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THERMAL ENERGY STORAGE WITH PHASE CHANGE MATERIALS (PCMS) FOR THE IMPROVEMENT OF THE ENERGY PERFORMANCE OF BUILDINGS

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MAIN GOALS

- **To evaluate how PCMs can be used to improve the energy performance of different typologies of residential buildings (lightweight steel-framed and heavyweight constructions) in different climates;**
- **To develop a methodology for the dynamic simulation of energy in buildings considering the influence of latent heat from the phase change processes;**
- **To develop a methodology for the assessment of the heat transfer through small thermal energy storage (TES) units to be used in the design of new construction solutions.**

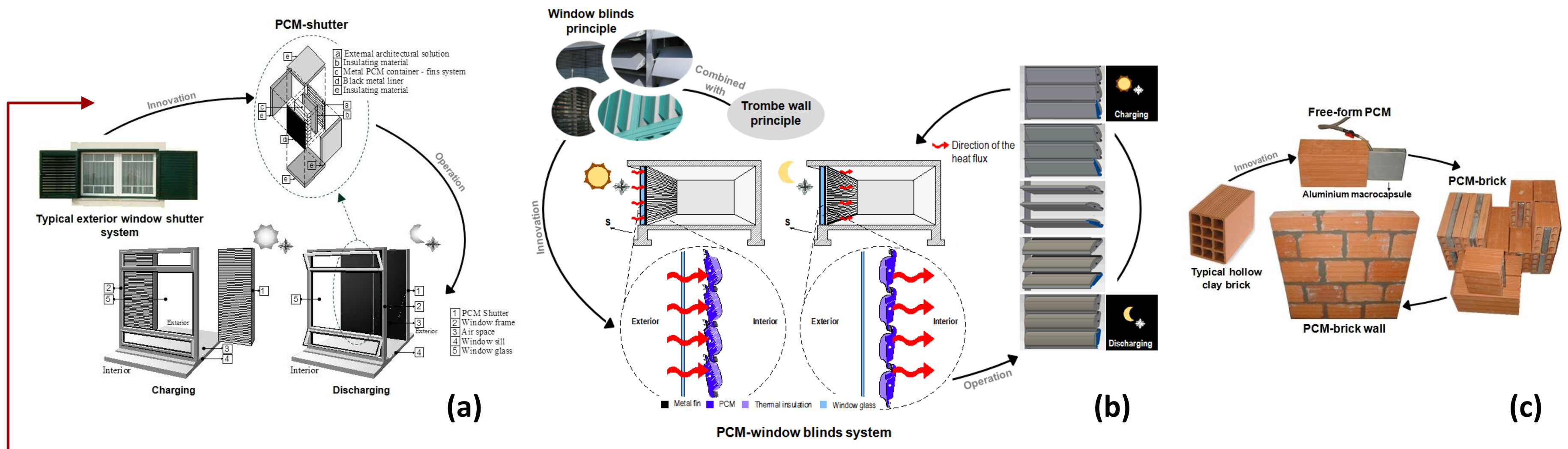


Fig. 1. Sketch of the configuration and operation of the (a) PCM-shutter system proposed by Soares *et al.* [2]; (b) PCM-window blinds system proposed by Soares *et al.* [3]; (c) PCM-brick proposed by Silva *et al.* [4].

PART A – HEAT TRANSFER WITH SOLID-LIQUID PHASE CHANGE

Experimental study of the heat transfer through a vertical stack of rectangular cavities filled with different PCMs (the free-form PCM – Rubitherm® RT 28 HC and the microencapsulated PCM – Micronal® DS 5001 X) [5].

Goals:

- To evaluate the melting and solidification processes;
- To discuss which PCM type is better for different buildings applications.

Methodology:

