Example name: PCM in building envelopes for passive and active systems

Template completed by:
Luisa F. Cabeza
University of Lleida (UdL), Spain
lcabeza@diei.udl.cat

For installations

BISTS Location: *Puigverd de Lleida, 0°44'14"E, 41°32'56"N*
Climate Type: *Csa*
Building Use: *Experimental set-up which can simulate residential or commercial schedules.*

Level of BISTS integration
According to Rush classification the installation is equipped with Level1, Level2 and Level3 systems

x New Build
x Refurbishment
O Other:
……………………

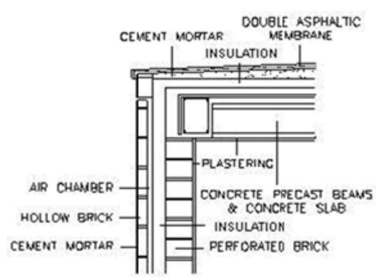
Type of BISTS:

Passive and Hybrid systems

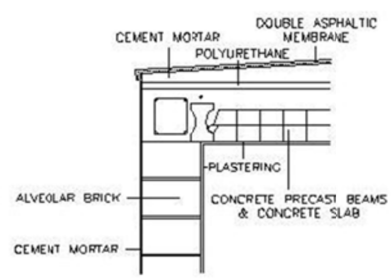
Function(s):
x Air heating
O Water heating
O Combi-system
x Cooling / ventilation / shading
O PV/T
O linked to another system
(e.g., heat pump)
O Other:
……………………….

Drawings/Sketches/Cross-sections

Passive systems



PERFORATED BRICK MORPHOLOGY

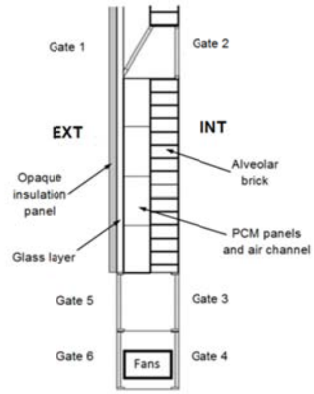


ALVEOLAR BRICK MORPHOLOGY

Hybrid systems

Building element:

x Facade
x Roof
O Other:
……………………..



BISTS characteristics:

Use of macro-encapsulated PCM in the building envelope to reduce the cooling load during summer period. Experimental tests showed a reduction of 18% in the electrical energy consumption of the HVAC to achieve a certain set point.

Use of macro-encapsulated PCM in the air chamber of a ventilated double skin facade. The PCM is used to reduce both heating and cooling loads. During winter, the solar energy melts the PCM, this heat can be stored to provide a heating supply when needed. The use of this system achieves net energy savings of 21% in comparison to a reference.
Moreover, the same system is used to provide a cooling supply in summer, using the low temperatures at night to solidify the PCM.

Stage of Development:	**Responsible:** *Research institute, Company, etc.*
O Idea/Patent	…………………………………..
X Prototype	UdL (collaboration with University of Sevilla,
X Demonstration	and the companies DETEA, AIDEPLA)
O Integral building element	…………………………………..
O Commercially available	…………………………………..

BISTS description and context

The experimental set-up consists of 20 different cubicles which are used to test different passive and hybrid systems. The inner dimensions of the passive cubicles are 2.4 m x 2.4 m x 2.4 m, while the dimensions of the hybrid ones are 2.4 m x 2.4 m x 5.1 m.

