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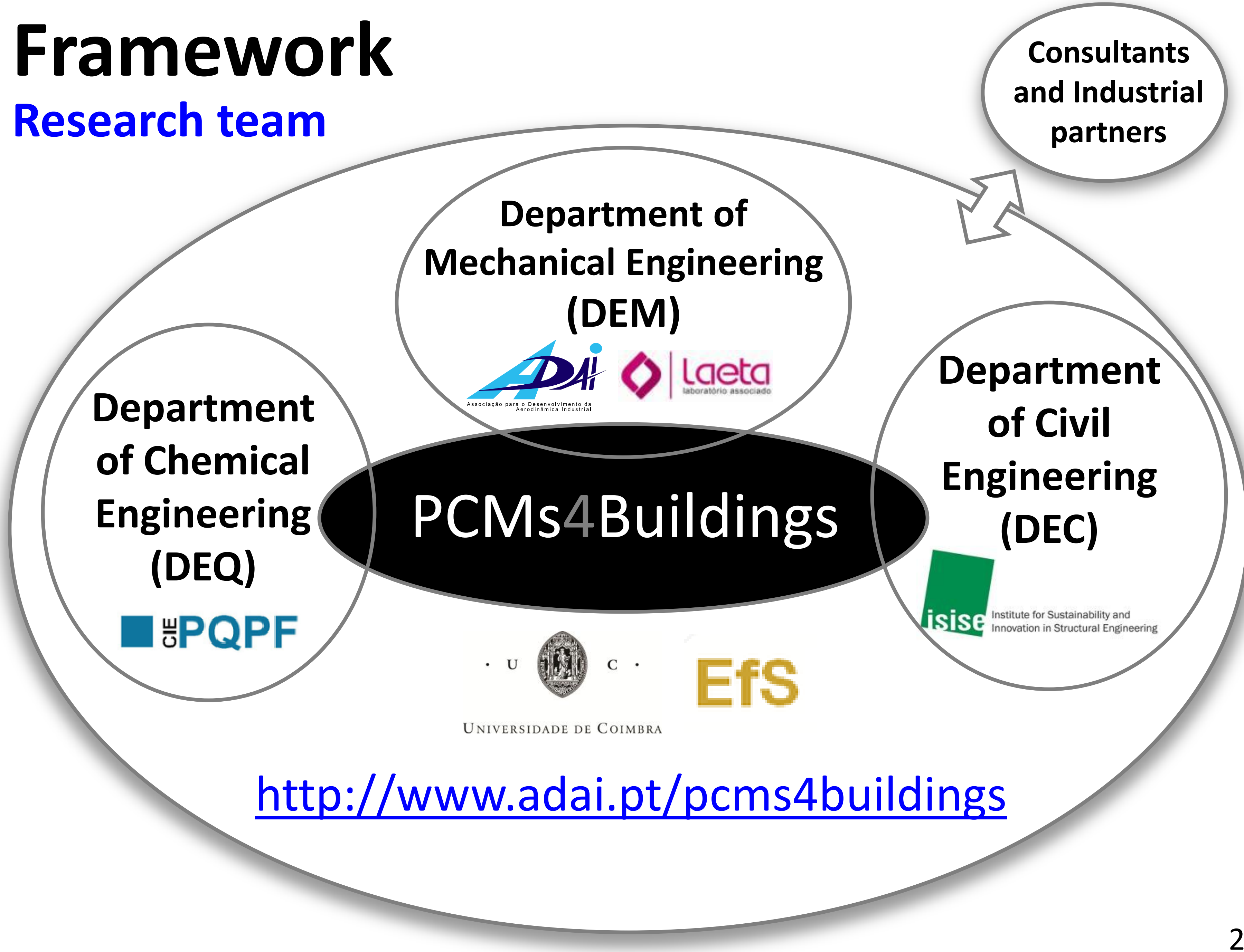
Temperature regulation of polycrystalline silicon photovoltaic panels with movable thermal energy storage units filled with phase change materials

