Effects of the District Heating Supply Temperature Level on the Efficiency of Borehole Thermal Energy Storage Systems

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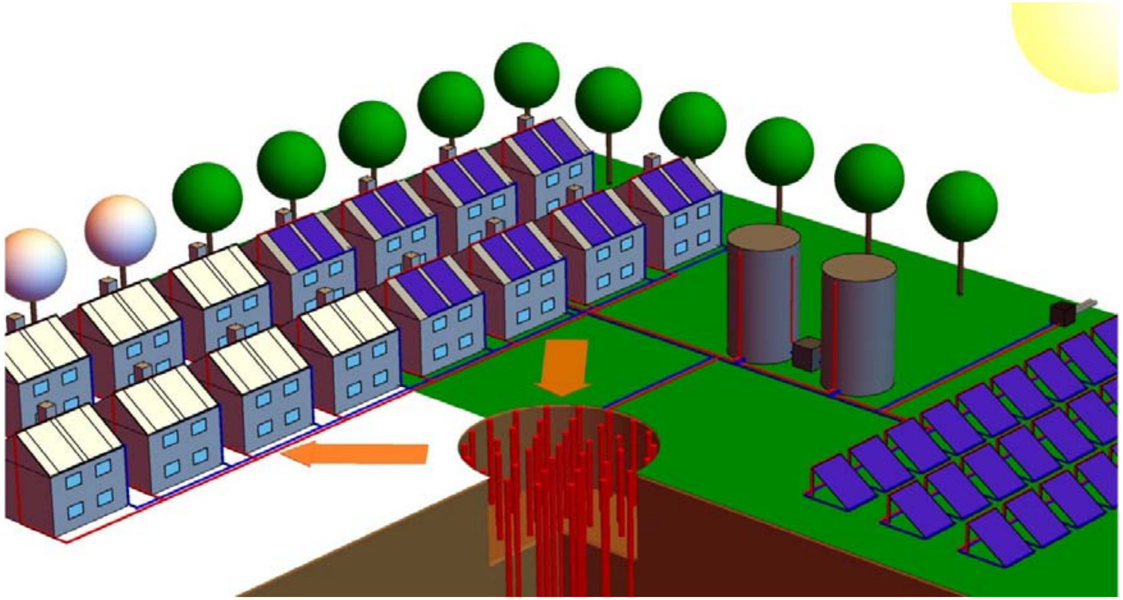

3rd international conference on smart energy systems and 4th generation district heating, 13.09.2017, Copenhagen
Session 24: Future district heating production and systems

Offset of Heat Demand and Renewable Heat Production

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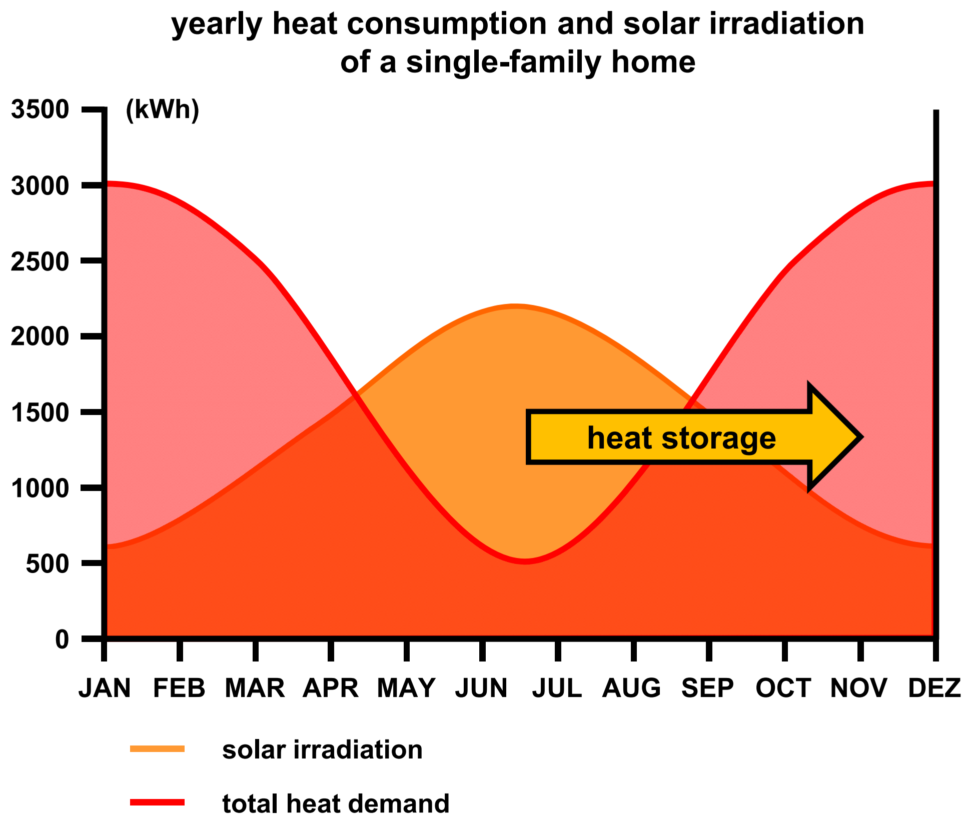
- **Summer:**
  production potential exceeds demand
- **Winter:**
  demand transcends production potential
- **Seasonal thermal energy storage:**
  shift excess heat to times of high heat demand



