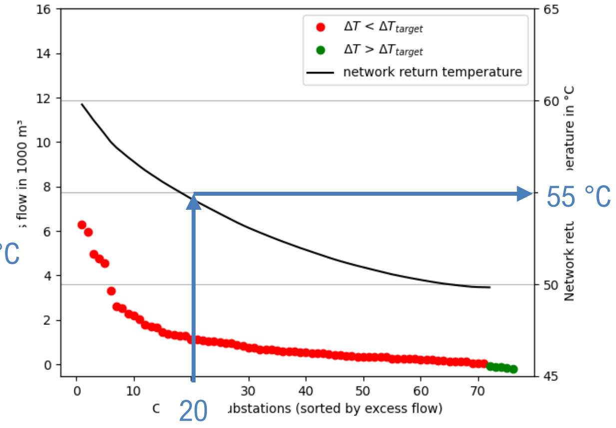
Network A



Network B



Network C



	Network A	Network B	Network C
Target temperature difference	45 K	40 K	20 K
Number of stations recommended for inspection			
Return temperature reduction with recommended substations			

Comparison Excess Flow Analyses of Evaluated Networks

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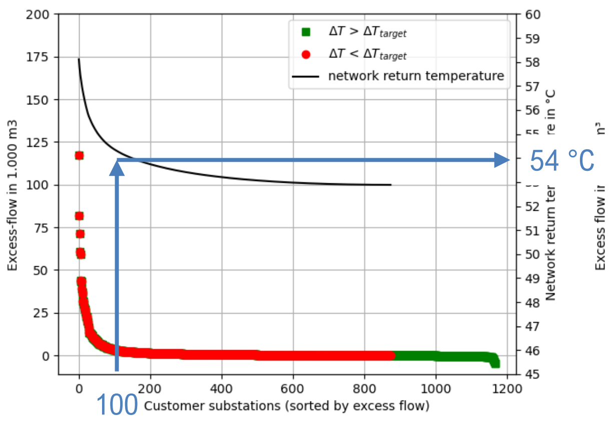
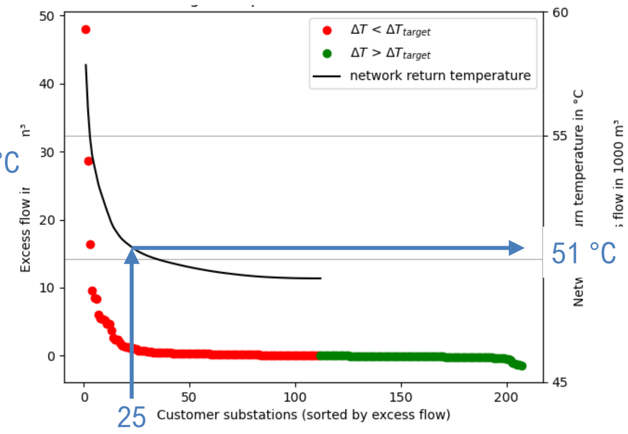
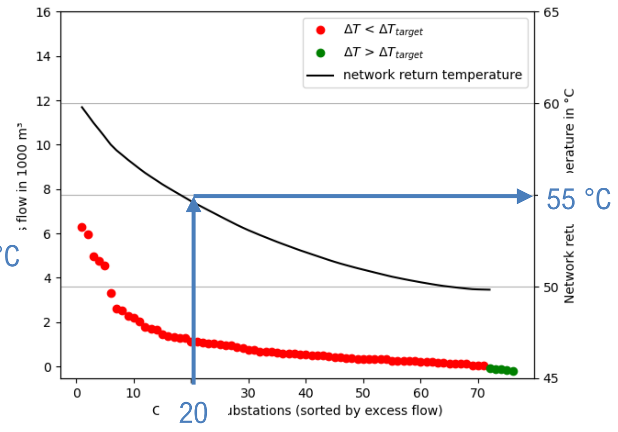
	Network A	Network B	Network C
Excess flow ranking			
Target temperature difference	45 K	40 K	20 K
Number of stations recommended for inspection	100	25	20
Return temperature reduction with recommended substations	4 K	7 K	5 K

