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

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UNIVERSITÉ DE LYON
Ben-Gurion University of the Negev

Partners:

THE UNIVERSITY OF AUCKLAND NEW ZEALAND Te Whare Wananga o Tamaki Makaurau
University of South Australia
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## D7.2 - Report on Staff Exchanges

| | Name and Institution | Date |
| --- | --- | --- |
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# 1 Objectives

The main objective of the secondment is to take advantage of the availability of two experimental set-ups to test PCM systems in buildings in order to combine both expertise and capabilities to foster the use of PCM in such applications. The goals of the project will focus in both passive and active systems incorporating PCM and integrated in the building components. This secondment is linked to Work package 2 (Building applications) and 4 (Modelling). The work developed is related to Task 2.1, 2.2, 2.3, 4.1, 4.3, and 4.4 since both active and passive systems are studied, a methodology based on simulations is experimentally validated using data from different locations and constructive systems, and a model of the active system is under development in EnergyPlus.

An additional goal of the secondment is the discussion of further ideas to develop within the project or in future collaborations.

# 2 Introduction

The use of phase change materials in building envelopes has been extensively studied and its benefits were demonstrated in the past ([1]-[4]). However, some issues still require further research.

The use of integrated hybrid systems in the building envelope is now seen as promising solution to the limitations demonstrated in purely passive systems, where the charge and discharge is not controlled by the user ([6]-[7]). The capture and storage of solar energy in the building structure is a good option for the improvement of energy efficiency of buildings. In this project, a storage system integrated into a pitch roof of an experimental hut will be evaluated. During the secondment, the design of such system has been addressed in collaboration between both institutions. After that, the experimental tests will be performed and results will be evaluated and compared to a numerical model developed in EnergyPlus. The first steps to implement the storage system in EnergyPlus were also done during the secondment.

On the other hand, also the evaluation of passive PCM systems is of great importance. Many years of experimental measurements are available in the experimental set-ups of both University of Auckland and Universitat de Lleida. Combining these data can be of great interest for the evaluation of PCM systems under different operating conditions. During the secondment, a previously proposed methodology [8] based on four indicators, which were tested through simulation only are experimentally validated using brick, concrete and timber constructions, incorporating PCM. Experimental data from both Universities is used to extend the analysis to a wider range of construction systems and solar radiation treatment.

These two topics are the main focus of the secondment, and from here on they will be referred as: PCM active system; Evaluation methodology for PCM passive cooling.

## 3 Description of work

- PCM active system

The use of active systems integrated in the building structure overcomes several problems encountered in passive systems. At the Universitat de Lleida, several works have been done in this topic, supervised by Dr. Castell. A ventilated facade incorporating PCM has been evaluated in the frame of a PhD thesis, and another thesis is under development regarding the use of a concrete slab for PCM energy storage. The expertise of Dr. Castell has been useful to design a new storage system integrated into a pitch roof in an experimental hut for solar energy storage.

Dr. Castell has assessed the PhD student leading this research topic in the critical design issues, accelerating the learning curve for such system. The new design is now being implemented and will be evaluated in the near future.

- Evaluation methodology for PCM passive cooling

Evola et al. [8] presented a new methodology to determine the effectiveness of using PCM in building envelopes for summer conditions. This methodology is based on four indicators (Intensity of Thermal Discomfort, Frequency of Thermal Comfort, Frequency of Activation, and PCM Storage Efficiency). These parameters will be used to assess the performance of specific cases and compare them with experimental results to determine the suitability of the methodology. The cases studied are those presented in [1], [4], and [5], where detailed experimental work has been performed and data is available to validate the methodology for different construction systems.

## 4 Materials and Methodology

- PCM active system

The experimental set-up used is located in Auckland and consists of a hose-like hut (Figure 1). The hut has dimensions 2.6 m long, 2.6 m wide, and height of 2.6 m with a Gable roof (double sloping roof with a ridge forming a triangle at each end). It is 0.4 m off the ground and supported by timber stands. There is a window on the north facing wall and a door on the east facing wall. The wall construction is made of a wooden frame with 0.1 m weatherboard exterior, 0.025 m particle board, 0.075 m fibreglass insulation, and 0.013 m gypsum board interior. The floor is made of 0.025 m particle board and carpet. The roof is made of corrugated iron with 0.025 m particle board, 0.075 m fibreglass insulation, and 0.013 m gypsum board interior.

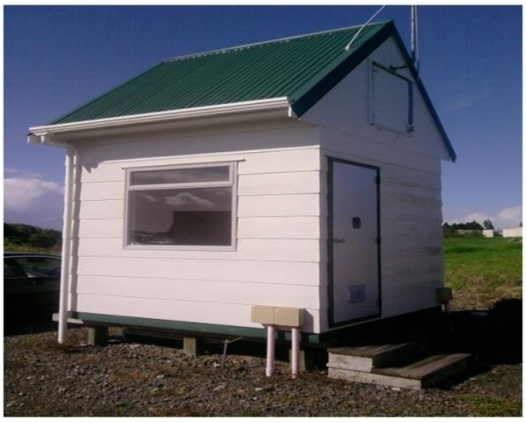

Figure 1 Experimental hut to be used with the solar energy storage system.

- <u>Evaluation methodology for PCM passive cooling</u>

Two different experimental set-ups (one located in Auckland, New Zealand, and the other one in Lleida, Spain) were used to provide the data needed for the evaluation of the parameters described earlier. Both experimental set-ups consist of small house-like constructions where PCM has been introduced in walls. The goal of such constructions is to analyze and characterize the behavior of incorporating PCM in different constructions under real climatic conditions. Side-by-side experiments were performed to allow for direct comparison. Results demonstrated the potential benefits of using PCM in building envelopes [1], [4], and [5].