N. Soares[1,2], A.R. Gaspar[1], T. Matias[3], A.G. Lopes[1], P.N. Simões[3], L. Durães[3], J.J. Costa[1]

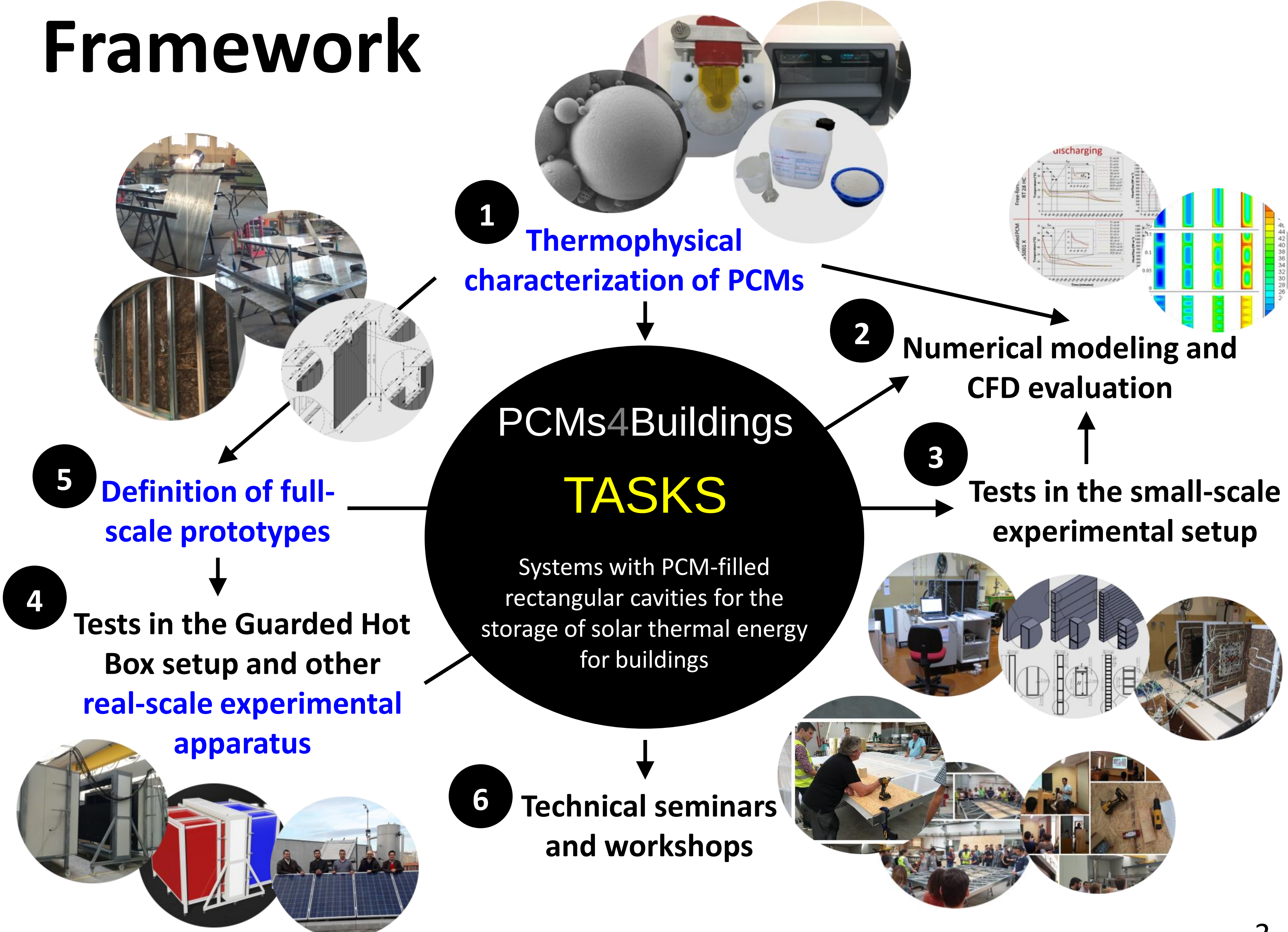
[1] ADAI, LAETA, Department of Mechanical Engineering, University of Coimbra, Coimbra, Portugal
[2] ISISE, Department of Civil Engineering, University of Coimbra, Coimbra, Portugal
[3] CIEPQPF, Department of Chemical Engineering, University of Coimbra, Portugal

