TECHNISCHE UNIVERSITÄT DRESDEN

DRESDEN concept

IEA SHC Solar Academy Task 55: Large Scale SHC Systems Integration into District Heating and Cooling Networks

Decentralized feed-in in existing district heating networks – comparison of the hydraulic effects of solar thermal and CHP integration

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Introduction

Main Focus

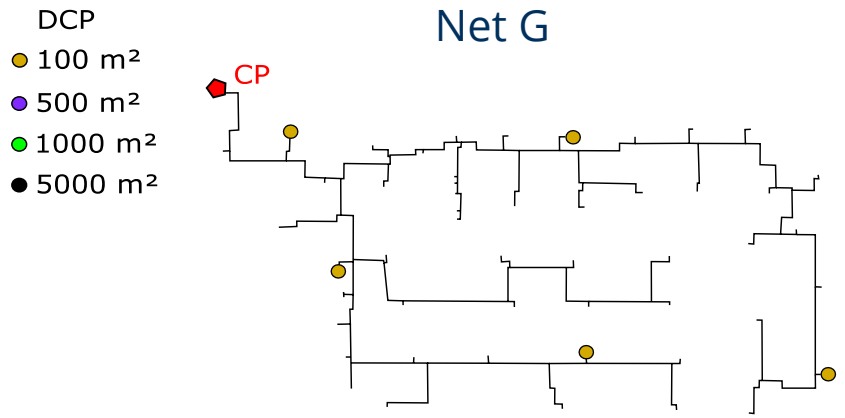
- existing district heating networks
- identification of thermo-hydraulic impact of decentralized feed-in (varying in size and position)

  → **Solar thermal (ST) in comparison to combined heat and power units (CHP)**
- resulting requirements for components (pumps, tubes, pressure maintenance, etc.)

Tools/Method

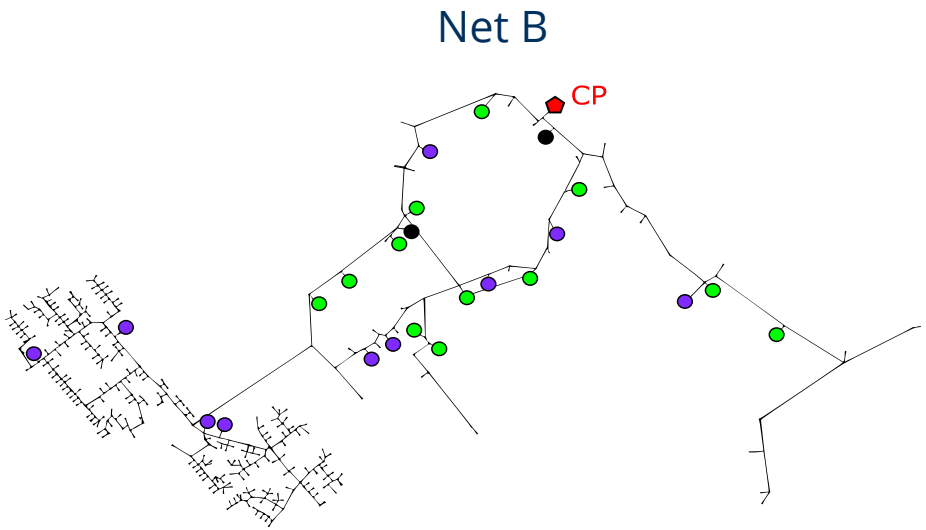
- TRNSYS TUD and DYMOLA with new types, both coupled via FMI master (own development)
- Quasi-dynamic annual simulations of the whole network, the feed-in values and the end user behavior (mass flow, temperatures) for a whole year
- Time-step 15 minutes
- Two different networks
- Two different weather conditions (Würzburg and Potsdam)
- Consideration of a central heat storage (ST) as part of the network control strategy

Considered Networks



- 3rd GEN radial DH network
- Supply line temperature 90 … 65 °C
- installed load of 2.2 MW
- length of 2.65 km
- 51 consumer; load range of 5 … 72 kW

Net G



- 2nd GEN meshed DH network
- Supply line temperature 115 … 80 °C
- installed load of 83 MW
- length of 41 km
- 485 consumer; load range of 22 kW … 14 MW

