COOL ROOFS IN EUROPE

INITIATIVES AND EXAMPLES

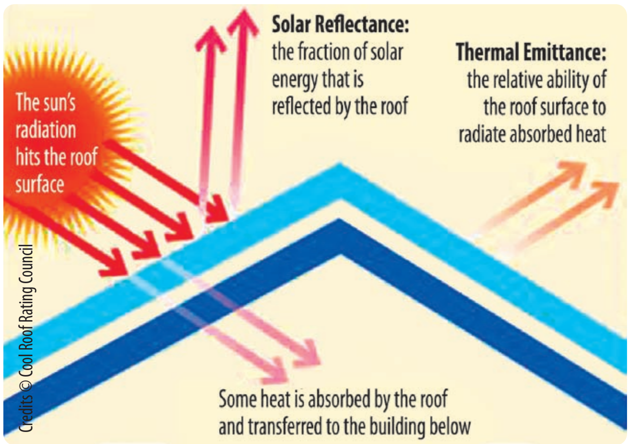
COOL ROOFS

www.coolroofs-eu.eu

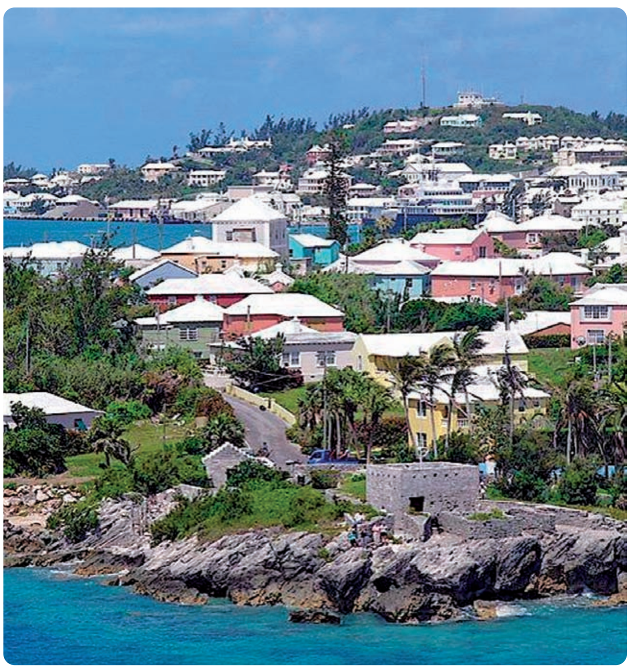
1. COOL ROOFS

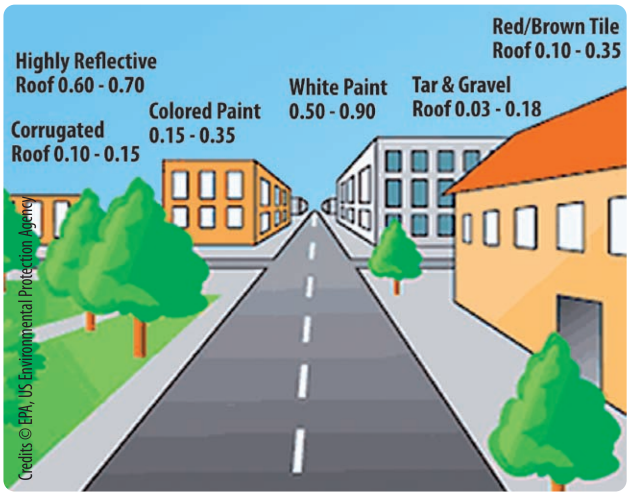
What is a Cool Roof

A Cool Roof is a roofing system able to reflect solar heat and keep roof surfaces cool under the sun. This is due to the properties of the reflective and emissive materials used which reflect solar radiation back into the atmosphere. As the roof stays cooler, this reduces the amount of heat transferred to the building below, keeping a cooler and more constant temperature in the interior.



The high solar reflectance (ability to reflect sunlight) and high thermal emittance (ability to radiate heat) of cool materials help roofs to absorb less heat and stay up to 28-33°C cooler than conventional materials during peak summer weather. Cool roofs can generate air-conditioning savings and peak demand reductions of 10-30% (measured in daily summertime use).





Benefits of Cool Roofs

- Energy savings and reduced energy costs because of reduced air-conditioning;
- Improved occupant comfort and health;
- Reduced roof maintenance and replacement expenses by extending the roof's life;
- Longer AC unit life due to decreased air-conditioning loads;
- Reduced "heat island effect" in cities and suburbs;
- Reduced air pollution and greenhouse gas emissions.

Materials for Cool Roofs

Nowadays, numerous roofing materials are rated with relatively high reflectance and emittance values, including materials for low and steep sloped roofs (white, colored, photo-catalytic, etc). This provides more choices for designers to employ aesthetic solutions, either for commercial and industrial buildings or residences, in both new construction and existing buildings.

Material databases are available in:

- EU Cool Roofs: http://www.coolroofs-eu.eu
- Cool Roofs Rating Council:
  http://www.coolroofs.org/products/search.php
- Energy Star roof products:
  http://downloads.energystar.gov/bi/qplist/roofs_prod_list.pdf

2. PROMOTION OF COOL ROOFS IN EUROPE

COOL ROOFS

The EU project "Cool Roofs" aims to develop and implement an action plan for the promotion of Cool Roofs in European countries. The main objectives are to:

- support policy development by transferring experience and improving understanding of Cool Roofs' contribution to reducing heating and cooling consumption;
- remove market barriers and simplify the procedures for Cool Roofs' integration in buildings;
- positively influence the behaviour of decision-makers and stakeholders;
- facilitate the development of favourable legislation, codes, permits and standards.