Framework

Research team



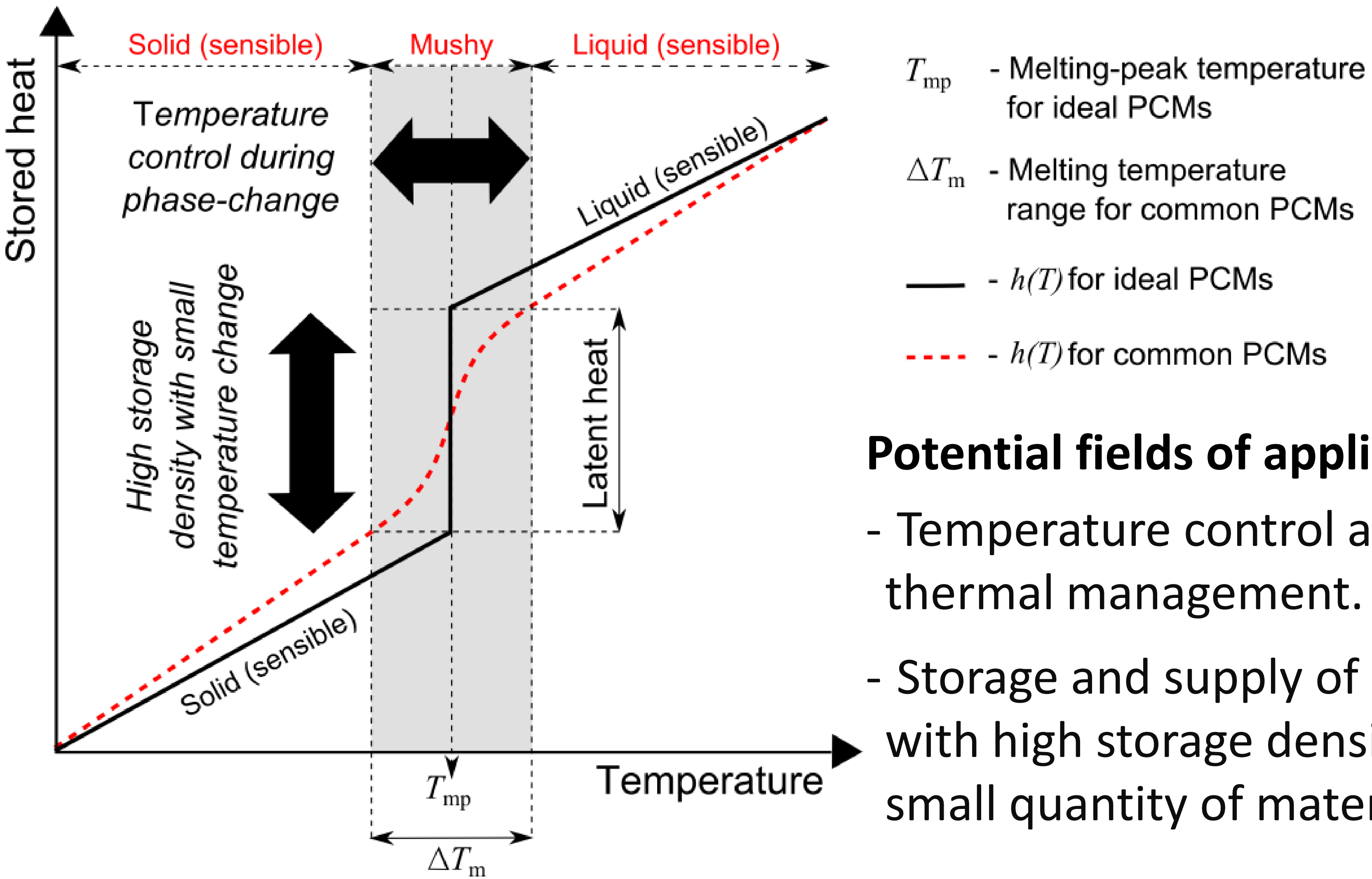
Framework



PCMs4Buildings
TASKS
Systems with PCM-filled rectangular cavities for the storage of solar thermal energy for buildings
1 Thermophysical characterization of PCMs
2 Numerical modeling and CFD evaluation
3 Tests in the small-scale experimental setup
4 Tests in the Guarded Hot Box setup and other real-scale experimental apparatus
5 Definition of full-scale prototypes
6 Technical seminars and workshops

Framework

PCMs How do they work?



Potential fields of application:

- Temperature control and thermal management.
- Storage and supply of heat with high storage density in a small quantity of material.

Framework

Problem

High operating temperatures reduce the performance of commercial polycrystalline silicon photovoltaic (PV) devices by reducing the efficiency of solar to electrical energy conversion in the PV cells. !

