4th International Conference on Smart Energy Systems and 4th Generation District Heating
Aalborg, 13-14 November 2018

4DH
4th Generation District Heating Technologies and Systems

Coupled local district heating and electrical distribution grids

Benedikt Pesendorfer[1], Edmund Widl[1], Wolfgang Gawlik[2], René Hofmann[1,2]
[1] Austrian Institute of Technology
[2] TU Wien

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

TU WIEN
TECHNISCHE UNIVERSITÄT WIEN

AALBORG UNIVERSITY
DENMARK

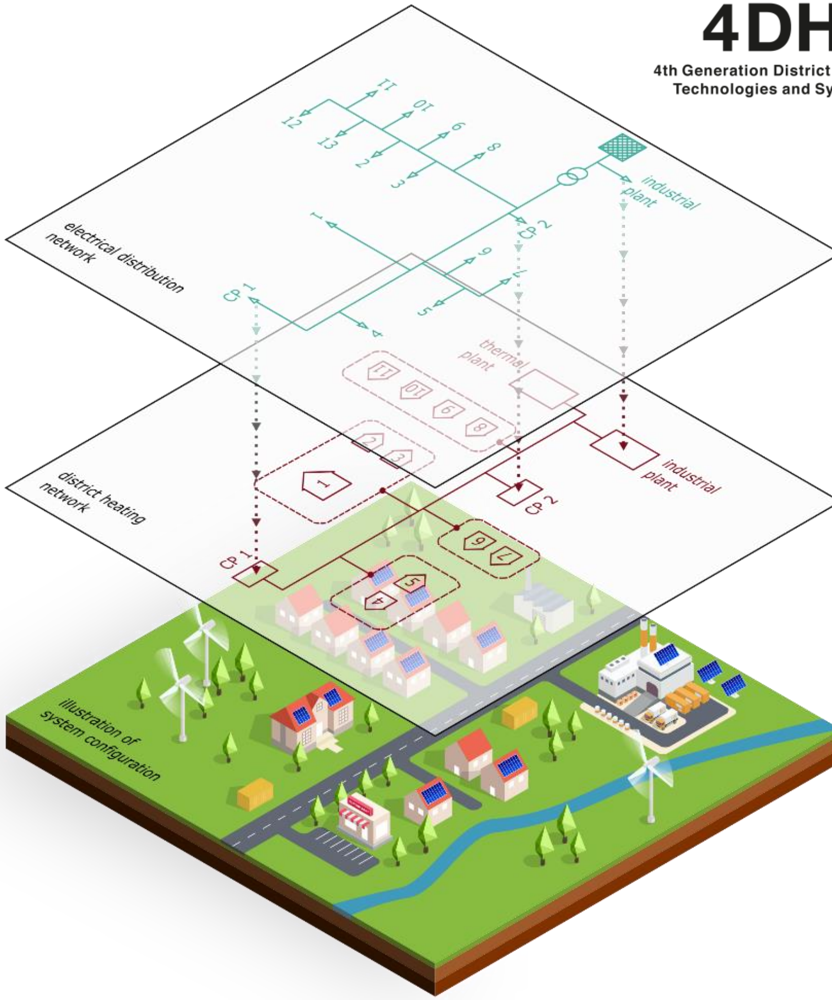
4DH
4th Generation District Heating Technologies and Systems

4th International Conference on Smart Energy Systems and 4th Generation District Heating 2018
#SES4DH2018

4DH
4th Generation District Heating Technologies and Systems

Motivation

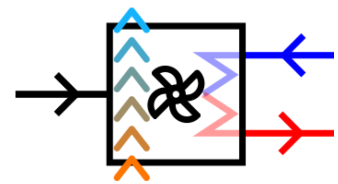
- Increasing share of volatile renewables in electric grid
- Need for decarbonization of heating sector
- Trend towards smart energy networks and energy communities
  - Decentralized prosumers and storages
  - Exploiting hitherto unused synergies between networks



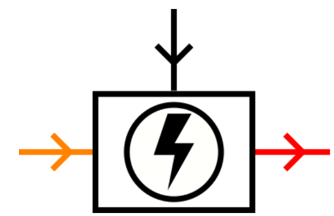
AALBORG UNIVERSITY
DENMARK

Use cases for distributed coupling of heat and electricity grids

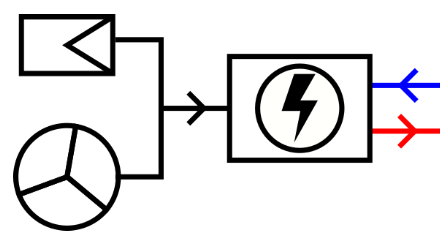
- Integration of low temperature waste heat
  - Heat pumps to upgrade temperature level