System viability

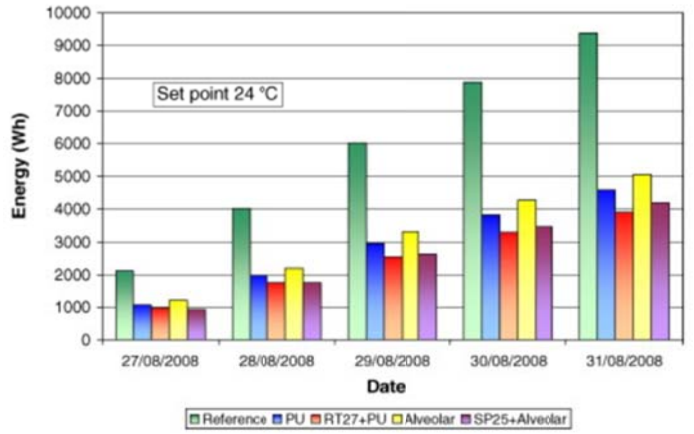
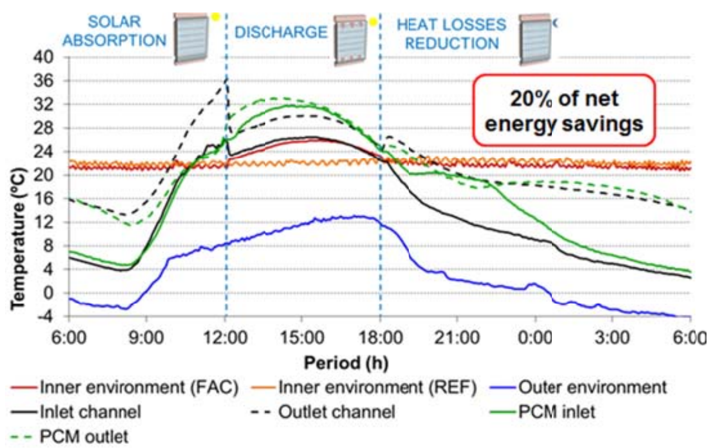
The environmental impact of both passive and hybrid systems has been analysed using LCA methodology.
Concerning the use of PCM as passive systems, the addition of PCM does not produce a significant variation of global impact results because the impact savings achieved during the operational phase are balanced out with the manufacturing impact of PCM. Moreover, It is better to use salt hydrates than paraffins in order to reduce the manufacturing/disposal impact.

On the other hand, the use of PCM in the VDSF reduces 7.5% the overall environmental impact if considering a building lifetime of 50 years.

Modelling and simulation tools developed/used

For the hybrid system an own developed numerical model was validated using experimental data from the set-up. The model was based on a control volume approach and was used to improve the operational schedule of the charge/discharge process of the VDSF with PCM for cooling purposes.

Moreover, EnergyPlus simulations have been driven for improve the design of the passive systems with PCM.

BISTS Performance data	Energy consumption of the HVAC using PCM as passive systems:
Based on: O Estimation O Detailed simulation *Specify software(s) used* O Measurement/testing x Long-term monitoring *tick all that apply* **Performance parameters** For integrated systems: key performance indicators - *Net energy savings during cooling season with passive systems: 18%* *Net energy savings during heating season with hybrid systems: 20%* For separate collectors: performance rating coefficients - (EN12975, a0,a1,a2), ASHRAE, etc Other:	 Thermal profiles of the VDSF with PCM in its air chamber 
Additional information:	

Sources and references:

Castell A, Martorell I, Medrano M, Pérez G, Cabeza L.F, Experimental study of using PCM in brick constructive solutions for passive cooling, Energy and Buildings 42 (2010) 534-540.

de Gracia A, Rincón L, Castell A, Jiménez M, Boer D, Medrano M, Cabeza L.F, Life cycle assessment of the inclusion of phase change materials (PCM) in experimental buildings, Energy and Buildings 42 (2010) 1517-1523.

Menoufi, K., Castell, A., Navarro, L., Pérez, G., Boer, D., Cabeza, L.F., Evaluation of the environmental impact of experimental cubicles using Life Cycle Assessment: A highlight on the manufacturing phase, Applied Energy 92 (2012) 534-544.

de Gracia A, Navarro L, Castell A, Ruiz-Pardo A, Álvarez S, Cabeza L.F, Experimental study of a ventilated façade with PCM during winter period, Energy and Buildings 58 (2013) 324-332.

de Gracia A, Navarro L, Castell A, Cabeza L.F, Numerical study on the thermal performance of a ventilated façade with PCM, Applied Thermal Engineering 61 (2013) 372-380.

Rincón, L., Castell, A., Pérez, G., Solé, C., Boer, D., Cabeza, L.F., Evaluation of the environmental impact of experimental buildings with different constructive systems using Material Flow Analysis and Life Cycle Assessment, Applied Energy 109 (2013) 544-552.

De Gracia, A., Navarro, L., Castell, A., Ruiz-Pardo, Á., Álvarez, S., Cabeza, L.F., Thermal analysis of a ventilated facade with PCM for cooling applications , Energy and Buildings 65 (2013) 508-515.

