Dynamic transition to a renewable and efficient campus solar district heating grid with integrated medium deep borehole thermal energy storage

Geothermal Science and Technology[1]
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Graduate School of Excellence Energy Science and Engineering[3]

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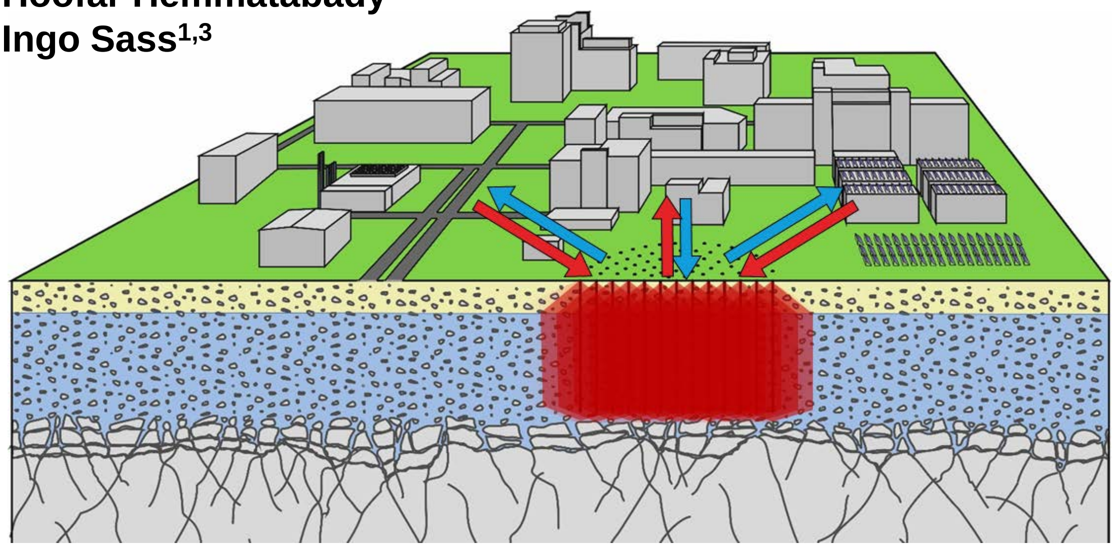
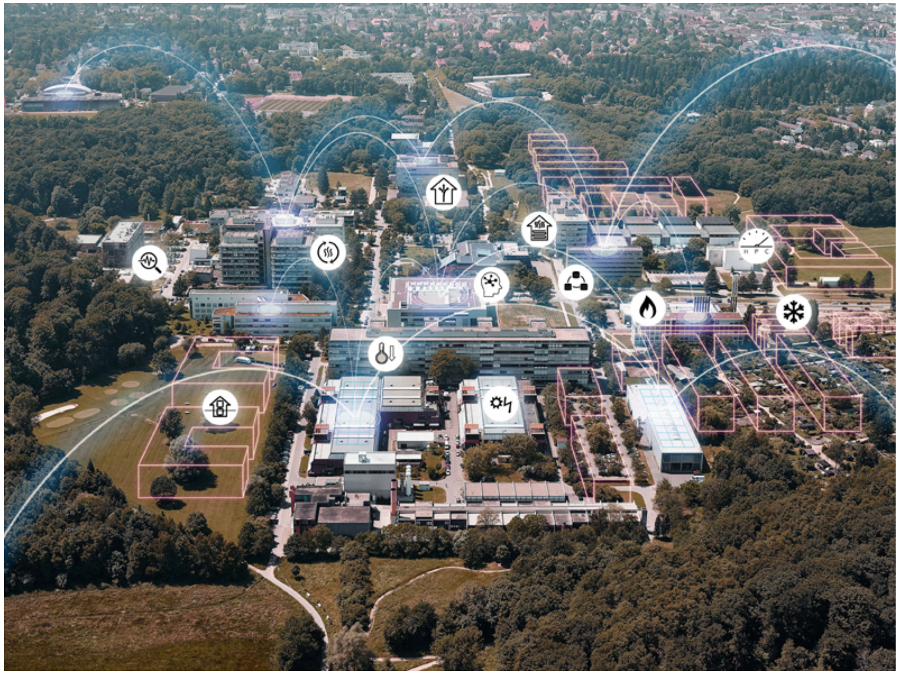


6th international conference on smart energy systems, 6.-7.10.2020, Aalborg.

