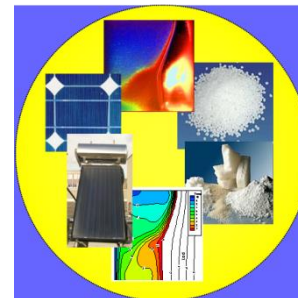
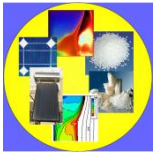




## Energy saving potential of a hybrid BIPV-T system integrated with heat storage material

Laura Aelenei  
21 de Junho de 2013



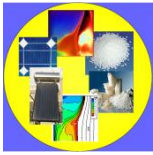


# 1. Background

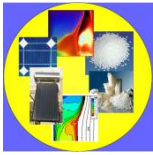
FRAME project  
Solar XXI building

# 2. Experimental analysis BIPV-T/PCM

Methodology and Results  
Conclusions



background - *FRAME project*



## FRAME

*Prefabricated systems for low-energy buildings: design, modulation, prototyping and testing*



## FRAME

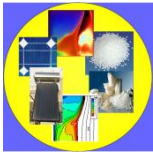
Prefabricated systems for low-energy buildings: design, modulation, prototyping and testing

**Starting date:** 15 of April 2012

**Duration:** 24 months

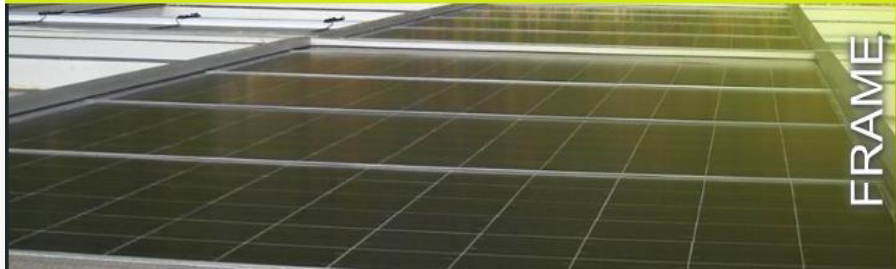
### Objectives

- scientific investigation (numerical and experimental) of the heat and mass transfer phenomena through a building integrated façade module, deep thermal efficiency analysis of the main processes (convection, radiation, conduction) developing through the module expecting to bring out the geometrical, physical features and the ventilation strategies for which the system will be likely to exhibit a maximum thermal and energy efficiency;
- study of innovative system, a prefabricated façade system integrating photovoltaic modules (PV) and phase change materials (PCM), in order to broaden knowledge of potential uses of PCM in energy storage applications and to increase PV efficiency by providing an energy storage mechanism thereby improving supply and demand load matching.
- integrated in building façade contribute to sustainable and energy efficient rehabilitation of buildings and also to the achievements of EU 2020 targets (20% reduction of energy demand, 20% ratio of renewable energy sources of the final energy consumption, 20% reduction of CO2 emissions).



## FRAME

*Prefabricated systems for low-energy buildings: design, modulation, prototyping and testing*



## FRAME

Prefabricated systems for low-energy buildings: design, modulation, prototyping and testing

**Starting date:** 15 of April 2012

**Duration:** 24 months

### Work plan

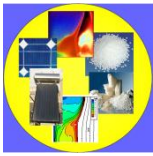
#### **Task 1:** Numerical evaluation and optimization (MATLAB/SIMULINK)

Scientific numerical investigation of the heat and mass transfer phenomena through the building integrated façade modules.