The project's work plan is developed in four axes: technical, market, policy and end-users. The expected results are the:

- Creation of a database of available materials;
- Evaluation of available testing procedures;
- Implementation of five demonstration projects, as shining examples of Cool Roofs' capabilities in improving the thermal conditions and reducing the energy consumption in buildings;
- Development of an efficient strategy to encourage policy makers to support Cool Roof technologies as a means to achieve policy goals of energy efficiency, sustainable development and climate change mitigation;
- Increased awareness of all stakeholder groups, including end-users.

The project is funded by the European Commission within the framework of the Intelligent Energy for Europe, and its duration is from September 2008 to February 2011.

EU Cool Roofs Council

The EU Cool Roofs Council (EU-CRC) was founded on February 2009, within the framework of the Cool Roofs Project, aiming to merge all the driving forces for the promotion and adoption of Cool Roofs in EU. The EU-CRC aims to accelerate the transfer of knowledge, to remove market barriers, to help manufacturers to develop Cool Roofs products, to educate the public and policy makers and to develop incentive programs. For this purpose the EU-CRC brings together all relevant actors, i.e. universities and research institutes, industry and market actors (manufacturers, suppliers, distributors, roofing contractors, energy service companies, consultants), non-profit groups (local authorities, chambers, professional associations, government), as well as end users. The EU-CRC has established 6 Committees:

- **Technical Committee**, to define Cool Roofing materials
- **Documentation Committee**, to compile information on Cool Roof technology
- **Policy Committee**, to prepare, propose and influence new policies in EU
- **Marketing Committee**, to identify market barriers in order to overcome them
- **End users Committee**, for the dissemination to stakeholders
- **Legal Committee**, for the legal aspects of the EU-CRC.

More information about the activities and how to join the EU-CRC: http://coolroofs-eu-crc.eu.

3. COOL ROOFS CASE STUDIES

Five case studies were implemented, within the framework of the Cool Roofs project, to demonstrate cool roof capabilities in real buildings, in terms of improving the thermal conditions in non-air conditioned buildings and reducing the energy consumption in air-conditioned buildings. The case studies were monitored, in regard to their energy performance and indoor environment, before and after the implementation of a cool roof technology. The buildings were selected to achieve maximum geographical and building typology coverage aiming to promote the benefits coming from this technique with reference to cooling energy demand and peak savings all around the EU. The corresponding activities were performed at two levels:

- experimental monitoring in real buildings treated with Cool Roof techniques (*hardware task*)
- numerical analysis of the same buildings with a number of variants (*software analysis*)

The findings of the case studies show 10-40% energy savings and 1.5-2°C reduction of the indoor temperatures, depending on the climatic conditions.

3.1 FRANCE

Le Parvis: Collective Dwellings, Poitiers

The building

"Le Parvis" was built in 1995, in the Saint-Eloi quarter in Poitiers, and is composed of 87 dwellings with 4 floors. The building (Fig.1) is owned by the SIPEA Contractor and is composed of collective dwellings intended for low income households. It has a slightly sloped roof (11.8%), was constructed with steel cladding, was insulated with a 100mm mineral wool and sealed with asphalt.

Figure 1. Collective dwellings in Poitiers

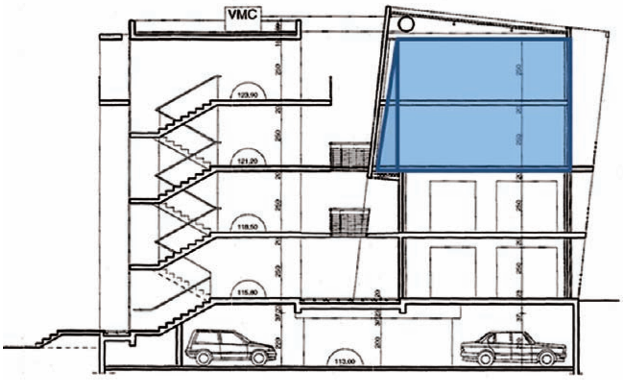


Figure 2. Duplex flat chosen for the case study

The roof slope faces east and is not shaded by adjacent dwellings. This Cool Roof case study focuses on the dwellings under the roof which are all duplex apartments of approximately 100m^2 each (Fig.2). The walls are insulated with 100mm polystyrene and the windows are made of PVC with double glazing. The attic above each duplex apartment is also insulated with 200mm mineral wool. The studied building has no cooling system for summertime, which is the common practice in most parts of France. So the impact of the Cool Roof's technology application is evaluated in terms of indoor temperature difference for the studied duplex flat compared to the adjacent duplex flats.

Cool Roof technology

The roof was coated with a cool paint, manufactured by Soprema (Model R' Nova), at the end of July 2009. The cool paint's solar reflectance is 0.88 and infrared emittance 0.90.

Evaluation results

The monitoring started on the 1st of June and ended on 31 August 2009. The cool paint was applied on the 28th of July. Figure 3 presents the surface temperature evolution.