TU Darmstadt Campus Lichtwiese

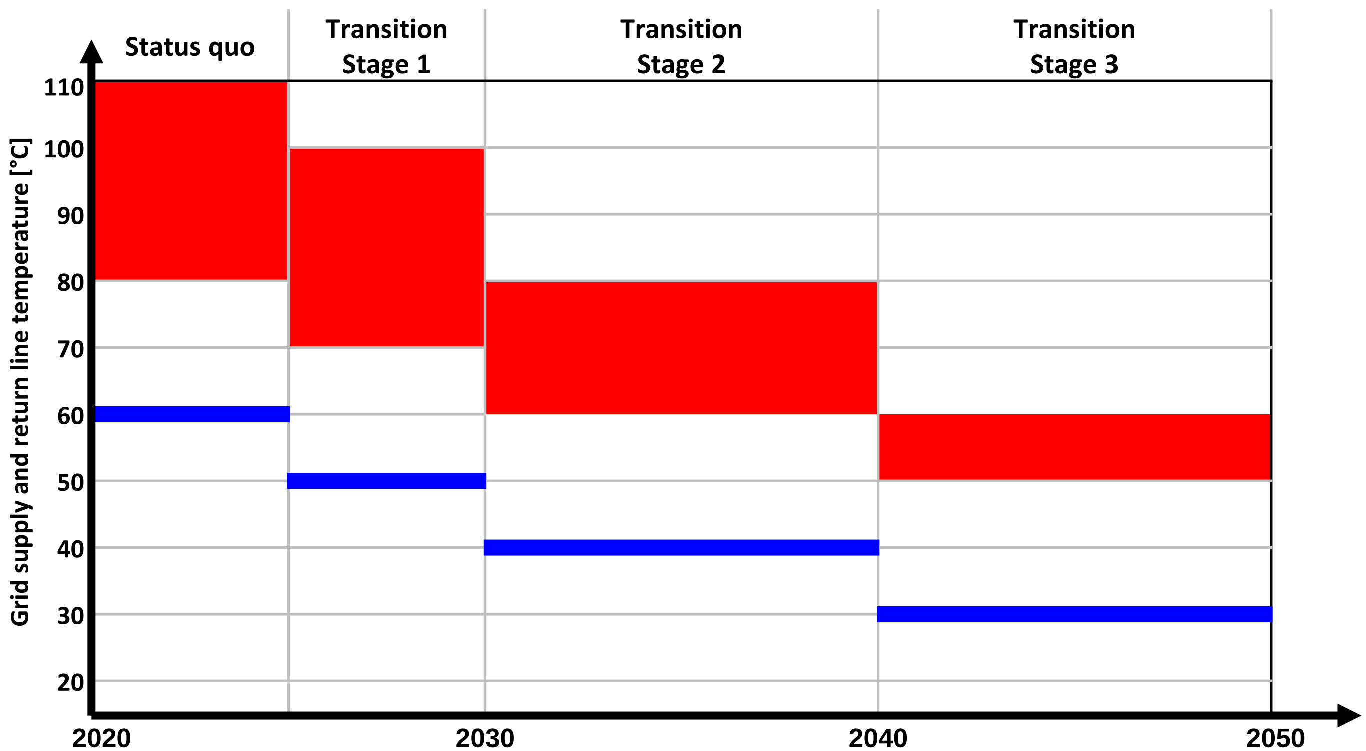


Institute for Sustainable Building Design, TU Darmstadt, 2020.

- **Complex architectures, monumental protection and high supply line temperatures**
- ***EnEff: Campus Lichtwiese* project**
  - **Increase energetic efficiency**
  - **Lowering of CO_2-emissions**
- ***SKEWS* project (preparation)**
  - **Medium deep borehole thermal energy storage (BTES) pilot**

Numerical case study for comparison of different scenarios for a stepwise transition to a 4th generation district heating grid

District Heating Grid – Transition Stages



350 kW HPC
(High Performance Computer cooling)

500 kW HPC
- 12 % GWP
(Global Warming Potential reduction target compared to 2025)