#### **Task 2:** Experimental evaluation: construction, integration on SOLARXXI building facade

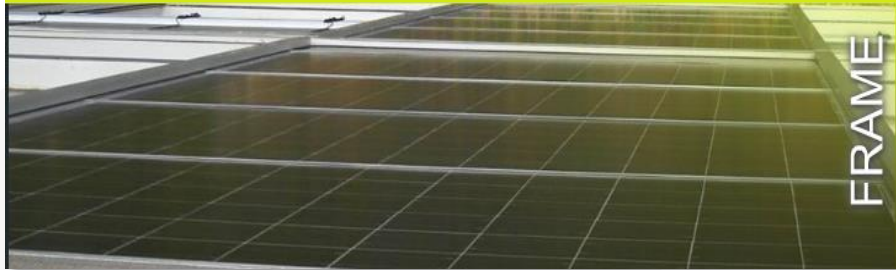
Two prototypes will be constructed and extensively tested through 12 month period under real conditions. Temperature and heat flux sensors will be installed on each system layers and in the air gap.

**Task 3:** Building Energy Savings Assessment: Energy Plus simulation towards the evaluation of the impact of the integration of the prefabricated module on the thermal comfort and on energy demand, economic cost-effective analysis.



## FRAME

*Prefabricated systems for low-energy buildings: design, modulation, prototyping and testing*



## FRAME

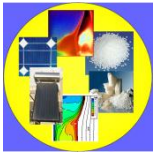
Prefabricated systems for low-energy buildings: design, modulation, prototyping and testing

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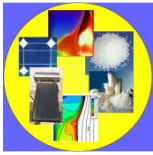
**Duration:** 24 months

### Stage of development (1/2 of the project)

- Numerical model developed and validated
- 1st Prototype installed and tested for the Winter conditions (and Spring time);
- 1st simulations for optimization started (changing the air gap width, PCM, operation mode, flow rate);
- Task 3 started – building energy savings assesment for a small scale space (one room), validation of the numerical model with experimental results



background - *Solar XXI building*



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**General characteristics**

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**Location**

Lisbon

Latitude 38°46'20.27" north

Longitude 9°10'39.83" west

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**Owner**

National Energy and Geology Laboratory (LNEG)

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**Project co-ordinator**

Helder Gonçalves

[helder.goncalves@lneg.pt](mailto:helder.goncalves@lneg.pt)

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**Architect**

Pedro Cabrita, Isabel Diniz

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**Building costs (tax included)**

800 €/m<sup>2</sup>

---

**Typology**

Office building

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**Climate data**

Temperate

Heating period 5.3 month

Heating Degree Days 1190°C (Tb 20°C)

---

**Main stimulation of the project**

Test, experimental, research

---

**Site context**

Urban

---

**Building construction**

High

---

**Number of occupants**

20 pc

---

**Number of stories**

3 pc

---

**Number of buildings**

1pc

---

**Heated net floor area**

1200 m<sup>2</sup>

---

**Gross floor area**

1500 m<sup>2</sup>

---

**Total envelope area**

1436 m<sup>2</sup>

---

**Envelope to volume ratio**

0.4 m<sup>-1</sup>

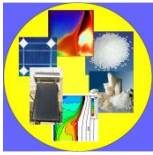
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Laura Aelenei



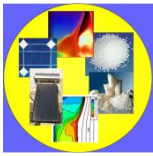
## SOLAR XXI

### general informations



The main objective of the project Solar XXI building was to design a office building with low energy consumption, integrating renewable technologies (solar thermal and photovoltaic) and passive systems for heating and cooling.

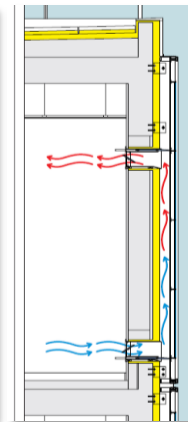
The strategies and systems were planned and integrated from the beginning of its design.

