Technology Collaboration Programme
by IEA

InteGradeDH

Status presentation

31 March 2026

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Eurac Research

Key messages

- Modelling and analysis of **medium-deep geothermal systems** as sources and seasonal storages for district heating
- Flexible **substation configurations** including heat pumps to manage the integration of medium-deep geothermal, waste heat, and district heating
- Identification of **risks** and of tailored **business models** (including risk mitigation strategies) for such systems
- Application to **2 case studies**: Göttingen, Bolzano

Project description

- InteGradeDH aims to study the integration of **medium-deep geothermal systems** – considered both as sources and as seasonal storages – with **low-temperature waste heat** (WH) and district heating (DH).
  - The range of considered temperatures requires heat pump (HP) interfaces with flexible configurations.
  - Operating temperatures can have a significant impact on the system efficiency.
  - Risks related to geothermal systems and long-term waste heat availability call for tailored business models.
  - Context of case studies:
    - Göttingen. The connection of the university campus network with low-temperature WH from the university datacenter coupled to a medium-deep geothermal system will be considered.
    - Bolzano has a DH network largely relying on a waste-to-energy plant. The expansion plans of the network call for new sources: WH and medium-deep geothermal might play an important role.

Project description

- InteGradeDH key objectives:
  - Estimating the technical and economic performance of DH supply systems given by medium-deep geothermal storage, continuous low-temperature WH, and HP substations
  - Estimating the optimal operating temperatures and HP configurations/positioning
  - Identifying risks and business models with proper risk mitigation strategies for such systems
  - Assessing the feasibility of these systems on 2 largely replicable cases studies

Most significant achievements

- Collection of Key economic data, including heat and electricity prices, and drilling cost.
- Review on WH and BTES in DH: A. Jodeiri et al., "Synergistic integration of waste heat and ground-source heat pumps in district heating systems", Renewable and Sustainable Energy Reviews, 235, 116917 (2026).
- Development of a model for rapid evaluations of medium-deep and deep borehole thermal energy storages: D. Romanov et al., "Rapid Open-Source-Based Simulation Approach for Coaxial Medium-Deep and Deep Borehole Heat Exchanger Systems", Energies, 18, 4921 (2025).
- (BTES) based on a modified *pygfunction* package in Python; validated against 12 available reference models and experimental data sets.
- Development of a techno-economic model combining the BTES, Carnot-based HP models, and an economic layer to compute key performance indicators (KPIs).