Net B

Boundary conditions for the simulation

Solar thermal (ST-variants)

© Willenberg

- Net G

gross area	**5 x 100 m²**
performance	0,35 $MW_{peak,th}$

- Net B

gross area	**10 x 500 m²**	**12 x 1 000 m²**	**2 x 5 000 m²**	**all 24 DCP's = 27 000 m²**
performance	3,5 $MW_{peak,th}$	8,4 $MW_{peak,th}$	7,0 $MW_{peak,th}$	18,9 $MW_{peak,th}$

Block heat and power units (CHP-variants)

© DREWAG

- Net B

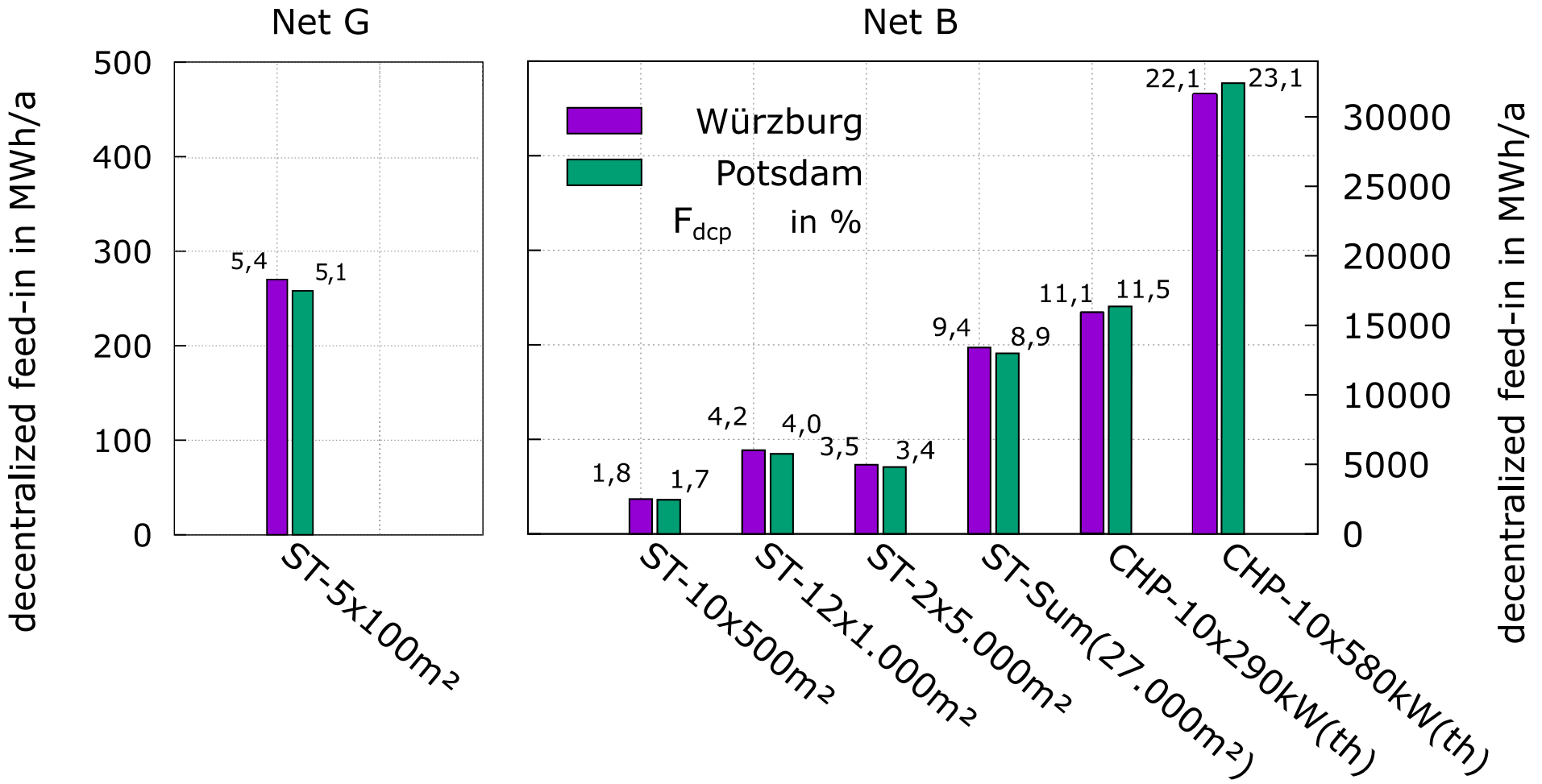
nominal power	**10 x 250 kW_{el} / 290 kW_{th}**	**10 x 500 kW_{el} / 580 kW_{th}**
performance	2,9 MW_{th}	5,8 MW_{th}