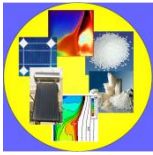


The building was constructed to maximize the use of renewable energy, integrating the following solutions and strategies:

### Winter time

- Optimization of thermal envelope;
- Increase the area of solar heat gains – south solar façade, as a direct gain system for heating;
- BIPV-T, heat recovery by natural convection in the photovoltaic façade for indoor environmental heating;
- Solar collectors for heating purpose



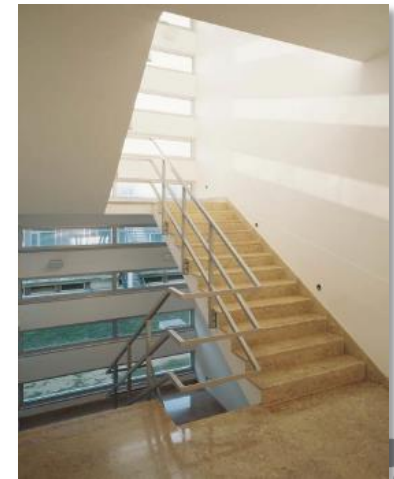


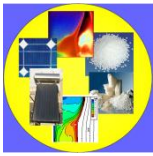
The building was constructed to maximize the use of renewable energy, integrating the following solutions and strategies:

Summer time:

- External shading devices in the south oriented windows;
- Passive cooling system using buried pipes;
- Natural ventilation;

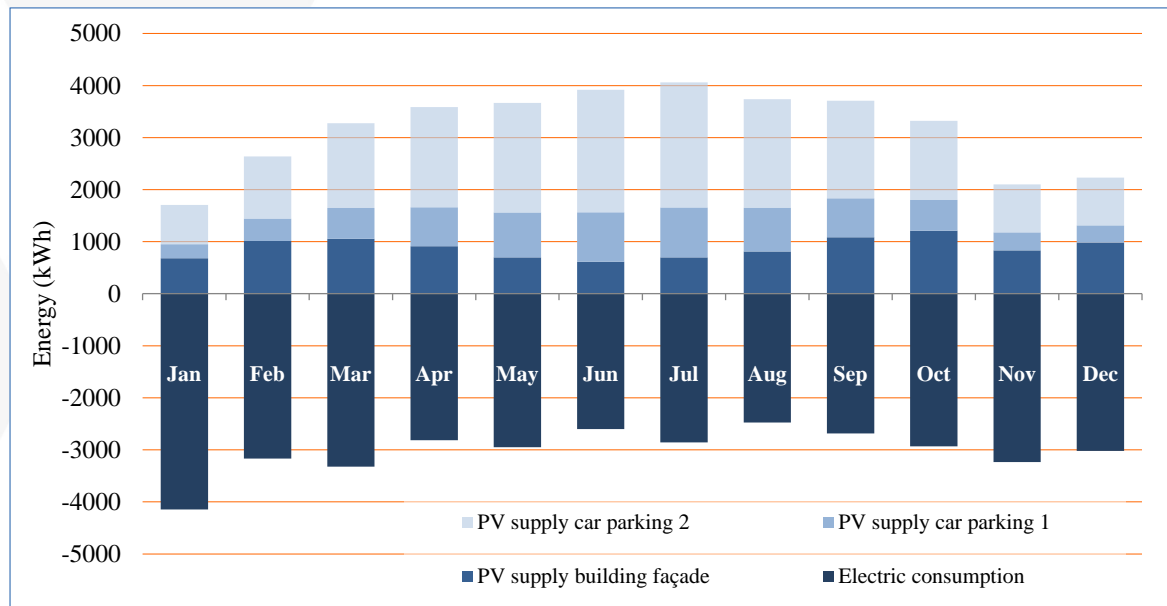
Natural lighting: large windows area, skylights

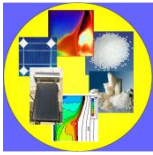




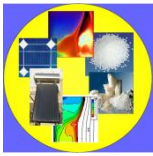
## Renewable Energy Systems

RES	Integration	Area (m <sup>2</sup> )	Installed Peak power (kW)	Productivity (kWh/kW)
76 PV multicristalline silicon modules	Building façade	96	12	1004
100 PV amorphous silicon	Car parking 1	95	6	1401
150 PV CIS thin-film modules	Car parking 2	110	12	1401
CPC Thermal Solar Collectors	Building roof	16	11 MWh, from which 5MWh being used	