Several strategies have been proposed to mitigate overheating of PV systems and to prevent resulting power loss, including natural or forced air ventilation, hydraulic or refrigerant cooling and the use of PCMs.

Research question

Can movable PCM-filled thermal energy storage (TES) units be used to improve the efficiency of polycrystalline silicon PV panels?

Goals

- To develop a real-scale experimental apparatus to evaluate the performance of PV/PCM systems incorporating movable TES units filled with free-form PCMs. **The TES units are intended to control the temperature rise in the PV cells**;

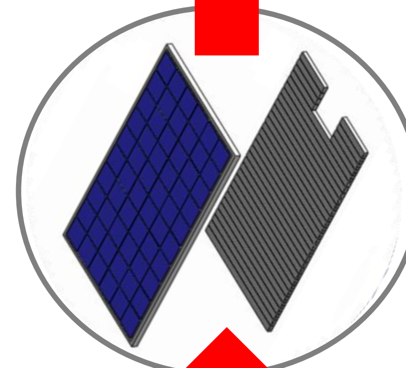
- To carry out an experimental parametric study to evaluate the influence of different configurations of the TES unit (horizontally and vertically oriented cavities) and the impact of different phase-change temperature ranges of the PCM;

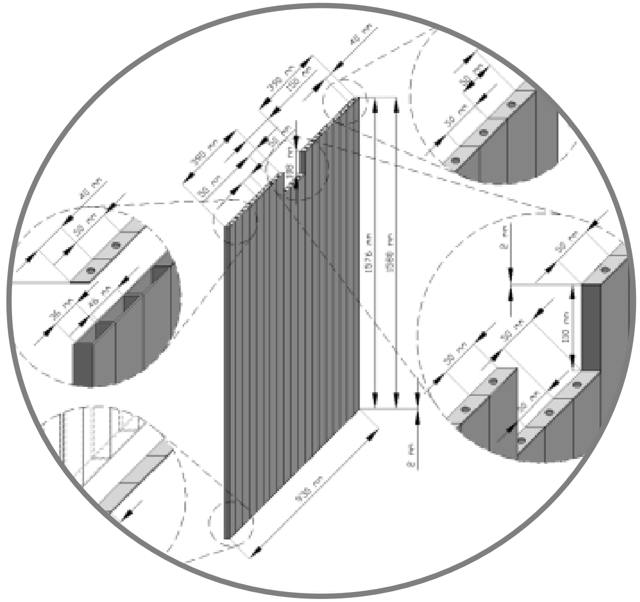
- To experimentally evaluate the main thermophysical properties of the PCMs used;

- To provide reliable experimental results for numerical validation purposes.

