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Thermodynamic Analysis of a High Temperature Hybrid Compressed Air Energy Storage (HTH-CAES) System

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1 Thermodynamic Analysis of a High Temperature Hybrid Compressed Air Energy Storage 2 (HTH-CAES) System

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13 Highlights

- 14 • A novel hybrid thermal and compressed air energy storage design is presented.
- 15 • An asymptotic isentropic condition in an adiabatic cavern is reported.
- 16 • An optimum operating pressure leading to maximum roundtrip efficiency is reported.
- 17 • Realistic isentropic component efficiencies and throttling losses were considered.
- 18 • A hybrid design is more efficient & energy dense than an advanced adiabatic design.
19

20 Abstract

21 The integration of energy storage with renewable sources is imperative as it mitigates the
22 intermittency of the available energy. A novel high temperature hybrid compressed air energy
23 storage (HTH-CAES) system design is presented as a viable solution, which has the benefit of
24 eliminating the necessary combustion and emissions in conventional CAES plants. The hybrid
25 configuration incorporates two stages of heating through separate low-temperature and high
26 temperature thermal energy storage units. A thermodynamic analysis of the HTH-CAES system
27 is presented along with parametric studies, which illustrate the importance of the operating
28 pressure and thermal storage temperature on the performance of the storage system. Realistic
29 isentropic component efficiencies and throttling losses were considered. Additionally, two
30 extreme cavern conditions were analyzed and the cyclic behavior of an adiabatic cavern was
31 investigated. An optimum operating pressure resulting in maximum roundtrip storage efficiency
32 of the hybrid storage system is reported. The hybrid system was found to be more efficient and
33 energy dense as compared with an advanced adiabatic design of the same power output.
34

35 Keywords

36 Hybrid Compressed Air Energy Storage

37 Compressed Air Energy Storage

38 CAES

39 Thermal Energy Storage

40 Grid Storage

41 Renewable Energy Storage
42

43 1. Introduction

44 Increasing the presence of renewable sources in the energy mix is challenging, as renewable
45 generation is intermittent by nature. The mismatch between production and the user demand
46 throughout the day can diminish the economic value of renewable sources, making them less
47 competitive compared to fossil fuels. The gap between renewable energy supply and demand has
48 led to the emergence of storage as a crucial element in the management of energy and is one of

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