Thermodynamic Analysis of a Thermo-electro-chemical Storage System

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by

Erez Wenger

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Abstract

Thermo-Electro-Chemical Storage (TECS) is a novel cycle for energy conversion and storage. The charging of energy is done by heat, while discharge is done by the generation of electricity in an electrochemical cell. During the charge process the materials of a discharged cathode are thermally decomposed in a reactor. The decomposed materials are then separated, cooled down to the battery's operating temperature, and stored to increase the state of charge of the battery. The reactor may be heated from various heat sources, in particular by concentrated sunlight with a suitable solar receiver. The TECS cycle operates as both the electricity generator and the energy storage device, without the need for a thermo-mechanical engine (turbine) or a thermal storage unit. Heat for TECS may also originate from industrial processes that create high temperature waste heat. This work analyzes the upper limit on the heat to work conversion efficiency of the TECS cycle at ideal thermodynamic conditions. Specific implementations of the TECS cycle are investigated with the chemistries of the sodium-sulfur and zinc-air batteries. Process simulations of the cycle were carried out at different temperatures, pressure and cycle configurations, which include internal heat recuperation and external utilization of waste heat. The results show that high heat to electricity conversion efficiency can be obtained, reaching close to the Carnot efficiency limit when all waste heat are captured. The main challenges are the high reactor temperature required to carry out the charging reactions, and the need to recover large amounts of waste heat from multiple streams.