Sensible and Latent Heat Storage: A Review of the State of the Art in the Brazilian Context

Paulo Henrique Neves Pimenta[1], Felipe Pamplona Mariano[2] , Gino Bertollucci Colherinhas[2], Getúlio Santiago dos Santos Junior[3], Gabriela Miguel Fraga[3]

[1] *Department of Academic Areas IV, Federal Institute of Goiás, Goiânia-GO, Brazil*
[2]*Dept. name of organization (of Aff.), Name of organization (of Aff.), City, Country*
[3] *General Secretariat of the Government of the State of Goiás, Goiânia-GO, Brazil*
**Corresponding author. E-mail: paulo.pimenta@ifg.edu.br*

ABSTRACT

This paper presents a brief review of the studies on thermal energy storage systems utilizing both sensible and latent heat in Brazil. The primary objective is to identify and evaluate the storage technologies that have been studied or installed in the country, with a focus on pinpointing key challenges and prospects for these systems. The bibliographic research was performed in the Scopus database, focusing on works in the fields of Engineering, Energy, and Physics and Astronomy, published between 2015 and 2024. The review reveals that most studies have concentrated on improving heat transfer to energy storage materials/fluids, either through the development of new materials or by incorporating fins in storage tanks. Furthermore, only one study addressed an installation in Northeast Brazil.

Keywords: Energy storage; Latent heat; Phase change material (PCM); Sensible heat; Thermal Storage.

INTRODUCTION

Solar energy generation is inherently unstable due to the fluctuating availability of sunlight throughout the day. The resource is only accessible during specific hours and can be further disrupted by cloud cover, leading to reduced reliability in the solar photovoltaic energy generation process. To overcome this limitation, thermal storage units can be employed. This technology is based on the transfer of heat to a storage medium, allowing for its later use in heating, cooling, or electricity generation applications [1]. The storage method is classified according to the physical processes involved: (i) Sensible Heat Storage (SHS), where the working fluid is stored without a phase change; (ii) Latent Heat Storage (LHS), in which the working fluid is evaporated (or melted) and stored, returning to its initial phase when thermal energy is transferred to an energy conversion process.

Numerous studies have been conducted globally, focusing on various aspects such as performance analysis through numerical and experimental methods [2], the development of new technologies and applications [1], the use of different phase change materials (PCM) [3], and high-temperature storage systems [4]. In this context, a brief review of studies conducted in Brazil on thermal storage systems is proposed. The objective is to identify and evaluate the storage technologies that have been studied or installed in Brazil, aiming to identify the main challenges and prospects for these installations in the coming years.

MATERIALS AND METHODS

We searched for articles with one of the three keywords in their title: Energy storage, Heat storage, or Thermal storage, and that also included in the subject, title, or keywords: Latent heat or Sensible heat. Additionally, we filtered documents in the following fields: Engineering, Energy, and Physics and Astronomy, with Brazil as the country of origin, published between 2015 and 2024. For this search, we used the following algorithm in the Scopus database: (TITLE(("energy storage") OR ("therm* storage") OR ("Heat storage")) AND TITLE-ABS-KEY ("sensible heat" OR "latent heat")) AND PUBYEAR > 2014 AND PUBYEAR < 2025 AND (LIMIT-TO (AFFILCOUNTRY , "Brazil")) AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "ENER") OR LIMIT-TO (SUBJAREA , "PHYS")).

RESULTS AND DISCUSSION

As a result of the research, 23 papers were found. Expanding the search to a global context yields 4,533 papers. This significant disparity suggests that the use/study of latent or sensible heat energy storage systems in Brazil is still a relatively unexplored topic. In Table 1, we present some remarks from five papers on the following topics, respectively: losses in a sensible heat storage tank for a concentrated solar power plant; increasing the thermal performance of PCMs; use of fins in latent heat thermal energy storage systems to improve the poor thermal conductivity of phase-change materials (PCMs); modeling the thermal performance of PCMs; and modeling a concentrated solar power plant with a linear Fresnel reflector.

Table 1. Studies on thermal storage systems in Brazil.

Reference	Remarks
[5]	A numerical study of the heat losses to the external environment, considering factors such as solar irradiation levels, ambient temperature, and wind speed. The model was validated using experimental data from the Solar Two and Andasol I solar power plants in Spain.
[6]	A study examined the use of metallic foam and the concentration of nanoparticles, which have a significant effect on the thermal performance of the PCM, accelerating the charging/discharging process.
[7]	A numerical study investigated the use of fins with different arrangements, including fins-nanoparticles and fins-metallic foam, in the heat transfer process for LHS systems.
[8]	3D numerical modeling of a triplex tube heat exchanger with finned walls, that analyze the complete geometry of latent heat thermal energy storage systems and the thermal and fluid dynamic phenomena influenced by this geometry.
[9]	Modeling of a linear Fresnel reflector concentrated solar power plant to assess its potential for electricity generation in Northeast Brazil. The results showed that stored energy is more significant during the dry period. Thus, the satisfactory performance of the proposed storage system and the obtained solar-to-electric efficiencies

suggest that direct steam generation and the integration of sensible-latent storage could play a crucial role in making concentrated solar power plants with linear Fresnel reflectors competitive in the Brazilian energy market.

CONCLUSION

We conducted a brief literature review of the storage technologies studied or installed in Brazil. We found that for Latent Heat Storage (LHS), most studies have focused on improving heat transfer to phase change materials (PCMs), either by developing new PCMs or by using fins in storage tanks. However, Sensible Heat Storage (SHS) systems have not been explored in the national context. Only one study has addressed an installation in Northeast Brazil. Overall, these technologies can play a crucial role in balancing electricity supply and demand over daily, weekly, or even seasonal periods, reducing system investment costs and increasing efficiency, as they do not need to be sized according to peak demand. This efficiency improvement helps increase the share of renewable energy in the energy matrix, mitigating the impacts of its intermittency.

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