700 kW HPC
- 32 % GWP

- 61 % GWP

System Model Layout

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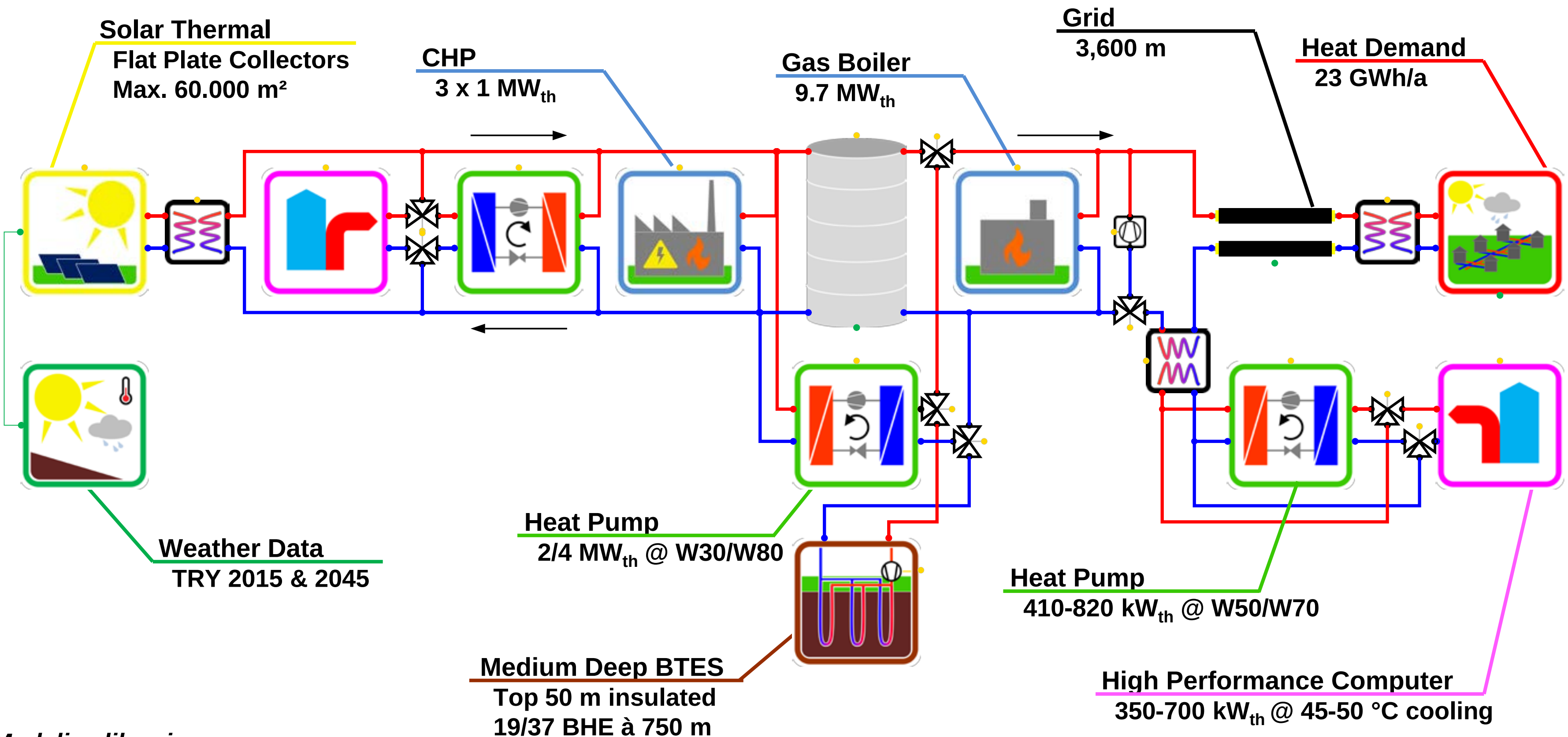

Modelica libraries

MoBTES 2.0 (Formhals et al, 2020)

MoSDH 0.6 (Formhals, unpublished)

BHE = Borehole heat exchanger
BTES = Borehole Thermal Energy Storage
CHP = Combined Heat and Power

Transition Levels and Scenarios

Transition Level	0	I	II	III	IV
Solar Thermal [m²]	0	10,000	20,000	30,000	40,000
CHP [MW]	3	2,25	1,5	0,5	0
BTES [BHEs]	0	-	19	-	37
HPC [kW]	350 HP/ret	350 HP/sup	500 dir/ret	500 HP/sup	700 dir/sup

Solar Thermal Field Size	50 %	75 %	100 %	125 %	150 %

X

	Component	2025-2030	2030-2040	2040-2050
Immediate	Solar Thermal	IV	IV	IV
	CHP	IV	IV	IV
	BTES	IV	IV	IV
	HPC	I	III	IV
Progressive	Solar Thermal	II	IV	IV
	CHP	0	III	IV
	BTES	II	IV	IV
	HPC	0	III	IV
Step	Solar Thermal	0	IV	IV
	CHP	0	IV	IV
	BTES	0	IV	IV
	HPC	0	II	IV
Medium	Solar Thermal	I	II	III
	CHP	0	II	III
	BTES	0	II	IV
	HPC	0	III	IV
Conservative	Solar Thermal	0	I	II
	CHP	0	0	II
	BTES	0	0	II
	HPC	0	II	IV
Reference	Solar Thermal	0	0	0
	CHP	0	0	0
	BTES	0	0	0
	HPC	0	0	0