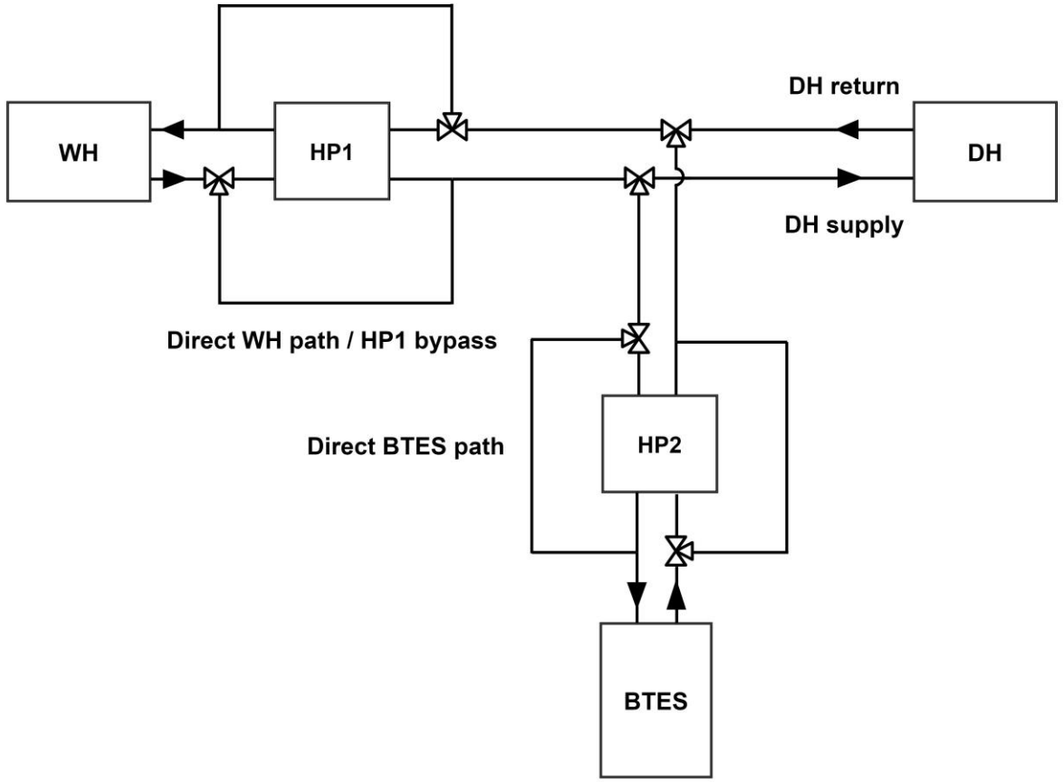
Most significant achievements

- Analysis of scenarios with data center WH and different BTES depths for the Göttingen campus DH case.
  D. Romanov et al., "Comparative analysis of scenarios of data center waste heat utilization for district heating networks of different generations", Energy Conversion and Management, 334, 119856 (2025).
- Analysis of two scenarios of low- and high-temperature WH with medium-deep BTES for the Bolzano DH case.
  A. Jodeiri et al., "Enhanced integration of waste-to-energy heat into district heating using medium-deep borehole thermal energy storage and heat pumps: Techno-economic analysis for an Italian case", submitted to Applied Thermal Engineering.
- Sensitivity analysis of LCOH to various risk and uncertainty factors, e.g., drilling costs, electricity price, interest rate, lifetime, HP costs and efficiency, BTES geometry, ground properties, network temperature.
- Likelihood–gravity risk analysis for case studies, identifying key risk and opportunity factors in WH recovery and borehole storage across the DH process.
- Business and price model analysis.