Solar District Heating with Borehole Thermal Energy Storage – Basic Concept

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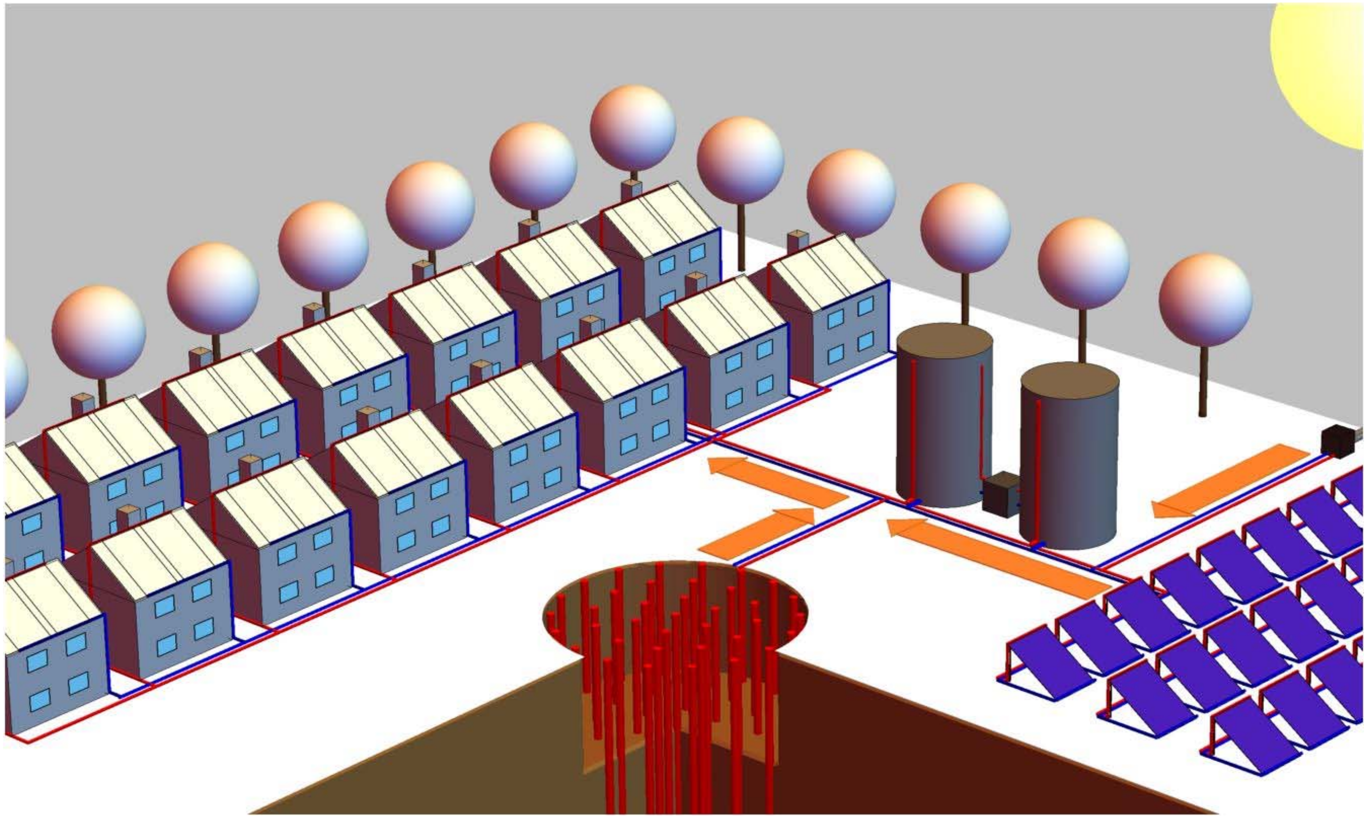
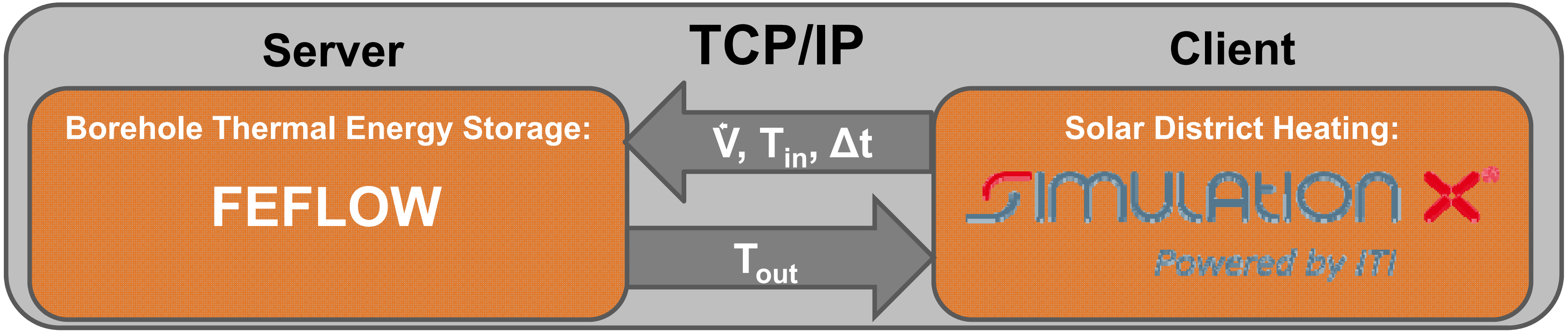
Summer