Comparison Excess Flow Analyses of Evaluated Networks

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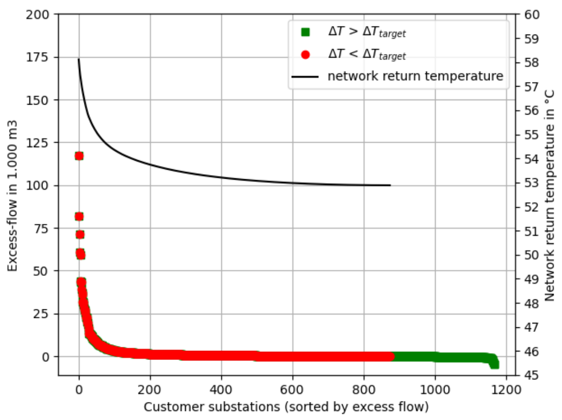
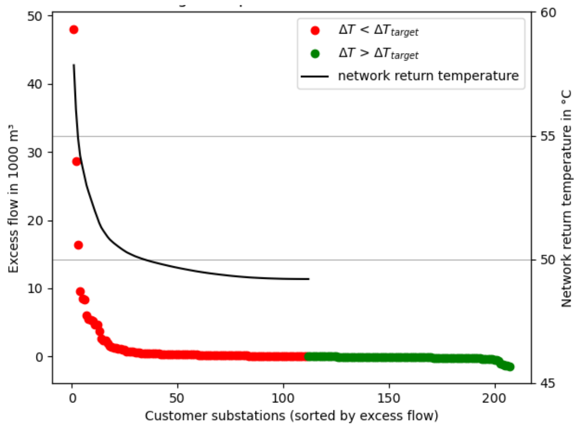
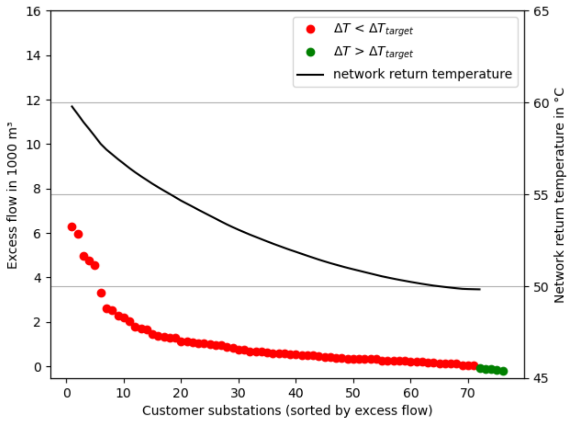
Excess flow ranking (Network A, Network B, Network C)







	Network A	**Network B**	**Network C**
Target temperature difference	45 K	40 K	20 K
Number of stations recommended for inspection	100	25	20
Return temperature reduction with recommended substations	4 K	7 K	5 K
Share of recommended inspections	8 %	12 %	25 %

- Network C has significantly lower target temperature difference due to design temperature difference
- Share of substations recommended for inspection depends on network size (8…25 %)

Identification of Faulty Substations

Further Steps

- typical steps to achieve return temperature reduction:

1 Excess flow analysis → **2** Inspection of substations with highest excess flow → **3** Development of measures to achieve lower return temperatures → **4** Estimation of cost and actual return temperature benefit → **5** Implementation of proposed measures

PROBLEM: Often implementation (step 5) is prevented due to low profitability of proposed measures in current district heating system with energy producers with low temperature sensitivity.

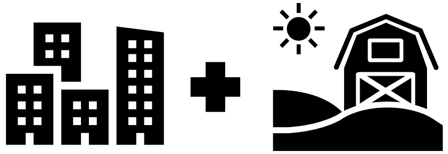
Customers own most of the faulty systems and have no reason to act.

Which financing mechanisms can counteract?

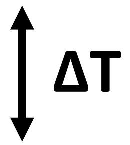
1. Customer: Pricing schemes with flow demand component → often not yet implemented (Germany) but possible
2. Supplier: Easier and more efficient integration of renewable energy sources by supply temperature reduction only possible with return temperature reduction → inclusion of costs into renewable energy concepts

Conclusions and Outlook

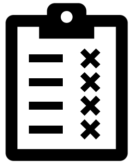
- excess flow method **applicable** to both **urban and rural dh-networks**



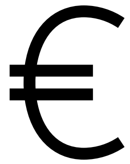
- chosen **target temperature difference** can vary according to built-in substation types and network design temperatures



- **reliable identification** of **faulty substations** → diverse findings



- possible **financing mechanisms**:
  1. costumer: pricing scheme with flow demand component in a system with temperature sensitive energy producers
  2. supplier: part of renewable energy concept



- **Vision of the future energy system** (3rd and 4th generation dh-systems) can be **used to justify** the implementation of measures for **return temperature reduction**