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Efficient electrochemical system for waste heat recovery

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Thermally Regenerative Electrochemical Cycle (TREC) was developed about half a century ago for harvesting thermal energy. This strategy is based on the temperature dependence of electrochemical potential. For a half reaction, $A + n\, e^- \rightarrow B$, the temperature coefficient is defined as

$$\alpha = \frac{\partial V}{\partial T} = \frac{\Delta S_{A,B}}{nF}$$

where *V* is the electrochemical potential, *T* is temperature, n is the number of electrons transferred in the reaction, F is Faraday's constant, and $\Delta S_{A,B}$ is the partial molar entropy change for the half cell reaction in isothermal condition. This effect indicates that the voltage of a battery depends on temperature; thus a thermodynamic cycle can be constructed by discharging the battery at T_1 and charging back at T_2. If the charging voltage at T_2 is lower than the discharging voltage at T_1, net energy is produced by the voltage difference and it originates from heat absorbed at the higher temperature, similar to a thermomechanical engine whose theoretical efficiency is limited by Carnot efficiency. The use of traditional TREC systems is often impractical, as such systems must often be operated at conditions that are incompatible with many processes in which heat recovery would be useful.

In this talk, new electrochemical systems for heat recovery are presented and discussed. We experimentally demonstrate high efficiency for heat-to-electricity conversion. This new system has applications in a variety of systems in which waste heat recovery is desired.