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APPLICATION OF INNOVATIVE COMPOSITE COOL THERMAL INSULATING MATERIALS

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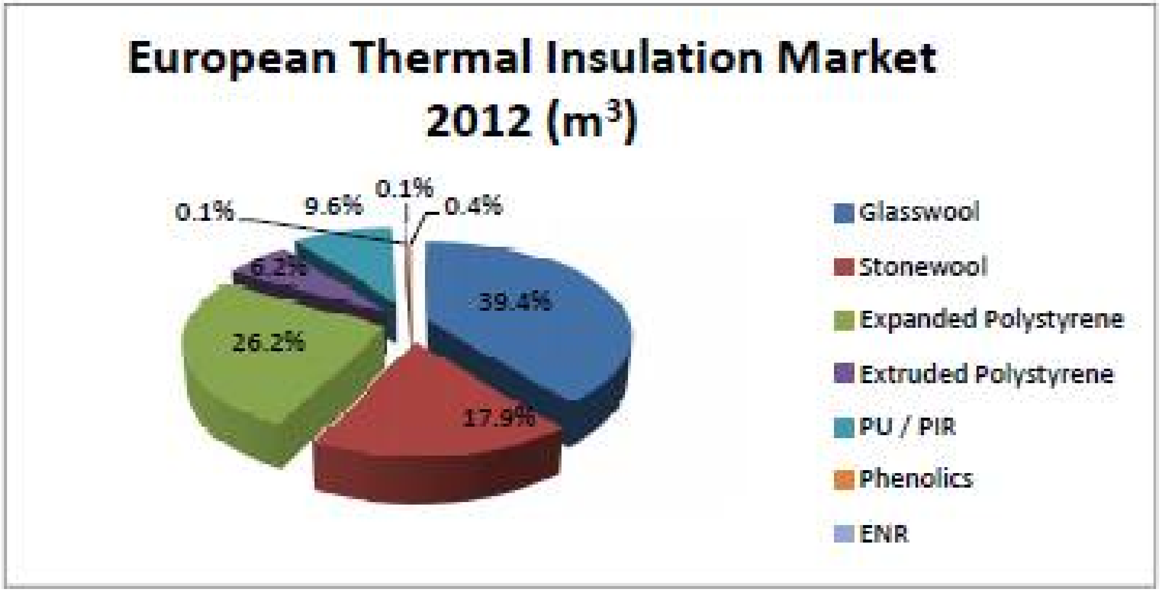
The European thermal insulation materials' market

After the 2008/09 crisis, the market has recovered, albeit slowly.

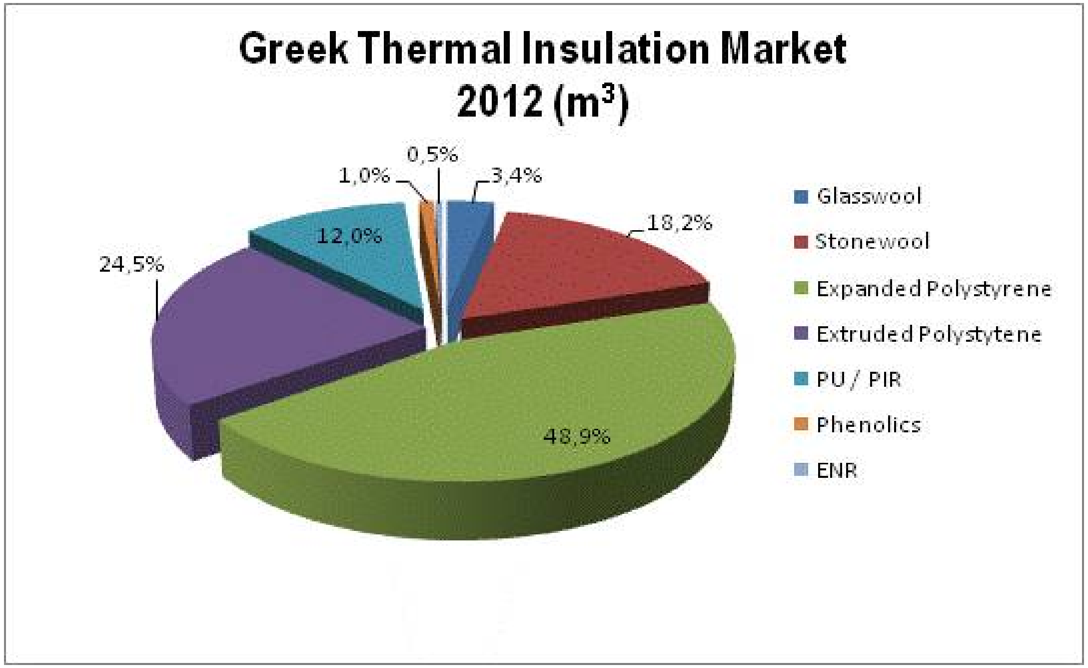
- 192.650.000 m3
- 9.600 million €
- Expected to grow by 2,0% annually in the next few years



The Greek thermal insulation materials' market

Since beginning of the recession in 2009, the market has shrunk.