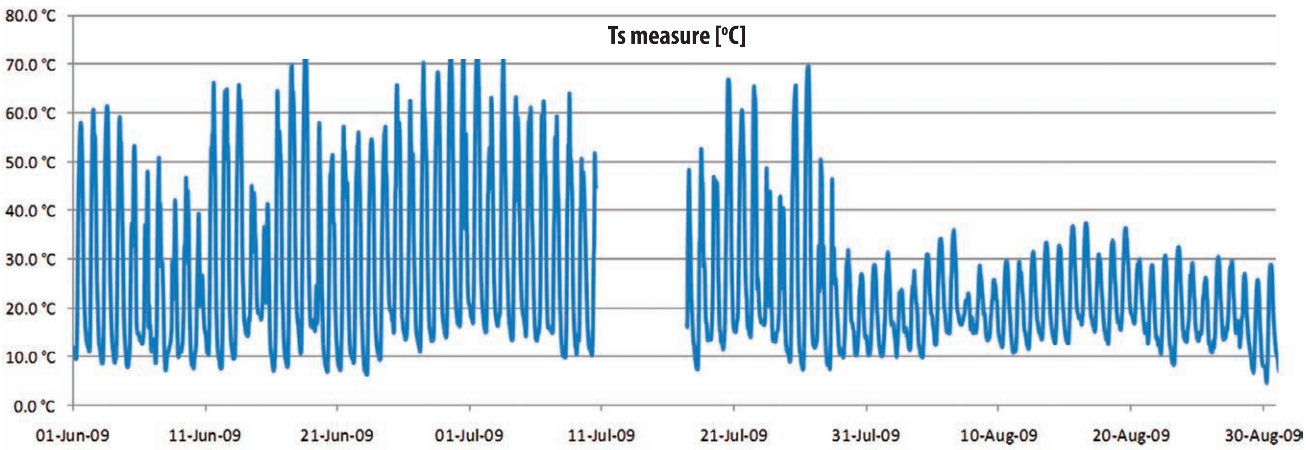


Figure 3. Surface temperatures before and after the Cool Roofs application

The temperatures evolved with the same daily variation, with high maximum temperatures differences. During the night, the minimum temperatures were very similar. The predicted mean surface temperature for the cool painted surface is 21.6°C compared to 34.1°C for the default roof surface for the summer period. The difference in the indoor operative temperature (Fig. 4) is less visible due to the good insulation of the attic: the mean operative temperature in the room decreased from 24.9°C to 24.2°C. In this case, with a very well insulated roof, there is a predicted gain of approximately 1°C on the maximum operative temperature, from 30.2°C to 29.3°C.

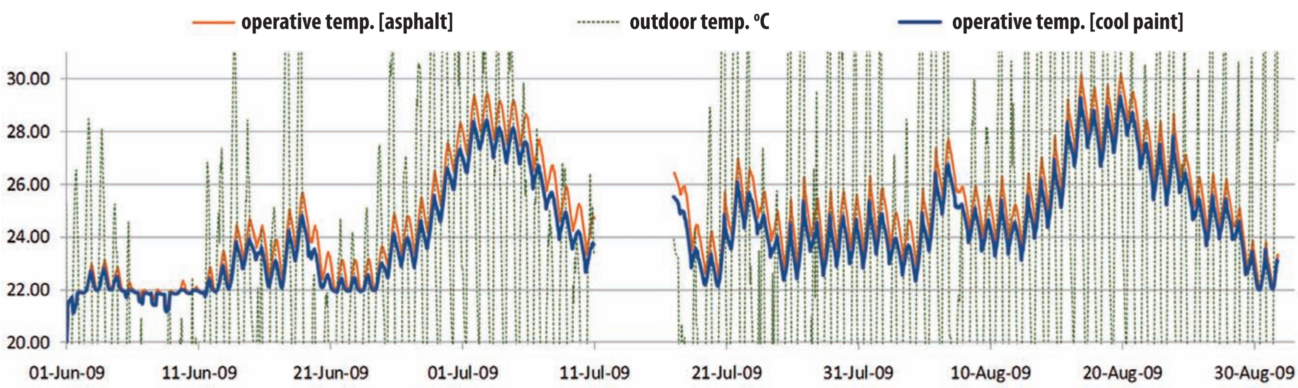


Figure 4. Operative temperatures evolution before and after the Cool Roofs application

3.2 GREECE

3.2.1 School building in Kaisariani, Athens, Greece

The building

This case study involves a 410m^2 school building located at the Municipality of Kaisariani, a densely built urban area near the centre of Athens (Fig.5). It is a rectangular, two floor building with a school courtyard and was constructed in 1980. The load bearing structure of the building is made of reinforced concrete and an overall concrete masonry construction which is not insulated. The school building is occupied by 120 children and 15 adults (the school staff) and is non-cooled and naturally ventilated. There is an installed heating system using natural gas.

Figure 5. School building in Kaisariani, Athens, Greece

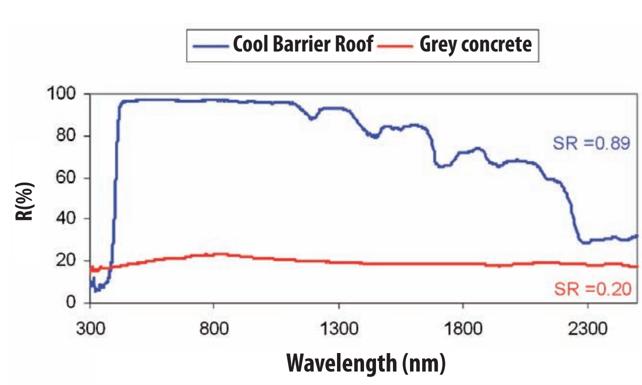


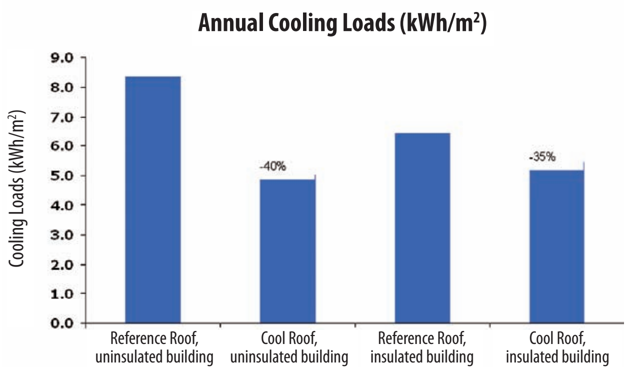
Figure 6. The spectral reflectance of the roof surface before (grey concrete, SR=0.2) and after the Cool Roof application (ABOLIN Cool Roof barrier, SR=0.89)