Consumer modeling

© KBB Kollektorbau Berlin

- Measurement based regression models for 24 types of buildings
- Calculation in each time step (15 minutes) for each regression model

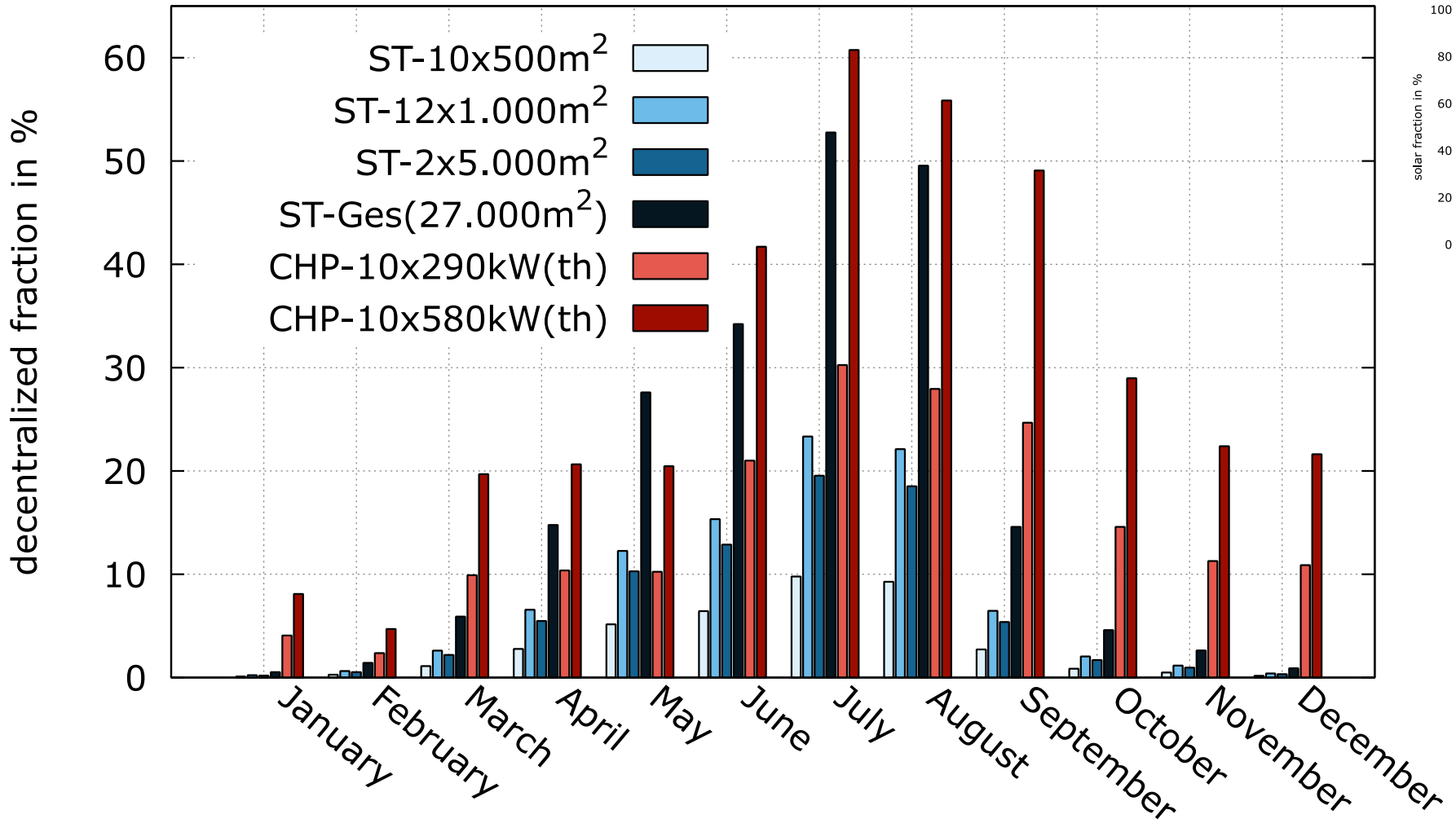
Annual heat production and F_{dcp} for the two networks