- 1.950.000 m3 in 2009, 950.000 m3 in 2013
- Not expected to improve in the next few years



DICOM research project

Development of Innovative Composite Cool insulating Materials

Aim of the project:

The design, development, production, evaluation, certification and introduction to the market of innovative, composite cool - thermal insulating materials based

(a) on the new generation of extruded polystyrene (XPS) with improved vapour permeability (lower vapour diffusion resistance factor μ)

and in combination with

(b) cool and photocatalytic coatings with low emissivity coefficient ε and self cleaning proper, to minimize overheating of the building in summer

DICOM research project

Development of Innovative Composite Cool insulating Materials

The products:

1. Have to be suitable for simple and quick installation in new-built and existing buildings.
2. Easily transported and storage on worksite.
3. Low environmental impact, proven by LCA, to eventually lead to the eco-label sign.
4. Cost-competitive

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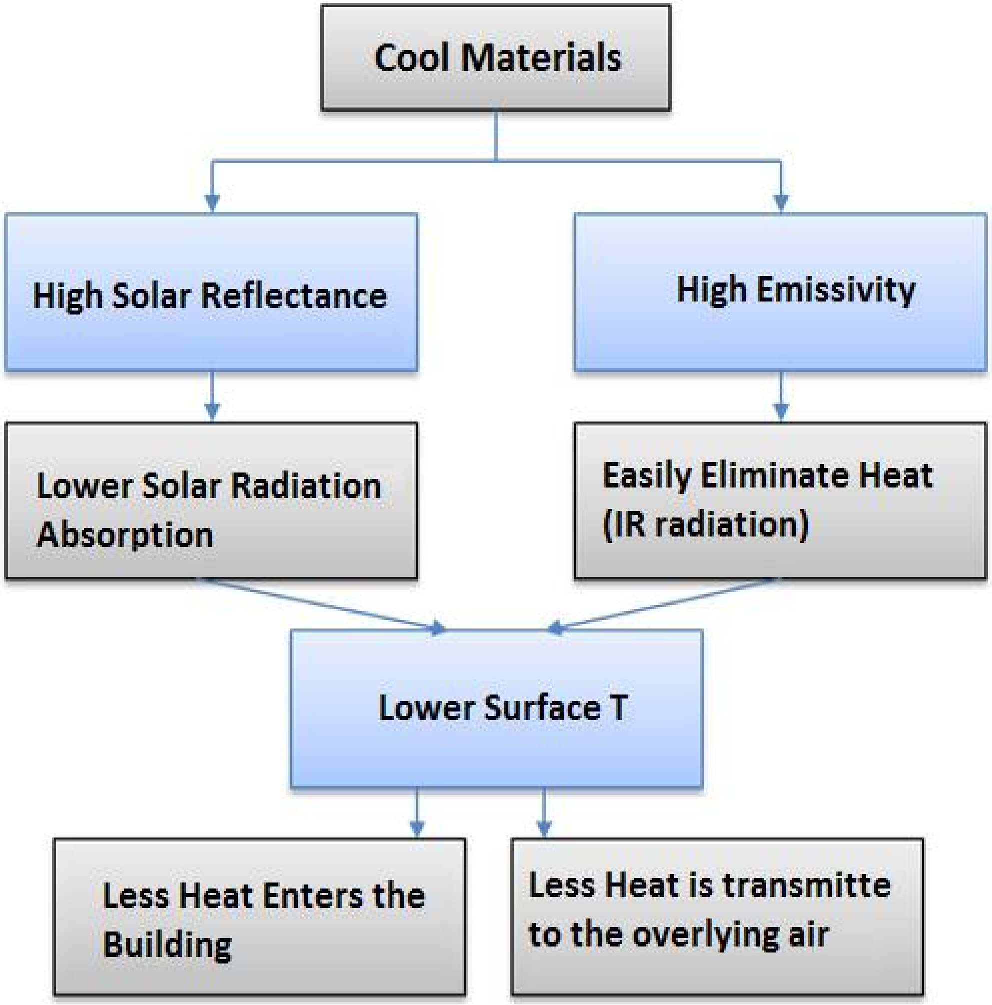
New, composite thermal insulating-cool materials

Cool Materials

As **cool materials** are defined the materials, which main characteristics are:

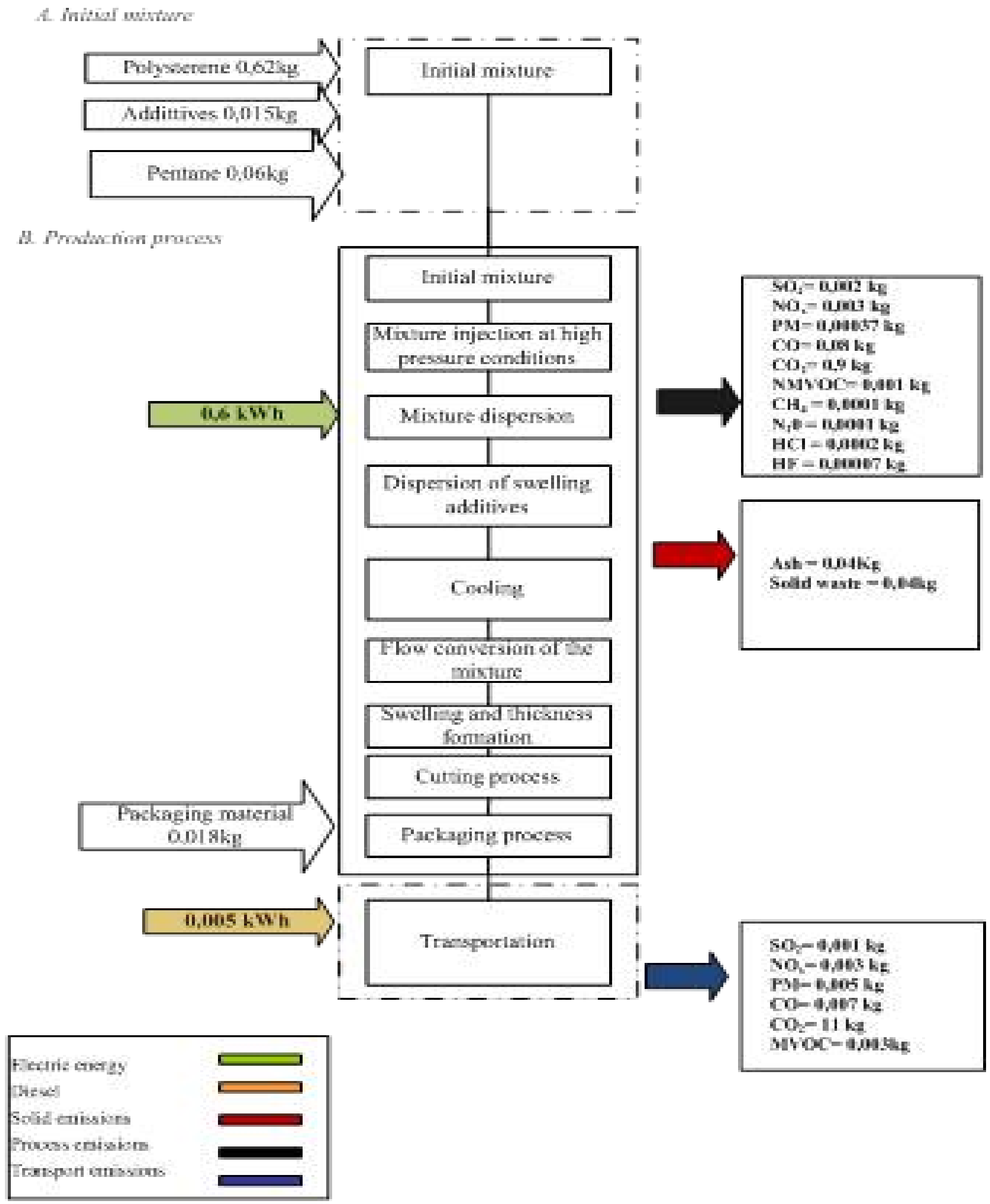
- the high Solar Reflectance &
- the high Emissivity, so that a large percentage of the daily ingested heat is retransmitted to the environment during the night.



Life Cycle Analysis

The processes that are taken into consideration during the environmental assessment are

- (a) the mining & production of the raw materials,
- (b) the transportation of the raw materials to the production areas,
- (c) the production process and
- (d) the transportation to the construction area.



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Life Cycle Analysis

LCA of Extruded Polystyrene

- Equivalent emissions of organic insulation materials.

Equivalent Emissions	kg CO2eq	kg SO2eq	kg PO4eq	kg C2H4eq	Energy Consumption
Material (/kg)	kg	kg	kg	kg	MJ
Cellulose	0,37207	0,00353	0,00024	0,00015	7,07
Cork	0,00000	0,00926	0,00074	0,00061	29,30
Expanded Polystyrene (EPS)	3,24197	0,01268	0,00096	0,00054	76,16
Extruded Polystyrene (XPS)	3,93111	0,01490	0,00118	0,00080	90,99
Foam of Polyurethane (PUR)	4,42797	0,01934	0,00279	0,00212	92,30

Energy savings' evaluation

Two software tools were used, TEE-KENAK & "ENERGYNIOUS", the latter created by PEDL, in compliance with the EPBD and its implementation in Greece.

The results given are referring to (a) final and (b) primary energy consumption per use.