Cool Roof technology

The initial roof surface was covered by cement and gravel having a solar reflectance of 0.2. The cool material used is a white elastomeric coating (Cool Roof Barrier by ABOLIN) with a solar reflectance of 0.89, infrared emittance 0.89 and SRI 113.

Evaluation results

After the Cool Roof application, the indoor air temperature was reduced by 1.5-2°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 Roof application. Daily fluctuations of the surface temperature are significantly reduced suggesting a longer lifespan of the material, as thermal fatigue is more likely with greater temperature swings (Fig.7, Fig.8).



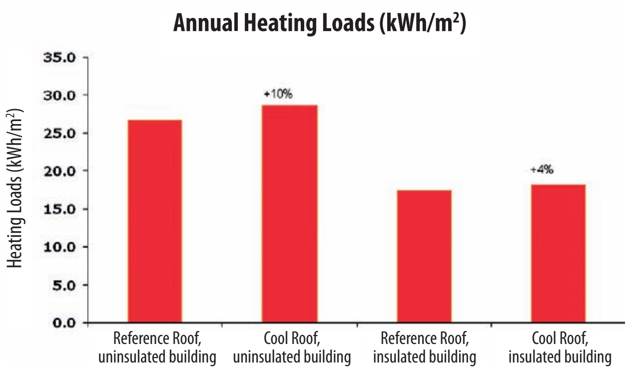


Figure 7. Annual heating and cooling loads (for the actual un-insulated building and for the same building with increased insulation)

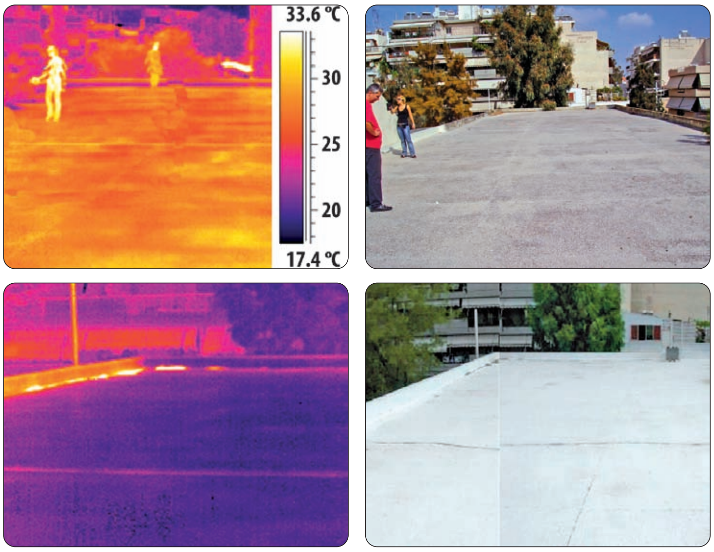


Figure 8. Visible and infrared images of the roof surface, depicting the surface temperature differences prior and after the Cool Roof application

3.2.2 Laboratory building in Iraklion, Crete, Greece

The building

A bioclimatic building housing an administrative office for research programs, within the Technological Educational Institute of Crete campus in the suburbs of Iraklion, was selected for the Cretan case study (Fig.9). Constructed in 1997, the building was initially designed using bioclimatic techniques in order to minimise its heating and cooling needs. Part of the building's electricity demand is covered by a hybrid energy system consisting of a 1000W wind turbine and a 450Wp photovoltaic array.

The building covers a total area of approximately 50m^2 and it is actually a uniform area, with a kitchen, a bathroom and two other rooms. The walls and roofs of the building have increased insulation. Moreover, approximately half of the building's ceiling (at the north side) is covered by a pitched roof with tiles. The structure of the building's floor consists basically of one layer of a 15cm massive concrete. All windows and doors have aluminium frame with double glazing and are coated to protect the building from sun exposure during summer.

Figure 9. Bioclimatic house in the Iraklion suburbs

Figure 10. The roof after the cool coating was applied

Finally, at the south of the building, there is a shading mat. The large glazing area on the building roof is aligned to the south, so as to function as a heating storage system during winter. Although it was initially designed to be a passive house, air conditioning is needed during summer due to increased cooling loads. The energy consumption is estimated as 38 kWh/m^2 for cooling and 7 kWh/m^2 for heating, according to a 2008 audit.

Cool Roof technology

The cool coating used was a cool white paint manufactured by ABOLIN named Cool Barrier Roof with solar reflectance 0.89 and infrared emittance 0.89. The coating was applied on 15 July 2009 (Fig.10).

Evaluation results

The indoor temperature decrease -before and after the Cool Roof application- reached 1.5°C in summer and 0.5°C in the winter. The heating and cooling load reduction -due to the Cool Roof application- is approximately 27%, while the total energy efficiency is almost 19.8%, even though there is an increase in the energy consumption for heating that reaches 37%. This is because the energy consumption for heating is a small portion of the total energy demand for the specific building. The surface temperature decrease is depicted in Figure 11. The Cool Roof application is the most effective solution compared to increased insulation or window improvement, for the specific building, as illustrated in Figure 12.