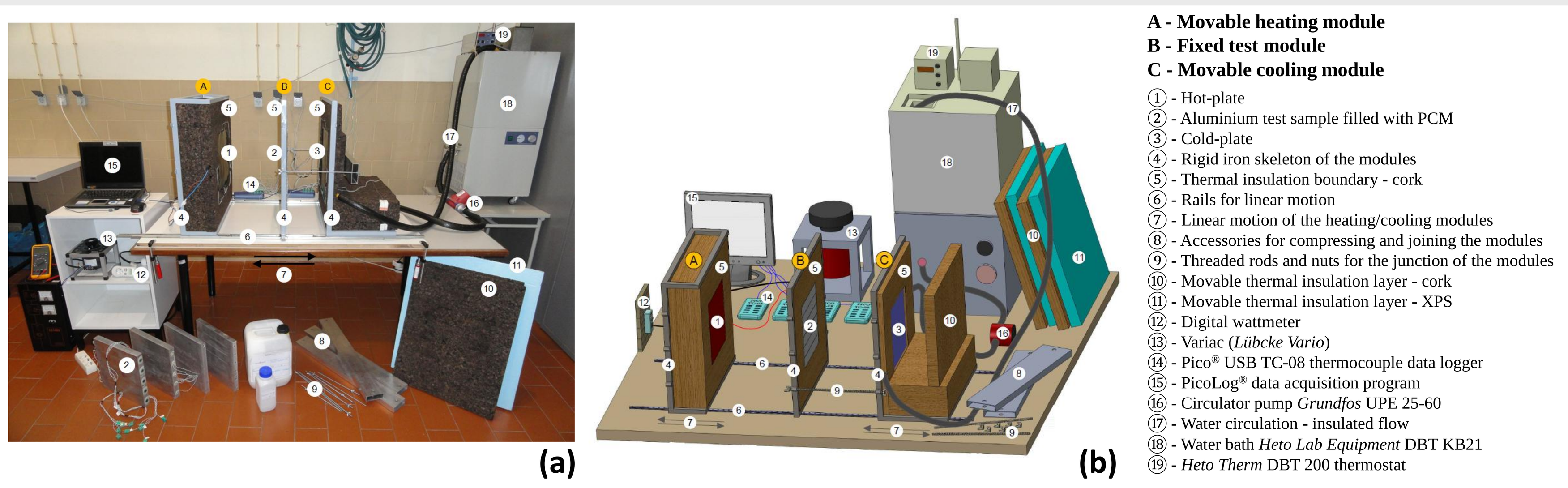


Fig. 2. (a) Photographic view and (b) 3D sketch of the experimental setup described by Soares *et al.* [5].

Results:

- Data for benchmarking and validation of numerical models;
- Assessment of the influence of natural convection and subcooling phenomena during charging and discharging.

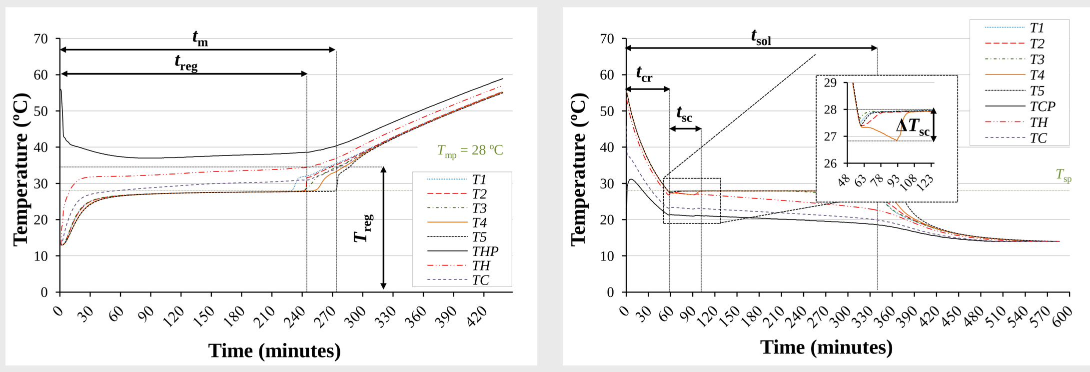


Fig. 3. Evolution of the average measured temperatures during (a) charging - 34 W power level, and (b) discharging - T_{water} = 14 ºC. 5 cavities test-sample filled with the free-form PCM - RT 28 HC.

Heat transfer through small TES units filled with PCMs for vertical buildings applications: experimental and parametric analysis [6].

Goals:

- To evaluate the thermal performance of several TES units considering 3 test samples filled with different cavity aspect ratios (A); 2 types of PCMs; 2 input power levels during charging; and 4 temperatures of the cooling water flow during discharging.