Winter



Coupled Simulation Methodology



DHI-WASY, www.feflow.com, 2017.

ESI ITI, www.simulationx.com, 2017.

- **Finite Element subsurface FLOW system**
- **Bedrock: Finite-Element-Method**
- **BHE: 1D analytical model**
- **High flexibility**
- **Detailed geography**

- **System simulation tool based on Modelica**
- **Library „Green City“ for renewable and conventional energy systems**

Case Study Questions

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Questions:

- **What are the effects of a lower grid temperature on the components and the whole system?**
- **How does the combination of SDH and BTES work for older grids?**
- **Is retrofitting of older DH grids with a BTES possible?**

Case Study System Design

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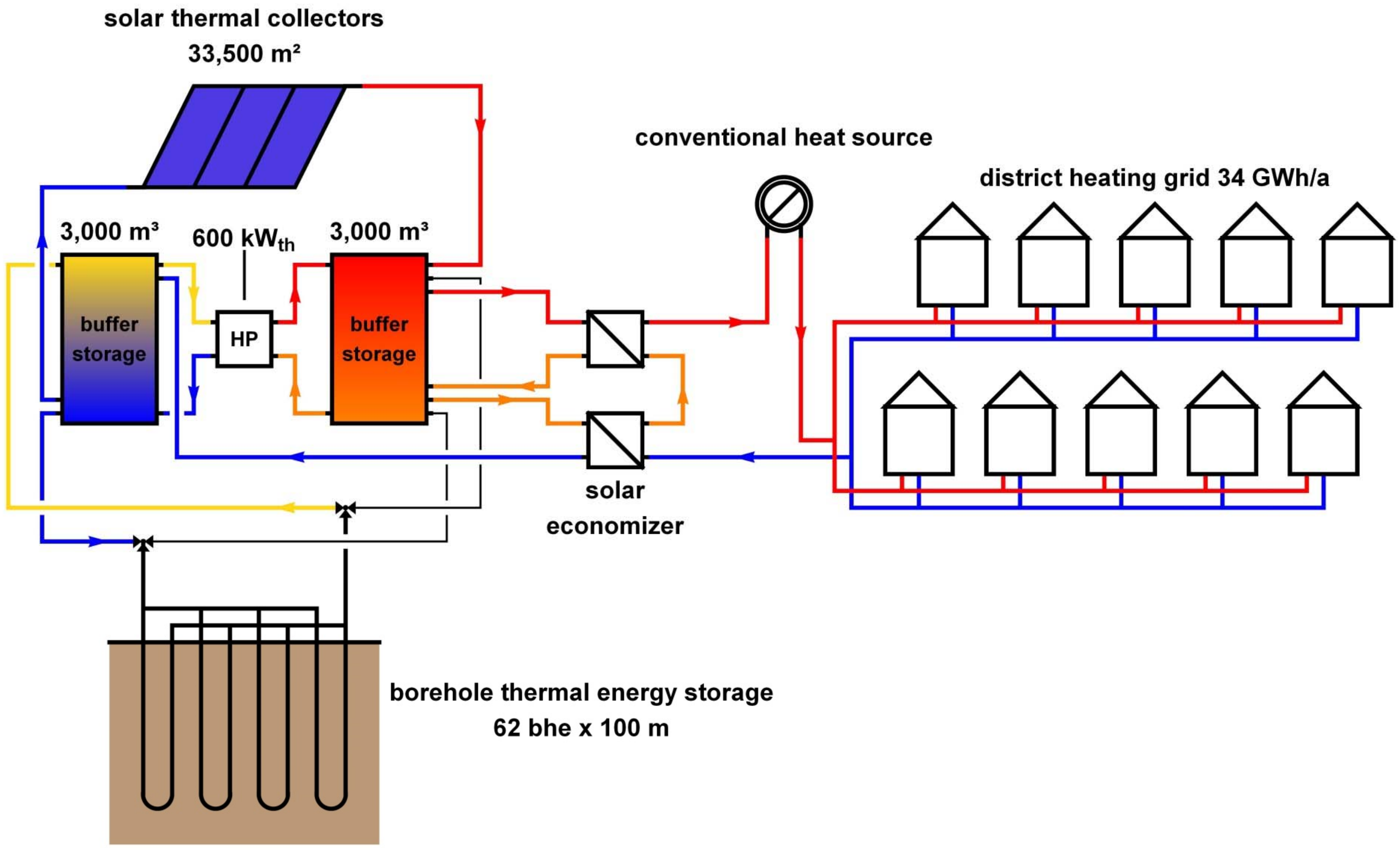
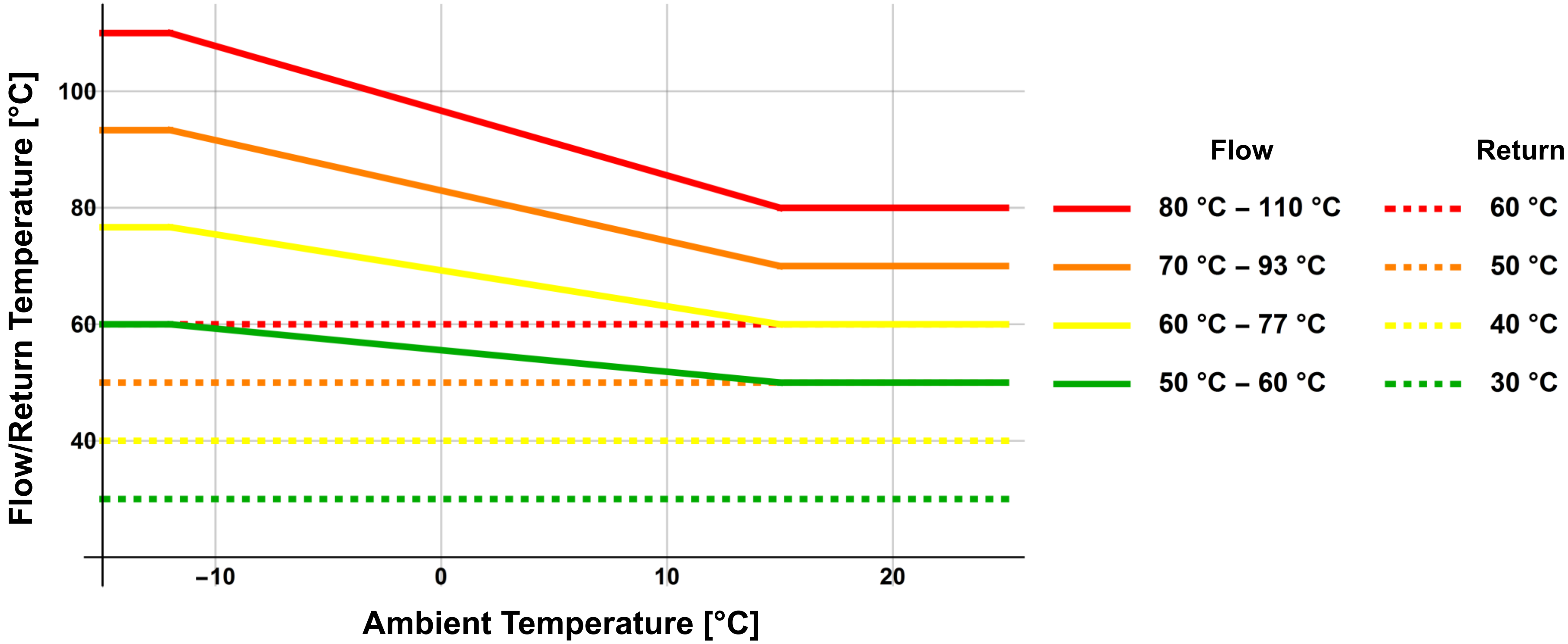


Case Study Scenarios



- Fixed sytsem design and control strategy
- Heat pump power adapted to temperature shift
- Simulation over 8 years