- Mitigation of recirculation
  - Supply-supply connected electric heaters guarantee supply temperature and avoid need for bypass



- Integration of excess power from RES
  - Power-to-heat of surplus electricity to increase self-sufficiency and relieve stress in electric network



AALBORG UNIVERSITY
DENMARK

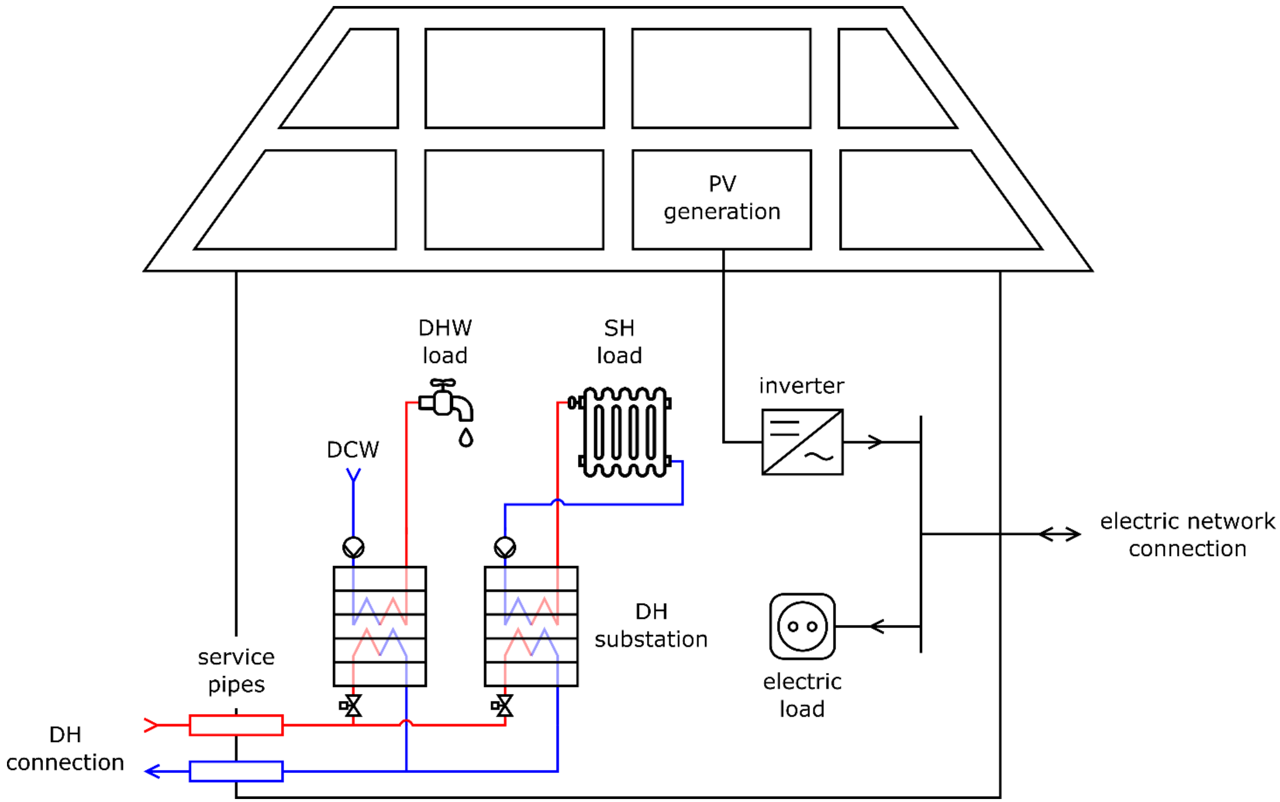
Modelling: District heating

- Dynamic approach
  - Necessary realism in systems with energy storage
  - Time-varying loads and generation
  - Thermal mass in constructions and pipes
  - Multiple heat sources with varying supply temperatures
  - Requires control strategy and control systems
- Modelling tool: Modelica/Dymola
  - Open source libraries (e.g., IBPSA)
  - AIT internal district heating library (will be made open source soon)