Final energy consumption per final use (kWh/m2) with the use of ENERGYNIOUS.													
Months	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	TOTAL
Heating	18,8	13,7	8,8	2	0	0	0	0	0	0,1	7,3	16	66,7
Cooling	0	0	0	0	0	1,6	2,4	2,1	0	0	0	0	6
DHW	2,1	1,9	1,9	1,7	1,5	1,2	1,1	1,1	1,2	1,5	1,7	2	18,9
Total	20,9	15,6	10,8	3,7	1,5	2,8	3,5	3,2	1,2	1,6	9	18	91,7

Primary energy use per final use (kWh/m2) with the use of ENERGYNIOUS.							
Final Use	Heating	Cooling	DHW	Lighting	RES-CHP Contribution	Total	Classification
Reference Building	51,5	16,8	18,4	0	0	86,7	-
Existing Building	236,3	29,8	20,8	0	0	286,9	G
Scenario	76,8	17,5	20,8	0	0	115,2	C

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Laboratory

Solar-reflectance is the primary determinant of cool-roof performance.

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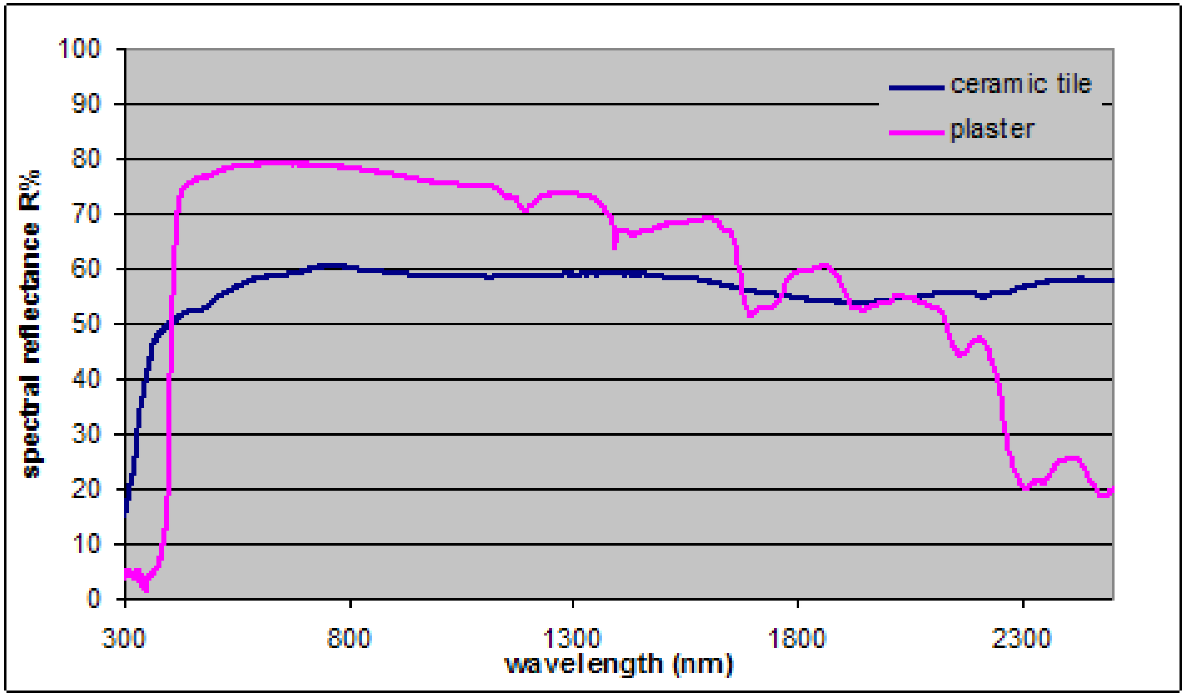
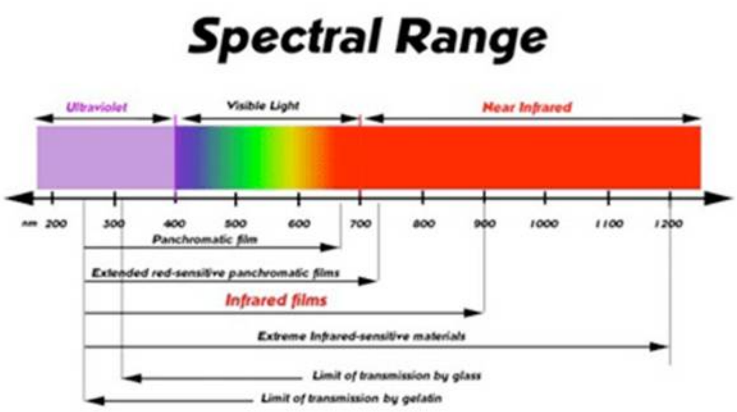