Case Study Results – Solar Thermal

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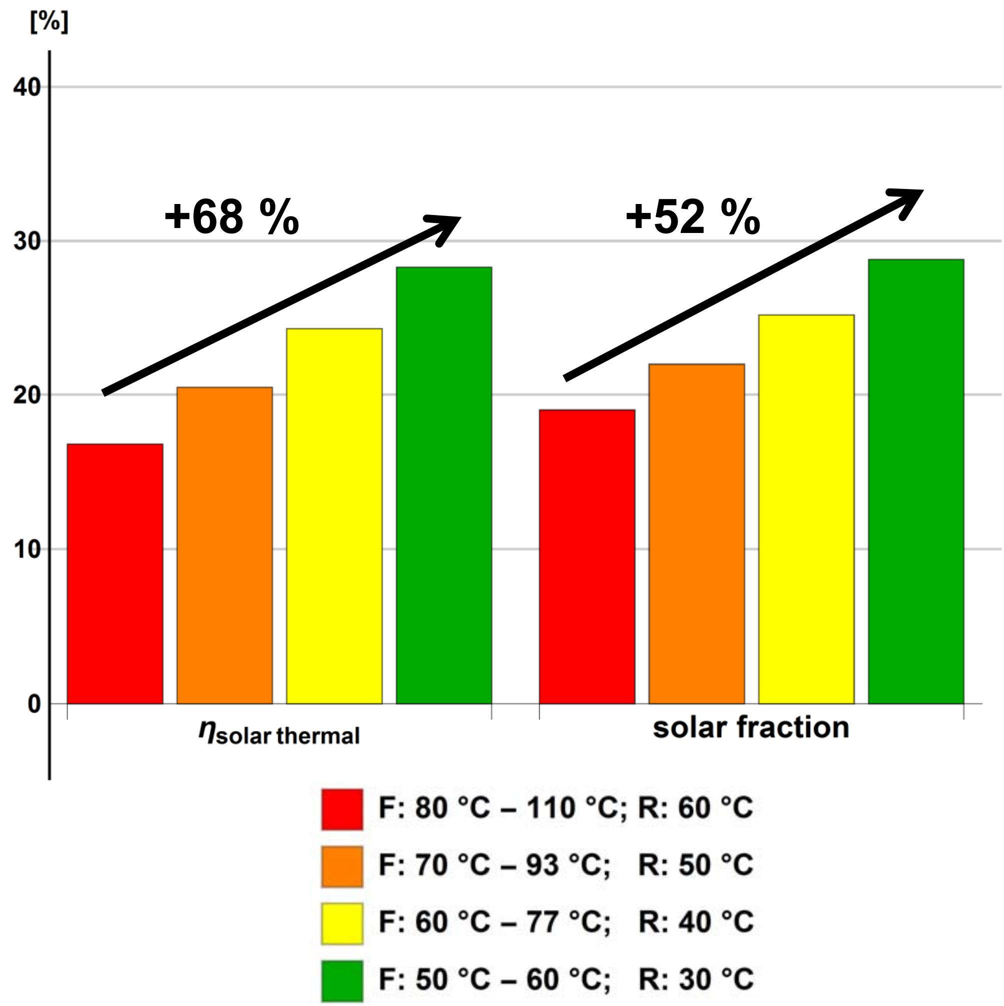
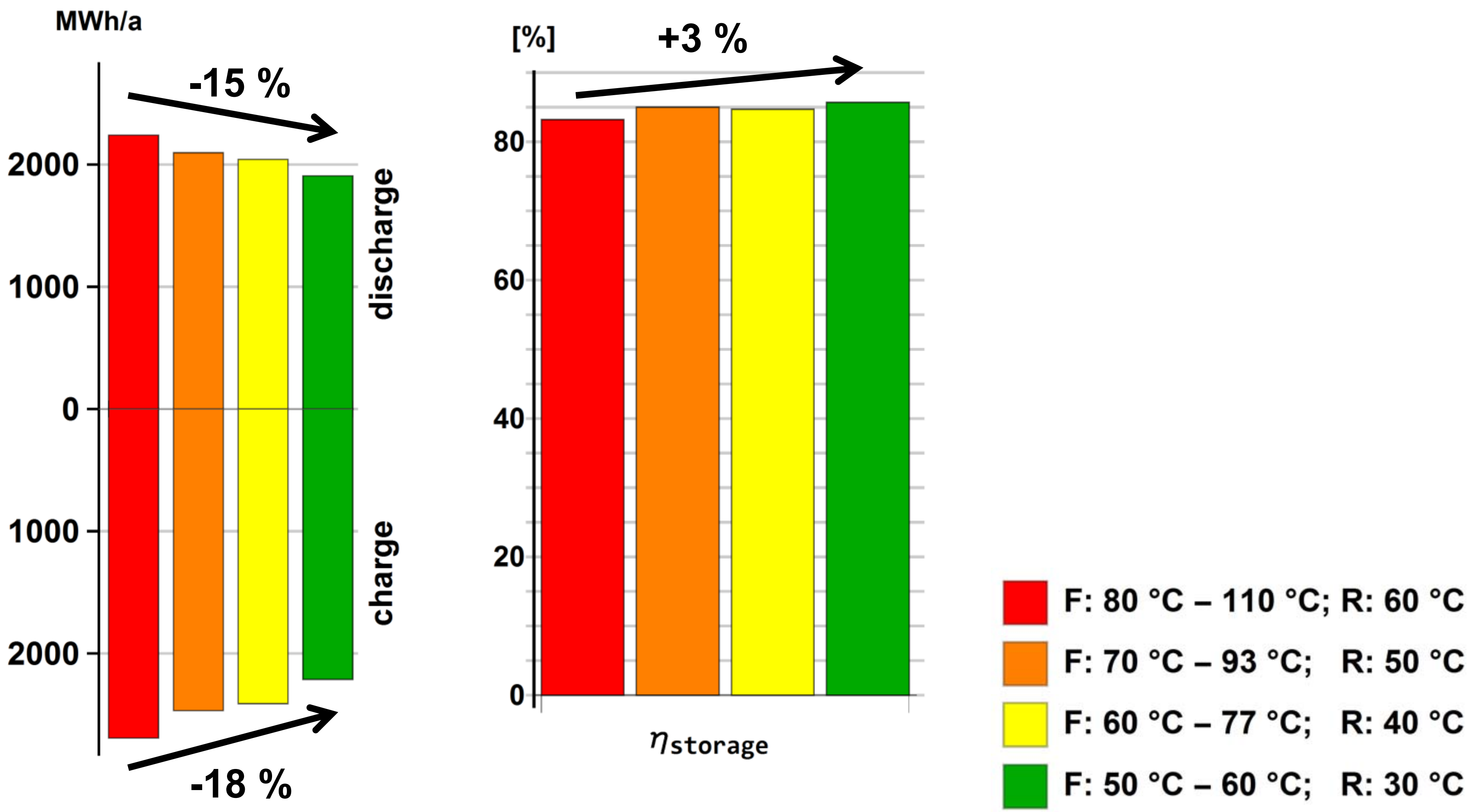
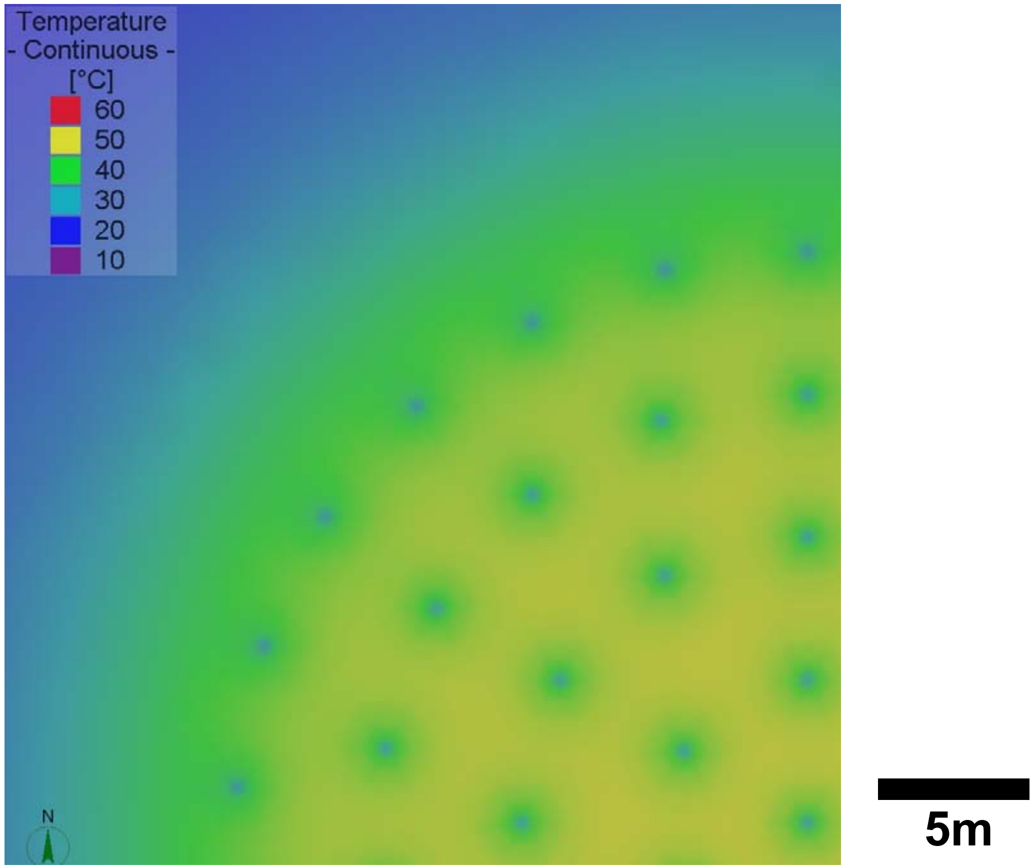


