DECREASING DISTRICT HEATING NETWORK HEAT LOSSES IN THE SUMMER MONTHS USING DECENTRALIZED SYSTEMS: A SIMULATION CASE STUDY

3rd International Conference on Smart Energy Systems and 4th Generation District Heating

Copenhagen, 12-13 September 2017

Paolo Leoni, Ralf-Roman Schmidt

AIT Austrian Institute of Technology GmbH

INTRODUCTION

- **Challenges**: Network heat losses are particularly critical in DH systems with low density or in periods with low heat demand
- **Objective**: simulation-based techno-economic evaluation of solutions to decrease the heat losses in non-heating period
- **Case study**: typical rural district heating network in Austria
- **Proposed solutions**: Integrating decentralized storage tanks at the customers, deactivating of the DH network during Summer, and charging TES tanks by:
  - Scenario 1: Additional solar thermal collectors on every buildings
  - Scenario 2: Existing biomass boiler via part time re-activation of the DH network

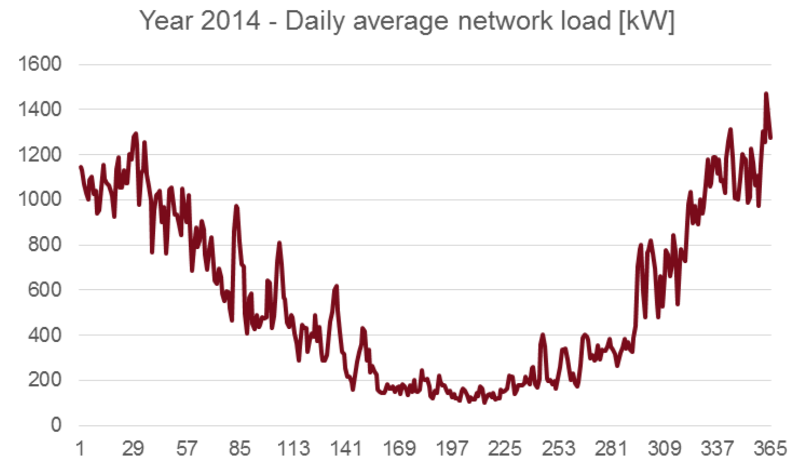
APPROACH

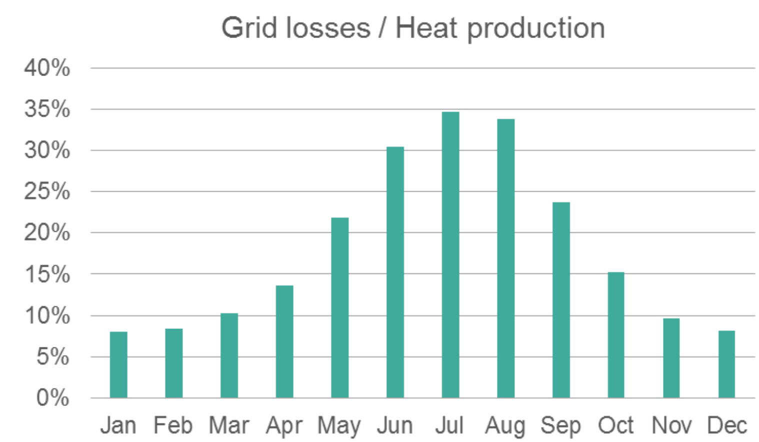
- Scenario evaluation with an internally developed simulation tool:
  - Simulation of: heat production plants, storage systems, network, users' demand
  - Yearly simulation horizon with hourly steps
  - Model validated with operational data
- Evaluation based on simulation outputs:
  - Grid losses
  - Primary energy consumption
  - Economic parameters

CASE STUDY
HEATING NETWORK

Number of users	50
Network length	4300 m
Linear load density	**0.50 kW/m**
Linear heat density	**1.3 MWh/(m·a)**
Supply temperature	80÷90 ºC
Return temperature	50÷55 ºC

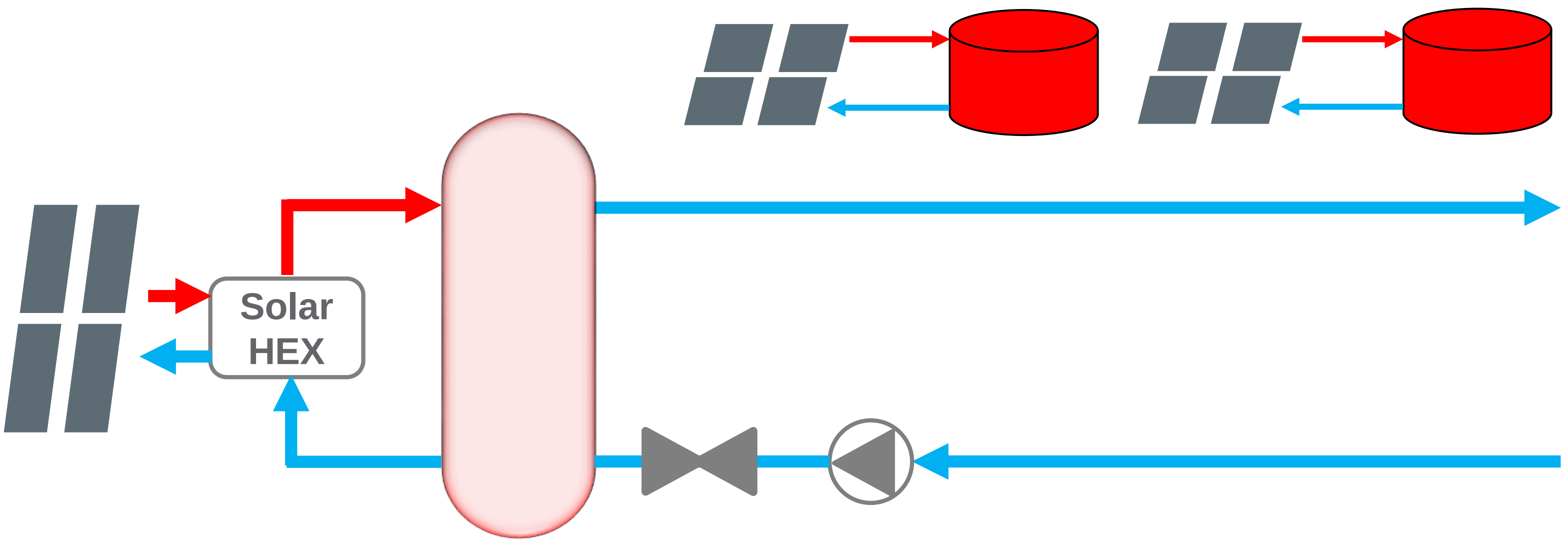
	Year	Winter	May-Sep
Users' demand [MWh]	5641	4766	875
Grid losses [MWh]	856	519	337
Production [MWh]	6512	5294	1218
Grid losses vs production	**13.2%**	9.8%	**27.4%**
Demand/production	86.6%	90.0%	**71.8%**
Global efficiency	67.9%	68.5%	65.0%
Pump electricity [MWh]	6.41	6.16	0.25





