Life-Cycle assessment of innovative mobile concepts of thermal storage for Baden-Württemberg based upon branch and company specific heat demand structures

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Abstract

In the discussion of energy prices and climate protection, attention is paid to technical, economic and ecological improvements of the energy system in Baden-Wuerttemberg. One of the issues is the amount of use of industrial waste heat. This use can take place at the site where the waste heat is generated (internal waste heat utilization) or simply externally. For storing
and transporting the waste heat to external users, apart from grid-bound systems, grid-free systems can also be adopted. These systems are referred to as “mobile heat”.

The objective of the study is to deliver a holistic assessment of different heat storage concepts that involve the thermal oil technique, the group of latent heat storage media and the zeolite
storage technology.

To start with, the physical and technical parameters of the respective technology are determined and the corresponding plant concepts are described. Next, the current heat demand in Baden-Wuerttemberg is ascertained and sorted by consumption sectors (industry; trade, commerce and service sectors; households), temperature segment as well as spatial distribution at district level. It is shown that in Baden-Wuerttemberg, the highest heat demand can be found in the districts Ortenau, Rhine-Neckar, Ostalb and Heidenheim. Simultaneously, the amount of available industrial waste heat resources of each individual sector are estimated and similarly sorted by temperature range and spatial distribution. The data of the heat demand and the
waste heat supply in Baden-Wuerttemberg are then recorded and edited in a geographic information system (GIS).

The next step is to build up tools for the assessment of storage applications over the life cycle period of construction, operation and disposal of the plants and facilities. The parameterized configuration of the tools that caters particularly for requirements of heat storage, offers a much simpler handling than the common programs of this kind. The simpler handling makes an impact on the areas of determination of emission values and the optimization of plants and concepts in ecological point of view. The practical application of the life cycle analysis can be
accomplished by using concrete examples for possible pilot projects of mobile heat in Baden-Wuerttemberg.

Next step is the identification of key economic data that stretches from waste heat storage to transport and further to utilization in the heat supply system at the end user site across the entire process chain. For ease of estimation of the economic indicators of potential applications, the identified economic data is integrated into a parameterized model of cost calculation for all observed storage concepts. The application of the cost model is illustrated by concrete case studies that are already taken into account in the life cycle assessment. In addition, apart from the economic and life cycle assessment of these possible projects, the identified data can also determine the related CO_2 abatement costs.

One of the findings shows that mobile storage systems are significantly superior to conventional heat supply systems using natural gas with respect to CO_2 emissions. But the distribution radii of each individual system are from ecological point of view obviously broader than those from an economic perspective under the prevailing circumstances.

Since the available techniques of heat storage compete in practice with other possible uses, for instance with power generation, the corresponding techniques are described in a separate section and similarly analysed with regard to their economic and ecological characteristics. In regard to the mentioned case studies of heat storage, selected alternative uses are compared in ecological and economic terms.

Another finding is, the technique of heat storage, in particular including the thermal oil technique that is heavily dependent on high performances and operation lives, faces stiff competitions with power production. The heat storage suffers as a consequence increasingly from rise in electricity prices in mid and long term, since it is more profitable to generate electricity. Nevertheless, the systems of the mobile heat offer a readily available potential and possibly a cost-effective contribution to the reduction of CO_2-emissions in Baden-Wuerttemberg. In order to increase this potential, pilot projects are necessary so as to overcome the existing obstacles that still exist. For this purpose, steel mills, foundries, glass factories or cement and brick yards for the thermal oil technique as well as biomass and biogas plants for the latent heat storage concepts can be used as heat source. Suitable heat users can be the public facilities and buildings such as hospitals, schools, swimming pools, or the integration into existing heat grids.