Promotion of Cool Roofs in the EU-The Cool Roofs Project

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ABSTRACT

Cool roofs technology is an energy efficient, financially viable and sustainable solution for mitigating the heat island effect and its consequences and for reducing building energy consumption for cooling. This technology is well known and applied in the U.S.: it is a part of the energy code in many states, organizations like the Environmental Protection Agency (USEPA, Energy Star) and the U.S. Cool Roof Rating Council and programs and incentives are promoting it. In Europe, this technology is not extensively known and very little information exists on cool roof products and their benefits. Several barriers explain this situation and they can be summarized in four categories: Lack of awareness, Lack of experience, Lack of incentives and Skepticism.

This paper presents the Cool Roofs project, an EU supported project aiming to remove these barriers by the implementation of an Action Plan for the promotion, market transformation and changing behavior towards cool roofs technology in the European Union. The work will be developed in four axes: technical, market, policy and end-users. The Action Plan will be steered by the development of the EU Cool Roofs Council that will bring together under the same umbrella all related stakeholders.

Introduction

Urban areas around the world are facing rapid population growth, urban sprawl and long commuting distances. Forests and open spaces covered with low natural vegetation are being replaced by residential buildings. As a result, solar energy is absorbed by concrete and paved surfaces, causing the surface temperature of urban structures to become several degrees higher than ambient air temperatures. As surfaces become warmer, overall ambient temperature increases. This phenomenon is called “the heat island effect” and represents a significant change in the urban microclimate. Summer urban heat islands (UHIs) with daytime air temperatures of 1°–6°C higher than the surrounding rural areas are present in many cities around the world and create significant problems related with increased energy demand and prices, accelerating the formation of harmful smog and causing human thermal discomfort and health problems by intensifying heat waves over cities (Clarke 1972, Oke et al., 1991, Akbari et al. 1992, Taha 1997a, Hassid et al. 2000, Santamouris 2001, Cartalis et al., 2001, Santamouris 2007, EPA 2009a)

Mitigation of the heat island effect can be achieved by the use of cool materials (on roofs and other surfaces of the urban environment). A cool roof is roofing system that can deliver: a) High solar reflectance (the ability to reflect the visible, infrared and ultraviolet wavelengths of the sun, reducing heat transfer to the building and the surrounding air) and b) High thermal emittance (the ability to release faster the absorbed solar energy) (Bretz and Akbari, 1997). Cool roofing materials include coatings, membranes, tiles, shingles and metal roofing (EPA2009b).

A large number of experimental and modeling studies (LBNL Heat Island Group, EPA 2009b, Konopacki et al., 1997, Konopacki and Akbari, 2001; Akbari et al., 1997, Akbari et al., 2009, Rosenfeld et al., 1997, Taha et al., 1997b, Taha 2005, Synnefa et al., 2008) demonstrate the benefits of cool roofs that can be summarized below:

- Reduction of building heat-gain: the T of a cool reflective roof typically increases only a few degrees C above ambient temperature during the day
- Savings on summertime air conditioning expenditures, in conditioned buildings ranging averagely 10-40% depending on building characteristics and use, climatic conditions.
- Improvement of thermal comfort conditions in non AC buildings.
- Reduction of peak electricity demand (resulting in downsizing of equipment, reduction of likelihood of power failures on extremely hot days, financial savings for electricity customers who are charged for the largest amount of power (watts) they demand during a billing period)
- Enhancement the life expectancy of the roof system reducing expenses for maintenance (because of less UV degradation and less thermal fatigue)
- As less heat is transferred to the surrounding air, mitigation of the Heat Island Effect by 1-2°C.
- Reduce resulting air pollution and CO_2 emissions.

The cool roofs technology is well known and applied in the U.S.: there are measurement standards related to cool roofs (ASTM Standard E1980-01, E903-92, E408-71(2002), G159-91 etc.), it is a part of the energy code in many states (ASHRAE Standard 90.1 and 90.2, California's Title 24, Chicago Energy Conservation Code etc.), organizations like the USEPA Energy Star, the U.S. Cool Roof Council and programs (e.g. LEED) and incentives are promoting it.