The constructive system consists of (Figure 2): (1) prefabricated concrete walls; (2) alveolar brick; (3) timber. However, although both experimental set-ups are similar in concept, there are important differences between them that need to be highlighted as shown in Table 1.

Table 1. Main differences between the two experimental set-ups used for the evaluation.

| | Auckland Huts | Lleida Cubicles | |
|---|---|---|---|
| **Constructive system** | Lightweight (wood) | Massive (concrete) | Massive (brick) |
| **Openings** | A window facing North | Windows facing South, East, and West | No windows |
| **PCM** | RT-21 | Micronal® PCM | SP-25 A8 |
| **PCM incorporation** | Embedded | Micro-encapsulated | Macro-encapsulated |

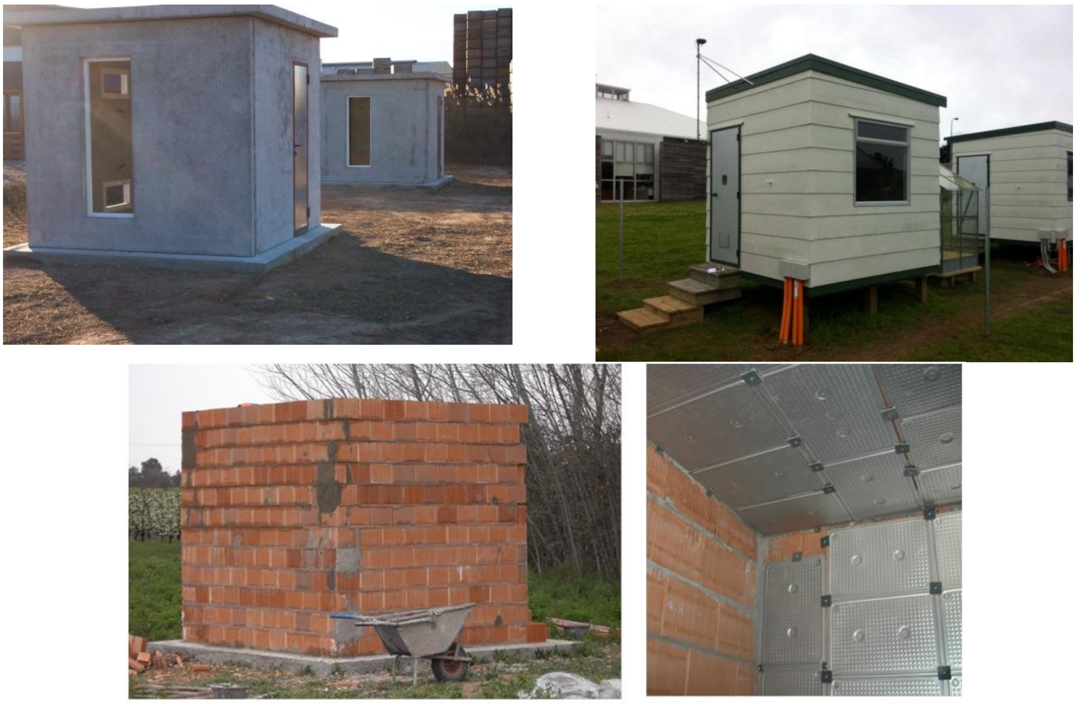

Figure 2 Experimental set-up used for the evaluation. Top left: concrete cubicle; top right: timber hut; bottom: alveolar brick cubicle.

# 5 Results

- PCM active system

This research is still ongoing. Results from the secondment are the design of the storage system; however, its implementation is still in progress and experimental data will be gathered in the near future.

Regarding numerical simulation, the model is under development, but it still needs further work and validation with experimental data.

- Evaluation methodology for PCM passive cooling

The Intensity of Thermal Discomfort is found to be the most relevant indicator, since it can give an idea about potential energy savings due to the use of PCM if HVAC systems are used. This parameter reflects the real situation for construction with significant heat gains, and with limited insulation or low thermal inertia. On the other hand, for buildings with high thermal inertia, heavy insulation, and with no solar gain, ITD is not representative of the PCM benefits. Moreover, ITD must be evaluated for both overheating and low temperatures discomfort.

# 6 Outcomes or future work

The outcome of the secondment refers to both research developed and proposed future ideas.

- PCM active system

A prototype of the active PCM storage system in the pitch roof is being constructed and will be evaluated in the future. Experimental results will be compared to numerical ones.

A journal paper is expected from this work.

- Evaluation methodology for PCM passive cooling

Results from this work have been submitted for publication to the journal Energy and Buildings (Albert Castell, Mohammed M. Farid. Experimental validation of a methodology to assess PCM effectiveness in cooling building envelopes passively. ENB-S-14-00886).

- Proposed future ideas

During the secondment new ideas to be tested at the Universitat de Lleida were proposed, since a PhD student from the University of Auckland will perform a secondment there. Based on the expertise of the PhD student and the facilities available in Lleida, experiments using a new control strategy based on electricity price will be developed using a heat pump system coupled to PCM tanks. Experiments will be performed under different weather conditions and results will enable to determine if the economic benefit of such system is feasible or not in a near future.

# 7 References

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# 8 Assessment

The objectives of the secondment were fulfilled. Although the research period was tight in time, two main topics were developed, being one already finalized and submitted for publication, and the other one in construction process. Therefore, the secondment is considered as successful. Moreover, the discussion and collaboration started between researchers and institutions will continue with further secondments and related ideas rising from discussions during this secondment.

The experience of working in a different environment and in a different way is very enriching. The knowledge gained during the stay will be of great profit in the future for the development of both the researcher career and further research projects.