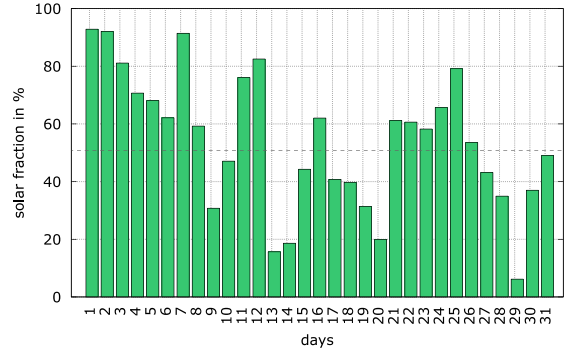


Fraction of **dec**entralized **p**roduction

$$F_{dcp} = \frac{\sum \dot{Q}_{dcp}}{\sum \dot{Q}_{net}} = \frac{sum\ of\ decentralized\ solar\ thermal\ ST\ or\ CHP feed-in}{sum\ of\ heat\ consumption\ for\ the\ whole\ network}$$

Fraction of decentralized production (Net B, monthly, Würzburg)





ST Ges (27 000m²)
daily, July

Attention! CHP feed-in depends on European Energy Exchange (EEX) prices and the local optimization on other aspects.

Possible effects of feed-in

Flow reversal in parts of the net segments can occur

- Normal situation for mashed parts
- Effect of decentralized feed-in for radial parts

Moving supply frontiers

- border between positive and negative mass flow in pipe
- thermal stress due to alternating temperatures

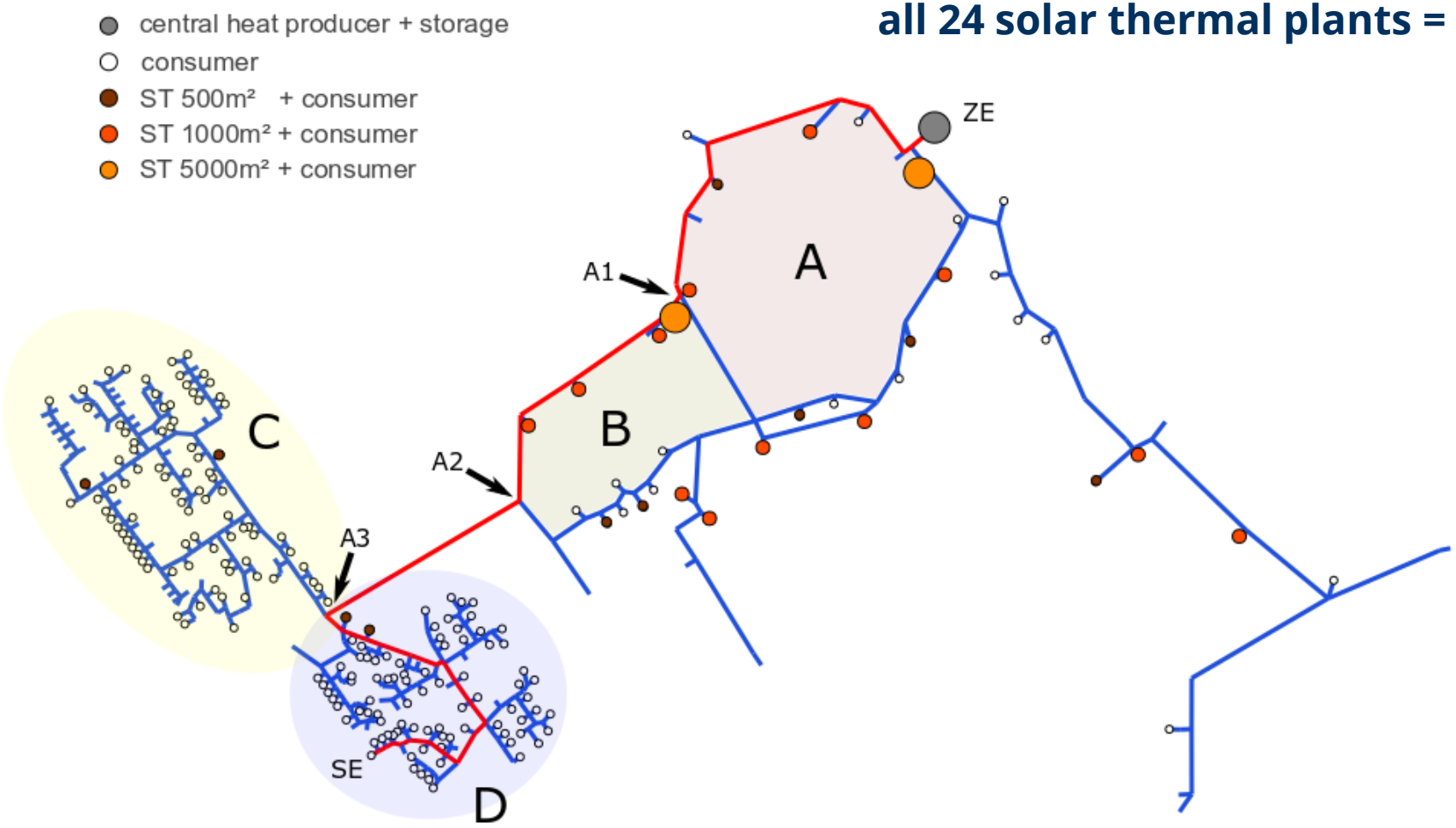
Full supply by decentralized heat producers