Overall methodology

Monitoring the performance of the PV/PCM systems in outdoor conditions

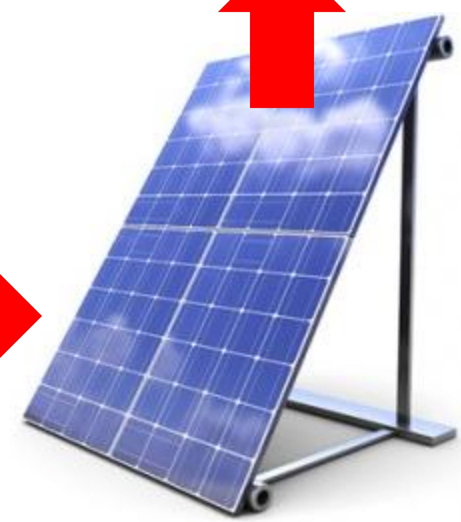




Thermophysical characterization of the PCM

Free-form PCM

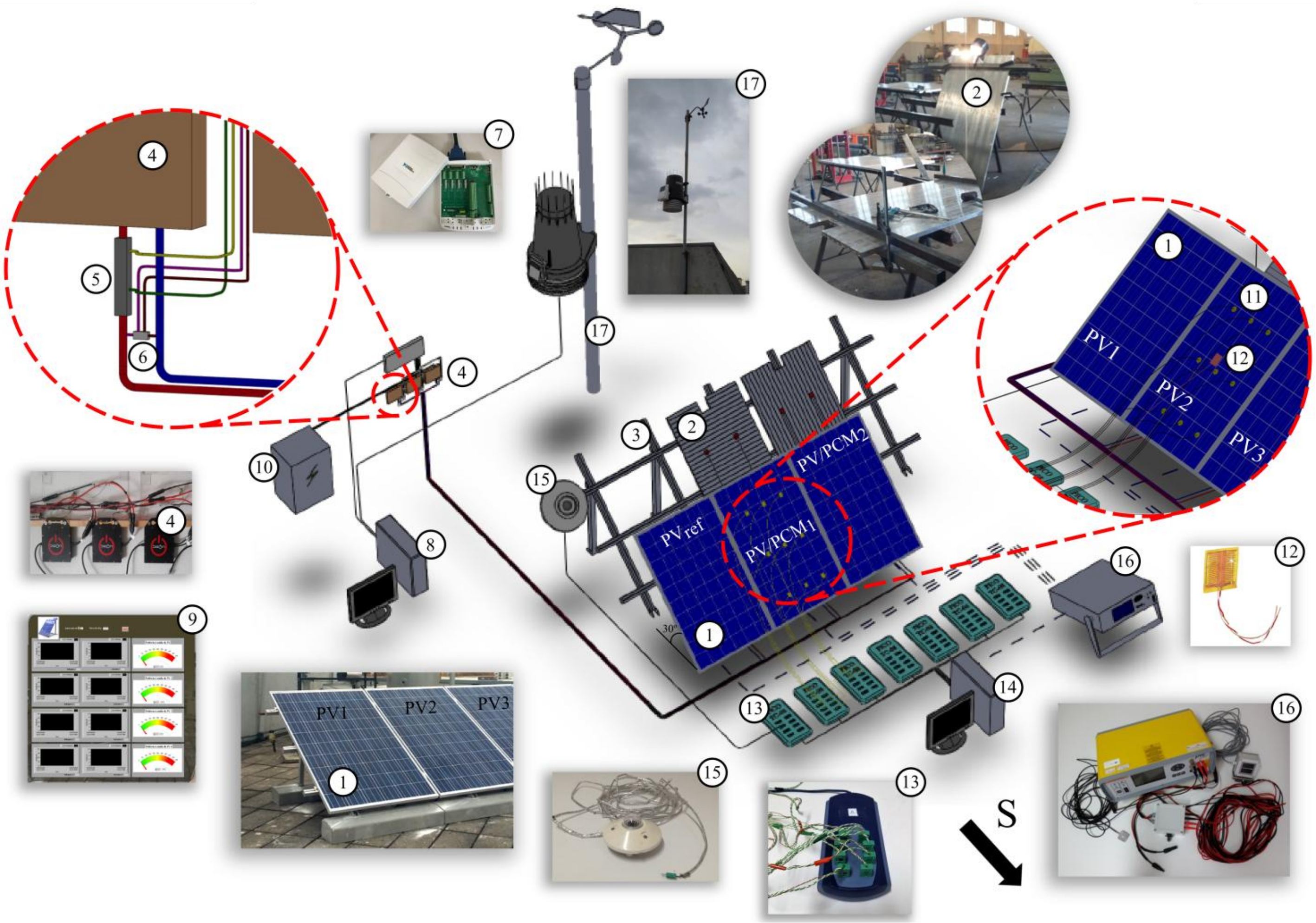
TES unit



Assembly PV/PCM Systems

Assembly of the PV/PCM systems

Experimental apparatus



1. *Risen* RSM60-6-250P PV modules
2. TES units filled with the PCM
3. Support system
4. DC/AC microinverter *BeOn*
5. Shunt resistor
6. Voltage divider
7. *National Instruments*™ SCC-68 I/O connector block
8. Computer for data acquisition
9. *LabView*™ program interface - current, voltage and power monitoring/recording
10. Main service panel
11. Thermocouples (K-type)
12. *Omega*™ flexible heat flux sensor HFS-4
13. *Pico*® USB TC-08 thermocouple data logger
14. *PicoLog*® data acquisition program
15. *Kipp&Zonen* CM11 pyranometer
16. PVPM2540C mobile peak power and *I-V*-curve measurement device for PV modules
17. *Davis Instruments* Vantage Pro2™ weather station