Methodology:

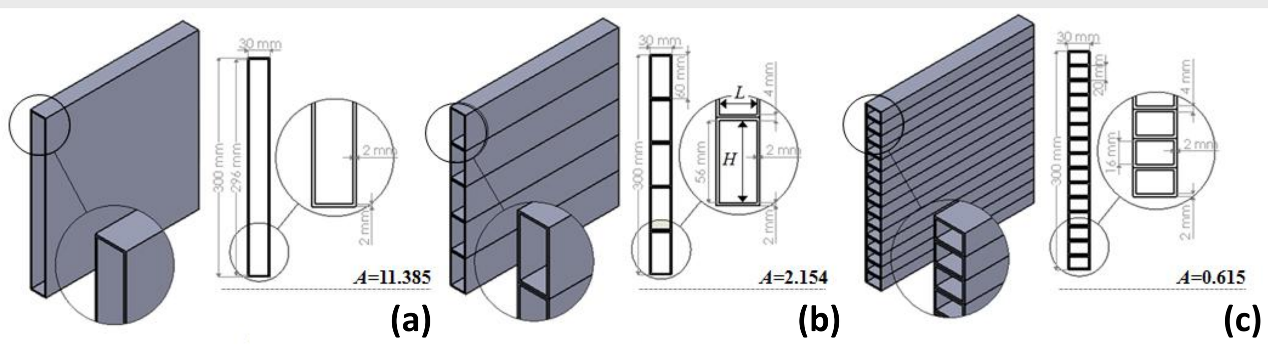


Fig. 4. Sketch of the 3 aluminum test samples used as PCM containers [6]: (a) 1 single rectangular cavity; (b) 5 cavities; (c) 15 cavities.

Results:

- The results allow discussing which arrangement is better for specific applications considering the thermal regulation effect of the TES unit during charging; the influence of subcooling during discharging, and the influence of natural convection during both processes.

Upcoming work

- Research project **"PCMs4Buildings"** - ***Systems with PCM-filled rectangular cavities for the storage of solar thermal energy for buildings***, ref. POCI-01-0145-FEDER-016750 (FEDER) | PTDC/EMS-ENE/6079/2014 (FCT), co-funded by the European Fund for Regional Development (FEDER), COMPETE 2020 - Operational Program for Competitiveness and Internationalization (POCI), Portugal 2020 and by the Portuguese Foundation for Science and Technology I.P. (PIDDAC).

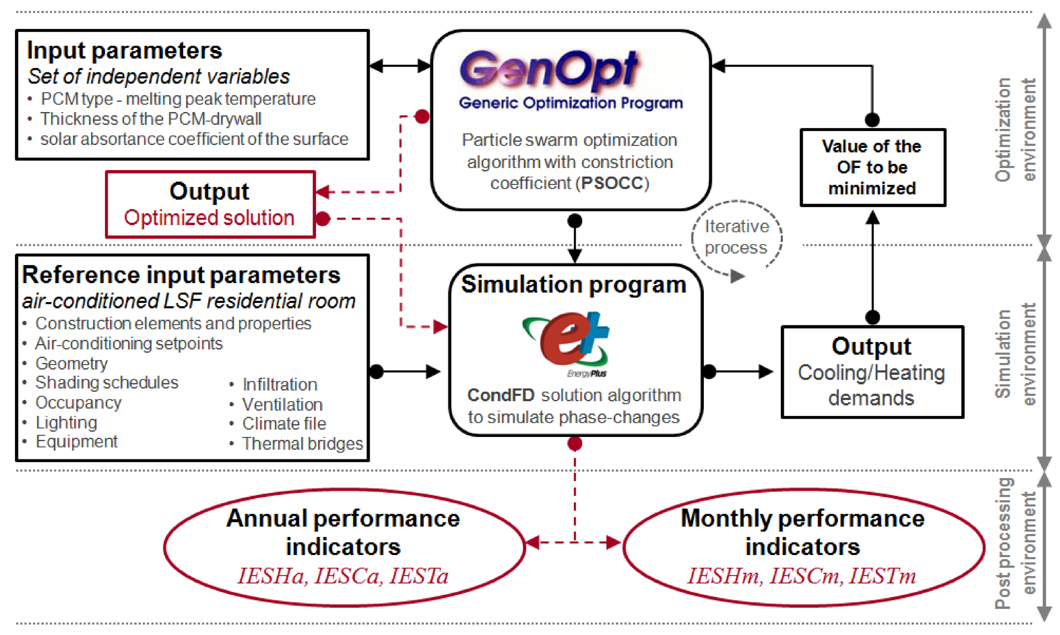
PART B – DYNAMIC SIMULATION OF ENERGY IN BUILDINGS

Multi-dimensional optimization of the incorporation of PCM-drywalls in lightweight steel-framed (LSF) residential buildings in different European climates [7].