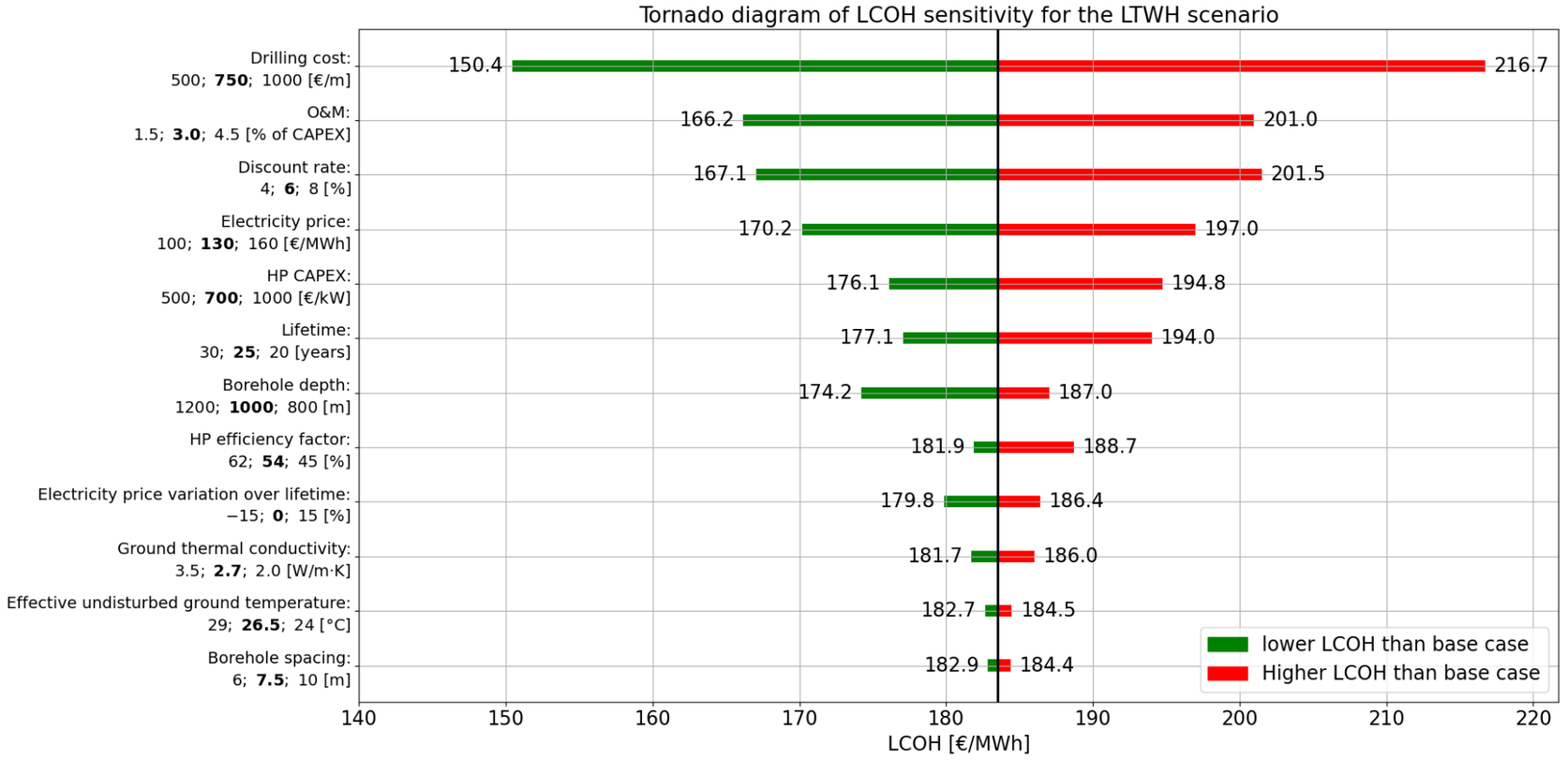
Conclusions

- The developed models are suitable to carry out quick assessments for WH + HP + medium-deep BTES systems with limited input data and computational cost.
- For the considered case studies:
  - From a technical point of view, it was possible to identify sizing conditions able to guarantee a largely enhanced WH exploitation with long-term stable operation (i.e., without significant BTES temperature drift after every year).
  - From an economic point of view, feasibility was not achieved, with drilling costs and electricity costs providing two key bottlenecks.
- In general, economic feasibility was found to be achievable exploring realistic parameter ranges with a sensitivity analysis and assuming 50 % incentives on investments.

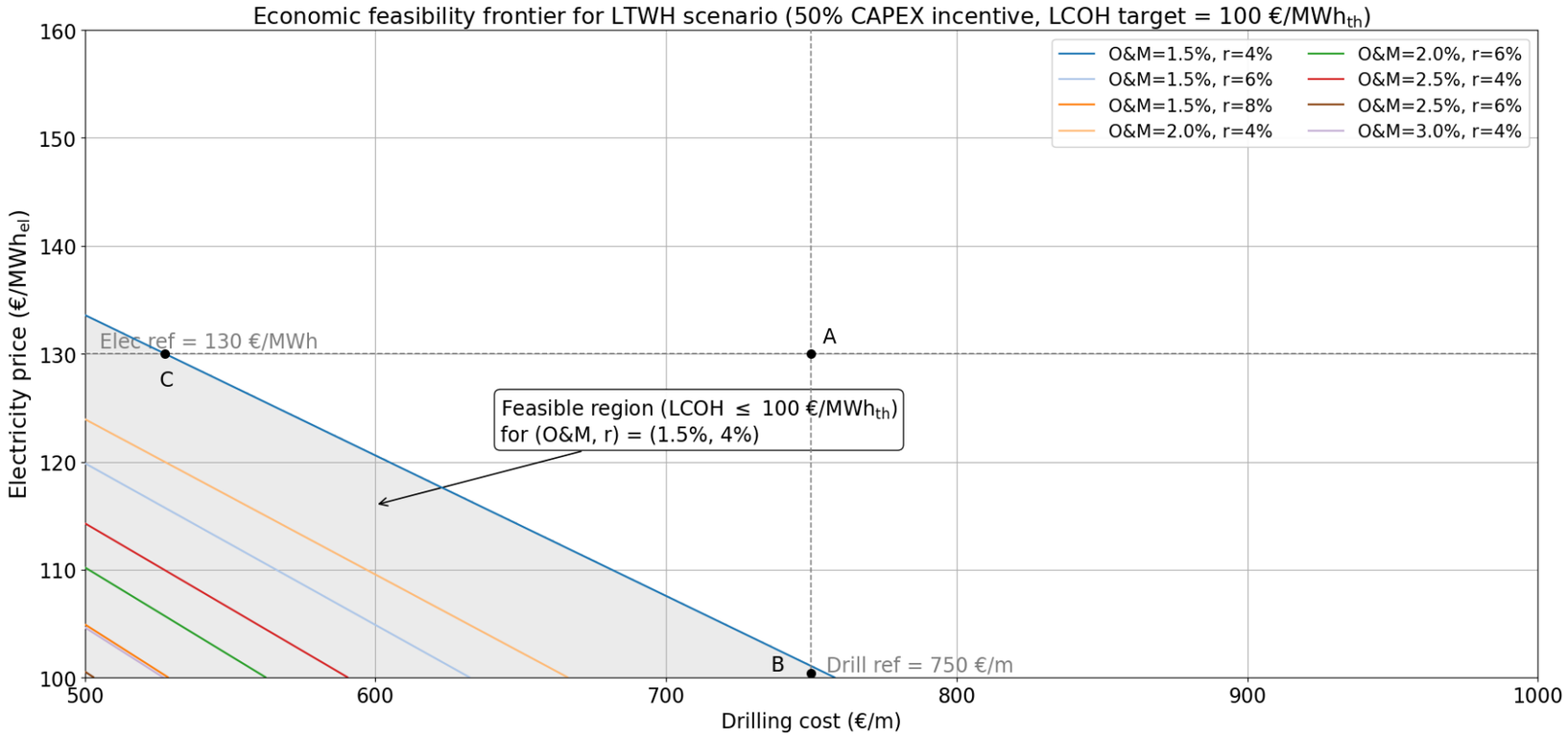
General connection configuration



Sensitivity analysis



Feasibility conditions



Contact us!

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