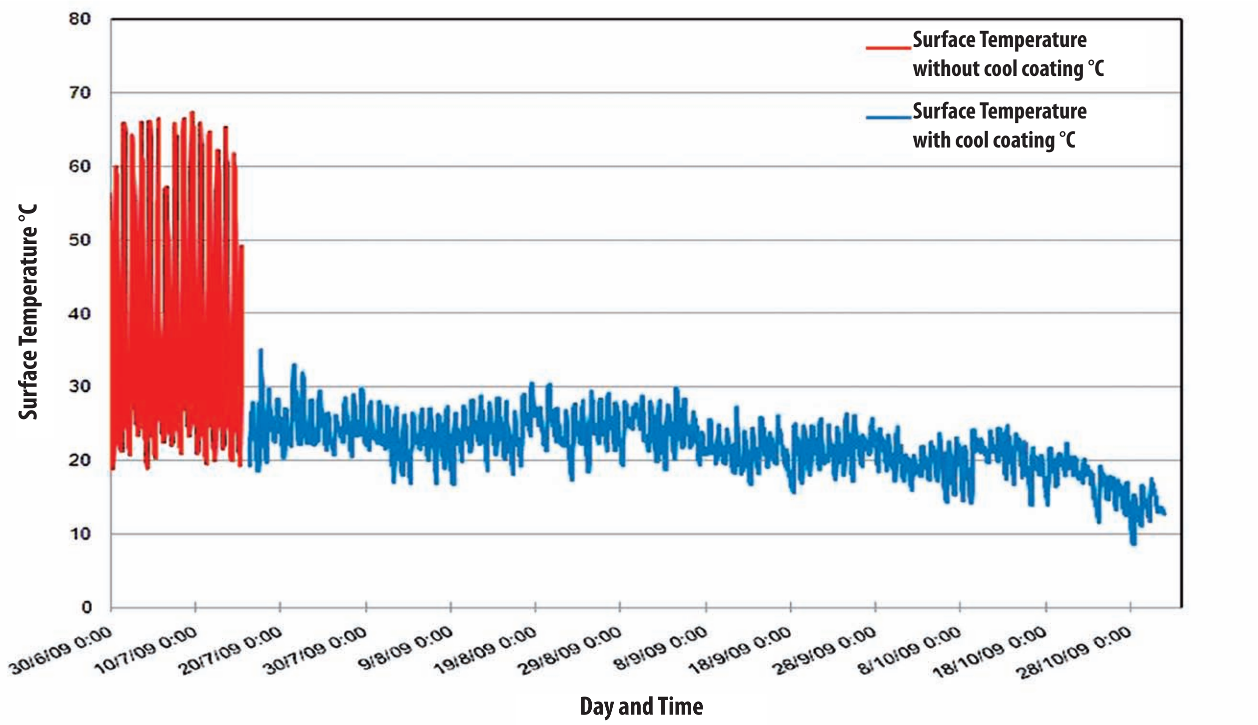


Figure 11. The roof's surface temperature before and after applying cool coating

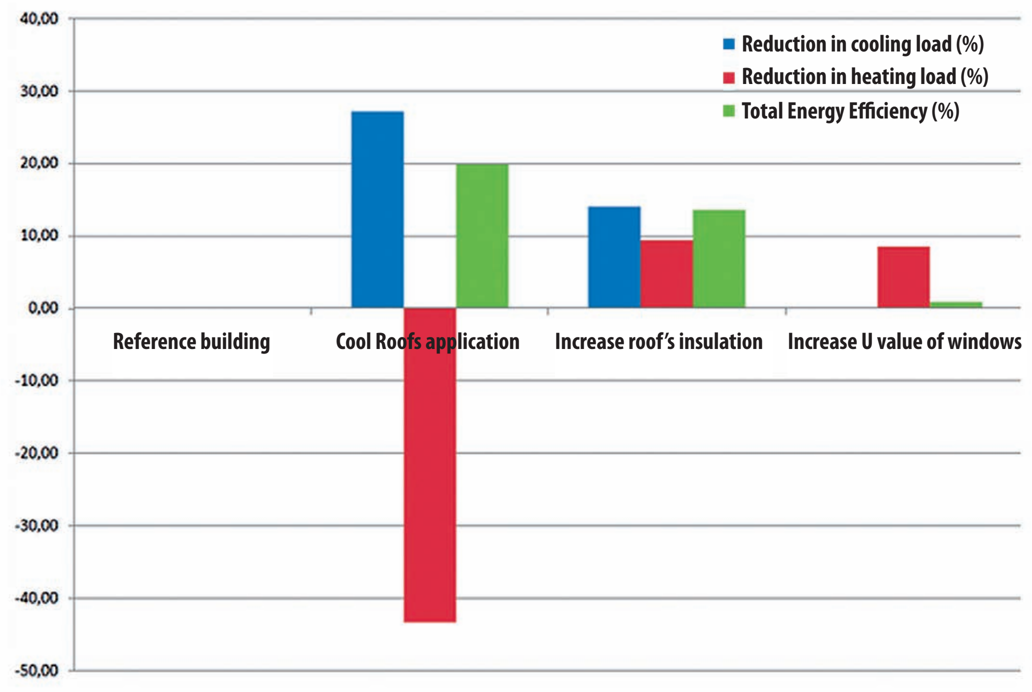


Figure 12. Comparison of different energy efficiency scenarios

3.3 ITALY

Public building in Trapani, Italy

The building

The building selected for the Italian case study (Fig.13) is a part of a school complex, hosting offices and laboratories and is located in Trapani, a town on the west coast of Sicily. It is greater than 700 m^2, has one floor and the load bearing structure is reinforced concrete. The walls have not been insulated and are made of *tufo* -a typical material in the area, and the windows are single glazed with non-thermally designed aluminium frames. The building is naturally ventilated and a compression heat pump was installed in summer 2009 in order to provide cooling and heating. The windows have been covered with internal shading.

