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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

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Contents

1 Objectives

UniSA has been conducting research into PCM thermal storage systems for nearly two decades. The focus of this visit was to cement collaboration between UniSA and UDL.

UniSA has conducted research into the heat transfer enhancement with PCM thermal storage systems, developing a technique known as 'dynamic melting'. The first objective of the secondment was to begin the experimental program here at UDL into this field.

UniSA have recently commercialised a PCM storage system in Australia, applicable to refrigeration applications. This technology is well suited to complement distributed renewable energy. The second objective of the secondment involved beginning the simulation modelling research to explore the benefits of this concept in Spain.

2 Introduction

Phase change material (PCM) thermal storage technology is an effective means by which to store thermal energy produced from renewable energy resources. A key concern of this technology is the low heat transfer rates within these systems due to the low thermal conductivity of the PCM. Overcoming this issue at low cost, represents a challenge. Previous research from UniSA has developed 'dynamic melting' a technique by which the liquid portion of the PCM is moved through the PCM enhancing heat transfer. This process has been evaluated at both low and high temperature (Tay *et al*, 2013 and Tay *et al,* 2015). UniSA is continuing to research on this technique for both refrigeration and high temperature storage applications. A focus of UDL is developing high temperature thermal storage for waste heat recovery. UDL have a hot oil facility capable of testing large PCM prototypes. Therefore the objective involved developing the dynamic melting concept here at UDL for waste heat storage.

Distributed renewable energy, both in Australia and Spain has uniquely attractive economic characteristics, due to high radiation levels and electricity prices. Australia in particular has the largest penetration of solar PV in households. Many large commercial customers have shown interest in Australia to install solar PV, however are restricted or the economics are limited due to peak demand tariffs. Refrigeration is a large user of electricity. In Australia more electricity is used for refrigeration than domestic hot water. UniSA has commercialised a PCM storage system for electricity load shifting for large refrigeration installations. UniSA has conducted preliminary investigations to show that solar PV coupled to PCM thermal storage has the capacity to offer a sound financial investment for customers. Spain has somewhat similar weather to parts of Australia, and also has a large cold chain industry. Therefore, there is possibility for the Australian technology to be demonstrated in Spain, and opportunities warrant investigation.

3 Description of work

The work involved developing the research program associated with both objectives.

For the first objective, it was clear that the initial concept for applying dynamic melting was infeasible, and therefore a new strategy was developed and investigated. This new strategy involves building a number of smaller rigs both at UDL and at UniSA, to investigate specific phenomena, after which a larger rig is to be constructed and tested.

For the second objective, industry visits were made and potential projects formulated for the application of thermal storage for refrigeration. The scope of research was identified needed to identify the costs and benefits of this concept. Furthermore, funding opportunities were investigated.

4 Materials and Methodology

The demonstration of dynamic melting at high temperature required an approach which would minimise technical risk and maximise research value. A research program was developed which could achieve this outcome.

The scope of research for identifying the benefits of using thermal storage in refrigeration for the integration of renewable energy required investigating the electricity pricing system, understanding the specific application related to industry, and determining the most effective modelling approach.

5 Results

The dynamic melting experimental program will involve the following testing. This program will be conducted involving UDL and UniSA over the next few years.

Design and construct a small conductivity measurement rig. This rig will be used to measure the effective conductivity when dynamic melting is applied. A PCM with melting point above 50 deg. C will be used.

Design and construct a single tube dynamic melting rig. The previous rig applies 1D heat flow, whereas this rig applies 2D heat flow with a heat transfer fluid flowing through the single tube. UniSA has already constructed such a rig for low temperature applications. A similar rig will be constructed for higher temperatures at UDL. The rig will be used to validate numerical modelling, as well as identify the optimal parameters for effective dynamic melting.

Apply effective dynamic melting methods to UniSA dynamic melting rig. UniSA is in the process of commissioning its dynamic melting rig of a multi-tube system with a PCM melting at 308 deg. C. The optimal parameters identified with the previous rig will be applied to the

UniSA rig to demonstrate the improvement that dynamic melting can have at high temperature.

The investigation of applying PCM storage for refrigeration together with solar PV proved promising. Discussions were held with Endessa Power which highlighted that the Spanish and Australian electricity market and pricing operate in a similar way. An investigation was conducted of the tariffs and the potential financial benefit of shifting from peak to off peak tariffs with thermal storage was found to be 115 euros/kW of load shifted per year. This is defined by shifting 16 hours of load to 8 hours of off peak times.

Meetings were held with two firms, a winery (LaGravera) and a dairy processing facility (Pastoret), both of whom export high quality product. Both require refrigeration. The opportunity for solar PV coupled to thermal storage was identified. Both organisations were supportive of a simulation study, and willing to pursue the commercial/technical viability of the such a system.

The scope of a simulation study was developed. The study will simulate the demand from the facility, the output of a solar PV facility and the thermal storage system. A parametric study will be conducted to identify the optimum operation which maximises the amount of renewable energy that can be used by the facility as well as delivering an appropriate financial return to the end user.

6 Outcomes or future work

Overall, a deeper research relationship has been established and a scope of work which can deliver increased research outputs. Specifically the outcomes include:

- Established co supervision of a UDL PhD student by a UniSA colleague.
- UDL is a partner investigator in an Australian grant application from the Australian Renewable Energy Agency.
- Identified a potential demonstration project involving UniSA and UDL. An Australian company who is partner to UniSA is willing to support a demonstration project of its technology in Spain. A suitable EU funding source has been identified. Efforts are now underway to formulate the application.
- Two joint conference papers are planned to be presented in 2016. These papers will relate to on-going research previously outlined.

A contribution was made to the 2nd Training School at the University of Lyon, exposing the students to a more international perspective of the field of thermal energy storage.

7 References

Tay, N.H.S., Bruno, F., Belusko, M. (2013) Experimental investigation of dynamic melting in a tube-in-tank PCM system, Applied Energy, 104, 137 - 148

Tay, N.H.S., Belusko M., Liu M., Bruno F. (2015) Investigation of the effect of dynamic melting in a tube-in-tank PCM system using a CFD model, Applied Energy, 137, 738-747

8 Assessment

Overall the secondment has been a resounding success. Coming from well outside the EU system has meant it is difficult to establish effective collaborative research. This trip has enabled a deeper understanding of the EU funding process to be determined, as well as the internal regulations within relevant EU institutions. As a result our collaboration will more effective at obtaining funding within our respective jurisdictions. As far as the substance of the research collaboration, only through such a secondment can a serious scope of work be developed. We at UniSA look forward to future joint research within the Innostorage group.