- high performance of solar thermal “meets” low demand at the user side
  → central storage is necessary

Switching index circuit due to changed pressure conditions

- New control methods for central district heating pumps
- Influence on pressure maintenance

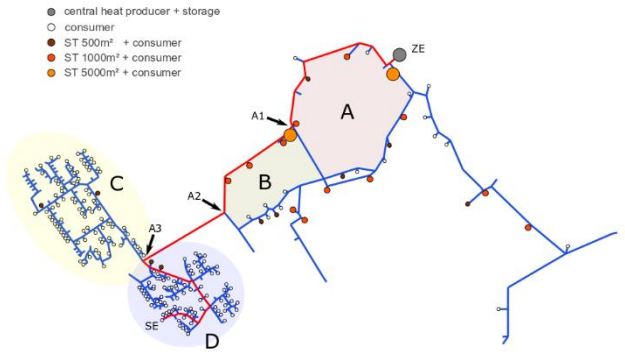
Example results of thermohydraulic simulation: branch 1 in Net B

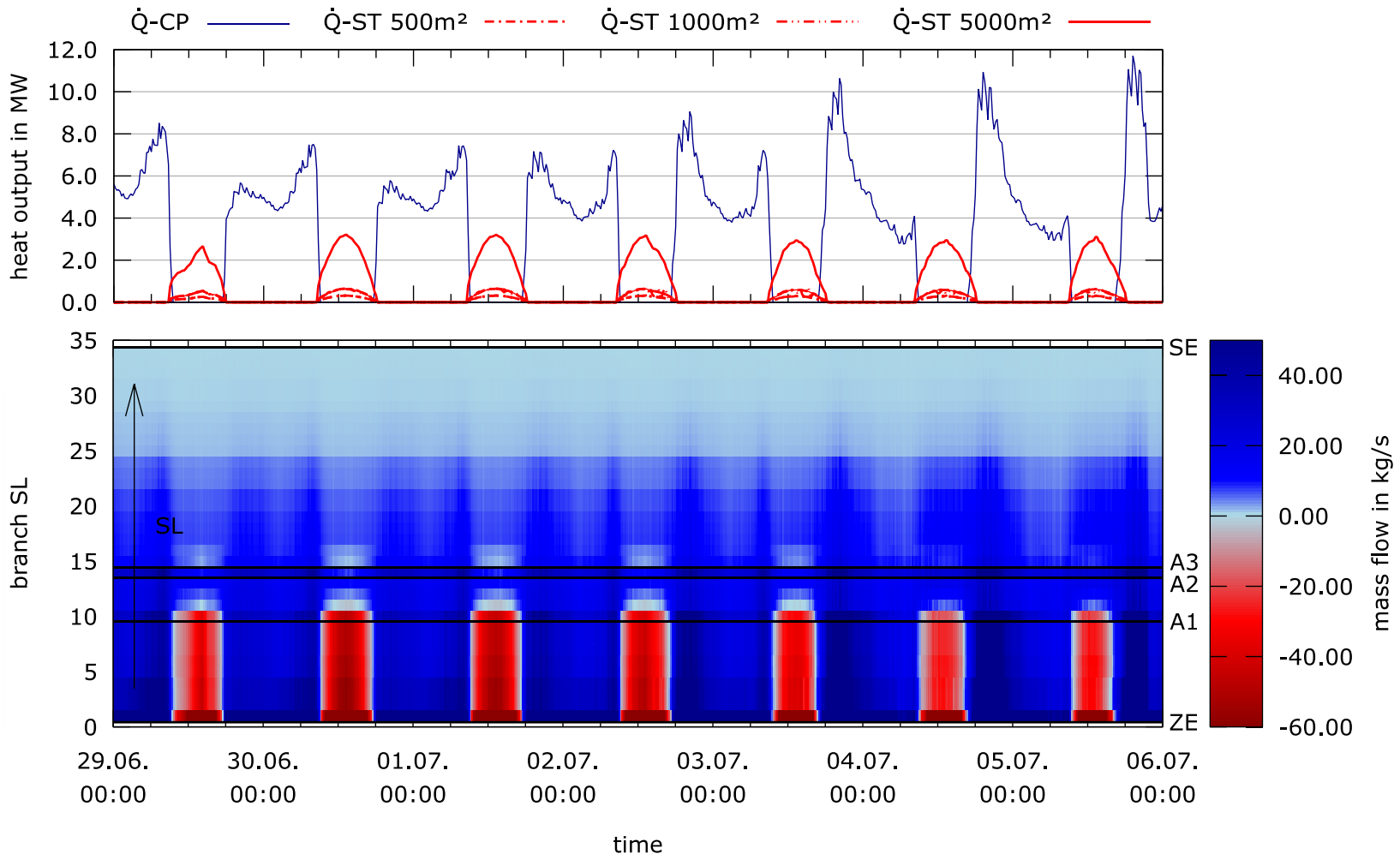


Mass flow distribution for branch 1 – summer week

Conclusions

- Without central storage, decentralized solar-thermal would have to be limited → stagnation
- Decentralized feed-in pumps take over the transport!