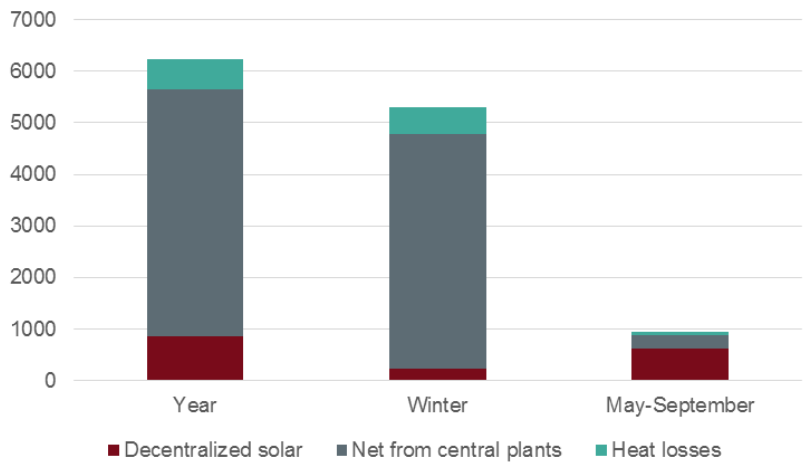
SCENARIO 1
DECENTRALIZED SOLAR COLLECTORS

When the grid is switched off, the heat produced by the central solar collectors is stored into the central TES.



- **Overall aperture area 3700 m^2**
- **Overall storage volume 5600 m^3**

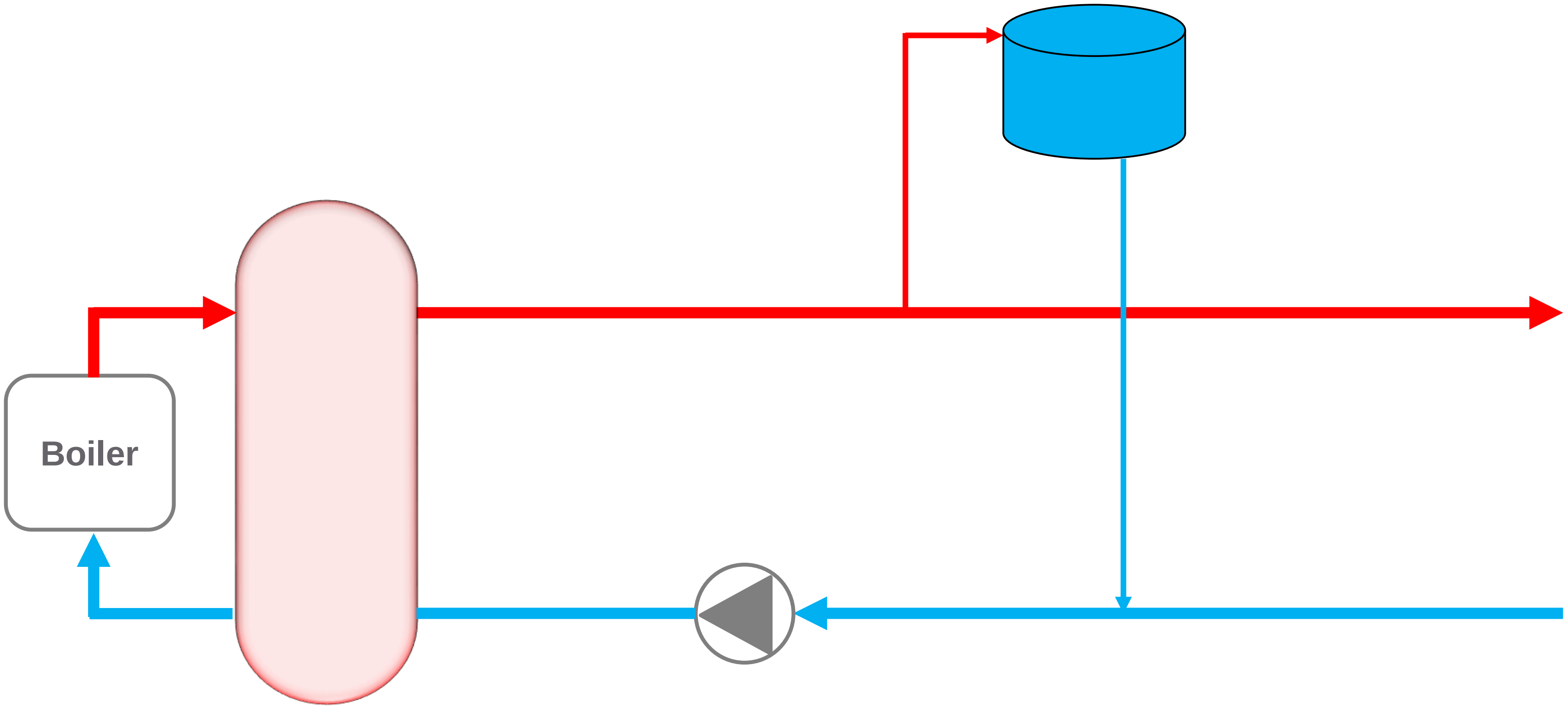
SCENARIO 1
DECENTRALIZED SOLAR COLLECTORS



- About 1500 h/a operation of solar systems
- **100% solar share from mid May to mid September → grid turned off**
- **Grid losses reduced by 268 MWh/a**
- Biomass boiler production reduced by 850 MWh in the mid season and 240 MWh in Winter

