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Energy Storage driving towards a clean energy future

1. Background

The transformation of energy systems towards a net-zero future accelerates the development of innovative and highly efficient technologies to generate clean, sustainable and affordable energy services, among which Energy Storage plays as a vital and irreplaceable role. The special issue of *Energy Reports* on Energy Storage collects new research findings and review articles including the following topics.

1. Thermal storage (e.g. Sensible heat thermal energy storage, Latent heat thermal energy storage, Thermochemical energy storage)
2. Electrochemical (e.g. Fuel cell, Rechargeable batteries, Flow battery)
3. Chemical energy storage (e.g. Hydrogen and synthetic natural gas as secondary energy carriers)
4. Mechanical storage (e.g. Hydroelectricity, Pumped-storage, Compressed air, Flywheel energy storage)
5. Electrical energy storage (e.g. Supercapacitor, Superconducting magnetic)

2. Summary

The collection 'SI: Energy Storage' of Energy Storage was set up in late 2019 and accomplished in 2020. In total 26 papers (24 research articles and 2 review articles) were accepted and published.

Energy Storage technologies such as batteries, thermal energy storage devices and integrated energy storage systems are critical for delivering various energy services such as electricity, mechanical power, heating and cooling. According to the report from the IRENA (2017), the requirements for energy storage will become triple of the present values by 2030. In this SI collection, Al Shaqsi et al. (2020) compares and evaluates different energy storage devices and systems aiming to be used as a critical reference for policymakers and practitioners.

Thermal Energy Storage

Zhang et al. (2020a) investigates the effects of condensation temperature, height difference and filling ratio on a closed-loop two-phase thermosiphon to understand the improvement of heat transfer performance of a latent heat storage device. Zhang et al. (2020b) analyses the ash distribution and heat transfer in a Radiant Syngas Cooler, which plays as key heat storage and thermal management device in the coal gasification process. A self-developed computational fluid dynamic-discrete element method (CFD-DEM) model is developed and reported in Wang et al. (2020a) to investigate the thermal energy storage characteristics of a spouted bed under various nozzle numbers. A new water heating system is proposed in Guan et al. (2020), which studies the potential of using solid graphite as a thermal energy storage medium to regulate the output temperature at a water heating system. Yang et al. (2020a) and Yang et al. (2020b) present detailed analysis considering the economics on mobilised thermal energy storage (M-TES) systems to transport and distribute industrial waste heat through case studies. Wang et al. (2020b) conducts a dynamic simulation on an industrial steam heating system to understand the energy storage capability of the steam network such as the internal volume of the pipelines and heat exchangers. Doretti et al. (2020) reports a numerical study on different concrete thermal energy storage systems considering the effects of the modules' arrangement for the application in a concentrated solar power plant. Large scale heat storage has the potential to achieve the energy system decarbonisation in the UK, such as the utilisation of seasonal storage method in the subsurface using aquifers and flooded mines as reported by researchers from Durham Energy Institute, University of Birmingham and the Coal Authority in Gluyas et al. (2020). Solid-state sorption technology such as adsorption thermal energy storage using acorn nutshell based activated carbon for water adsorption reported in Chairunnisa et al. (2020) is an environmentally friendly solution and promising technology for low-grade thermal energy storage.

Electrochemical Energy Storage

Fasakin et al. (2020) develops the anode of lithium-ion battery using anatase TiO_2 nanotubes. An environmentally friendly method to fabricate the lithium-sulfur battery with the capability to freely adjust the sulfur loading is presented in Tian et al. (2020). In order to potentially reduce the power consumption and cots of grids, Faisal et al. (2020) proposes a simulation tool called particle swarm optimisation (PSO) based fuzzy logic controller (FLC) to control the charging and discharging of battery energy storage systems. Advanced battery thermal management methods such as the utilisation of phase change material unit in Huang et al. (2020) and development of a two-phase cooling system in Fang et al. (2020) to control the temperature of batteries under both transient and steady operational conditions are potential solutions to be used in electrical vehicles.

Chemical energy storage

Panchal et al. (2020) reports a new method for biodiesel synthesis under mild conditions using methanol and an ionic liquid. A study on the oil–water interface isolation ball to reduce

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the oil mixing and ensure the smooth operation of crude oil production in the pipeline is reported in Liu et al. (2020a). The hydrogen production method through water electrolysis highly relies on the technological developments on the active and stable electrocatalysts. Kim et al. (2020) presents a facile direct growth method to synthesize NiFe-layered double hydroxides (LDHs) on nickel foil as an electrocatalyst for the oxygen evolution reaction and concludes the synthesis process has the potential to be used promoting the commercialization of alkaline water electrolysis.

Mechanical storage

Wang et al. (2020c) conducts a detailed component-level investigation focusing on the aerodynamic performance of an axial turbine used in compressed air energy storage (CAES) system. Flywheel energy storage integrated with diesel generator can be used to store and balance the variation of loads from the generator (Zhang et al., 2020).

Integrated Energy Storage Systems

Solar photovoltaic (PV) system can be used either as a combined heat and power system, alternatively, it can be integrated with battery energy storage as a hybrid storage system. A case study considering Malaysian weather conditions reported in Misha et al. (2020) presents a simulation and experimental study on the performance of thermal (PVT) system for combined heating and power generation with a newly developed dual oscillating absorber copper pipeline. In order to understand and promote the development of photovoltaic industry, Liu et al. (2020) studies the energy storage-involved photovoltaic value chain (ES-PVC) consisting of three nodes for upstream, midstream and downstream, in which photovoltaic power suppliers, battery energy storage business and electric vehicle manufacturers locate respectively. Maleki et al. (2020) develops an informative model to define the optimal sizing of hybrid solar photovoltaic (PV) and battery storage unit. Pumped Thermal Energy Storage (PTES) is an emerging large-scale energy storage technology integrating Thermal Energy Storage (TES) with compressor/expander as an alternative to pumped hydro energy storage or compressed air energy storage (Hassan et al., 2020). CHESTER (Compressed Heat Energy Storage) is an EU-H2020 funded project to develop and validate an innovative energy system based on heat pump, thermal storage, and Organic Rankine cycle. A detailed analysis of high-temperature pumped thermal energy systems conducted by the team from Spain, Egypt and Germany can be found in Hassan et al. (2020). As an environmentally friendly technology, Thermoelectric generators (TEGs) directly convert thermal energy into electrical power through Seebeck effect. Jaziri et al. (2020) provides a comprehensive review of Thermoelectric Generators mainly focusing on the application perspectives of the technologies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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