APPLICATION OF COOL BARRIER
High Solar Reflective Roof Coating
ON SCHOOL ROOFS

COOL ROOFS

WATERGY
International Group

With The Support of :

Intelligent Energy Europe

Experimental and Numerical Assesment of the Impact of Increased Roof Reflectance on a School Building In Athens

This presentation show the impact of the Cool Barrier–Cool Roof Coating By Abolin Co on the energy performance and thermal behaviour of a non–cooled school building **(7th Elementary)** in Athens, Greece.

An experimental monitoring campaign has been carried out before and after the application of a white elastomeric coating with a solar reflectance of 0.89 on the roof of the building. The air and surface temperature of the building have been measured and a set of meteorological parameters have been collected.

An infrared camera has been used to depict the differences in the surface temperature before and after the cool roof application.

The monitoring results are complemented and supported by building simulation. The building has been modelled into TRNSYS software and the model has been calibrated and validated using the experimental data. Simulation results show a decrease in the annual cooling load by 40%. The corresponding heating penalty (i.e. the increase of heating load) is 10%. Additionally, the impact of the cool roof on thermal comfort, peak power and surface temperature has been assessed.

The action took place into the frame of The EU Promotion Of Cool Roofs Project , supported by the Intelligent Energy Europe Programme.

1st Elementary School

7th Elementary School

1st Elementary School

1st Elementary School






1st Elementary School

1st Elementary School






7th Elementary School

7th Elementary School






7th Elementary School

7th Elementary School

7th Elementary School

Description of the 7th Elementary School

The building considered in this "Cool Roofs" case study is a school building located adjacent to a main road axis at the Municipality of Kaisariani, a densely built urban area near the Centre of Athens, Greece

The school building is part of a complex of two school buildings.

It is a public building constructed in 1980. The school is a rectangular two-floor building with a school-courtyard that is also used by another school (1st Elementary) in the same property. In the ground floor, two classrooms are located, the principal's office and the office of staff as well as auxiliary storage spaces. In the first floor there are four classrooms and three more storage spaces.

The ground floor and the first floor are connected with an internal staircase. The area of the roof is 410 m2. The gross floor area is 939 m2. The load bearing structure of the school building is of reinforced concrete and an overall concrete masonry construction that is not insulated.

The windows have been recently replaced by double-glazing windows.

➢ Continues…

Description of the 7th Elementary School

There is an installed heating system (water heating with radiators) using natural gas (power 100,000 kcal/h), but no installed systems for the cooling or ventilation of the school building. In the teachers' office there is a small fan that can be left open or closed. Infiltration is considered to be 1.2ACH.
Natural ventilation is being used by opening the windows during recess (Ventilation is considered to be 0.5ACH during winter and 1.5ACH during summer for the classrooms).
Lighting is provided from buildings doors and windows as well by the use of fluorescent lamps.
The operation schedule of the building is: • 8:00–14:00 h from Monday to Friday excluding national holidays, Christmas (23 December–8 January), Easter (two weeks) and summer holidays (22 June–31 August)
Each classroom is occupied by twenty children (120 children in total) and fifteen adults in total as the school's staff. For the classrooms the average occupancy is 0.3 persons/m2 and for the teacher's offices is 0.04 persons/m2. The installed heating systems are used whenever it is considered necessary according to the personal preferences of the staff. If heating is used this is done during the period 8:00–13:00 h.

➢ Continues…

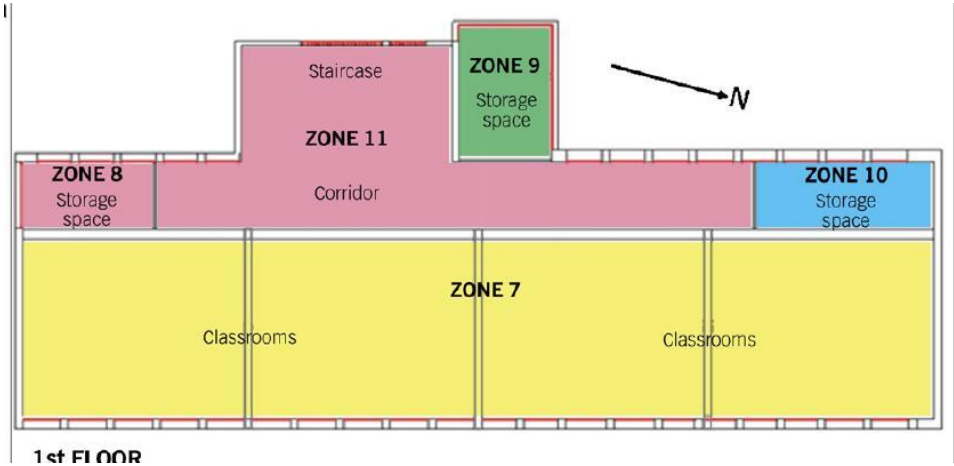
Description of the 7th Elementary School