Modelling: Electric grid

- Quasi-dynamic approach to cover impact of:
  - Consecutive power flow analysis
  - Time-varying loads and generation
  - Control implementation
  - Storage integration
  - Coupling with systems with different dynamics (such as district heating)
- Modelling tool: pandapower
  - Completely open source
  - Python based and easy to use

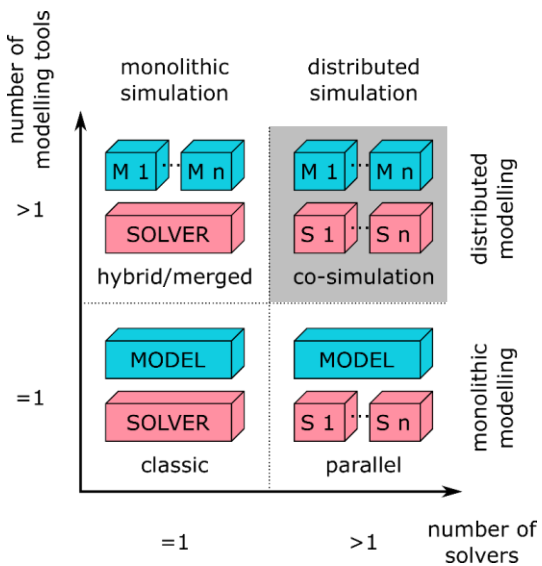
Modelling: Consumers



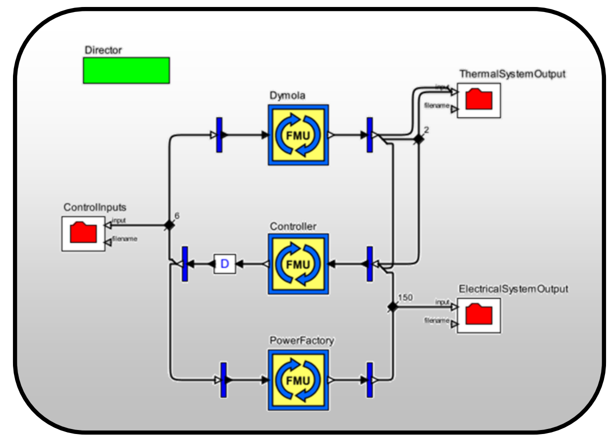
AALBORG UNIVERSITY
DENMARK

Modelling approach

How to simulate coupled energy networks?



No single tool that covers all



Co-Simulation

AALBORG UNIVERSITY
DENMARK

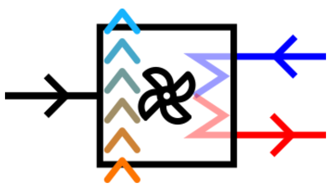
Case Study: Overview

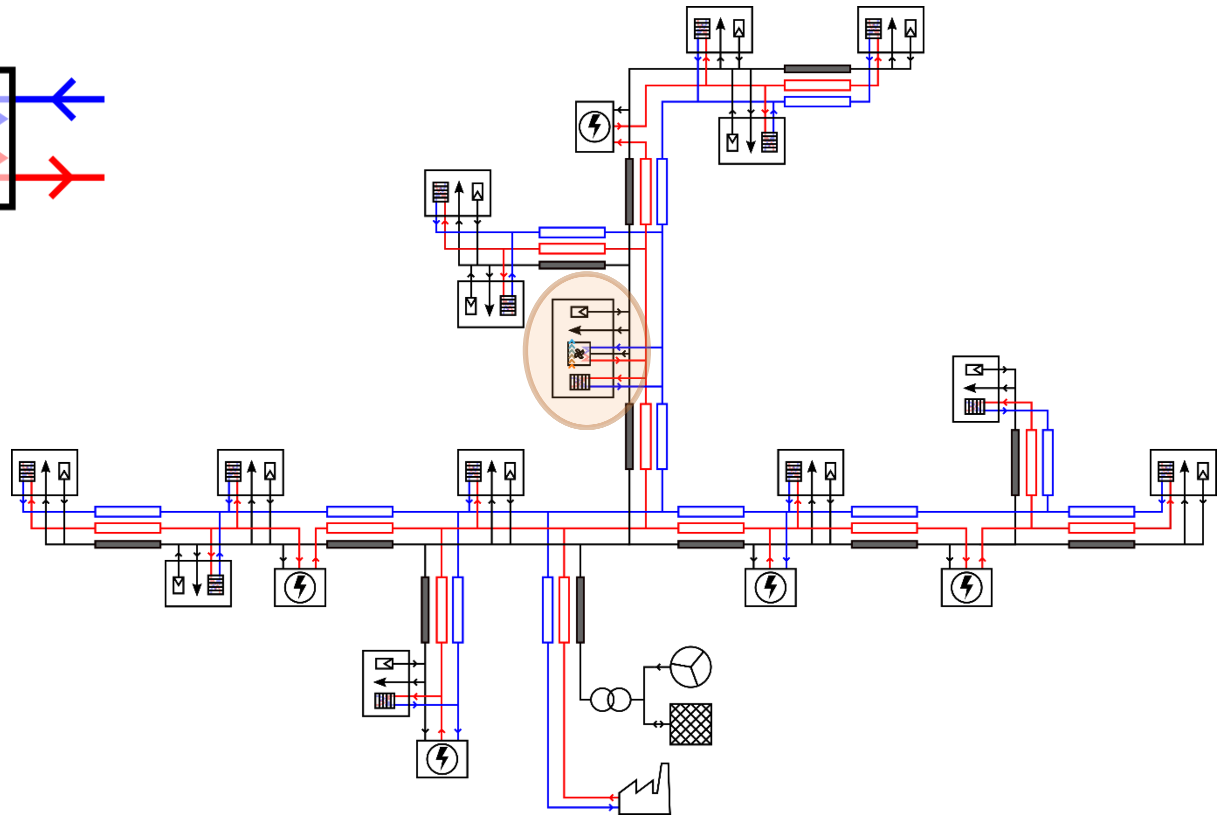
- Small low-density DH network
- Low voltage electric distribution network
- Mix of single- and multi-family homes, school, supermarket, etc.