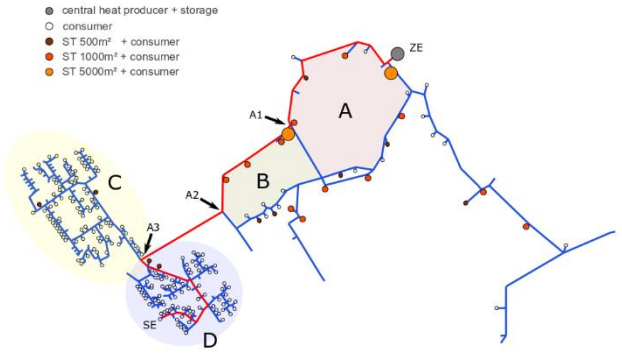


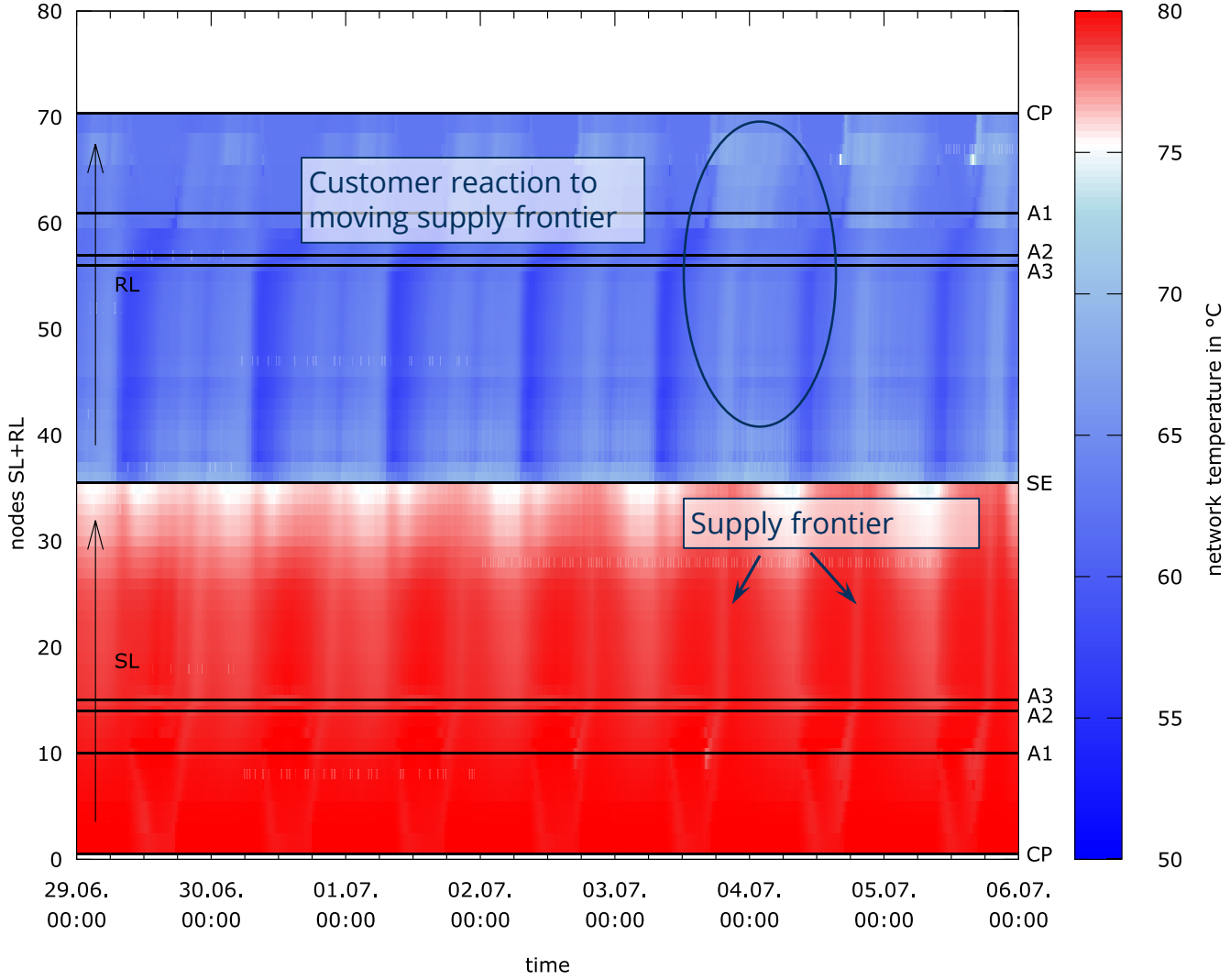


Temperature distribution for branch 1 – summer week

Conclusions

- Customers react with changed return-line temperatures
- Supply-line temperature drops in the direction of the supply frontier
- Effects on pipelines and network pumps as well as changes in working cycles pressure maintenance can be identified





Conclusions & Outlook

Conclusions

- annual solar fraction up to 9,2 % in Net B with 27 000 m²
- flow reversal and full supply by DCP identified, pre-dimensioning for central storages take place
- investigation of decentralized feed-in of combined heat and power plants

Outlook

- simulation of Net B with a large field solar-thermal system plant near mash A (> 25 000 m²)
- prediction of consequences for central heat producer → part load efficiency, CO_2-reduction
- requirements for feed-in pumps → comparison with the pump catalogues of the manufactures
- investigations regarding thermal stress → life time of district heating tubes

→ A short video presentation for simulation results of four summer days

Supported by:

Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

Project:
EnEff: Wärme – DELFIN
FKZ: 03ET1358B

Thank you for your attention!

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