BHE = Borehole heat exchanger
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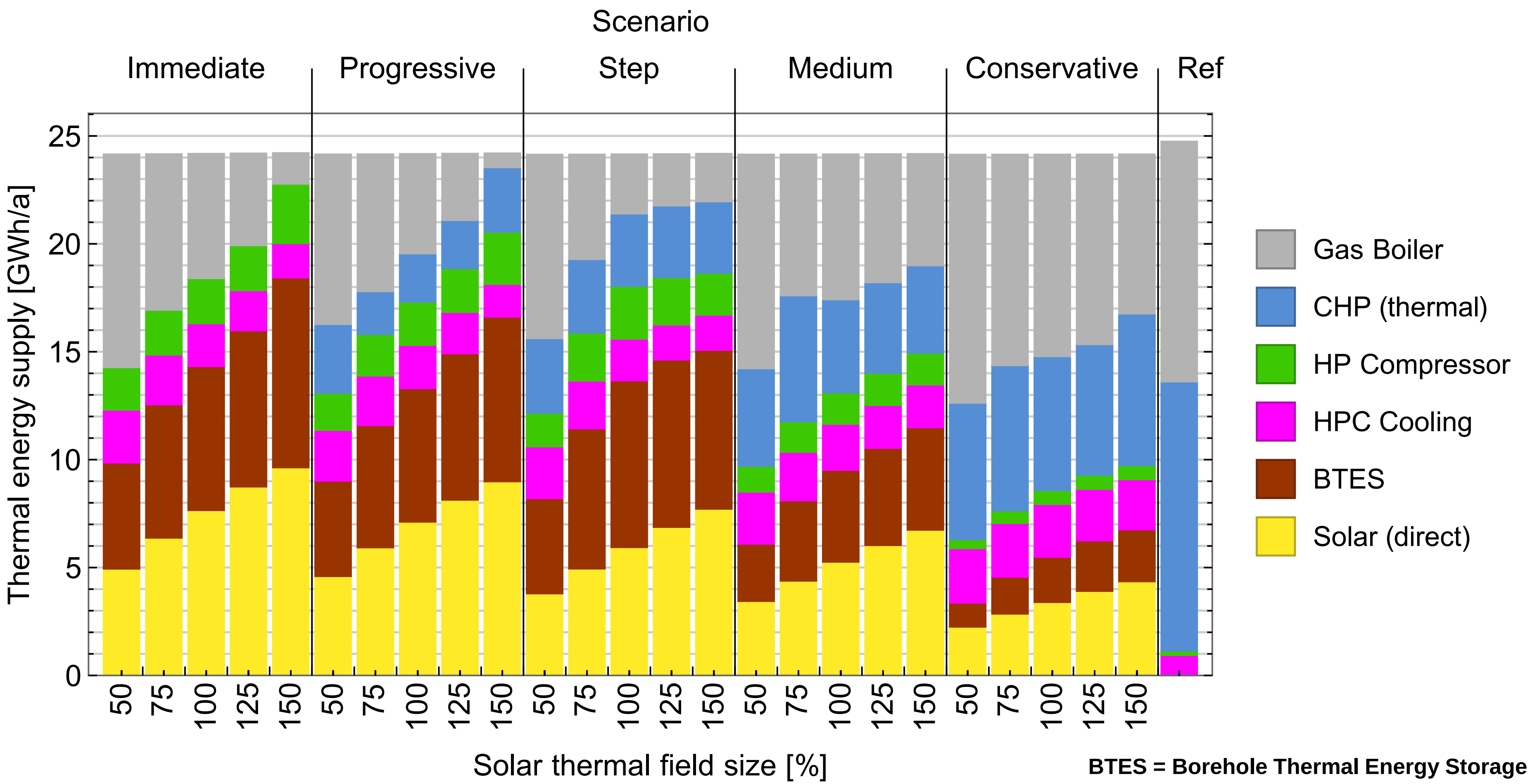
HPC = High Performance Computer

