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## Conference Proceedings



# USE OF WASTE HEAT POTENTIALS AND FLEXIBILITY ELEMENTS TO SPEED UP DECARBONIZATION IN AUSTRIAN THERMAL SPAS

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## SUMMARY

Austria's 38 thermal baths offers a unique opportunity to harness deep hydrothermal geothermal energy, reducing their reliance on fossil fuels and decreasing CO2 emissions by over 50,000 tonnes annually. The GEOMAT project's core focus is on efficiency enhancement by integrating various heat pump technologies, optimizing energy management, and transitioning to renewable energy sources for complete decarbonization. Geothermal energy is pivotal for Austria's sustainable energy future, with a particular emphasis on making it economically appealing for significant energy consumers, including thermal spas, municipalities, energy providers, and industries. By leveraging innovative heat pump systems and intelligent control concepts, GEOMAT aims to maximize energy efficiency and create flexibility in electricity and heating networks, thereby fostering synergy and systemic benefits.

Keywords: geothermal heat, thermal spas, heat pump, district heating, energy management, flexibility

## INTRODUCTION

Austria, renowned for its 38 thermal baths, is a top European tourist destination with immense potential for harnessing deep hydrothermal geothermal energy from depths exceeding 400 meters within water-bearing strata [1]. These thermal baths are significant energy consumers, with the potential to cut carbon emissions by up to 50,000 tons of CO2 annually. To preserve these facilities and make them more environmentally friendly, the focus should be on increasing the use of geothermal heat for their energy needs [2]. This involves optimizing existing infrastructure and exploring innovative solutions. Many thermal spas in Austria currently rely on fossil fuels for their substantial energy demands. For example, Sonnentherme Lutzmannsburg consumes 16 GWh of heat from natural gas each year, while Reduce Therme Bad Tatzmannsdorf relies on 9 GWh of heat from natural gas, and H2O Hoteltherme utilizes 5 GWh of heat sourced from biomass. Therefore, these thermal bath facilities hold substantial potential to play a crucial role in decarbonization and energy efficiency efforts by 2030/2050.

## FRAMEWORK CONDITIONS AND METHODOLOGY

Thermal bath facilities in Austria are unique energy systems with distinct characteristics, including [3, 4, 5, 6, 7]:

- Untapped waste heat potential from sources like splashing water.
- Opportunities for energy savings through reduced pool heat losses.
- Potential for energy savings through temperature-optimized supply systems, including infrastructure upgrades like heat exchangers.
- Large storage capacity in pool water content, often overlooked in control strategies.
- Complex control challenges due to simultaneous heating and cooling demands, often managed using simplistic methods.
- Utilization of thermal capacities for peak shaving and load shifting, tied to visitor patterns and weather forecasts, but often lacking advanced data-driven forecasting.
- Potential for effective energy management systems to integrate supply and demand-side factors.

Therefore, the GEO.MAT project aims to create carbon-neutral thermal baths by optimizing geothermal energy utilization. This includes repurposing unused splashing water at 30°C, reducing pool heat losses, and implementing temperature-oriented heating supply. The project also explores integrating non-stationary splashing water utilization and other renewable resources like biomass and solar power. An appropriate energy management system (EMS) is vital for this complex system.

The shift to a carbon-neutral energy supply therefore involves several measures:

- Using geothermal splashing water (waste heat at 30°C) through AHP and/or CHP to reduce the external heat demand (gas or biomass)
- Implementing demand-side management with data predictive control (DPC) for peak shaving and load shifting.
- Applying model predictive control (MPC) for the supply side, considering generated forecasts.
- Integrating all measures for optimal operation and load, including sector coupling options based on the facilities' high thermal inertia.
- Replacing gas with biomass and incorporating flue gas condensation through AHP

## DEMONSTRATION CASES AND RESULTS

Innovative energy system concepts including different measures for utilizing geothermal waste heat and increasing renewables' integration in thermal baths will be demonstrated in two Austrian facilities:

- Demo project 1: Sonnentherme Lutzmannsburg, which consumes 1.67 million m³ of natural gas annually and emits over 4,200 tons of $CO_2$ for heating.
- Demo project 2: H2O Hoteltherme, which currently uses biomass for their 5,000 MWh/year heat demand.

In both demonstrations, the focus is on efficiently utilizing geothermal waste heat, optimizing control systems, and reducing carbon emissions, contributing to more sustainable and environmentally friendly thermal bath operations in Austria. Initial analyses and results in the demo projects confirm the substantial waste heat potential.