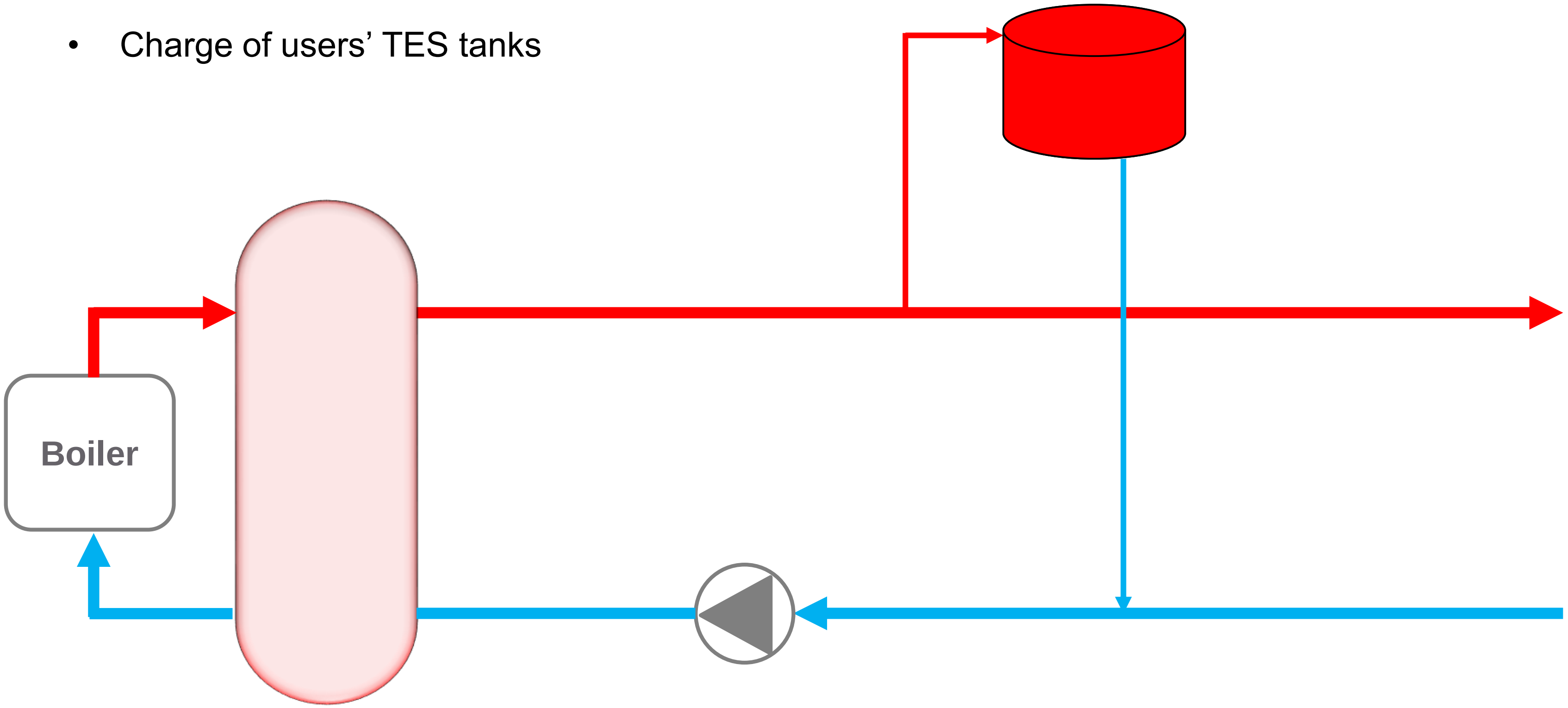
Overall annual irradiance [MWh]	4084
Year solar share	13.7%
Specific solar yield [(kWh/a)/m^2)]	246