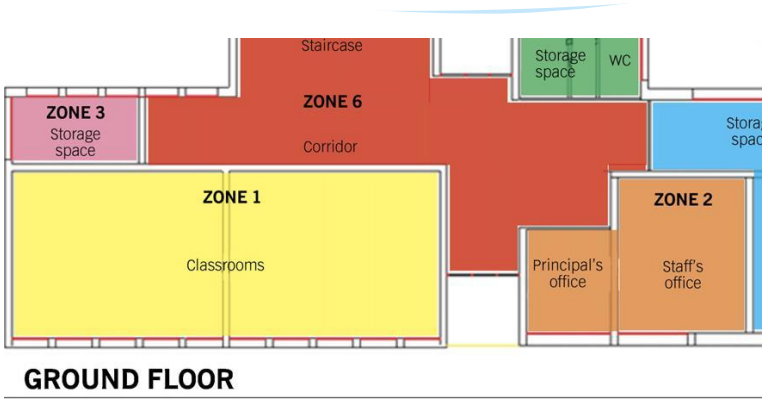
The building's characteristics are summarized in the following table:

Table 1
Thermophysical characteristics of the building envelope.

Building envelope:	
Walls	*U*-value = 2.85 W/m^2 K
Roof	*U*-value = 1.97 W/m^2 K; SR = 0.2
Windows	*U*-value = 2.95 W/m^2 K; *g*-value = 0.78; Frame *U*-value = 2.27 W/m^2 K
Floor	*U* = 2.46 W/m^2 K

Description of the 7th Elementary School





For the simulations carried out, which are described in the next slides, the set point temperature for heating is considered to be 20 ◦C for the classrooms and 18 ◦C for the offices and corridors. The set point temperature for cooling is considered to be 26 ◦C. The operation schedule is from 8:00 to 14:00 h daily except for weekends.

‘Cool Roof’ Technology

The initial roof surface was covered by cement and gravel screed. Although the solar reflectance (SR) of the initial roof could not be measured as no samples were available, the colour and composition lead us to consider a value of 0.2. A solar reflectance of 0.2 corresponds to a grey concrete surface.

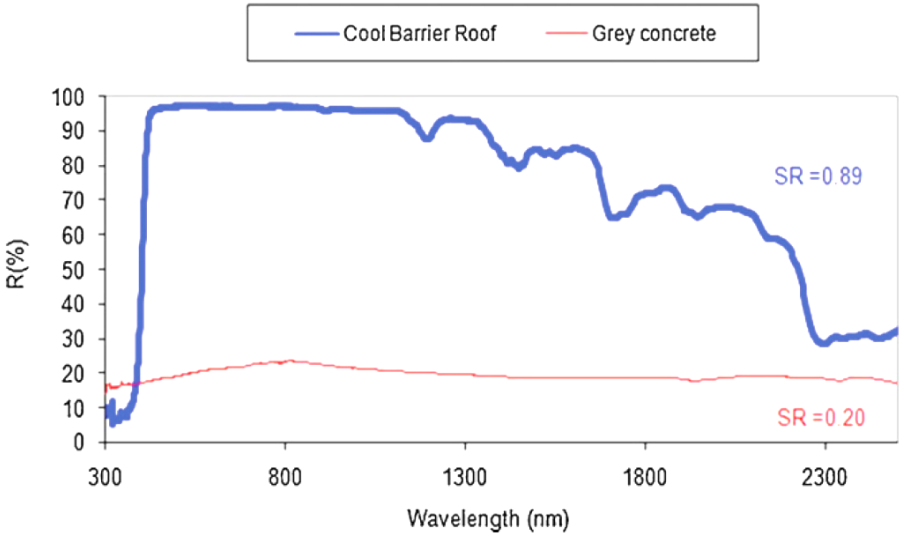
Cool Barrier Roof

For the implementation of the works, Abolin Co Cool Barrier Roof Coating System was used:

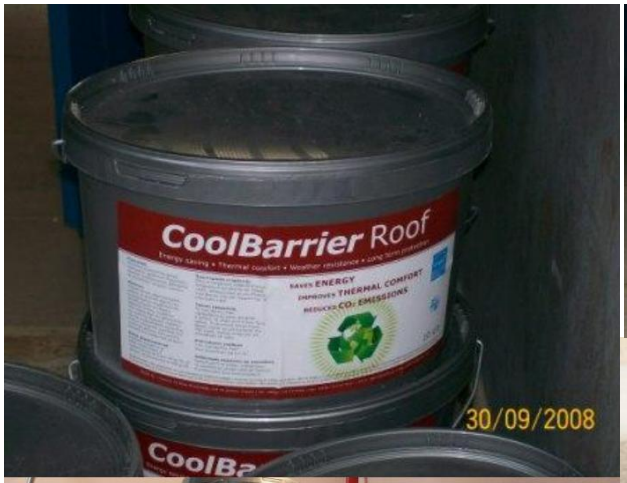
The spectral reflectance of the roof surface before (grey concrete, SR = 0.2) and after (ABOLIN cool roof barrier, SR = 0.89) the cool roofs application.