# Experimental analysis *BIPV-T/PCM*



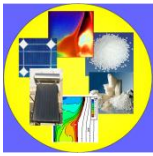
## DESCRIPTION OF THE SYSTEM



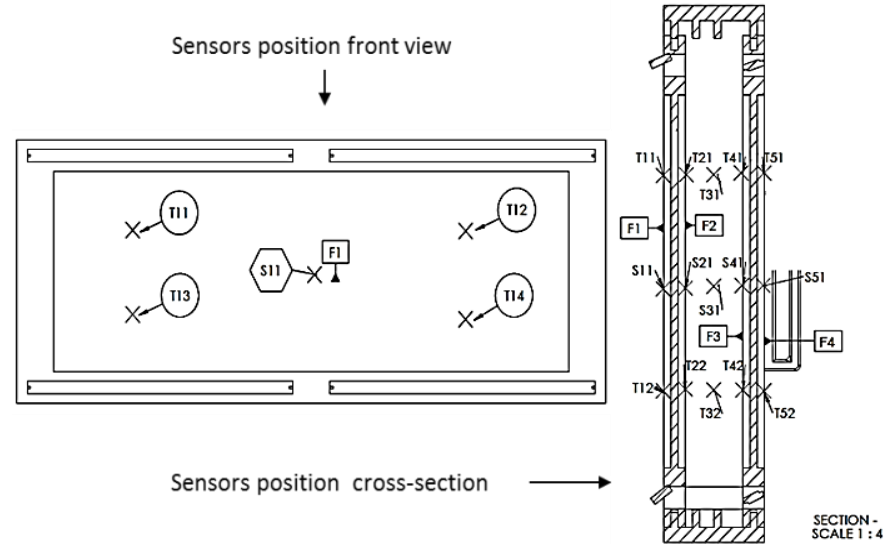
Material	Density (Kg/m <sup>3</sup> )	Specific heat (J/Kg K)	Thermal conductivity (W/m K)	Specifications
PV	2330	677	148	PV and PCM absorptivity and emissivity is 0.9
PCM gypsum board	1000	1800	0.27	Latent heat of PCM is 210 KJ/m <sup>2</sup>

### PCM CHARACTERISTICS

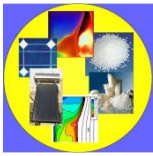
Alba@balance plasterboard construction material contains specially developed PCM microcapsules which change phase within comfort zone (23°C or 26°C)