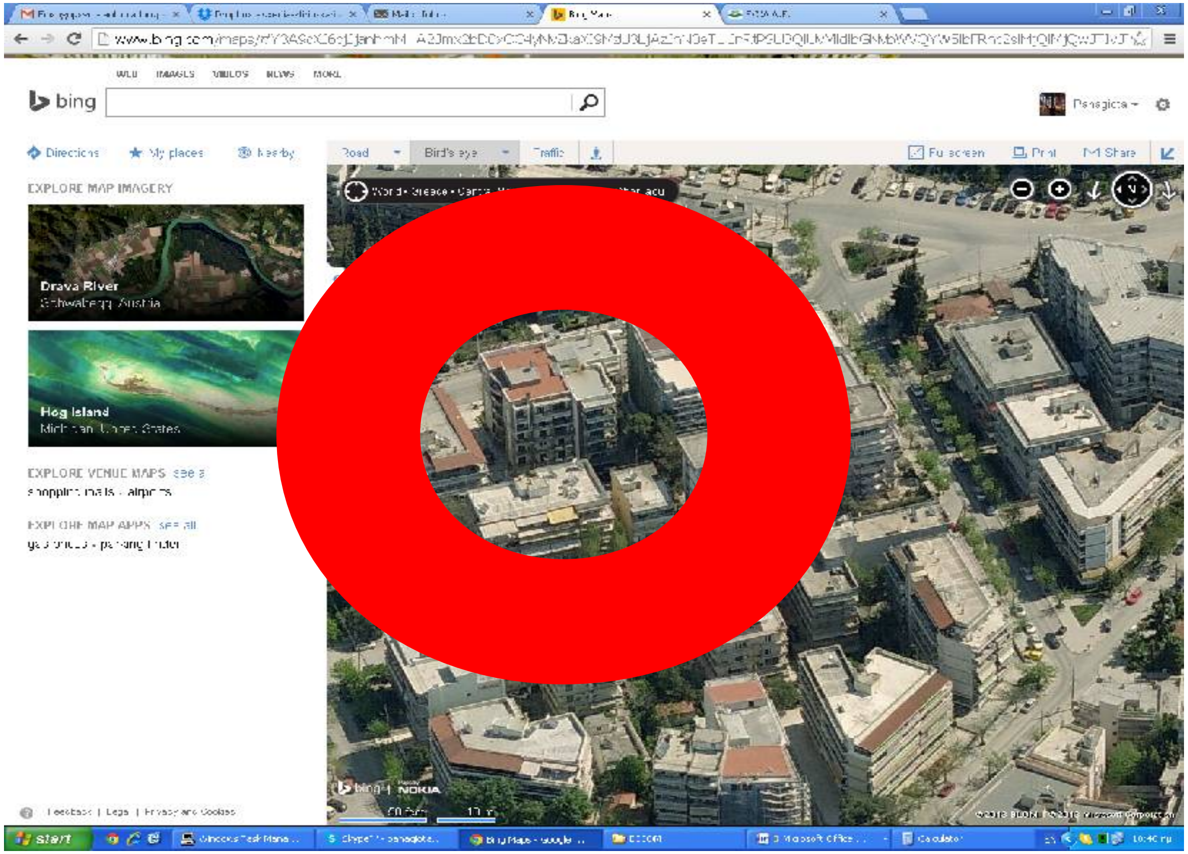
Reflectance R

Typical reflectance R values

Specimen	Reflectance %				Far Infrared Emittance
	Solar	UV	VIS	NIR	
Red concrete tile	17.6	7.0	13.1	23.1	0.91
Unpainted cement tile	24.9	9.7	18.1	32.8	0.90
White concrete tile	72.8	22.0	77.7	73.4	0.90
White cement shingle	76.6	18.1	85.9	74.0	0.88



In-situ evaluation of the materials’ performance



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Application of the materials in construction

Horizontal Building Components

- Point placement of polymeric glue.

- Joining of the ceramic tiles.

- Placement of embedded sensors for temperature measurements

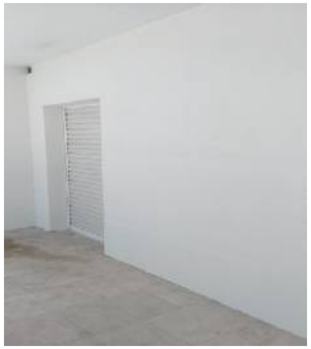
Application of the materials in construction

Vertical Building Components

- Punching holes & placing plugs.

- Fiberglass mesh attached to polystyrene board.

- Final coating of plaster with photocatalytic properties.