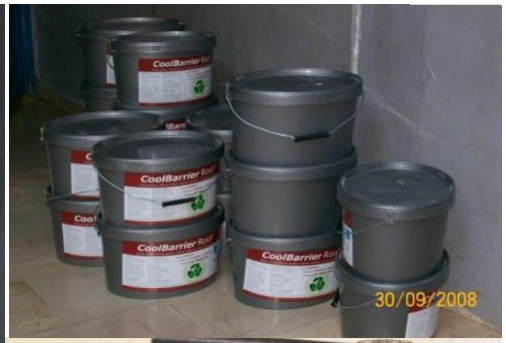
Table 2
Properties of the applied cool roof coating.

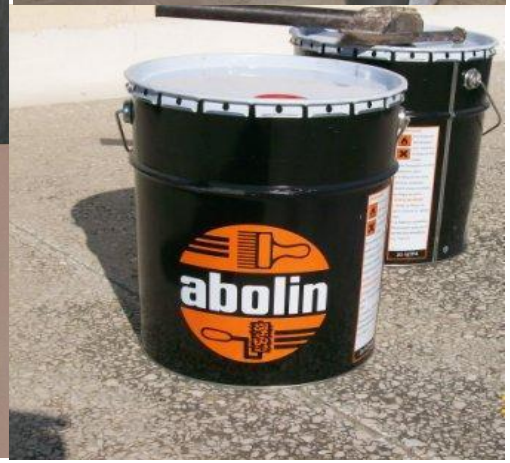
SR	SR_{UV}	SR_{VIS}	SR_{NIR}	ε	SRI
0.89	0.08	0.95	0.89	0.89	113



1st & 7th Elementary School Images of the Works







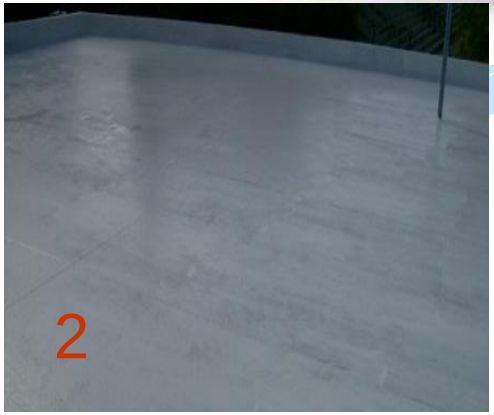
Images from the Cool Roof Products

1st & 7th Elementary School Images of the Works






1st & 7th Elementary School Images of the Works



1st & 7th Elementary School
Images of the Works






Monitoring Procedure

The monitoring campaign for the Athens case study at the school building in Kesariani included the following measurements:

a) On site measurements: air temperature (◦C), relative humidity, surface temperature.
Air temperature and relative humidity data sensors (Tinytag thermo-hygrometers) have been installed both inside and outside of the building. The sensors were installed in 3 classrooms (on the first floor that were adjacent to the roof), in the teachers' office and one outdoors. Additionally, on selected days, surface temperature measurements were taken on the roof of the building using an infrared thermometer (Infrared Thermometer) and an infrared 7.5–13 lm wavelength). Measurements were taken every hour from 9:00 to 18:00 h. The measurements were taken at several spots on the roof surface and an average value was deducted.

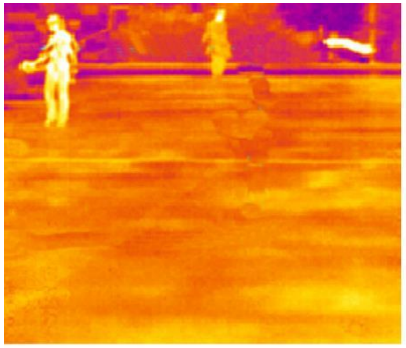
b) Collection of meteorological data from a near by meteorological Station The data were provided by the National Observatory of Athens and include hourly values of the following parameters: outdoor temperature, outdoor humidity, solar radiation (total and diffuse), wind speed and direction.

