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Seasonal underground thermal energy storage for district heating and cooling in the Czech Republic: potential and challenges

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Thanks to generous subsidies, many residential buildings in the Czech Republic are being equipped with photovoltaic and solar thermal panels, heat pumps, and heat and electricity accumulation systems. Photovoltaic roofs generate considerable savings overall (>50% in typical domestic installations). However, in summertime, they produce substantial and highly variable overflows of electricity into the grid, even with the use of air conditioning and electric vehicles charging. This result in volatile and at times negative wholesale prices of electricity. Conversely, in wintertime, the production is insufficient to balance the load from heat pumps (which are replacing wood burning and gas heaters), thereby contributing to high electricity prices. Hot water tanks and electric batteries can compensate load imbalances on a daily scale only, whereas national-scale solutions relying on gravitational energy storage are not viable. In this context, distributed systems for the seasonal accumulation of energy in the form of heat seem in principle an attractive solution. These systems could use the underground space as a heat source or sink according to needs, exploiting soil layers that are deep enough to ensure stability against seasonal fluctuations in temperature propagating from the surface, but also sufficiently shallow to ensure reasonable costs of installation. In new constructions, heat exchangers could be embedded in foundations or installed in boreholes below common areas such as access roads, parking lots and gardens. Similarly, they could be fitted in already built-up areas, and scaled in such a way to maximise their efficiency without disturbing the mechanical stability and performance of existing buildings and infrastructures. In the Czech Republic, despite a growing bottom-up demand for the creation of energy communities, their technical and regulatory viability remains unexplored. This is especially true for shallow underground seasonal thermal energy storage systems. In part, this relates to an insufficient knowledge of the ground response to thermo-hydro-mechanical forcing, as well as of possible ground-structure interactions. We are beginning to tackle this problem in upcoming research projects. Here, we will discuss our understanding of matters of priority to be addressed in our national context and present preliminary calculations demonstrating the potential of solutions at various scales.