The building's occupancy has a strong variation during the day and throughout the year, hosting from a dozen employees in the afternoons to up to 200 people during the summer with teacher recruitment activities. The office activities typically run from 08.00 to 17.00; laboratory activities run from 08.00 to 13.00.

Figure 13. The building in Trapani application of the cool paint

Figure 14. View of the roof with a partial application of the cool roof paint

Cool Roof technology

The initial roof surface was covered with cement and stone tiles, whose solar reflectance was estimated to be 0.25. For the study, the roof was covered with an eco-friendly cool paint based on milk and vinegar by Laboratori Ecobios. This product has a solar reflectance of 0.86 and a thermal emittance of 0.88.

Evaluation results

After the Cool Roof application, the percentage of hours in which the indoor temperature is above 25°C decreases from 78% to 52% (Fig.15). The percentage of temperatures above 27°C decreased from 54% to 15%. Before the Cool Roof application the daily mean indoor temperature was 1.8°C warmer than outside. After the application the indoor air is 0.9°C cooler than the outdoor temperature. The surface temperature of the cool roof is up to 20°C cooler than the original roof. The annual cooling energy demand is reduced by 54%. The cooling energy savings for the same building, if insulation is considered, is estimated around 28%. Comparisons of the Cool Roofs application with other techniques demonstrate that this is the most efficient solution to reduce the cooling demand of the Italian case study building (Fig.16).

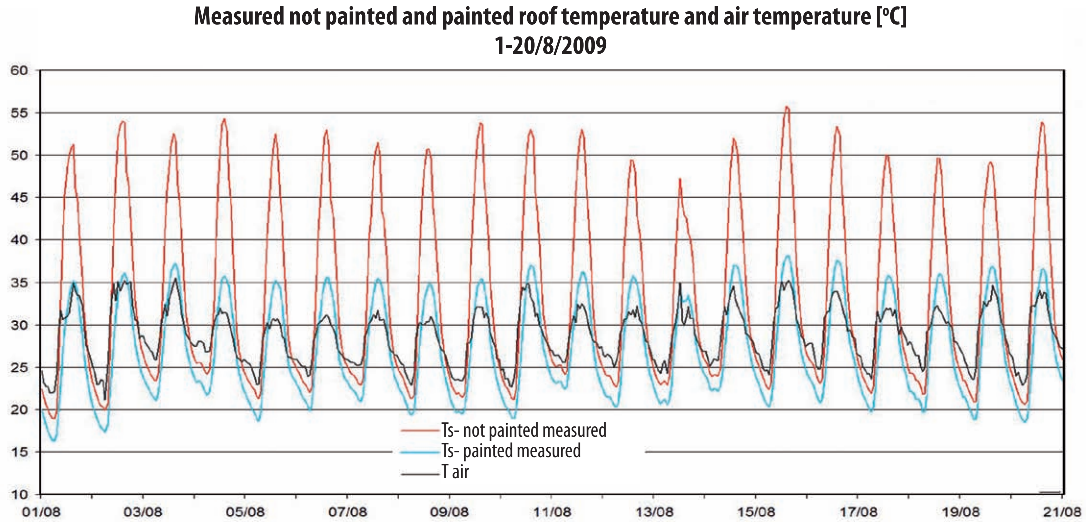


Figure 15. Comparison of cool and original roof surface temperatures in August 2009

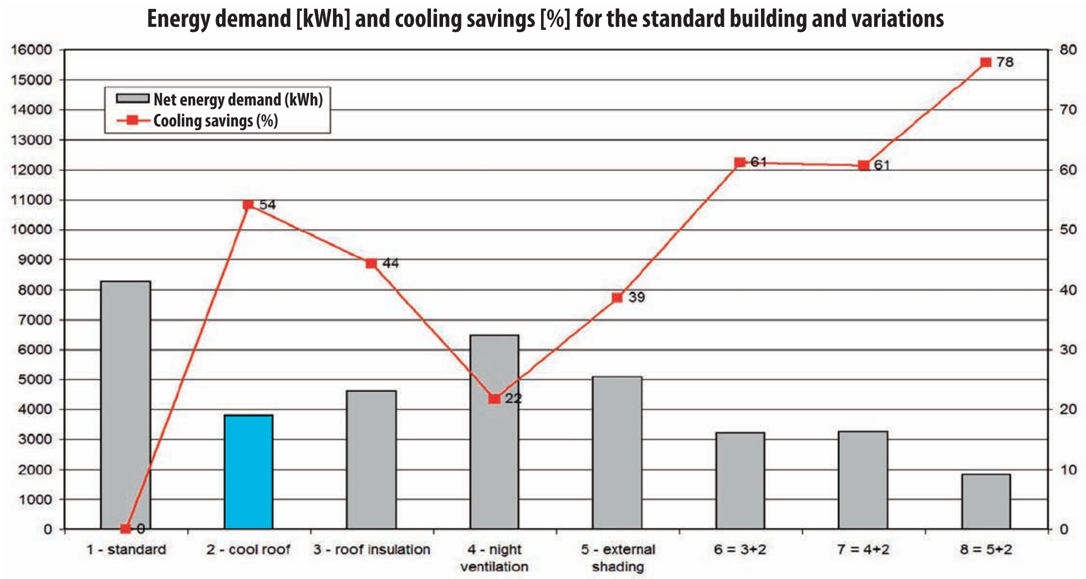


Figure 16. Potential cooling savings using Cool Roofs and other techniques
(including roof insulation, night ventilation, external shading and Cool Roofs in combination with these techniques)