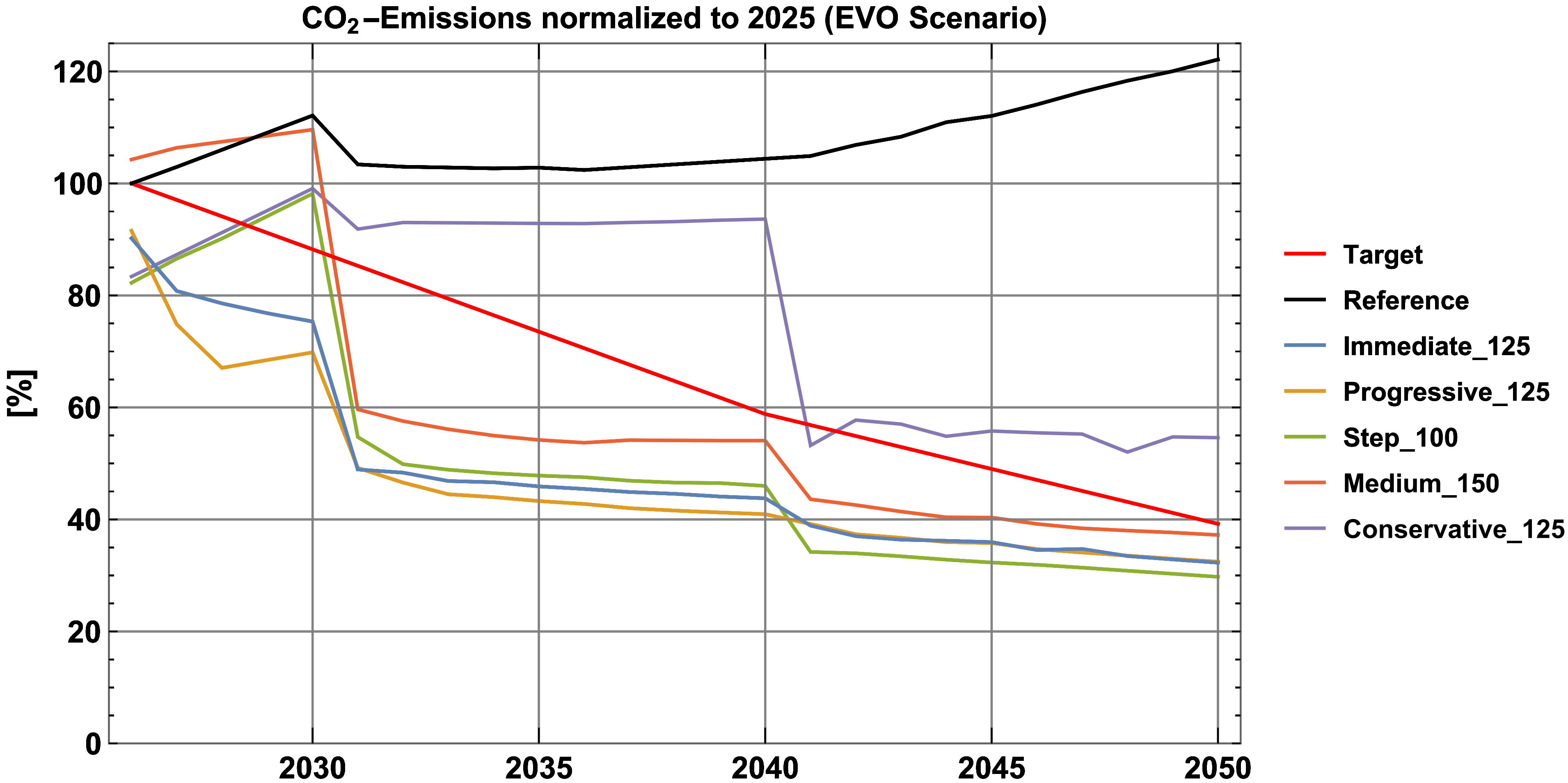
System perfomance and preliminary life cycle assessment results