SCENARIO 2
CASE A



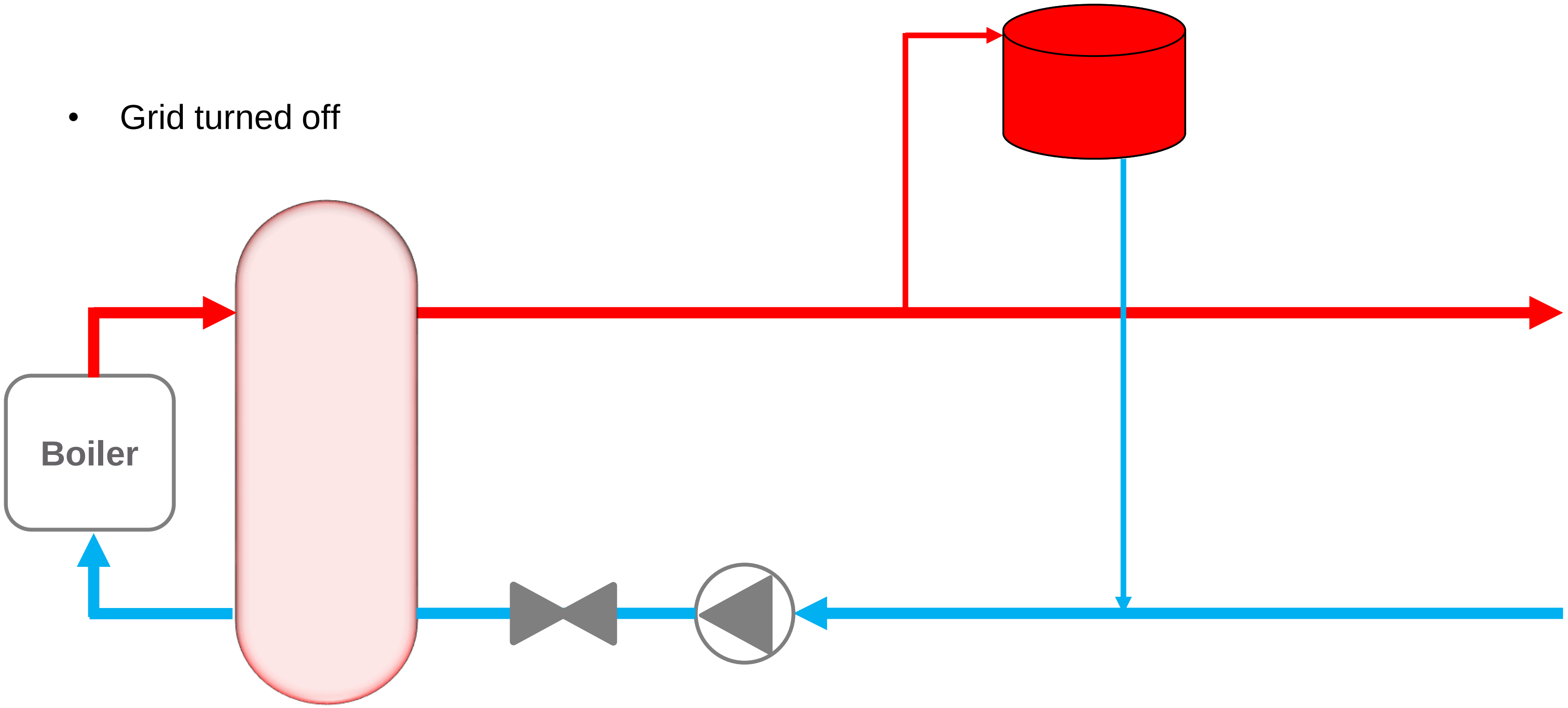
SCENARIO 2
CASE A

- Charge of users' TES tanks

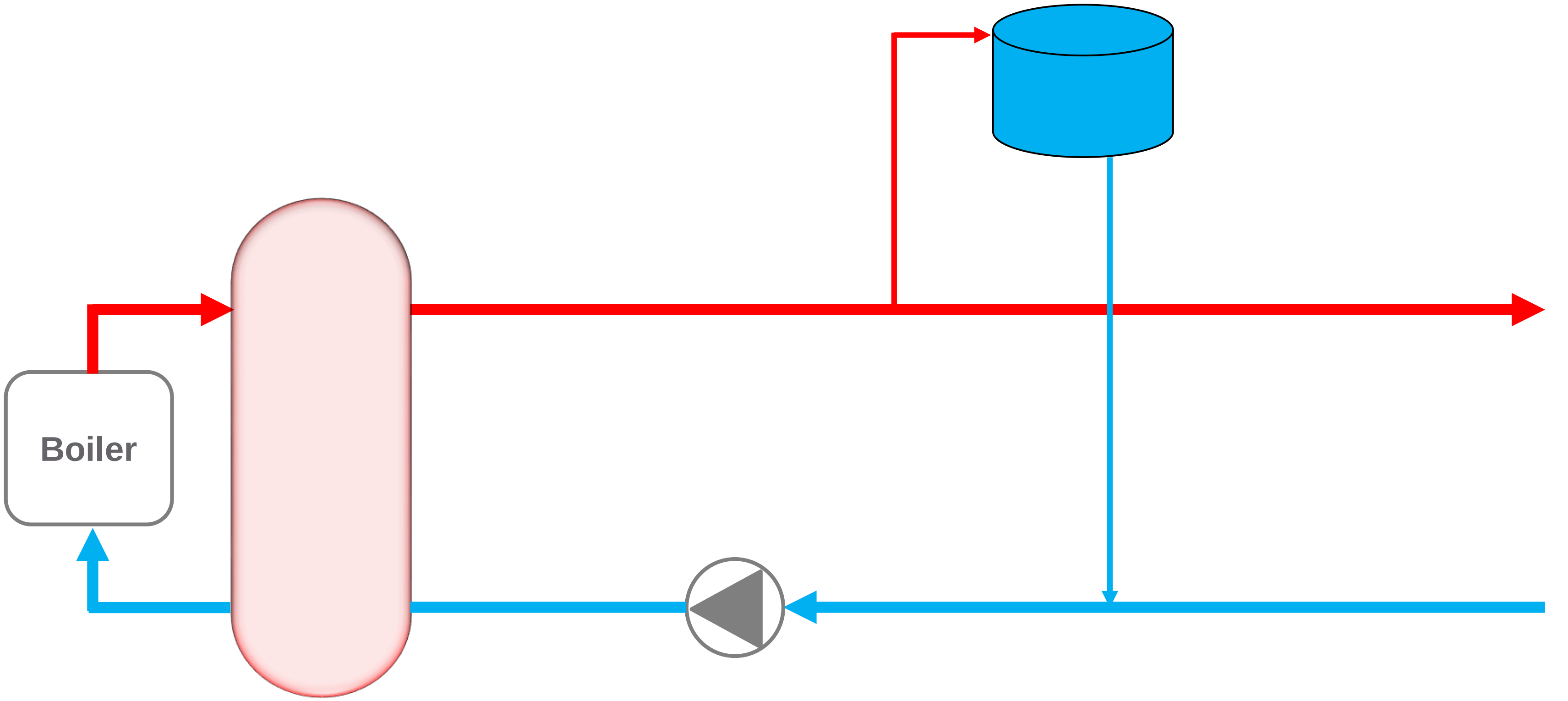


SCENARIO 2
CASE A

- Grid turned off

