LCA and LCC of Seasonal Thermal Energy Storage Systems

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Abstract

Resource efficiency and the integration of renewable energy sources into the energy mix is an integral part of the energy turnaround. One of the main energy consuming sectors for countries with comparable climatic conditions as Switzerland is the energy use for space heating and hot water demand. Space heating is accountable for over 35% of the Swiss final energy consumption in 2015, of which a remarkable share of 75% is generated by fossil fuels.

Seasonal thermal energy storage units could provide an environmentally friendly and cost-efficient solution for the introduction of an increasing share of renewable energy into the thermal energy mix. Thereby, the environmental impact of the heating sector may be lowered, which could contribute to a more environmentally friendly future heating sector. However, there is very little information about seasonal thermal energy storage available and the potential of seasonal thermal energy storage is still widely unknown.

The aim of this thesis is to evaluate the potential of seasonal thermal energy storage in Switzerland by the means of a Life-Cycle-Assessment and a Life-Cycle-Costing analysis. The results provide further insight into the environmental and economic performance of seasonal thermal energy storage. Scalable models of functioning seasonal thermal energy storage systems are derived in order to achieve same-size system evaluations.

The results indicate that certain large-scale seasonal thermal energy storage systems allow for a reduction of CO_2 equivalent emissions of 50% compared to the conventionally applied heating technologies in Switzerland. Moreover, small-scale seasonal thermal energy storage technologies utilized for single-family house heating also offer potential environmental benefits compared to conventional heating technologies.

The results of the LCC analysis demonstrate, however, that the cost-efficiency of heat generation of seasonal thermal energy storage systems still needs to improve in order to become cost competitive compared to conventional heating technologies.