Annual Thermal Energy Supply

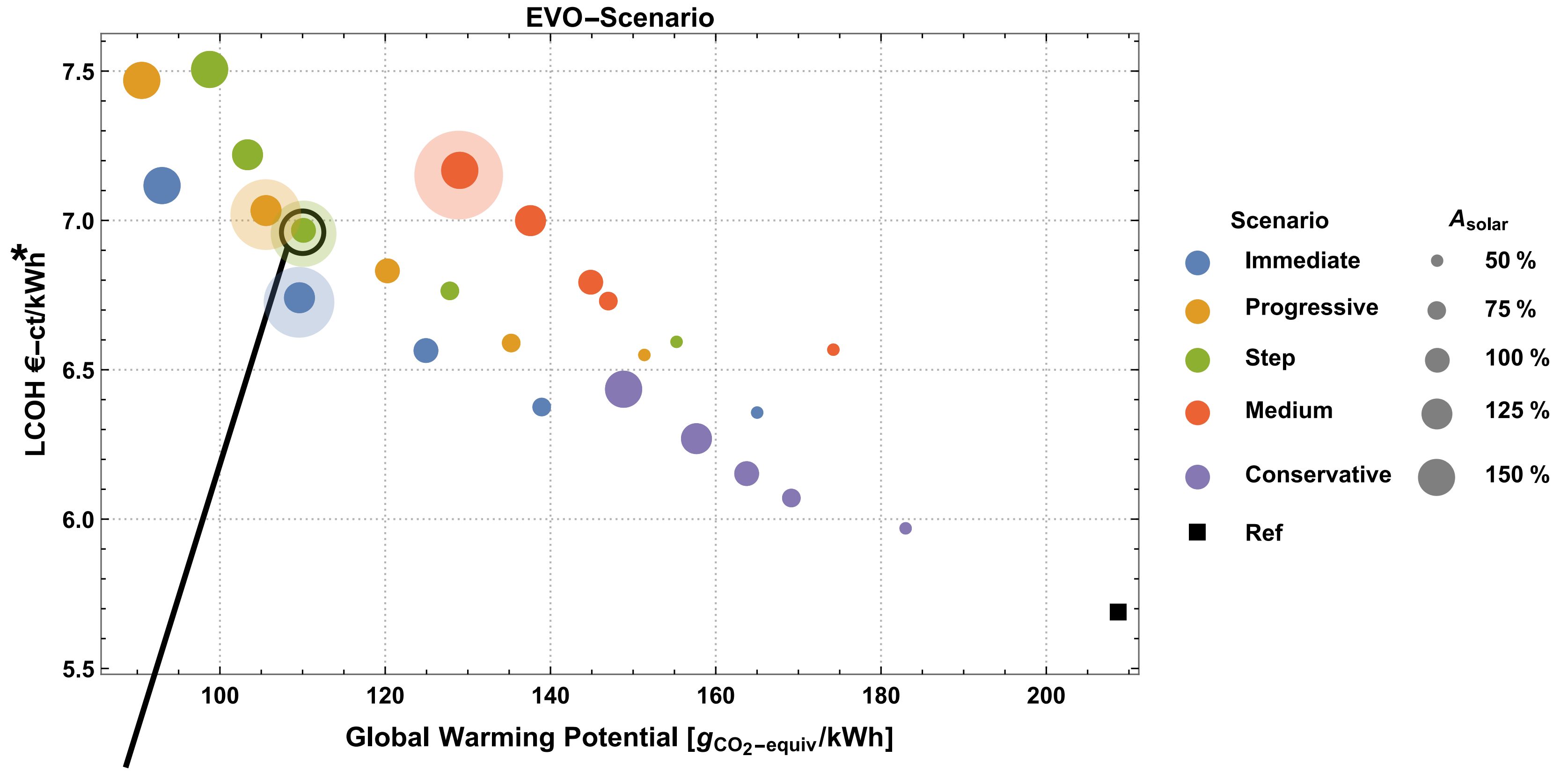


BTES = Borehole Thermal Energy Storage
CHP = Combined Heat and Power
HP = Heat Pump
HPC = High Performance Computer

CO_2-Emission Reduction Goals



Life Cycle Assessment



	Component	2025-2030	2030-2040	2040-2050
Step 100%	Solar Thermal [m²]	0	40,000	40,000
	CHP [MW]	3	0	0
	BTES [BHEs]	0	37	37
	HPC [kW]	350 HP/ret	500 ret	700 sup

*Preliminary cost calculations

Summary and Outlook

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Transition to 4th generation solar district heating scenarios:

- **Immediate and Progressive: satisfy the CO_2-emission reduction goals over the whole period.**
- **Medium and Step: fail to reach the goal in 2030, but reach the goals in 2040 and 2050.**
- **Conservative: Reduction goals are missed.**
- **Life Cycle Analysis: most cost efficient systems to reach the goals have a solar area of 40,000-50,000 m² and a BTES with 37 BHEs.**
- **Without subsidies the reference scenarios yields the lowest LCOH. Subsidies and CO_2 pricing would change this.**

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Thank you very much for your attention!

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References

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