Key data	
# of buildings	93
SH + DHW demand	2750 MWh
Waste heat potential	95 MWh
Electric demand	515 MWh
PV generation	215 MWh
Wind generation	170 MWh
Excess power	130 MWh

Case Study: Coupling points

- Heat pump utilizing waste heat



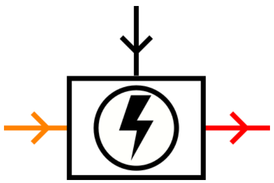


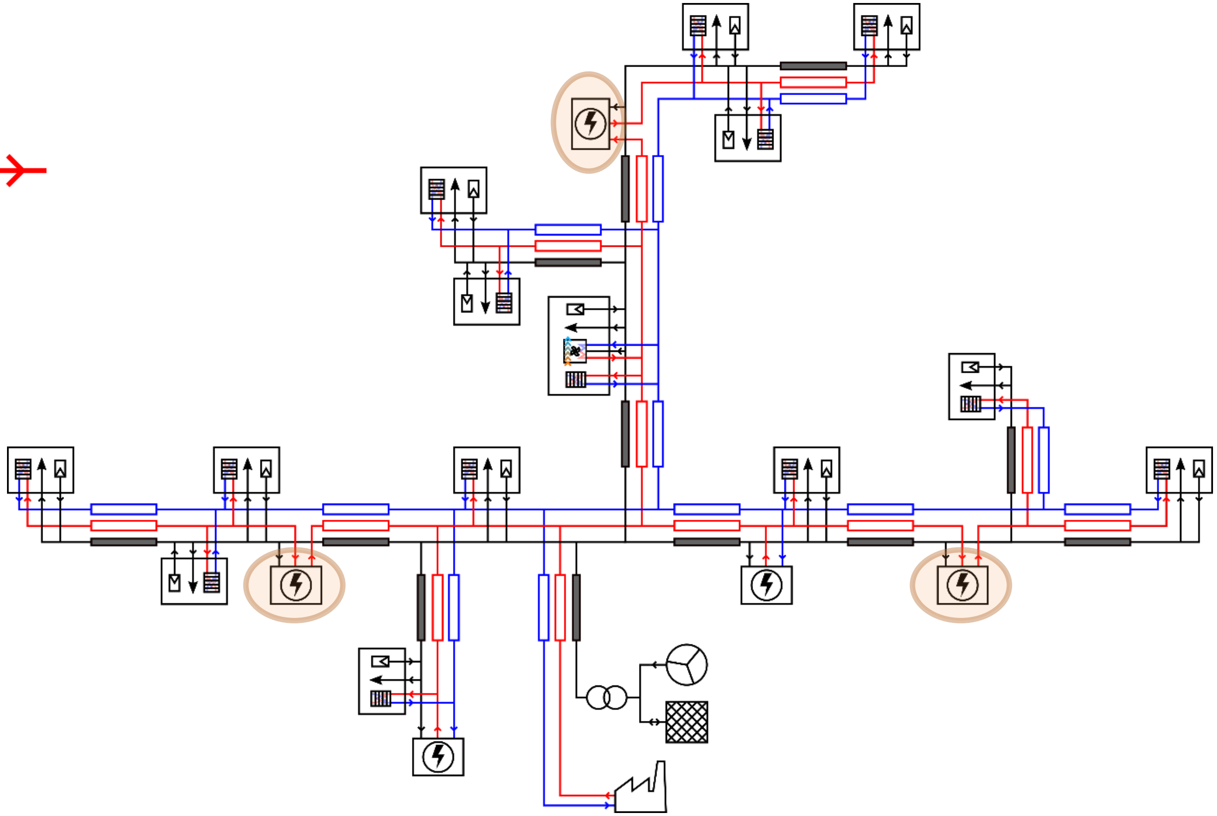
4DH
4th Generation District Heating Technologies and Systems