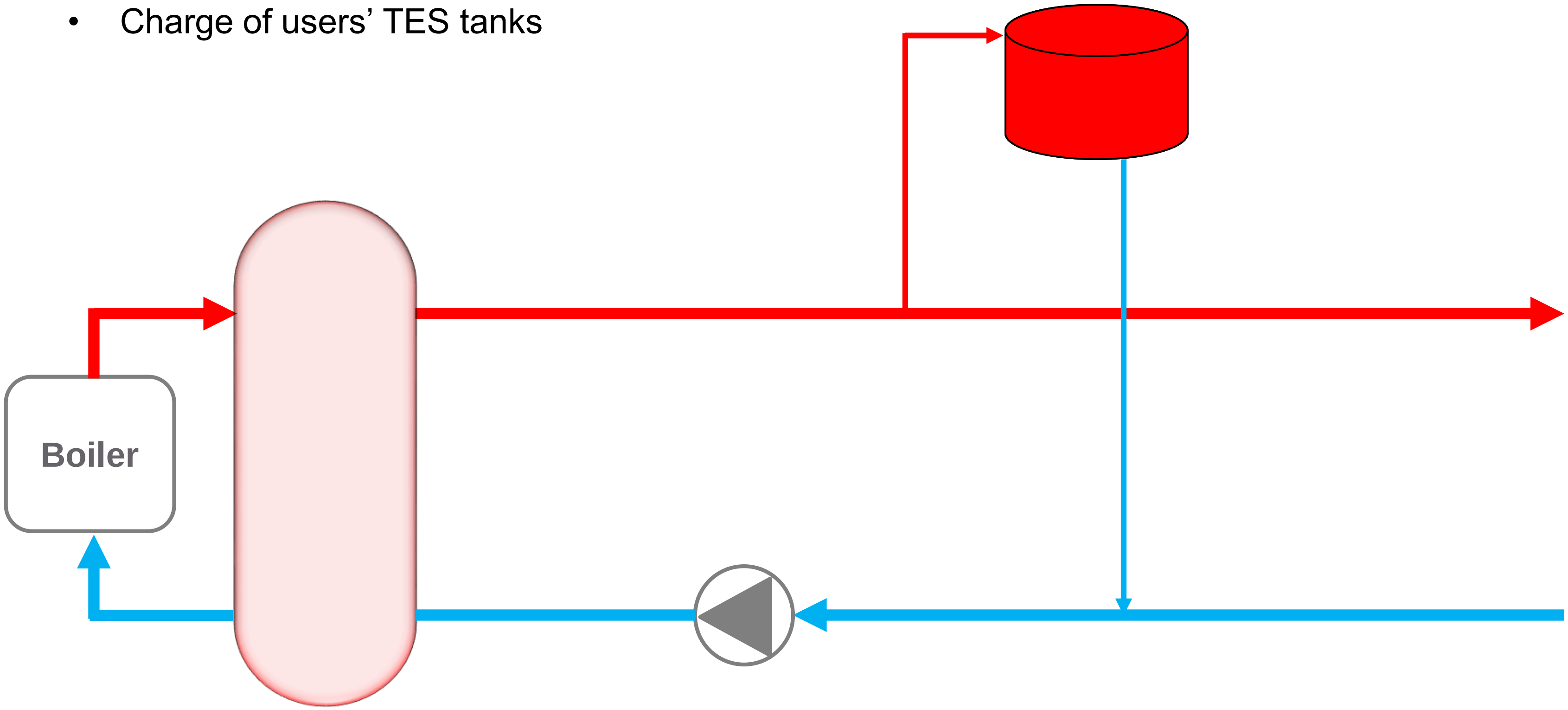


SCENARIO 2
CASE B



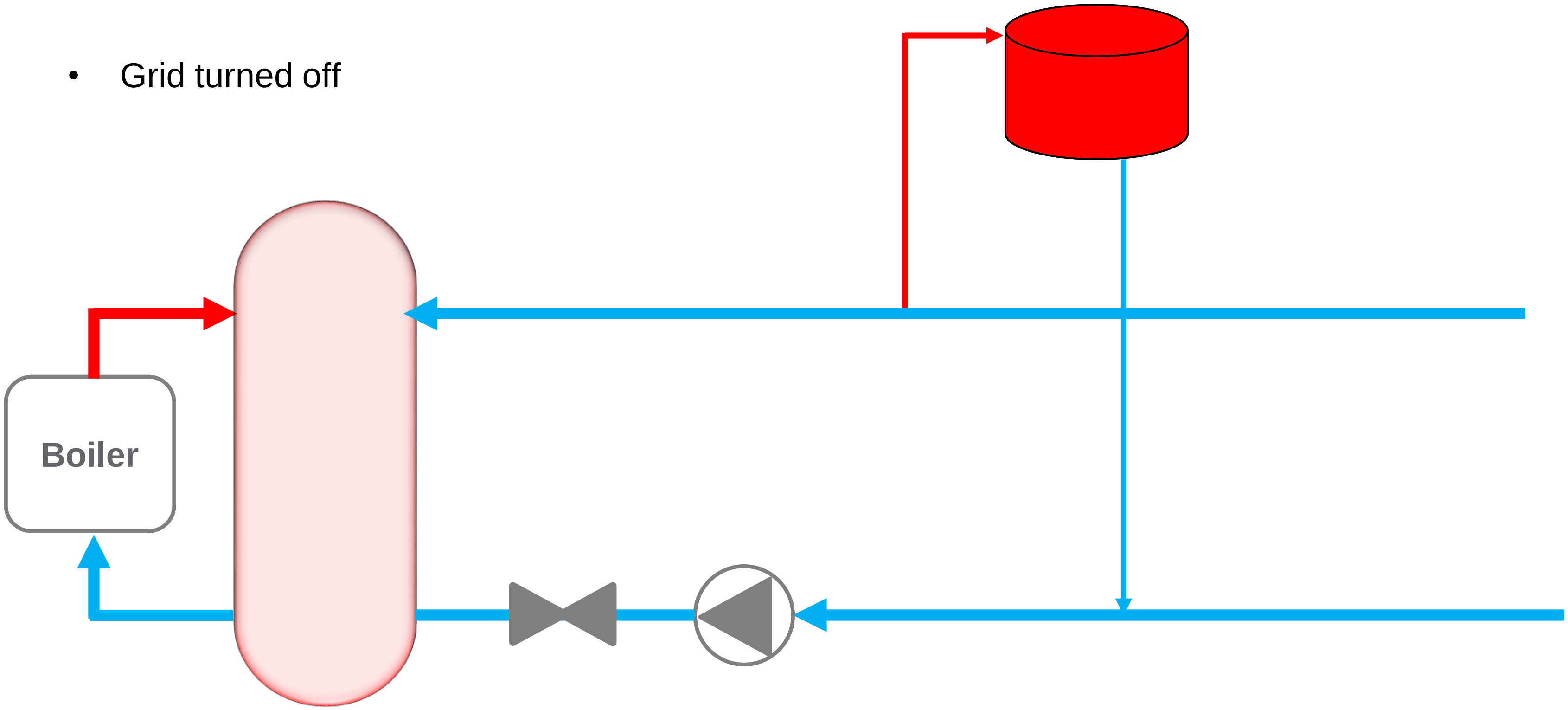
SCENARIO 2
CASE B

- Charge of users' TES tanks



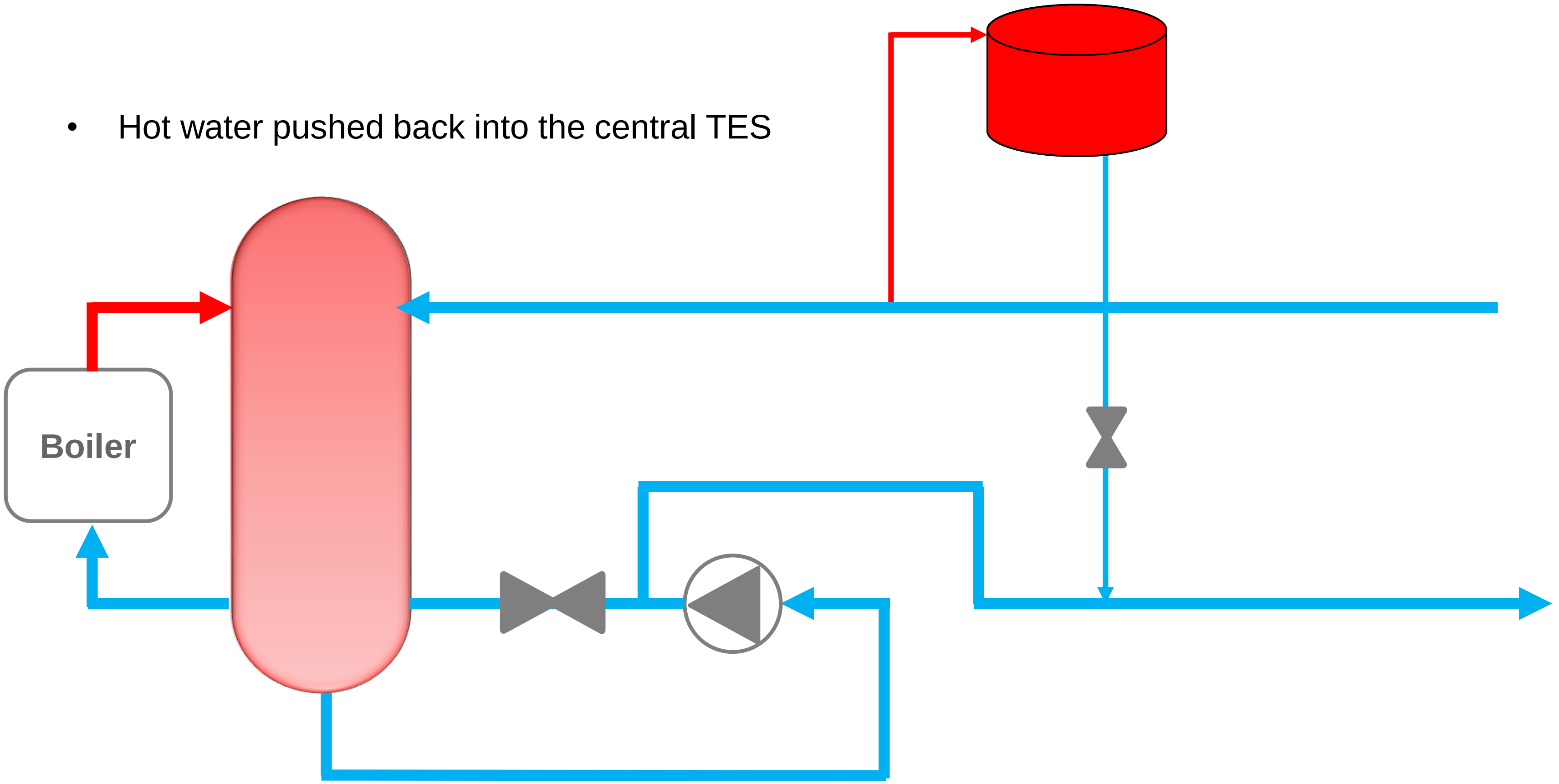