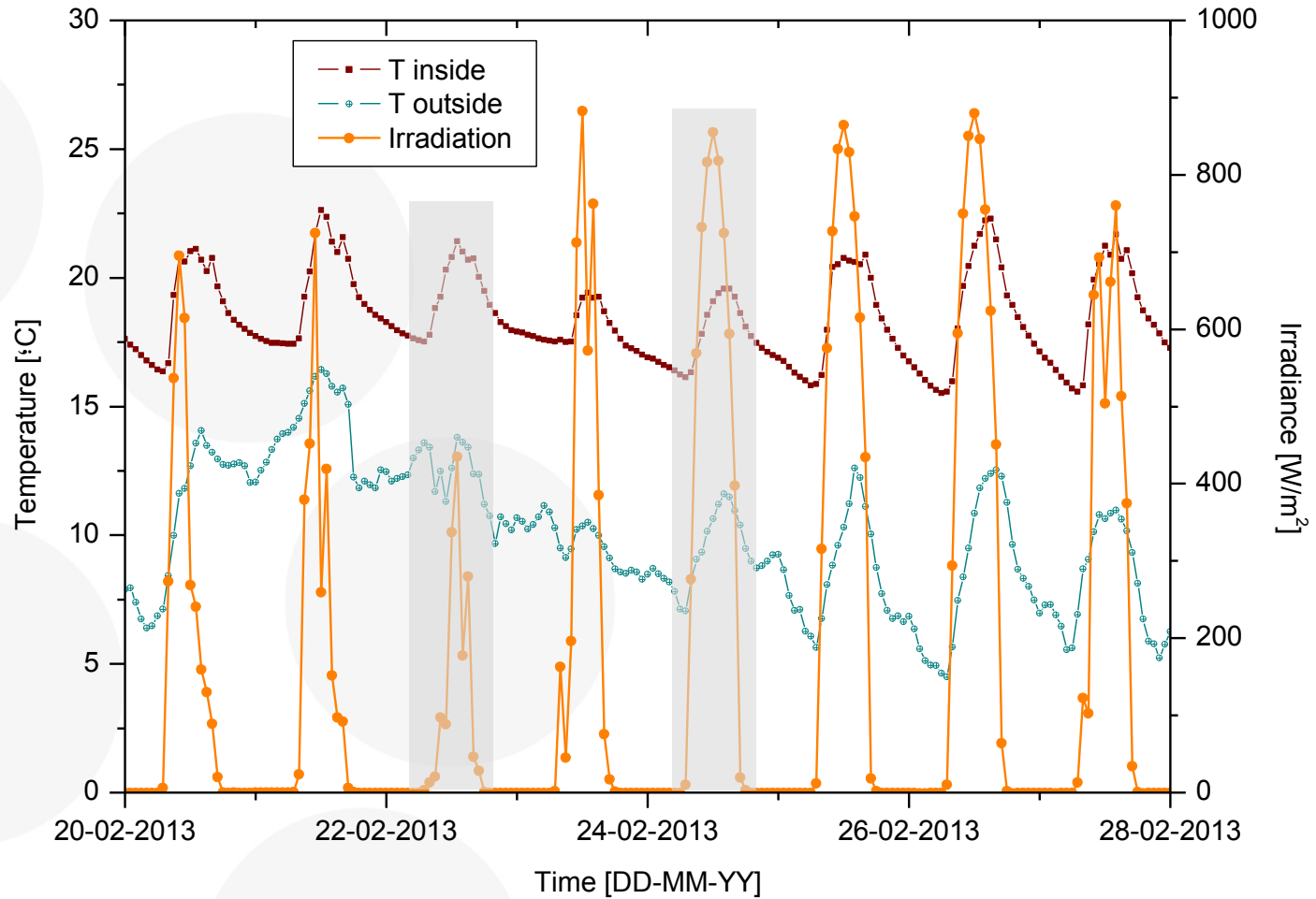
## EXPERIMENTAL SET-UP

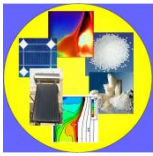


PCM surface facing air gap	Air gap between PCM and PV	PV facing air gap	PV outside
PT100 2x2,3mm	PT100 2x2,3mm	PT100 2x2,3mm	PT100 2x2,3mm
T41	T31	T21	T11
T42	T32	T22	T12
T43	T33	T24	T13
T44	T34	T25	T14
Patch PT100		Patch PT100	Patch PT100
S41		S21	S11
Hukseflux HFP01-05		Hukseflux HFP01-05	
F4		F2	