Menoufi, K., Castell, A., Farid, M.M., Boer, D., Cabeza, L.F., Life Cycle Assessment of experimental cubicles including PCM manufactured from natural resources (esters): A theoretical study, Renewable Energy 51 (2013) 398-403.

Castell, A., Menoufi, K., de Gracia, A., Rincón, L., Boer, D., Cabeza, L.F., Life Cycle Assessment of alveolar brick construction system incorporating phase change materials (PCMs), Applied Energy 101 (2013) 600-608.

INSTRUCTIONS

Please fill in as much information as possible.

Tick where appropriate.

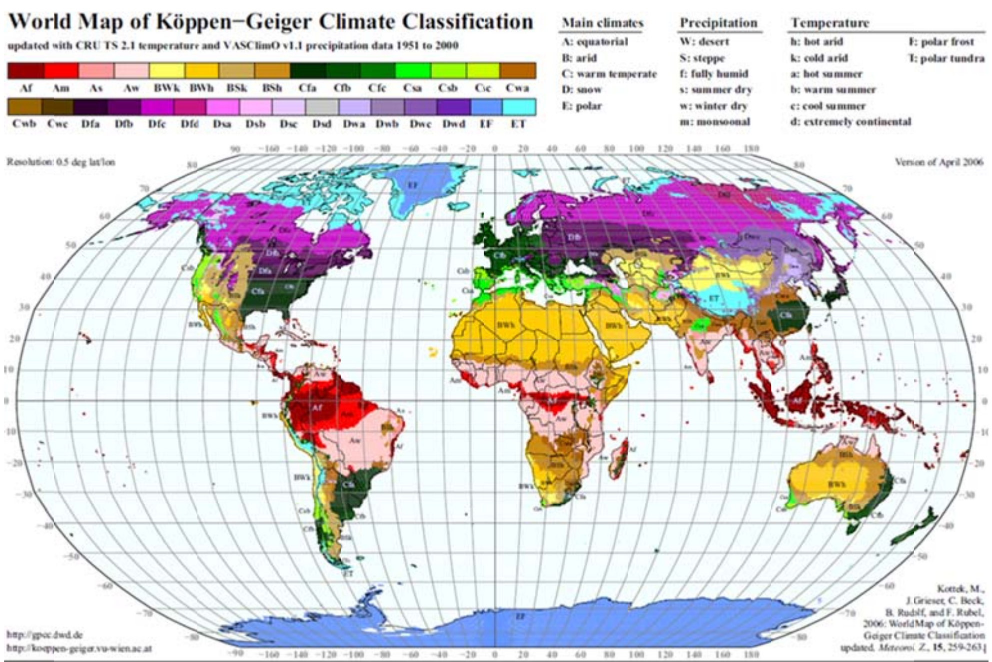
Text in red is suggested guidance. Insert information in provided space, removing red text as appropriate

If possible, use metric values.

If necessary, supply additional information on separate sheets

Reference listing

Köppen climate classification



(Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel, 2006: World Map of Köppen-Geiger Climate Classification updated. Meteorol. Z., 15, 259-263.)

Reijenga classification

The integration of PV systems in architecture can be divided into five categories:

1. Applied invisibly
2. Added to the design
3. Adding to the architectural image
4. Determining architectural image
5. Leading to new architectural concepts.

(Reijenga, TH and Kaan, HF. (2011) PV in Architecture, in Handbook of Photovoltaic Science and Engineering, Second Edition (eds A. Luque and S. Hegedus), John Wiley & Sons Ltd, Chichester, UK)

Rush classification

The architectural/visual expression of building services systems are identified as:

Level 1. Not visible, no change
Level 2. Visible, no change
Level 3. Visible, surface change
Level 4. Visible, with size or shape change
Level 5. Visible, with location or orientation change

(Rush, RD. (1986) The Building systems integration handbook Wiley, New York, USA)

Collector test standards

BS EN 12975-2 2006 ‘Thermal solar systems and components solar collectors - Part 2 test methods’
ASHRAE Standard 93-2010 ‘Methods of Testing to Determine the Thermal Performance of Solar Collectors’
ASHRAE Standard 95-1987 ‘Methods of Testing to Determine the Thermal Performance of Solar Domestic Water Heating Systems’