SCENARIO 2
CASE B

- Grid turned off

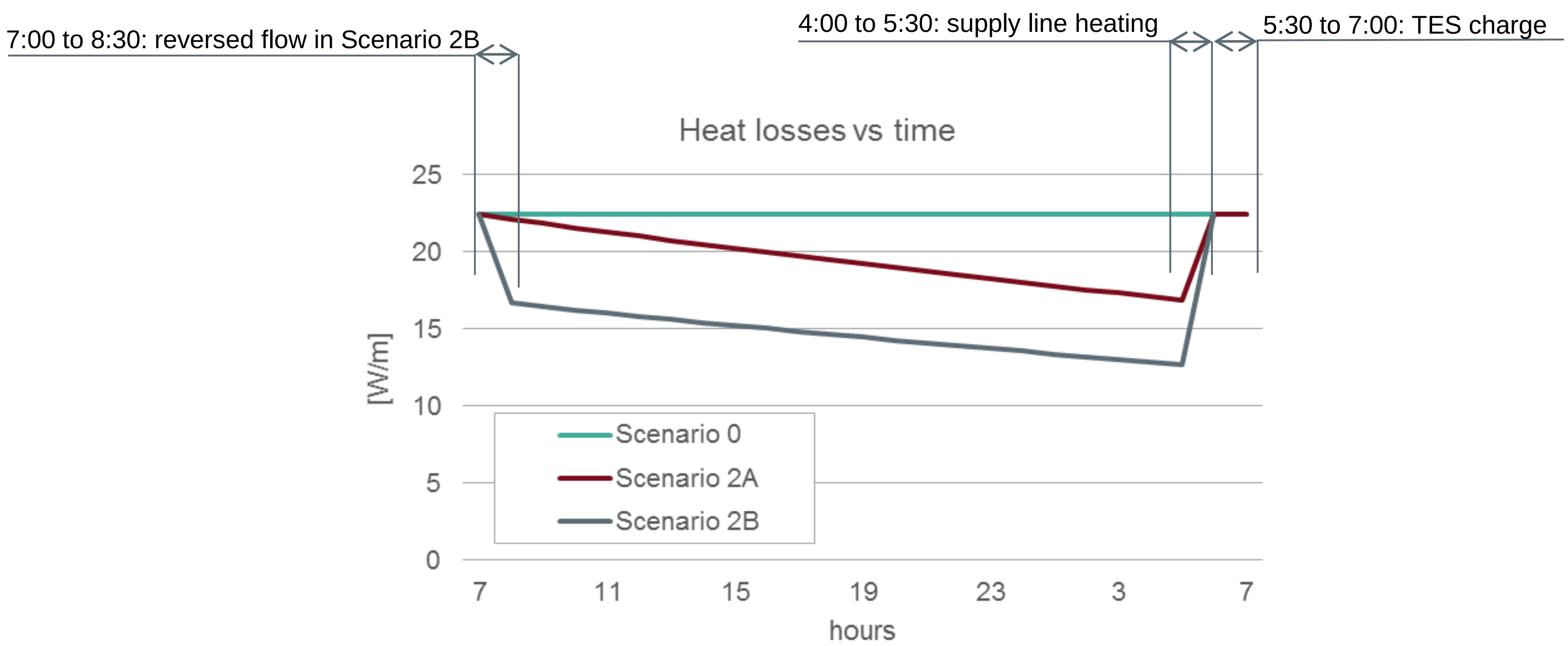


SCENARIO 2
CASE B

- Hot water pushed back into the central TES



SCENARIO 2
DAILY GRID LOSSES



Grid losses scenario 0 [kWh/d]	2220
Grid losses case A [kWh/d]	**2005**
Grid losses case B [kWh/d]	**1488**
Overall storage losses [kWh/d]	48

Daily reduction of grid losses:

- Case A: **9.7%**
- Case B: **33.0%**

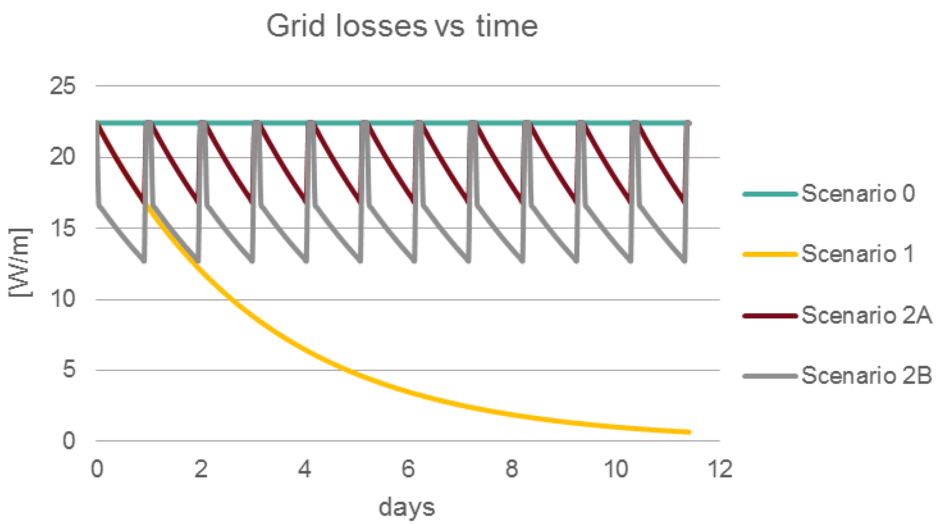
SCENARIO 2
DECENTRALIZED HOT-WATER STORAGE SYSTEMS

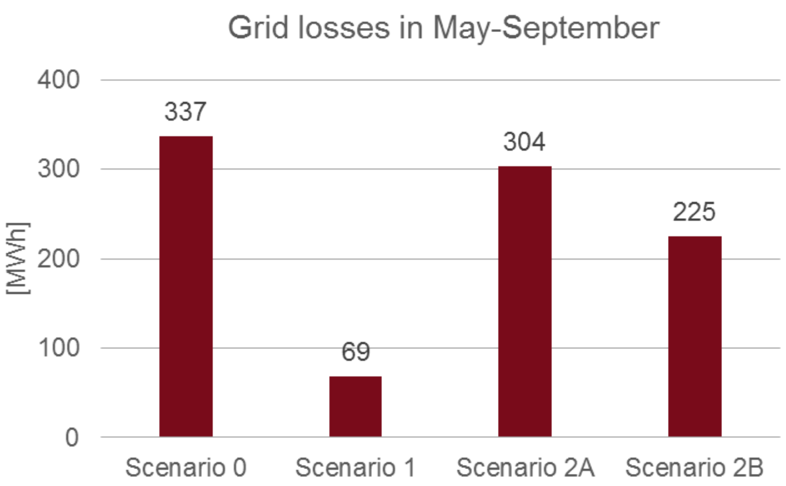
After turning off the grid, the grid losses decrease while cooling (decreasing driving force of thermal exchange).

$$Q_{loss} = \widehat{U}A\left(T_{water} - T_{ground}\right)$$

- From May to September, the grid is turned on only for daily charge of the TESs
- While charging, the central boiler operates at nominal power → increased thermal efficiency
- Assumed TES size:
  - 150 liters for single-family houses
  - 400 liters for multi-family houses, schools, commercial buildings

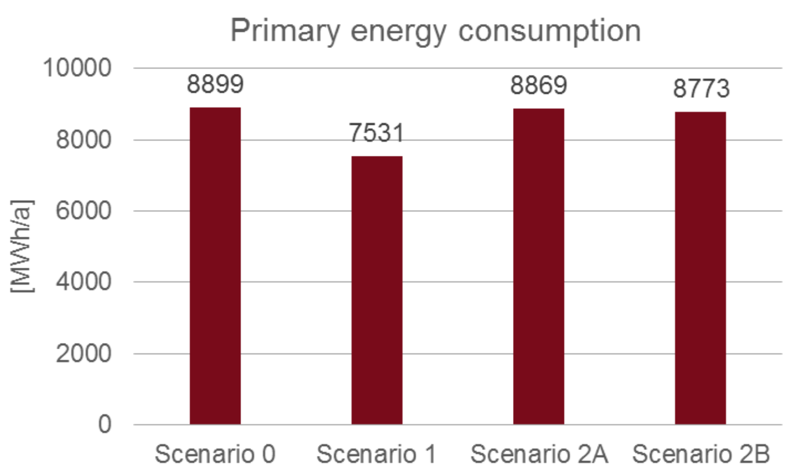
SCENARIO COMPARISON
GRID LOSSES

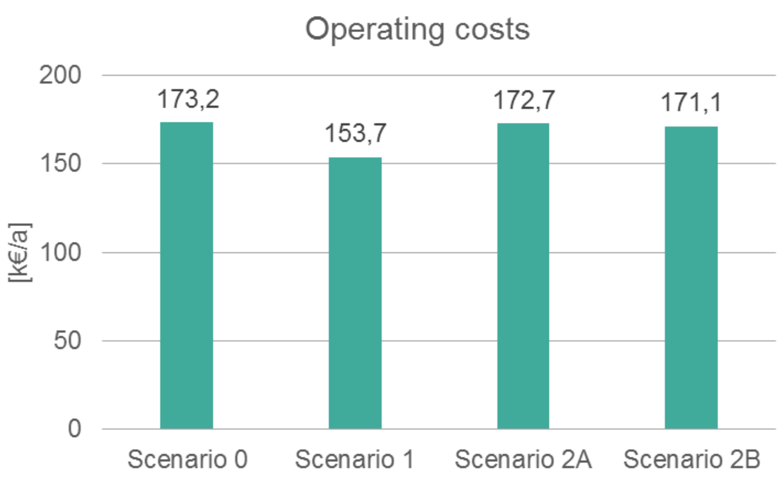




	Scenario 0	**Scenario 1**	**Scenario 2A**	**Scenario 2B**
Grid losses vs production	13.2%	9.4%	12.7%	11.6%
May-September grid losses vs production	27.4%	7.3%	25.6%	20.2%

SCENARIO COMPARISON RESULTS





	Scenario 1	Scenario 2A	Scenario 2B
Savings [k€/a]	19.5	0.5	2.1
Investment costs [k€]	663	19	26
Payback period [a]	34	38	12.4

CONCLUSIONS AND FUTURE WORK

- Scenario 1: Decentralized solar systems
  - remarkable reduction of annual heat losses → decreased primary energy consumption
  - very high investment costs → **payback period 34 years**
- Scenario 2: Decentralized TES units with daily charge
  - much lower impact on heat loss reduction, lower investment costs
  - Scenario 2A: negligible savings → **payback period 38 years**
  - Scenario 2B: a slightly higher investment cost allows 4 times higher cost savings than in Scenario 2A → **payback period 12.4 years**
- **The calculation of Scenario 2 is conservative**, as TES units might be present by some/every users
- Outlook: deeper investigation of Scenario 2B
  - study of appropriate **control systems for Scenario 2B**
  - experimental investigation at **demo scale** of the flow-reversal concept

FUNDED PROJECT

Activity carried out as minor part of the Austrian funded project heat_portfolio

- **Funds:** Climate and Energy Funds
- **Programme:** Energieforschungsprogramm 2014
- **Project number:** 848849
- **Objective:** Develop technical basis for increasing the share of decentralised alternative heat sources with fluctuating generation and low temperature levels, particularly industrial waste heat, heat pumps and solar thermal energy in district heating networks.
- **Period:** From 03.2015 to 02.2018

THANK YOU FOR YOUR ATTENTION!

Contact: Paolo Leoni

AIT Austrian Institute of Technology GmbH

Giefinggasse 2 | 1210 Vienna | Austria

T +43 50550-6361

Paolo.Leoni@ait.ac.at