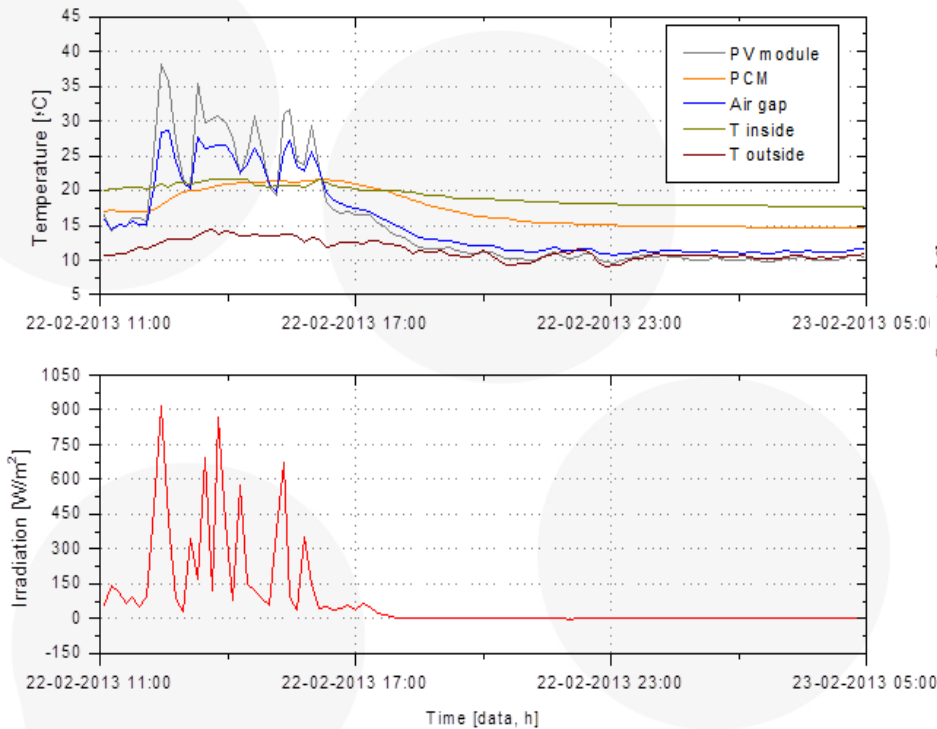
## METHODOLOGY



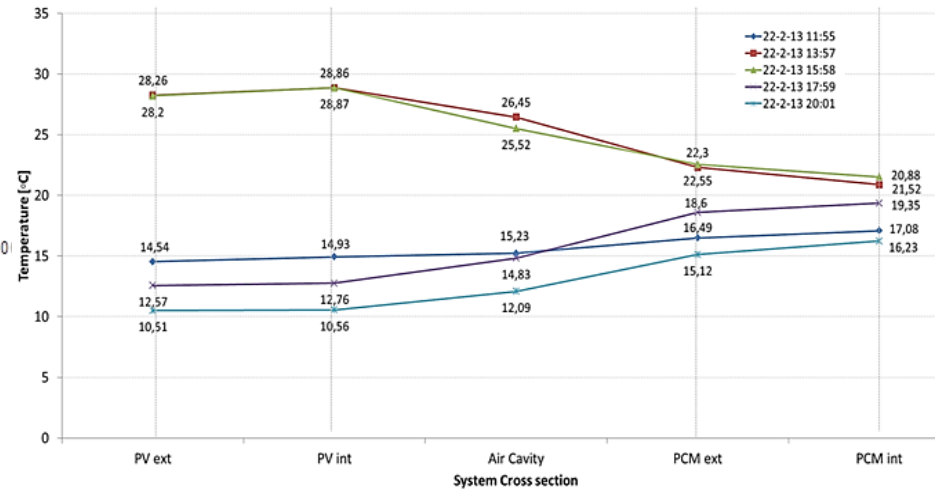


# METHODOLOGY

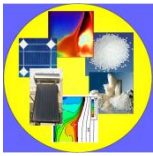
## Case 1: 22th of February 2013



Temperature and irradiation values

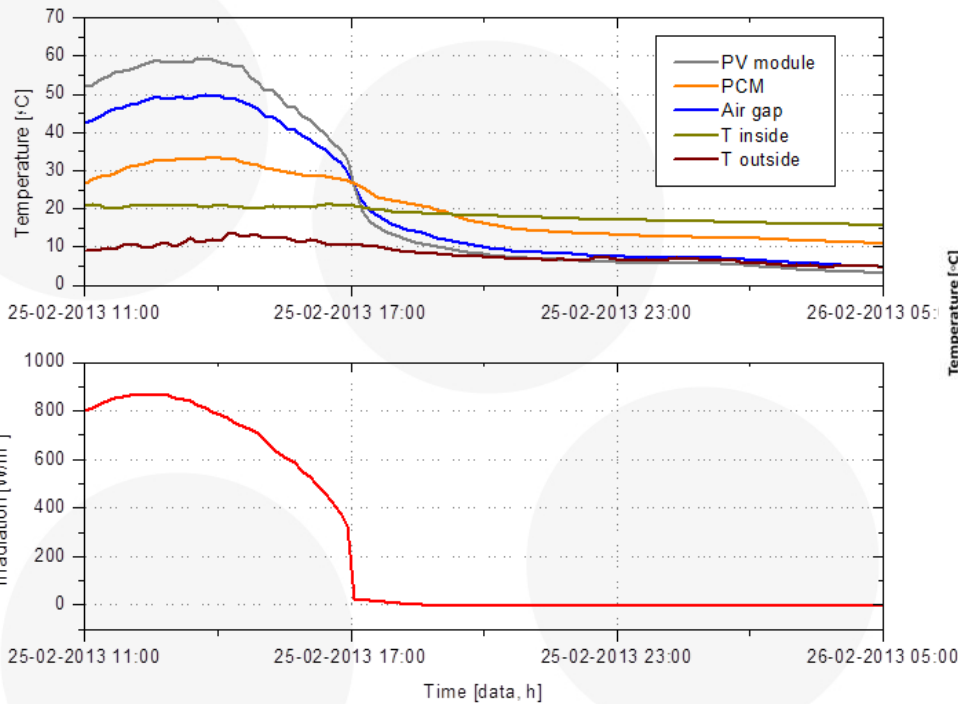


Cross section temperatures at different hours

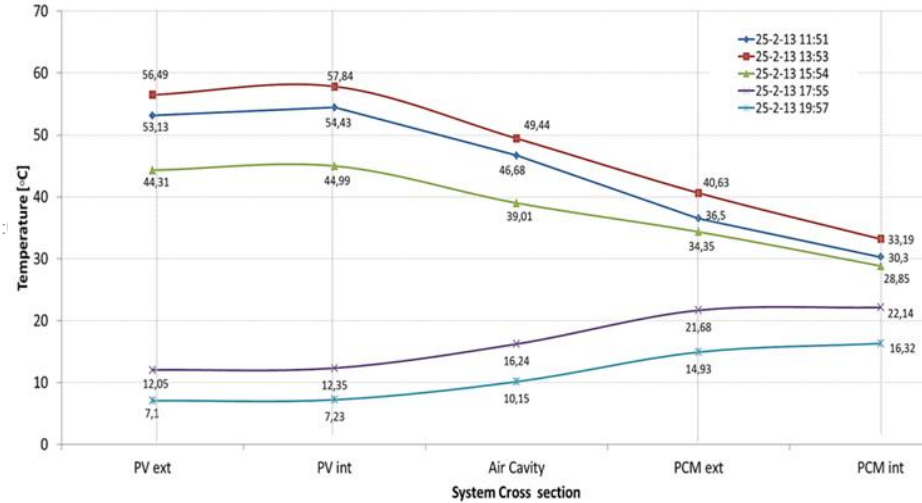


## METHODOLOGY

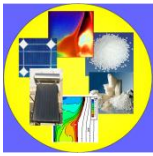
### Case 2: 25th of February 2013



Temperature and irradiation values



Cross section temperatures at different hours



## CONCLUSIONS

- For both cases the thermal behavior of the BIPV/T-PCM system presents a highest temperature difference at different hours and between the maximum and minimum values at the PV module and in the air gap and a more constant temperature at PCM gypsum board and inside room.
- Even, on a day with low irradiation, cloudy, the PCM gypsum board layer presents temperatures of about 20°C during daytime.
- The room temperature presents constant behavior with the values a of 20°C during daytime and between 16-18°C during nighttime.

# Thank you for your attention!

This work is part of a project FRAME-Prefabricated systems for low energy buildings: design, modulation, prototyping and testing, PTDC/AURAQI-AQI/117782/2010 co-financed by FEDER

Laura Aelenei

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[www.lneg.pt](http://www.lneg.pt)