3.4 UK

Office at Brunel University, Uxbridge, West London, UK

The building

The Estate Office at Brunel University consists of an open office area and three separate office rooms and is located at the top floor (flat roof) of a four floor building constructed in 1995 (Fig.17). It is heated with perimeter radiators and is naturally ventilated. The roof is made of a 0.15m thick concrete slab with a 0.04m insulation layer on top covered with a layer of water proofing material (asphalt). The external wall structure is made of concrete block work and is insulated externally.

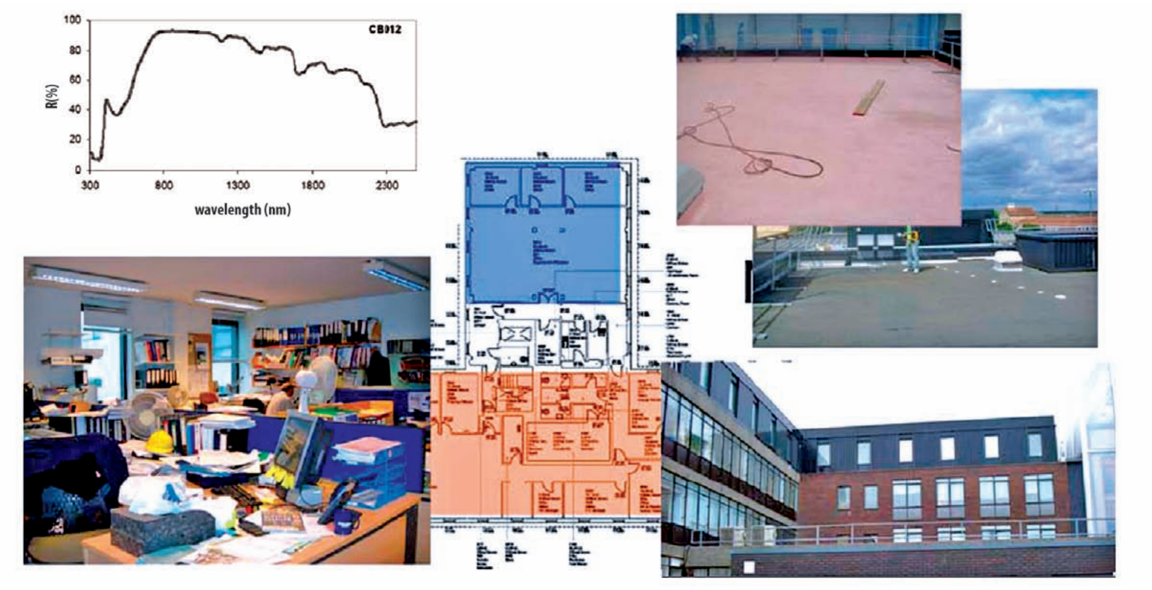


Figure 17. Floor plan and photos of the office and roof including the solar reflectance of the cool material applied

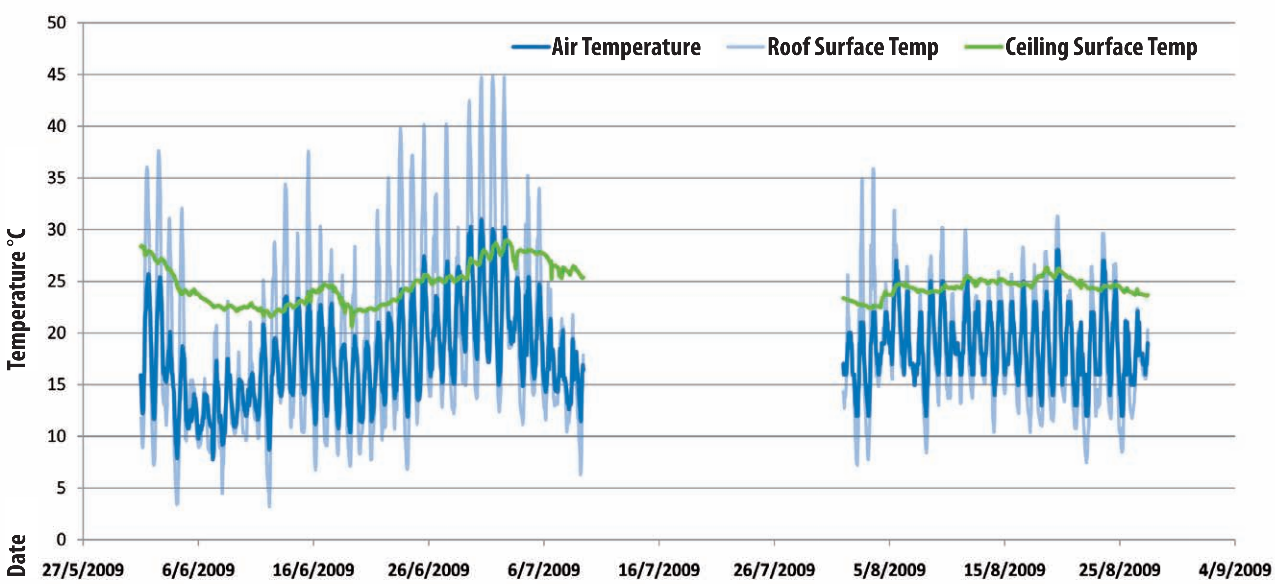


Figure 18. Measured surface and air temperature before and after the Cool Roof application

Cool Roof technology

Abolin's "Cool Barrier 012 (CB012)" was applied on the roof with an SR of 0.6 (measured on site after application) and an emissivity rating of 0.88. The reflectivity of the original roof was 0.1. The building was monitored from April 2009. Cool roof materials were applied in July 2009 and monitoring continued until October 2009 (Fig. 18).

