

Engineering the Next Generation of Thermochemical Energy Storage Materials and Components

Emanuela Mastronardo,^a Luigi Calabrese,^a Elpida Piperopoulos,^a Edoardo Proverbio,^a Candida Milone^{*,a}

^a*Department of Engineering, University of Messina, Contrada di Dio, Messina Italy*
e-mail: cmilone@unime.it,

Efficient use of energy is a cornerstone of sustainability, playing a crucial role in reducing greenhouse gas emissions and minimizing dependence on finite fossil fuel resources. Beyond environmental benefits, energy efficiency carries significant geopolitical weight: it strengthens energy security by lowering reliance on imported fuels and reducing exposure to supply disruptions. Nations that lead in energy-efficient technologies gain strategic advantages, shaping global power dynamics.

In this context, thermal energy storage (TES) integrated with renewable energy sources (solar, wind) offer promising solutions for more resilient and sustainable energy infrastructures [1].

Sensible and latent heat storage are among the most investigated technologies for storing the surplus of heat. Sensible heat storage is dependent on the thermophysical properties of the material used, while latent heat storage employs a phase transition at a constant temperature to accumulate or retrieve thermal energy by the latent heat of fusion of the storage medium. The first technology cannot be applied for long-term storage, while the second operates at a specific temperature, namely the melting temperature of a phase change material. Thermochemical heat storage (TCS) enables to overcome such limitations by storing and releasing heat on demand through a chemical reaction, exploiting a larger operating temperature range while also offering superior storage densities. The medium and the type of reaction significantly impact the performance of the thermal energy storage unit by the operating temperature range and storing/releasing heat rate.

This seminar presents an overview of TES technologies with a focus on TCS as a high-density, sustainable solution for meeting efficient energy use. Moreover, it introduces to cutting-edge strategies aimed at improving the performance and efficiency of materials used in TCS and overcoming some critical issues. [2-3]

References

- [1] IRENA (2020), Innovation Outlook: Thermal Energy Storage, *International Renewable Energy Agency*, Abu Dhabi, ISBN 978-92-9260-279-6
- [2] E.; Mastronardo, E.; Previti, L.; Calabrese, C.; Milone, *J. Energy Storage* **2025**, 108, 115065.
- [3] L.; Calabrese, D.; Palamara, E.; Piperopoulos, E.; Mastronardo, C.; Milone, E.; Proverbio, *J. Sci. Adv. Mater. Devices*, **2022**, 7, 100463.