Equipment for recording of meteorological and indoor conditions

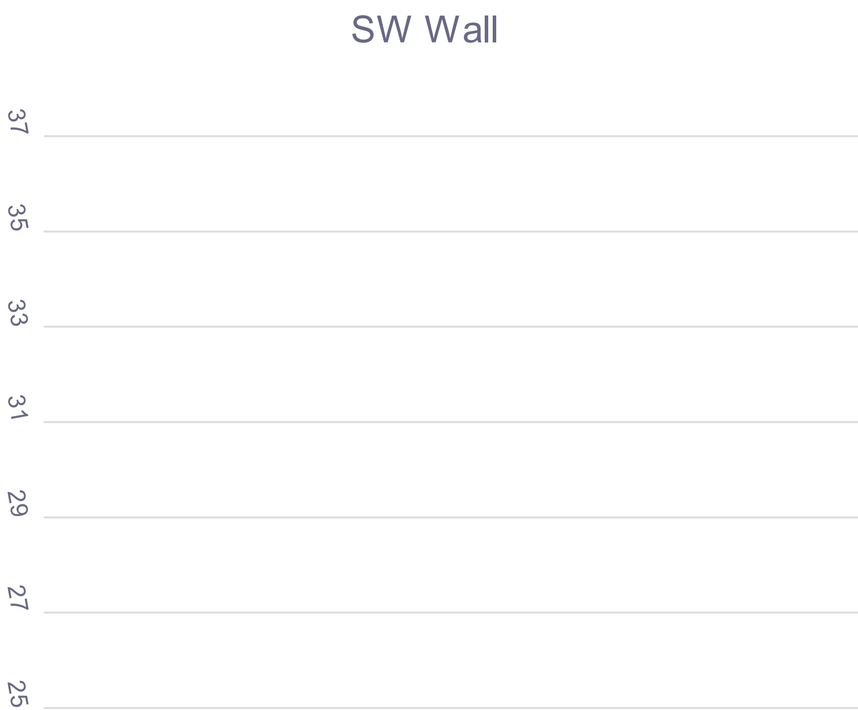
Meteorological station at rooftop.

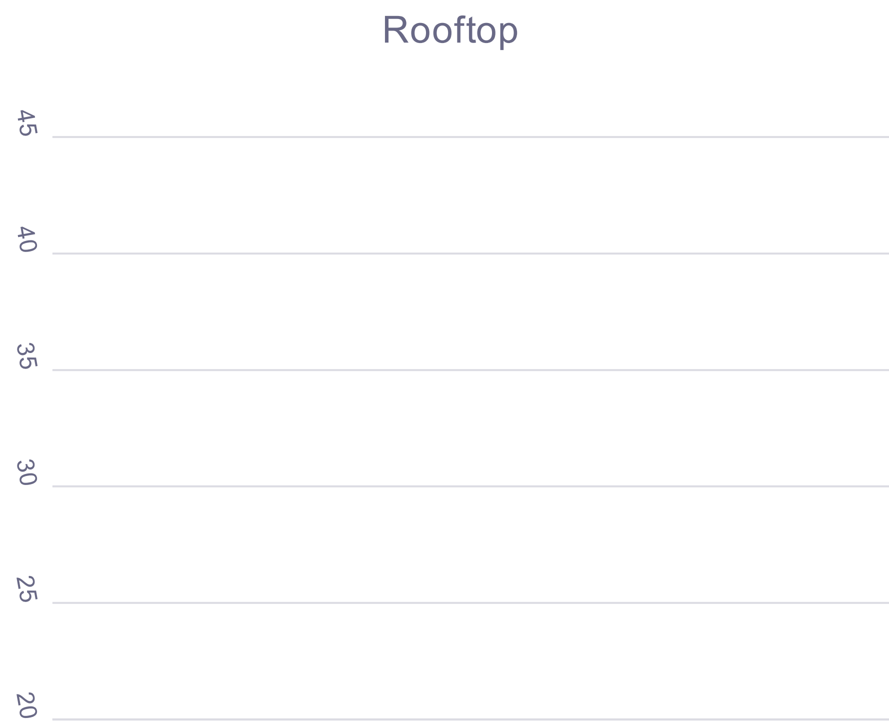
“FLIX E40” & “IR FlexCam Pro” (Infrared Solutions Thermal Imaging Cameras)

HOBO U14 LCD Temperature & Humidity Data Loggers.

Results

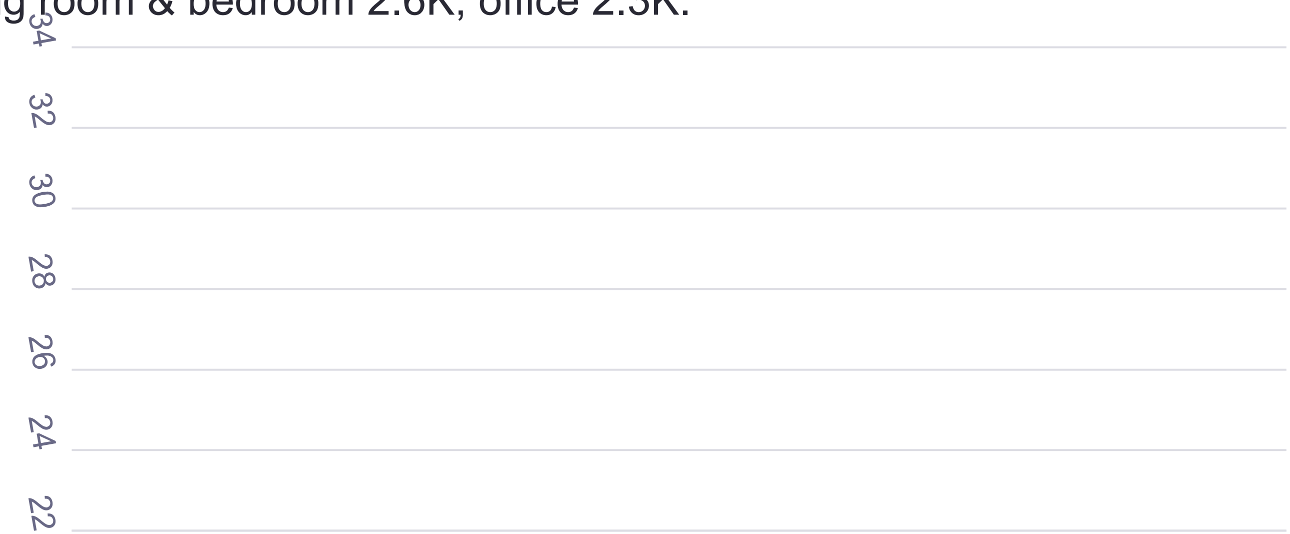
An important temperature reduction among the outdoor surface temperature and the indoor is mentioned. In case of the vertical building components this decrease is up to 18% and of the rooftop up to 32%.