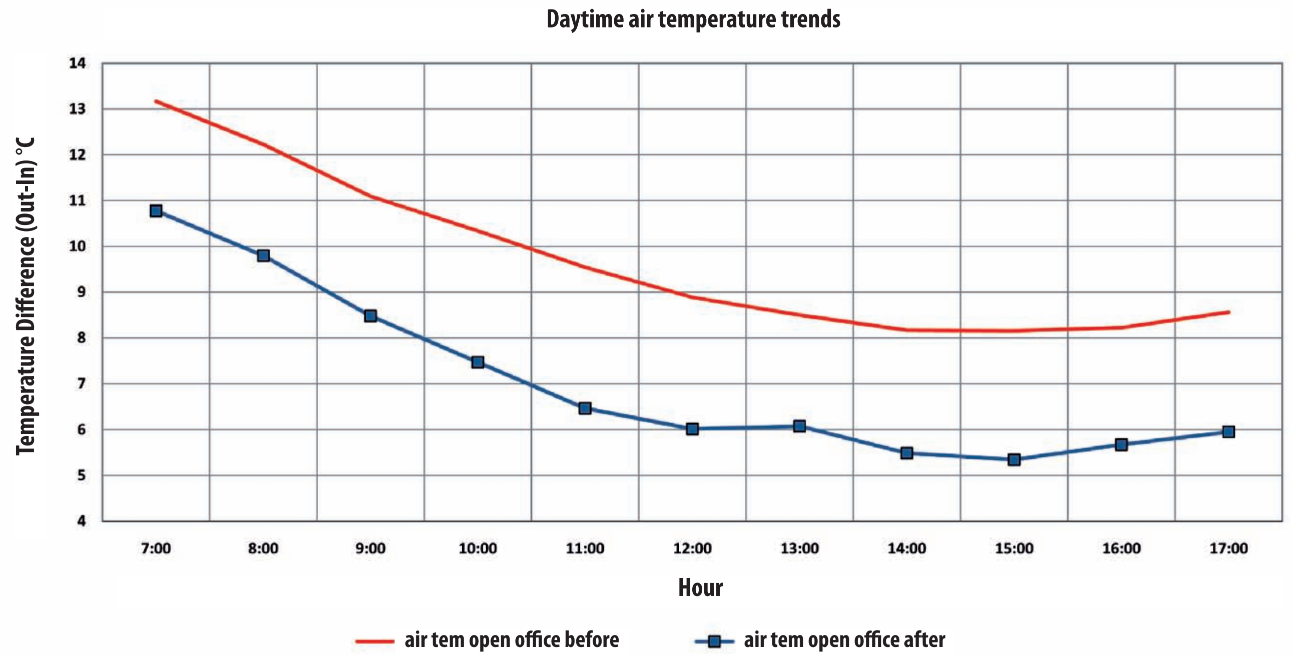


Figure 19. Measured daytime air temperature trends (external-internal difference), before and after the application of cool roof materials

Evaluation results

The measurements have shown that the:

- external surface temperature was reduced
- internal surface temperature was reduced by an average of 2°C in the middle of the day
- internal air temperature was reduced by an average of 3-4°C in the middle of the day.

Modelling with a calibrated model has shown:

- Overheating hours during the summer are significantly reduced with the application of cool roof materials resulting in an increase of the surface albedo (Fig.19).
- Cooling load is decreased; although there is a heating penalty, the overall contribution is positive.
- Optimum surface albedo is estimated between 0.6 and 0.7 with air exchange rate of 2 air exchanges per hour. This combination creates an overall heating and cooling load reduction of 3-6% depending on the set-point temperature for winter and summer.
- Increasing insulation levels would decrease the potential energy benefits in heating and cooling demand.

In conclusion, this case study analysis indicates that applying a Cool Roof technology could be beneficial for the moderate climate of South East England (suburban London), in terms of increased thermal comfort in the summer and could decrease overall energy use for heating and cooling. However, the energy savings are dependent on building related construction and operation conditions.

Project Coordinator
National and Kapodestrian University of Athens
Group Buildings Environmental Studies
www.grbes.phys.uoa.gr

Technological Educational Institute of Crete
www.teicrete.gr

Perdikis Bros Co.
www.abolincoolpaints.com

Municipality of Kessariani
www.kessariani.gr

Brunel University
www.brunel.ac.uk

Greater London Authority
www.london.gov.uk

University of la Rochelle
www.leptiab.univ-larochelle.fr

SIPEA Habitat
www.sipea-poitiers.fr

Italian National Agency for New Technologies,
Energy and the Environment
www.enea.it

Regional Province of Trapani
Sector for Land Environment Natural Resources
www.provincia.trapani.it

Ecobios Laboratori
www.ecobios-solaria.com

Federation of European heating and
air-conditioning associations
www.rehva.eu

Athena Consulting Group
www.athenanet.eu

Supported by:
Intelligent Energy Europe

GRAPHIC DESIGN: Nektarios Droudakis "pixelplus" / **PRODUCER, CREATIVE SUPERVISION:** Stavroula Tournaki