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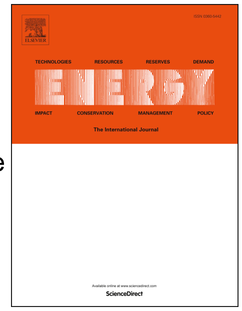

Comparative thermodynamic analysis of compressed air and liquid air energy storage systems

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Abstract:

The paper presents a thermodynamic analysis of selected CAES and LAES systems. The LAES cycle is a combination of an air liquefaction cycle and a gas turbine power generation cycle. CAES and LAES systems are simulated using Aspen HYSYS software. CAES is modeled in a dynamic mode. A comprehensive thermodynamic analysis was conducted along with the comparison of storage volumes. The results indicate that both systems are characterized by high energy storage efficiency, equal to approximately 40% for the CAES and 55% for the LAES systems. One clear advantage of the LAES over the CAES is the significantly lower volume demanded for energy storage. For the considered LAES system,the liquid air tank volume is around 5000 m^3, while for the CAES the cavern volume is approximately 310000 m^3. Heat exchangers and combustion chambers are the main contributors to the total exergy destruction in the analyzed systems.

Keywords:
Liquid air energy storage, Compressed air energy storage, energy analysis, storage efficiency.

Abbreviations

a – attraction parameter [$J^2/(mol^2 Pa)$],
b – van der Waals covolume [J/(mol Pa)],
B – exergy [kJ],
CF – correction factor [$kJ/(m^3 Pa)$],
$E_{el\ c}$ – energy consumed by compressors and pumps [kJ],
$E_{el\ g}$ – energy from generator [kJ],
h – specific enthalpy of the working medium [kJ/kg],
h_0 – specific enthalpy of the working medium in ambient conditions [kJ/kg],
h_1 – specific enthalpy of working medium at the inlet [kJ/kg],
h_2 – specific enthalpy of the working medium at the outlet [kJ/kg],
h'_2 – specific enthalpy of the working medium at the outlet for the isentropic process [kJ/kg],
I – moment of inertia [$kg\ m^2$],
k – coefficient representing the inverse of flow resistance (conductivity) [$kg/(s\ Pa^{0.5})$],
M – molecular weight of the working medium [kg/mol];
M_r – the rotating mass [kg];
$\dot{m}$ – mass flow [kg/s],
$\dot{m}_{shell}$ – flow rate of working medium on the shell side [kg/s],