Case Study Results – Borehole Thermal Energy Storage

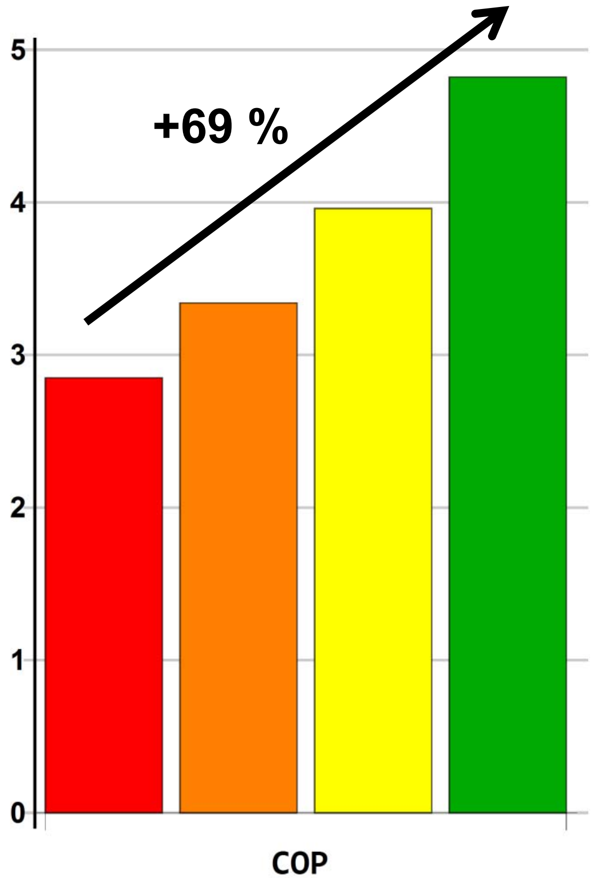


Case Study Results – Borehole Thermal Energy Storage

Temperature distribution in the storage during heat extraction



Case Study Results – Heat Pump



- F: 80 °C – 110 °C; R: 60 °C
- F: 70 °C – 93 °C; R: 50 °C
- F: 60 °C – 77 °C; R: 40 °C
- F: 50 °C – 60 °C; R: 30 °C

Case Study Results – System Efficiency

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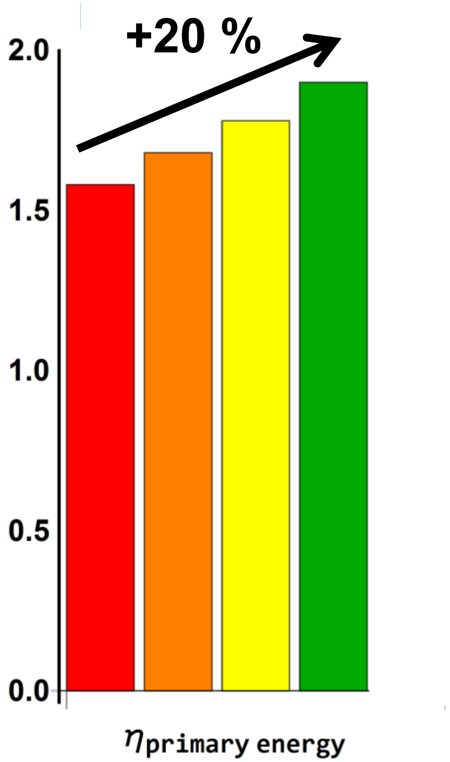

- F: 80 °C – 110 °C; R: 60 °C
- F: 70 °C – 93 °C; R: 50 °C
- F: 60 °C – 77 °C; R: 40 °C
- F: 50 °C – 60 °C; R: 30 °C

$$\eta_{\text{primary energy}} = \frac{\text{useful energy}}{\sum Q_i * f_i} = \frac{\text{heat supply}}{1.8 * Q_{el} + 0 * Q_{solar} + 0.7 * Q_{CHP}}$$

Conclusions

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- Solar District Heating Systems with integrated Borehole Thermal Energy Storage provide renewable solar thermal energy during winter
- System performances strongly dependant on framework conditions like grid temperatures
- Lower grid temperatures do not necessarily lead to much higher storage efficiencies → high temperature heat storage possible
- Integration of BTES into DH with high grid temperature possible
- heat is discharged from BTES on lower temperature levels
- Lower grid temperature increase system efficiencies substantially

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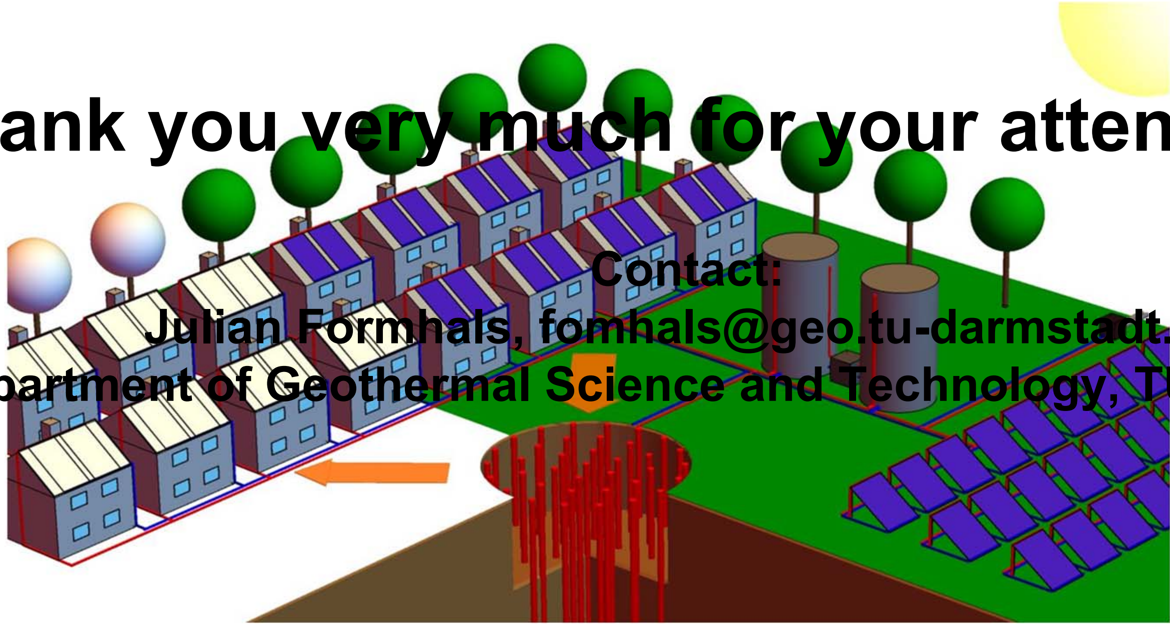
Thank you very much for your attention!



