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REFERENCE COURSE ON SOLAR THERMAL ELECTRICITY (STE) TECHNOLOGIES

Support document to the presentation “Upcoming Ideas and Concepts”

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Learning Module Information

Learning Module Description

This module gives an overview of upcoming ideas and concepts for thermal energy storage. After attending the module, the listener will be able to understand which shortcomings of current thermal energy storage technologies are there and what possible improvements are currently under research.

Prerequisite

The module will be based on the preceding module about current storage technologies. Hence, a general knowledge about thermal energy storage technology and their working principle is necessary.

Texts have been partly written for this document and are mainly taken from original publications. Occasionally, the original text has been shortened or altered to fit the needs for this document.

Recommended readings

Recommended readings are supplied at the end of each section.

Technical Requirements

There are no technical requirements to attend this module.

Learning Module Structure

The topic is divided into three main sections according to the underlying technologies.

The first technology is sensible heat storage, which is based on storing heat by changing the temperature of a substance. The technology has the highest maturity and some concepts are already commercially available. Research focus lies on the optimization of costs; hence system simulations play an important role. Experiments have left lab scale and are mostly at pilot or demonstrational scale.

The second technology is latent heat thermal energy storage, where the phase change enthalpy of matter is utilized to store heat. Research is still focusing on better understanding and simulating the phase change process in real systems as well as new concepts in general. The concept has also been demonstrated on a relevant scale.

Finally, the third technology is thermochemical energy storage, where the heat of reaction is used for thermal energy storage. Research is still in lab scale here, with the aim of investigating several possible reaction systems and understanding the underlying chemistry. Some concepts have been proved in a kW-scale.

1. Introduction

Thermal energy storage can be divided into three general technologies.

Sensible heat thermal energy storage, utilizes a temperature change to store thermal energy. This is principally possible in any kind of substance but in a large scale makes only sense in liquids or solids due to their high volumetric energy density.

Latent heat thermal energy storage uses the phase change enthalpy of liquids, which are usually salts at higher temperatures.

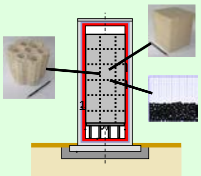
With thermochemical heat storage, the heat of reaction of mostly solids is utilized.

Upcoming Ideas and Concepts

Sensible heat

Solids

Concrete *Ceramics and rocks*



Liquids

Molten salt *Pressurized water*

Mixture of solids and liquids

Latent heat

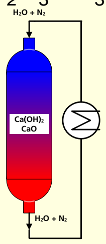
Phase change

- Solid-solid
- **Solid-liquid**
  Alkali nitrate/ nitrite salts

Chemical heat

Reactions

- Gas-gas
- Liquid-gas (Absorption)
- **Solid-gas**
  $Ca(OH)_2/CaO/H_2O$
  $CaCl_2/H_2O$
  $Mn_2O_3/Mn_3O_4/O_2$



When comparing the technologies, the highest energy densities are achieved by thermochemical thermal energy storage systems, whereas sensible heat has the lowest and latent heat lies in between. However, there are reasons why the technology with the lowest energy density (sensible heat) has nonetheless achieved highest maturity and is nowadays widely applicated.

Sensible heat	Latent heat	Chemical heat
$Q_{th} = m \cdot c_p \cdot \Delta T$	$Q_{th} = m \cdot \Delta h_{melt}$	$Q_{th} = m \cdot \Delta h_{reaction}$
20 – 100 kWh/m³	50 – 150 kWh/m³	100 – 400 kWh/m³

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Summary professional background of the lecturer:

- Mechanical Engineering at RWTH University and University of Bath
- PhD at Institute of Energy Storage (University of Stuttgart) and Institute of Engineering Thermodynamics (DLR Stuttgart)
- Research Fellow at Institute of Engineering Thermodynamics (DLR Cologne)

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