AALBORG UNIVERSITY
DENMARK

Case Study: Coupling points

- Electric heater guaranteeing supply temperature

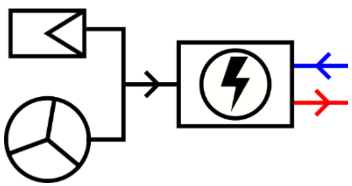


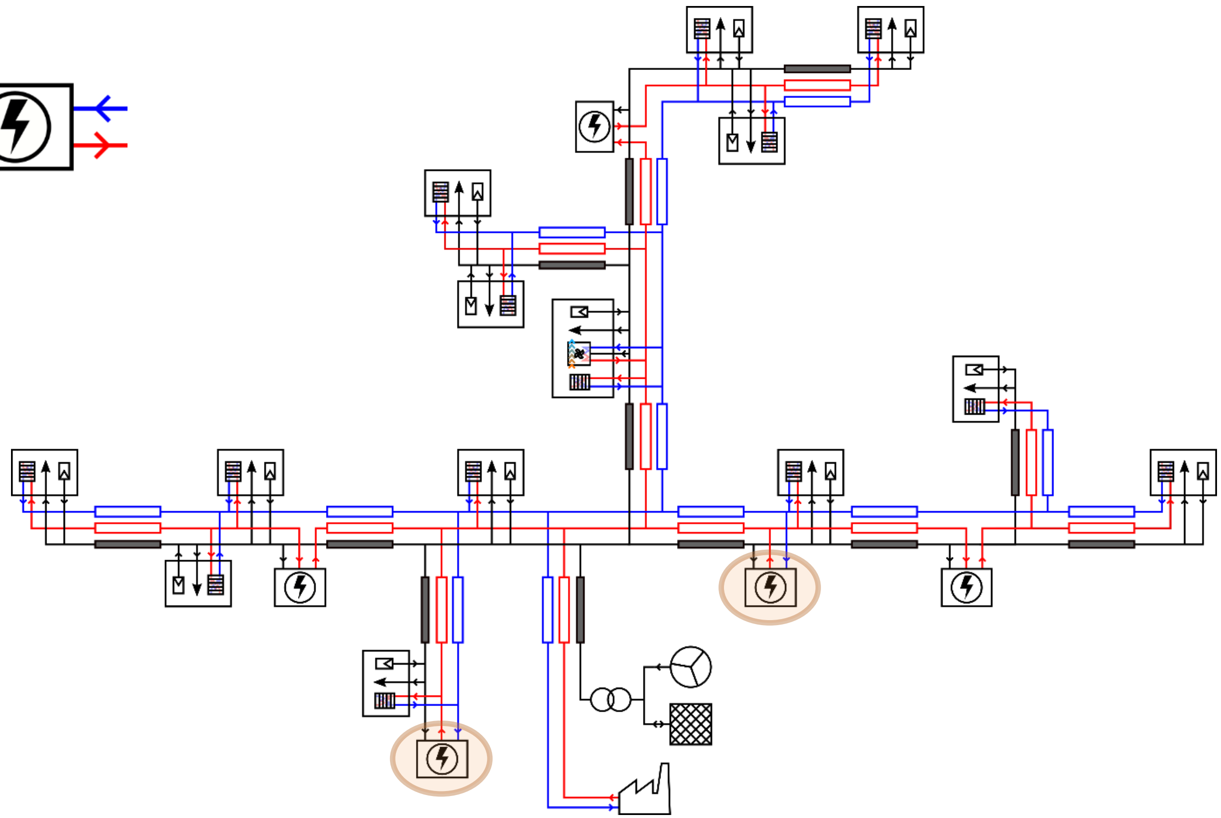


AALBORG UNIVERSITY
DENMARK

Case Study: Coupling points

- Electric heater integrating surplus wind and PV





AALBORG UNIVERSITY
DENMARK

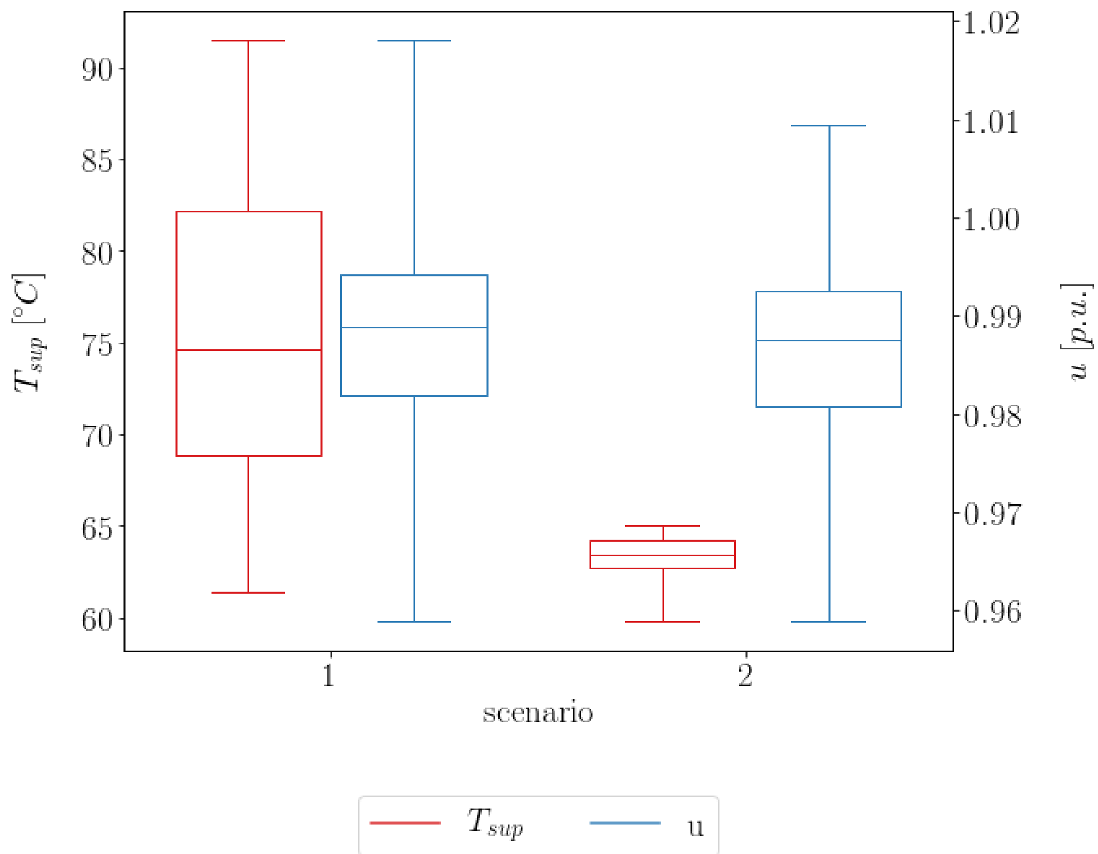
Case Study: Results

Scenario	Base supply	HP_{WH}	EH_{T}	EH_{RES}	Heat loss	GWP	Energy imports
Uncoupled networks	95°C/75 °C	-	-	-	280 MWh	303 $tCO_{2,eq}$	3285 MWh
Coupled networks	65°C	65°C	min 60°C	65°C	- 13%	- 5%	- 6%

- High potential to use synergies
- More results available (share of RES, etc.)

Results: Effort variables

- Supply temperatures and voltages at consumers as measure for supply quality
- Times of higher voltages reduced
- Supply temperature above minimum



Summary & Conculsion

- Assessment of different use case that enable actively coupled district heating and electric distribution networks
- Synergies between networks can help on the path to 4th generation district heating and higher share of decentralized generation in both networks
- How about impact of grid storages? Working on it → next year‘s conference?!

Thank you!