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Simulation of Re-Used Basin Structures for Long-Term, Large-Scale Sensible Thermal Energy Storage

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Heat storages have become an increasingly important component of innovative energy systems on a district-level, characterized by a high share of renewable energy and/or a high degree of autarky. Large-scale thermal energy storages are required to compensate for the seasonal mismatch between demand and supply; they form a central junction in the distribution network of a district, linking the various sources and sinks.

Established geothermal heat storage systems (Aquifer/borehole thermal energy storages) already show a high market availability. Based on a large number of customized implementations, substantial expertise and best practice is available in this sector. Additionally, closed systems based on artificial basins (Tank, pit, water-gravel thermal energy storages) were developed for site-independent implementation; they can be distinguished by different components, materials and construction methods. However, they still lack market maturity, with two key aspects as critical barriers: firstly, building complexity of such facilities is high, resulting in high investment costs. Secondly, planning processes are still subject to a significant degree of uncertainty. Consequently, such sophisticated and expensive projects are often contrasted with a high financial and technological risk.

In order to tackle both of these key issues, we present two solutions within our study. We introduce an interesting alternative based on recycling. As high investment costs result mainly from excavations and expenses for structural components, we suggest the re-use of existing infrastructures and artificial basin installations. In our presentation, we estimate the potential of these technical conversions. From a conceptual perspective, we demonstrate the variety of possible types of infrastructures and analyze their suitability for being re-used as storage based on different requirements, e.g., accessibility, integrability, competing interests and legal constraints. From this, we derive an overall assessment with regard to the suitability of sites and highlight advantages and weaknesses of the various types of infrastructures.

Still, any implementation can only be successful if the structure used shows sufficient performance. This is in high contrast to the usually considerable deviations from common design conventions for closed seasonal thermal energy storages, e.g., geometrically with respect to the surface/volume ratio. Here, the possible maximum storage capacity, charging/discharging power and efficiency of a re-used infrastructure after its conversion needs to be analyzed from a

technical perspective. To address this suitability aspect, we use a recently developed simulation tool “STORE”, which allows versatile modelling and evaluation of storage design scenarios on a component level using a 2.5D approach. In our presentation, we employ “STORE” to a case study and examine a potential re-use of a former water-treatment basin. After applying common boundary conditions of an energy system and setting different design scenarios, we focus on performance indicators and reveal the best technical solution for this specific case study and discuss transferability of the results.

Finally, we use our study to demonstrate, under which conditions the conversion and re-use of artificial infrastructures can be a promising approach: By reducing investment costs of large-scale, closed thermal energy storage systems, it can pave their way to full market availability.