Due to hygienic reasons for water treatments in the considered spa facility (DEMO 1 – Sonnentherme Lutzmannsburg), 54 till 71 m³ wastewater with about 32°C is daily produced and stored in a wastewater basin (WWB) for several hours, bevor it is discharged into the sewer. On the other hand, there is a high demand for heating energy for pool heating in spa areas at low temperature from about 45°C. So, the high potential of energy in the WWB can be utilized to partly cover the heat demand of pools using heat pump technology.
Figure 1 shows an example of the determined waste heat utilisation potential for a day in early April. It was analysed how much heat is contained in the wastewater and how it can cover the heat losses of one of the existing outdoor swimming pools. It is estimated that the wastewater can be used till 10°C, taking temperature difference of intermediate heat exchangers into account. So, energy of approximately 2 MWh per day can be utilized and cover 2/3 of the energy demand of the outdoor pool (SP).
In the bottom right-hand diagram, the temporal trend of the heating capacity for the SP is shown in orange. Since the pool temperature is lowered during the night hours (to reduce heat losses), there is a peak in heating capacity in the morning hours. It is evident that the heat from the WWB, which is represented by the green area, would be completely consumed during this reheating process. Backup heat sources are necessary to cover the further need which is illustrated as red area.
Additionally, in the top right-hand diagram, the cumulative temporal trend of heat quantities is depicted. From approximately 02:00 AM, the wastewater is available as a heat source, with a total of about 2 MWh. This is used for pool heating until no more heat can be extracted from the wastewater (green curve). From this point onwards, other heat sources must be utilized (red curve). In comparison, the cumulative heat demand of the outdoor pool is shown in orange. It is evident that by fully utilizing the heat content of the wastewater, the heat consumption of backup sources, in this case a gas boiler, can be reduced by approximately 68%. This share decreases during winter months, but in the summer months, the energy need for the SP can be completely covered.

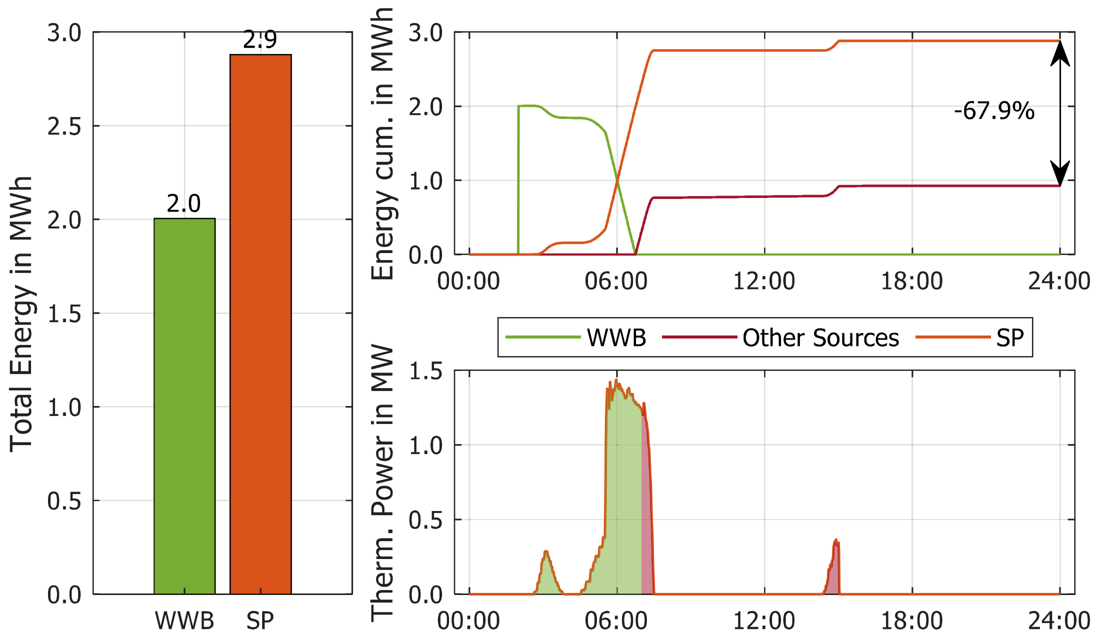


Fig. 1: Waste water utilization potential for heating demand of an outdoor swimming pool

Actually, the peak loads can hardly be covered by a heat pump if an efficient operation mode is expected. Therefore, peak shaving and load shift methods are under investigation to, which should be realised using data driven predictive control strategy.

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## CONFERENCE TOPIC

Main related Conference Topics of the abstract

- Excess Heat Energy and Resource Recovery from Low-grade Sources
- Solutions for Energy Efficiency