Results

- Difference of indoor temperature air **before** and **after** the placement of the composite materials.
- After the placement of the materials a temperature reduction around 12% was monitored during the summer period
- Living room & bedroom 2.6K, office 2.3K.



Results

In order to evaluate the effect of the thermal insulation materials to the temperature difference mentioned among the outdoor and indoor temperature, an inferential statistical analysis T-test was applied.

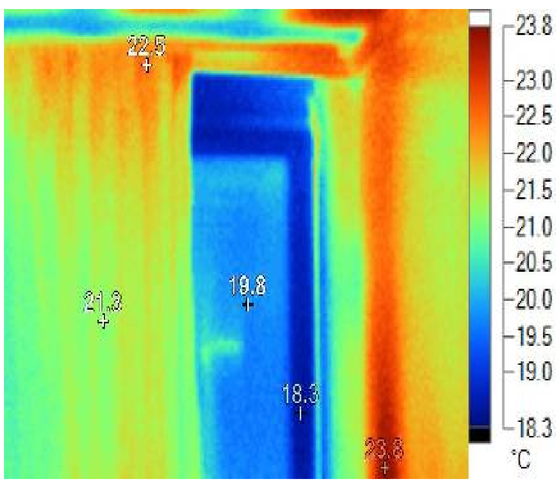
At the analysis, the temperature differences of the areas and the external air temperature are taken into consideration, **before** and **after** the placement of the new materials. The T-test analysis concluded that the new materials change the temperature of the building areas to the external air temperature with confidential region 99% (p-value <0.001).

Results of t-test analysis.

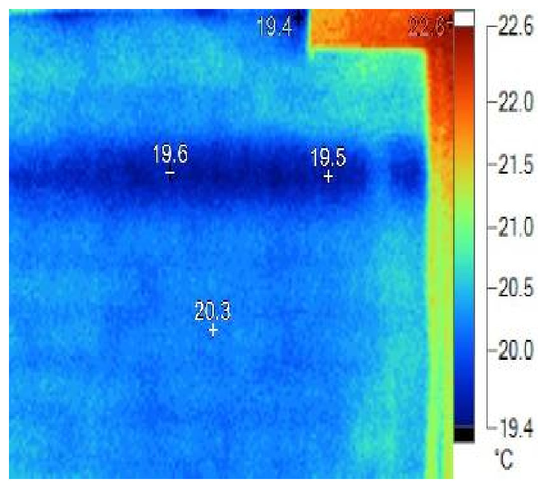
Temperature Difference	t	df	Sig. (2-tailed)	Mean Difference
Bedroom-External Air	3,697	32	0,0008	1,92941
Living room-External Air	3,68	32	0,0009	1,88235
Office-External Air	2,926	32	0,006	1,61176

Thermal Imaging of the surfaces before the refurbishment

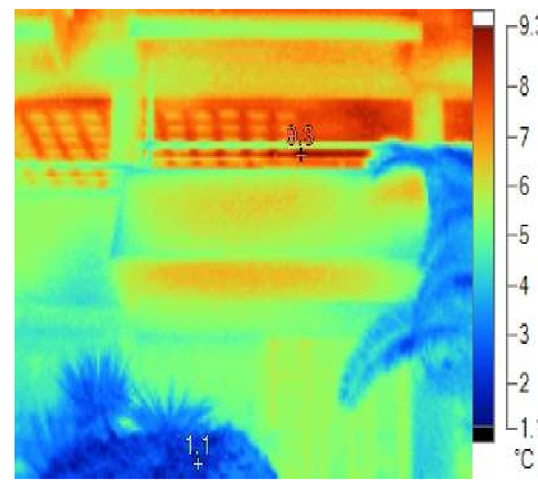
Southwest opening from the inside.



Northwest wall from the inside.

