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INNOSTORAGE – USE OF INNOVATIVE THERMAL ENERGY STORAGE FOR MARKED ENERGY SAVINGS AND SIGNIFICANT LOWERING CO_2 EMISSIONS

Beneficiaries:

Partners:

D7.2 - Report on Staff Exchanges

	Name and Institution	Date
Prepared by:	Rhys Jacob University of South Australia	31/03/16
Checked by:	Dr. Aran Solé University of Lleida	30/04/16
Approved by:	Prof. Dr. Luisa F. Cabeza University of Lleida	15/05/16

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1 Objectives

The secondment was broken into two parts to utilise the expertise of each university.

While at the University of Barcelona the objective was to characterise the geopolymer shell (composition, material properties, etc.) and find ways to improve if necessary. A presentation made at INNOSTORAGE 2016 was also during this time.

The objective of the secondment at the University of Lleida was twofold:

- Revalidation of numerical model of an encapsulated phase change material (EPCM) system in Python.
- Discussion about pilot-scale high temperature thermal energy storage (TES) facilities and the capabilities of the University of Lleida.

The secondment also allowed the ability to enhance the collaboration between the University of Lleida, University of Barcelona and the University of South Australia through publications, conferences etc.

2 Introduction

The secondment was used to enhance the current work being performed in the field of high temperature TES, and in particular EPCM systems. In an EPCM system the phase change material is coated in another material to contain the PCM during heating/cooling to increase thermal conductivity, control volume expansion and increase material compatibility (among other things). The University of Lleida has a strong background in this field, mainly in low temperature EPCM and high temperature molten salt storage, and the lessons learned here will be important when trying to move to high temperatures. The University of Barcelona has a strong background in material characterisation and in particular with geopolymer materials. The performance of the shell is paramount to the current work.

3 Description of work

The aim of the current work is to investigate, develop, design and (possibly) showcase a high temperature EPCM storage system (<600°C) at the University of South Australia. To achieve this, it was important to investigate existing EPCM systems, materials and designs. The submitted design must meet certain design considerations such as a long service life, four-six hours of full load capacity and a capital cost of less than AUD$25/$kWh_t$.

4 Materials and Methodology

To achieve the aims and objectives of the current work new materials and designs had to be investigated. To this end a geopolymer material (developed at the University of South Australia) has been shown to withstand the design temperatures with minimal degradation.

Other important factors to consider are the specific heat, thermal conductivity, density and composition. The chosen PCM is a chloride eutectic comprising of barium, sodium and potassium chloride with a melting temperature of 540°C. This material has shown good cycling capabilities, favourable thermophysical properties and a very low material cost. The methodology of the project is broken into several parts, with the work performed at the University of Barcelona (shown in blue) and the University of Lleida (shown in red) highlighted:

- **Investigation of:**
    - Existing high temperature TES systems [pilot/industrial scale molten salt] and available EPCM systems.
    - Current materials that can achieve the design and economic criteria.
    - Embodied energy of potential systems and a comparison to other potential systems.
- **Material Testing and Capsule Fabrication:**
    - Characterisation of chosen PCM (cycling performance and thermophysical properties [latent heat and specific heat])
    - Characterisation of developed geopolymer shell (Thermophysical properties [density, porosity, specific heat, thermal conductivity] and material compatibility [in contact with solar salt and air])
    - Fabrication of capsules [cycling ability and energy storage density]
- **Numerical Modelling of EPCM systems:**
    - Development of a fast and effective way to predict the EPCM system performance (written in Python)
    - Experimental validation of the previously developed model using previous literature
    - Use of the developed model to investigate various effects on system performance and system design

5 Results

During the secondment several important results were found:

- **The initial characterisation of the geopolymer was completed.**
    - The thermal conductivity, porosity and composition analysis was completed at the University of Barcelona.
    - The cycling performance of the geopolymer in a molten salt and an air environment was completed for 25 cycles with results showing severe degradation of the salt but negligible degradation in air.
    - The specific heat analysis was performed at the University of Lleida.
- Lessons learned from the pilot-plant system operating at the University of Lleida was discussed with future collaboration should a pilot-plant be built at the University of South Australia.

- The revalidation of the developed Python code was completed. This model will be used to further develop the system and compare various tank designs, materials and heat transfer fluids.

6 Outcomes or future work

The results from the secondment have led to the production of at least two journal papers; one on the embodied energy and cost of the proposed systems and another on the characterisation of the geopolymer material. The results of the embodied energy investigation were also presented at INNOSTORAGE 2016 in February.

7 References

8 Assessment

The secondment was largely a success with the majority of objectives being met during the timeframe. Unfortunately, the proposed tour of a nearby concentrated solar power plant (CSP) was unable to be completed during my stay due to external factors. The characterisation of the geopolymer is an important step in showing the value of the proposed EPCM storage and I'm grateful for both universities in helping to achieve this. Also, the lessons learned from the pilot-plant at the University of Lleida will be important for future development of the system. Lastly the validation of the numerical code will allow accurate design and comparison of system parameters that are too costly to experimentally compare. Overall the secondment was important to achieving the goals of the project while strengthening the partnership between the universities. However, for future secondments I would recommend at least 6-8 weeks in each university to maximise experimental time.