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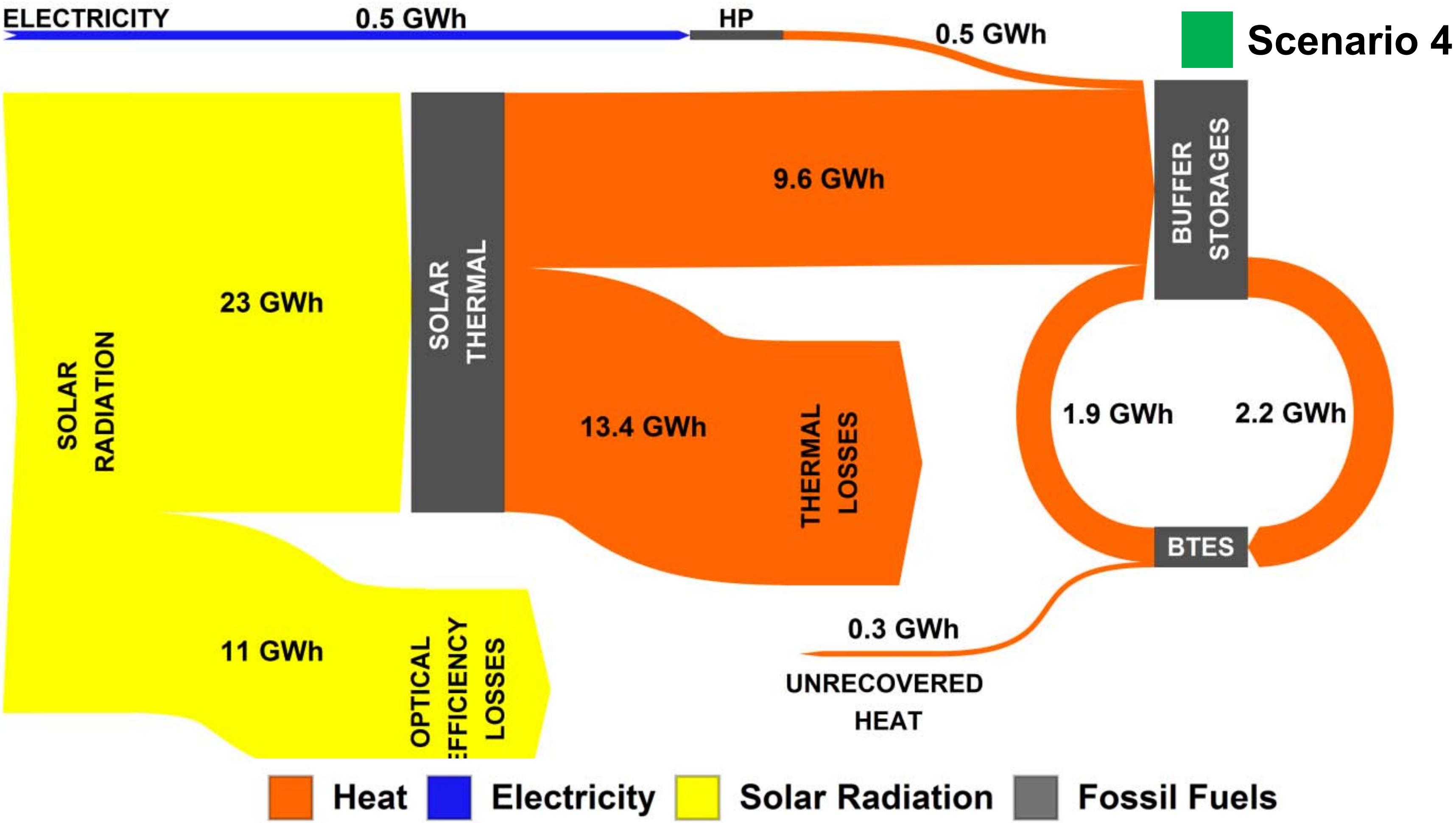
Case Study Results – Annual Energy Flows



Case Study Results – Annual Energy Flows