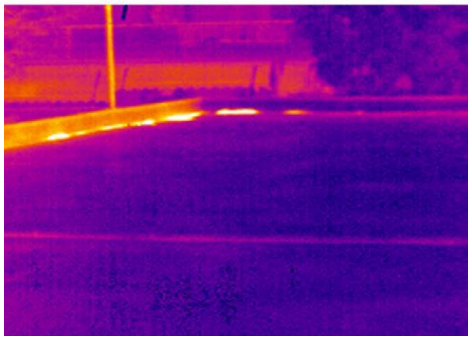
The previously mentioned measurements were performed during two separate periods

(a) October 2007 (prior to the application of the cool roof coating)
(b) 15th May–30th September 2009 (after the application of the cool roof coating)

Visible and Infrared Image

7th Elementary School



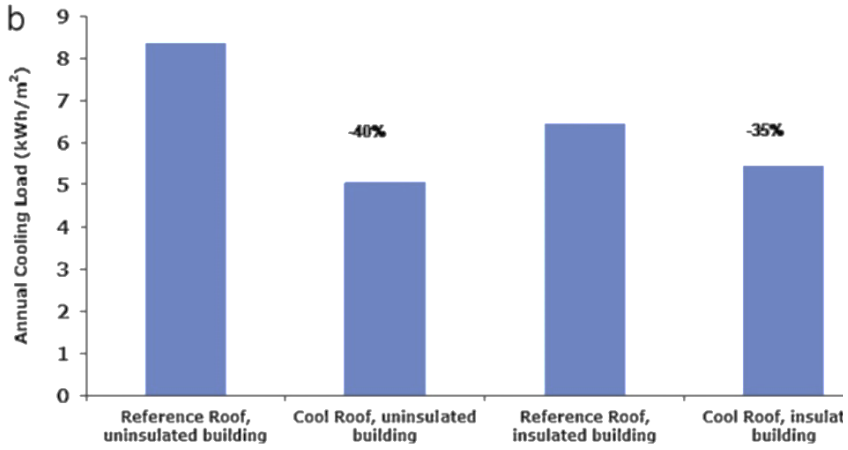


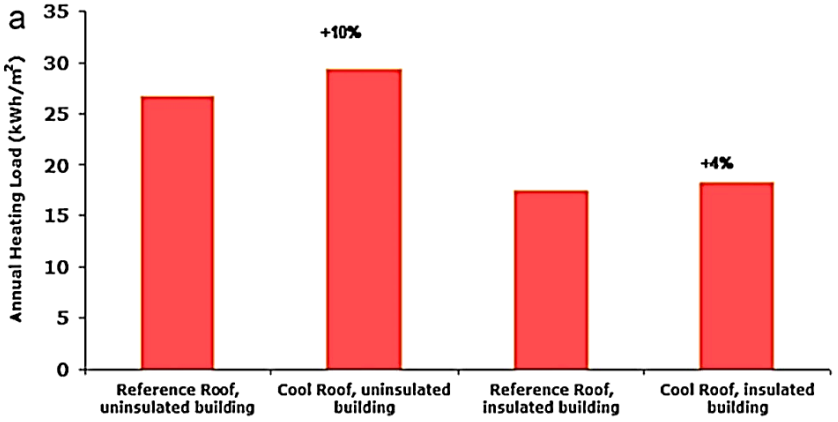
Visible and infrared images of the roof surface depicting the differences in the surface temperature prior and after the Cool Barrier Roof coating system application

Building Simulations: Impact on Energy

To perform the numerical analyses, the building was modelled into TRNSYS software for transient building simulations, to extend the performance of the building to the whole solar year. The building's model is set up with the assistance of the TRNBuild tool.

An additional assessment is performed considering the same building with increased insulation. External insulation of 5cm has been added to the walls resulting in a U-value of 0.417 W/m2K and 7cm on the roof resulting in a U-value of 0.302 W/m2K.





Annual Cooling and Heating Loads

Simulation Analysis Results

	Annual Cooling Loads (kWh/m²)	Annual Heating Loads (kWh/m²)
Un-insulated building	-40%	+10%
Insulated building	-35%	+ 4%

The analysis has shown that after the cool roof application, the indoor air temperature was reduced by 2 ◦C during summer and 0.5 ◦C during winter.
The annual cooling energy load reduction was 40% and the heating penalty was 10%.
A significant decrease in the surface temperature, reaching 25 ◦C during summer, is recorded after the 'Cool Barrier Roof Coating application.

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The project was organized from the Municipality of Kesariani Athens and scheduled by the National Organization for Schools (department of Innovative solutions) and was conducted by the technical service department of the Municipality.

The action took place into the framework of The EU Promotion Of Cool Roofs Project , supported by the Intelligent Energy Europe Programme.

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Works supervision:

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Thank you for your Attention