Goals:

- To optimize the impact of PCM-drywalls in the annual heating and cooling energy-saving of an air-conditioned LSF residential single-zone building, considering real-life conditions and 7 European climates (Köppen-Geiger climate classification).

Methodology:



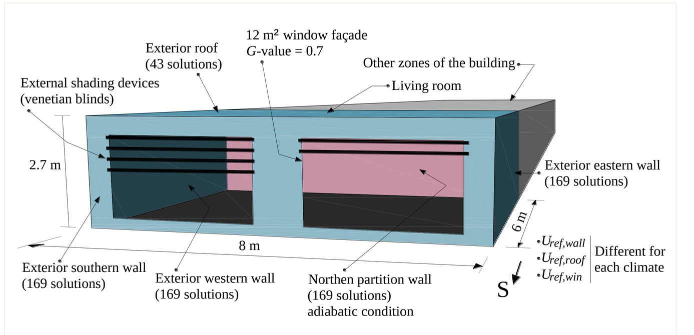


Fig. 5. Sketch of the room model described by Soares *et al.* [7].

Fig. 6. Sketch of the methodology carried out and described by Soares *et al.* [7].

Results:

- An optimum PCM-drywall solution was found for each climate leading to significant annual energy savings.

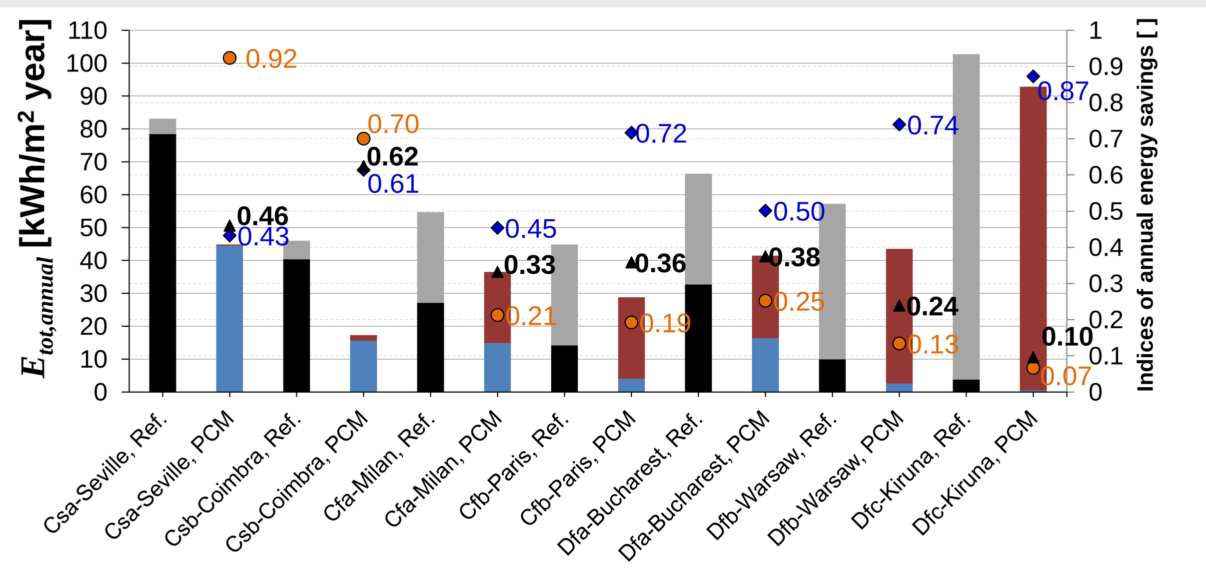


Fig. 7. Heating and cooling energy demand for both the reference and the PCM-enhanced rooms for each climate. Indices of annual energy savings for each climate considering the optimized solution.

PCM-drywalls for reducing cooling demand and cooling peak loads in residential heavyweight buildings in Kuwait in the framework of the MIT-Kuwait Signature Project - "Sustainability of Kuwait's Built Environment" [8].

Goals:

- To discuss the existence of a fully-customized PCM-drywall solution regarding its thickness and the melting-peak temperature of the PCM; to evaluate the impact of PCM-drywalls in the reduction of both cooling demand and peak loads; to provide some guidelines for incorporating PCM-drywalls in Kuwait.

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References

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