



Designing and analyzing an electric energy storage system based on reversible solid oxide cells

Alessandra Perna^a, Mariagiovanna Minutillo^{b,*}, Elio Jannelli^b

^a Department of Civil and Mechanical Engineering, University of Cassino and Southern Lazio, Via G. di Biasio 43, 03043 Cassino, Italy

^b Department of Engineering, University of Naples "Parthenope", Centro Direzionale, Isola C4, Naples, Italy

ARTICLE INFO

Keywords:

Energy storage
Reversible solid oxide cell
Modeling
Balance of plant
Roundtrip efficiency

ABSTRACT

The Reversible Solid Oxide Cell (ReSOC), operating under electrolysis and fuel cell modes, is a promising technology that, thanks to high efficiency and fuel flexibility, can be applied in the development of Electric Energy Storage (EES) systems.

Several critical issues are required to be addressed, which are specific to ReSOC, such as oxidant electrode performance and reversibility, set of materials, cell/stack design and operating parameters suitable for reversible operation. Moreover, the optimal system design, to demonstrate the feasibility of the technology as well as the Balance of Plant (BoP) components at high operating temperatures, are also challenging factors.

Therefore, the objective of this work is to propose an HEES (Hydrogen-based Electric Energy Storage) system for distributed scale energy storage applications (100–200 kW) by taking into account some of these challenging issues. The proposed system consists of (i) the BoP section needed for the energy storage, (ii) the ReSOC module operating in reversible mode, (iii) the BoP section needed for the energy production.

In order to guarantee a competitive roundtrip efficiency, the design of the solid oxide cell unit and of the supporting auxiliary systems (BoP components) has been performed without external heat sources for the heating of feeding streams and for the thermal requirements of the ReSOC during its operation in the electrolysis mode.

The study has been carried out by developing a steady-state thermo-electrochemical model that has been built with a modular architecture. The model, validated by means of experimental data, has been used to assist the system designing and the thermal management optimization to ensure high performances from electric and thermal points of view.

Results highlight that the proposed system is able to store and use the renewable energy with a roundtrip efficiency of 60%. Moreover, thanks to the optimized thermal integration, additional heat is available for cogeneration purpose, with a cogeneration efficiency of 91%.

1. Background and scope

In the last decade, the increasing environmental concerns have led the European Countries to energy and climate policies, aiming to a significant CO₂ emissions reduction by up to 95% by 2050. To achieve the target of reducing CO₂ emissions, the integration of renewable energy sources in the energy mix of the future is expected to grow. However, the output of many renewable energy sources, such as wind and solar, is highly variable, producing fluctuating and partly unpredictable amounts of electricity over time. Therefore, the constant mismatch between supply and demand can have a serious impact on grid reliability and security of supply. This represents a new challenge, in energy generation and load balance maintenance to ensure power

network stability and reliability. Among all the possible solutions, Electric Energy Storage (EES) has been recognized as one of the most promising approaches [1–10].

There are a number of benefits associated with the introduction of bulk energy storage systems into the electricity grid: (1) enabling time-shift of energy delivery to facilitate the balancing of electricity supply and load at reduced cost, (2) providing grid operational support to facilitate smooth, coordinated operation of the components of the electricity supply system, (3) maintaining power quality and reliability by providing energy to the system with very short response times, and (4) allowing integration of intermittent renewables generation by smoothing their energy output over time [5].

EES technologies can be separated into two categories [6]: *high*

* Corresponding author.

E-mail address: mariagiovanna.minutillo@uniparthenope.it (M. Minutillo).

Download English Version:

<https://daneshyari.com/en/article/7159100>

Download Persian Version:

<https://daneshyari.com/article/7159100>

[Daneshyari.com](https://daneshyari.com)