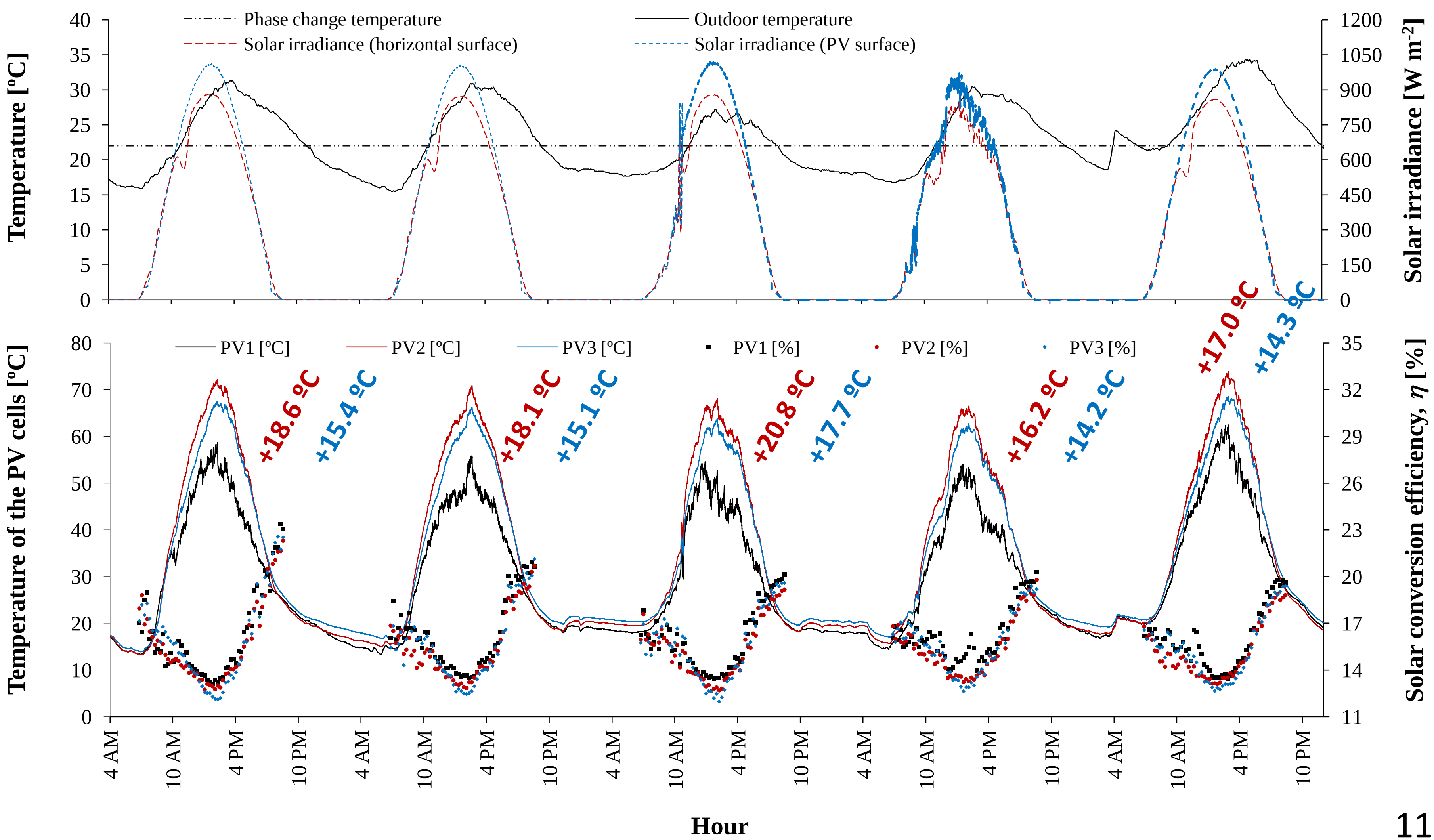
Monitoring data:

- Time evolution of temperature and heat flux on the surfaces of both the PV panels and the TES units to be compared with each other;
- Time evolution of current and voltage of each PV module to determine the power output of each PV and the solar conversion efficiency;
- Time evolution of the weather conditions.