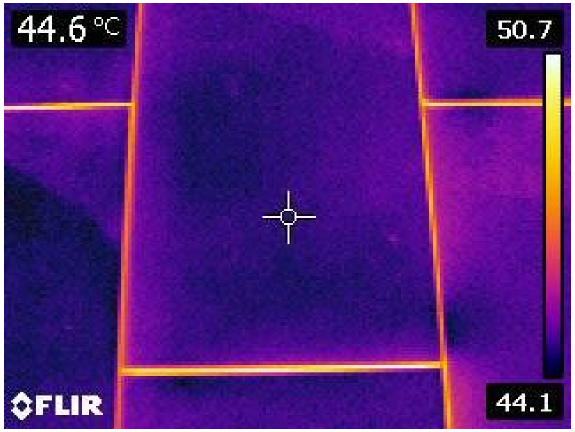


Southwest side of the construction.

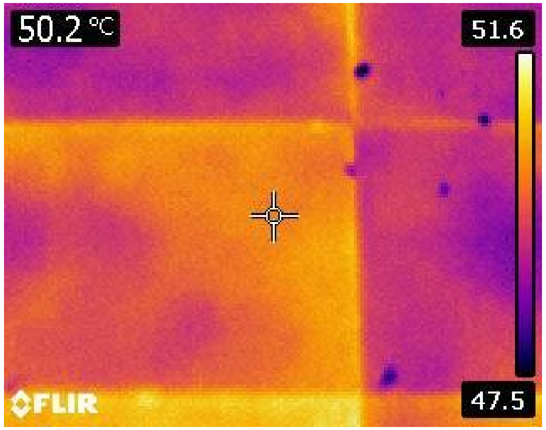


Thermal imaging of the flat roof

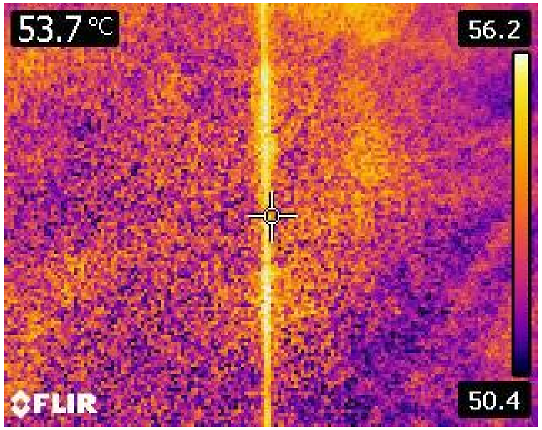
Innovative product
(XPS with cool ceramic tile).



Conventional product
(XPS with concrete tile).

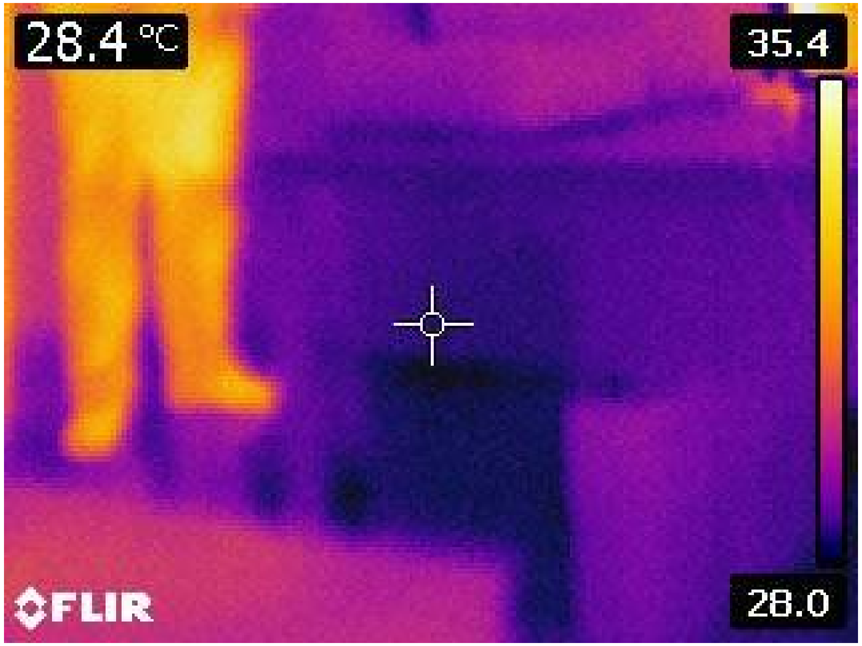


Conventional roof coating
(Bituminous membrane).



Conclusions

- The placement of the materials is easy as they are very light to carry and the connection of the pieces shows no exceptional difficulties.
- A significant reduction of the surface temperature of the layers was noticed after the placement of the new material. It is approx. 15% compared to the conventional roof tile and 21% compared to the flat roof with bituminous membrane. This reduction is a result of an increase around 25% of the reflectance coefficient of the ceramic tile (SR=58%) and the photocatalytic plaster (SR=71%).
- The application of the new materials led to a decrease of energy demand, resulting in a reduction of primary energy use of up to 13.9% for heating and 5% for cooling for the whole building, but, and that is more important, in a reduction of 34.1% & 22.8% respectively for the underlying floor.



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