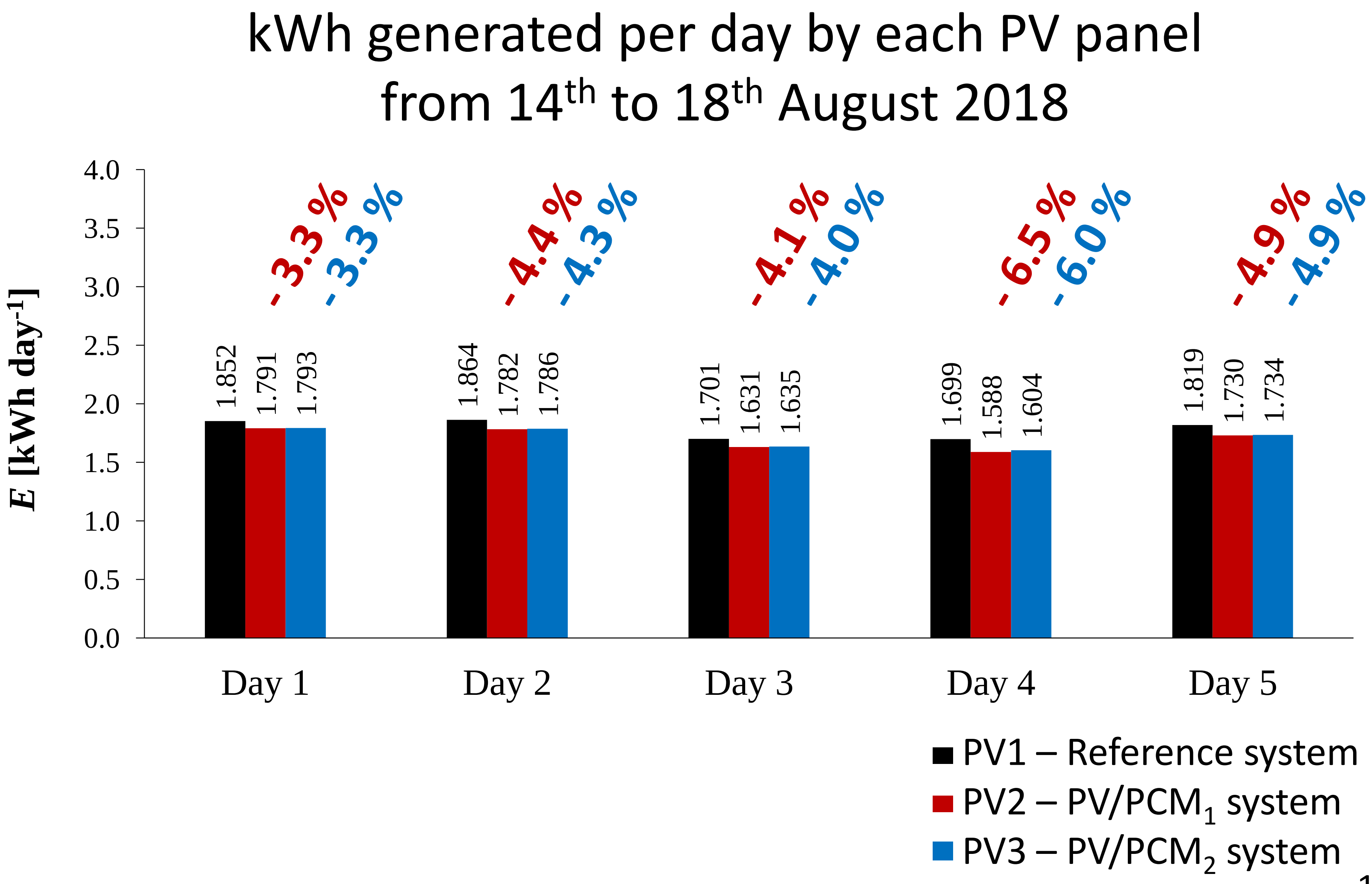
Location: *Coimbra, Portugal.*
Measurements: *during summer, 2018.*

Preliminary results

Time evolutions of the weather conditions, temperature of the PV panels and solar conversion efficiency of the PV panels from 14th to 18th August 2018



Preliminary results



Main conclusions

- The PV operating temperature has increased ca. 16–21ºC and 14–18 ºC in the PV/PCM_1 and PV/PCM_2 systems, respectively, in comparison with the reference PV panel (at peak time).
- The daily energy produced by the PV panel of the PV/PCM_1 and PV/PCM_2 systems was, respectively, 3.3–6.5% and 3.3–6.0% lower than that produced by the reference PV panel during the measured short-term summer operation period.
- **The movable TES units filled with the PCM RT 22 HC (with a phase-change temperature of about 22 ºC) have a negative impact on the performance of the PV/PCM systems during the summer conditions under evaluation.**
- **A PCM with a higher phase-change temperature must be chosen to fill-up the movable TES units!**

Forthcoming work

- Evaluation of the influence of the movable TES units filled with the PCM RT 22 HC during winter and middle seasons.
- Evaluation of the influence of the movable TES units filled with PCMs with higher phase-change temperature ranges through the year.
- To investigate the influence of a movable metallic fin-enhanced heat dissipator to be placed on the TES units' back to improve the discharging of the PCM during the night.

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Thank you!

Nelson Soares
nelson.soares@dem.uc.pt
http://www.adai.pt/pcms4buildings

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