In Europe, this technology is not extensively known and very little information exists on cool roof products and their benefits. There are a lot of reasons for that. For example, the lack of a legislative framework results in owners and developers choosing roofs that minimize initial construction cost, rather than the aggregate cost of construction and lifetime energy consumption. Furthermore, it is believed that all cool materials must be white or light colored and the fact that cool colored materials do exist is not known (Levinson et al. 2007, Synnefa et al. 2007). The conservative building industry does not want to change the conventional roofing techniques used for decades or does not have the experience regarding the availability and benefits of cool roof products. Many people think that cool roofs will significantly increase their heating bills in the winter months not knowing that even in colder climates the cooling benefits of a cool roof far outweigh the potential winter month heating benefits of a less reflective, or black, roof surface. Cool Roofs barriers can be summarized into four categories: Lack of awareness, Lack of experience, Lack of incentives and Scepticism.

Cool Roofs is an EU supported project aiming to remove these barriers by the implementation of an Action Plan for the promotion, market transformation and changing behavior towards cool roofs technology in the European Union. The work will be developed in

four axes, technical, market, policy and end-users. The Action Plan will be steered by the development of the EU Cool Roofs Council that will bring together under the same umbrella all related stakeholders.
The major objective of the Cool Roofs proposal is the implementation of an Action Plan for the promotion, market transformation and changing behavior towards cool roofs technology in the European Union.

The project is coordinated by the National and Kapodistrian University of Athens, Greece, and the other 12 participants are the Technological Educational Institute of Crete, Perdikis Bros CO (ABOLIN), and the Municipality of Kaissariani, from Greece, the Brunel University, and the Greater London Authority from the UK, the University of La Rochelle, SIPEA HABITAT from France, the Ente Nazionale per le Nuove Technologie, l' Energia e l' Ambiente, The Provincia Regionale di Trapani, and the Laboratori Ecobios s.r.l. from Italy, the Federation of European Heating and Air-conditioning Associations and Athena Consulting Group from Belgium. Its duration is 30 months and has started on September 2008.

The EU Cool Roofs Council

In the framework of the COOL ROOFS project the EU -COOL ROOFS COUNCIL (EU-CRC) has been founded. The objective of the EU CRC is to bring together all the relevant actors in the field, i.e. industry, research institutes, market actors and cool roofs manufacturers, suppliers, and distributors, roofing contractors, consultants, as well as the end users. EU-CRC will merge all the driving forces for the promotion and adoption of cool roofs in EU targeting to accelerate the transfer of knowledge, to remove the market barriers, to help manufacturers to develop cool roofs products, to educate the public, policy makers and to develop incentive programs.

The 1st EU Cool Roofs Council meeting was held at Brunel University in London, UK, in February 2009. Apart from the project partners, important participation from the industry and institutions (BASF, Akzo Nobel, Daikin, Hambleside Danelaw, the Cyprus Institute, Monier Technical Center, Sonnergy Ltd., SOPREMA and Bioni CS GmbH (represented by ABOLIN)) underlines the great interest in Cool Roofs technology. The experience from the U.S. Cool Roof Rating Council was presented by Prof. H. Akbari, from the Heat Island Group at Lawrence Berkeley National Lab. The EU CRC at its present form has established 6 Committees in order to fulfill its objectives:

a) A Technical Committee to define Cool Roofing materials
b) A Documentation Committee to compile information on Cool Roofs technology
c) A Policy Committee to prepare, propose and influence new policies in EU
d) A Marketing Committee to identify market barriers in order to overcome them
e) An End users Committee for the dissemination to the relevant stakeholders
f) A Legal Committee for the legal matters of the EU CRC.

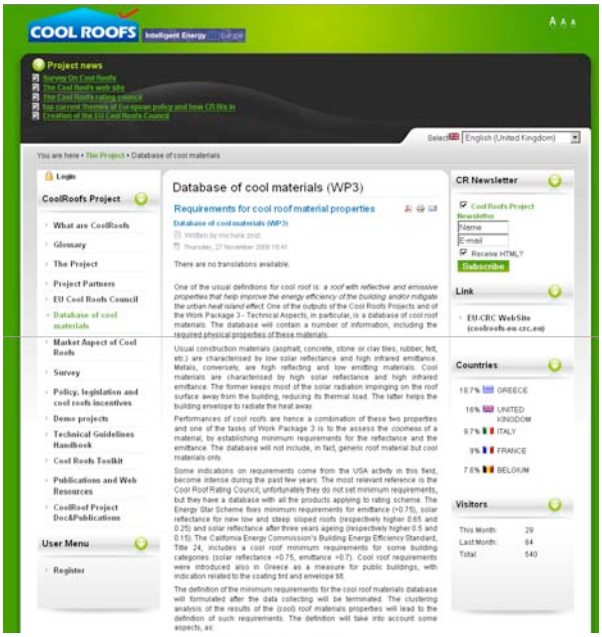
Now, the action plan of the EU-CRC is being elaborated. It can be viewed as a checklist of actions and strategies assisting the accomplishment of the objectives of the plan. The specific objectives of the cool roofs Action Plan are:

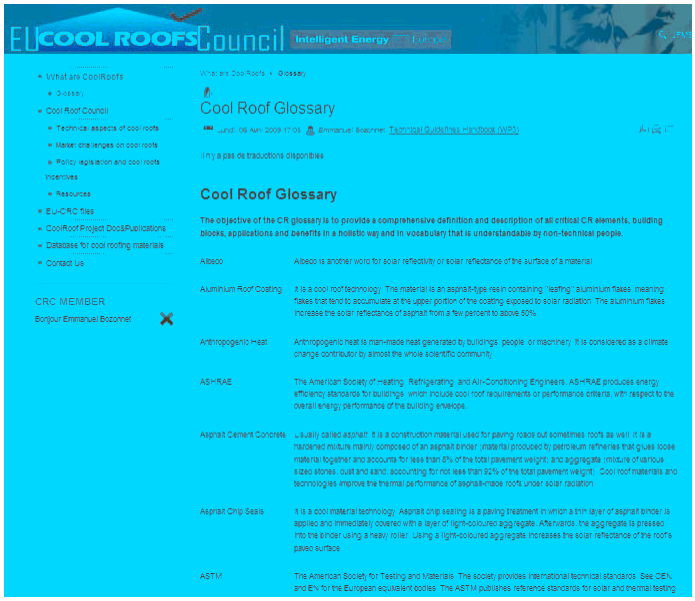
- to support policy development by transferring experience and improving understanding of the potential contributions by cool roofs to heating and cooling consumption in the EU

- to remove market barriers and simplify the procedures for cool roofs integration in construction and building's stock
- to change the behaviour of decision-makers and stakeholders so to improve acceptability of the cool roofs
- to disseminate and promote the development of innovative legislation, codes, permits and standards, including application procedures, construction and planning permits concerning cool roofs.

The European CRC has its own website: http://coolroofs-eu-crc.eu/ (contact: eucrc@phys.uoa.gr) on which all information related to the Council action and development is available. The EU-CRC website offers a technical glossary, articles on the three aspects (technical, market, policy) of cool roofs, some resources provided by the CRC, publications related to this technology also provided by the CRC, and finally a database of cool roofs material will be developed and provided via the website. Moreover, the website interface is available in 5 languages (English, Greek, Italian, French and German) and the most important resources will be translated too. This website is also an interactive platform for CRC members to share documents and communicate apart from CRC meetings.

Figure 1. The cool roofs project web site (A) and the glossary on cool roofs that is available directly from the main menu at the EU Cool Roofs Council web site (B)





The four aspects of cool roofs

The work that will be carried out in the framework of the COOL ROOFS project and the EU Cool Roofs Council will be developed in four axes, technical, market, policy and end-users, analysed below.

Technical aspect of cool roofs

The objective is to develop a deep understanding and to keep the EU-CRC up to date regarding the new technological developments and the evolution in the cool roofs sector. Through the continuous provision of expertise, new developments in the sector will be immediately transferred to the market through the EU-CRC.

A database of cool roofing materials has been developed representing an important tool for all the key actors; they can be informed about the products available on the market with all the relevant information. The main requirements of the database are:

- Supply general and technological information about each product (Name of the product, company (with hyperlink if applicable), country, type of product, roof slope, substrate)
- Include relevant physical data and performance indicators (Solar reflectance, infrared emittance, max. surface temperature, solar reflectance index)
- Easy to handle and to move through (excel file that will continuously be updated)

Currently the database contains about 100 different materials measured by specialised labs and will be on line by September 2009.

Furthermore, five demonstration projects are intended to be used as shining examples of the cool roof capabilities in improving the thermal conditions in not-cooled buildings and in reducing the energy consumption in cooled buildings. The demonstration activities take place at two levels: experimental monitoring in real buildings before and after the application of cool roof techniques and numerical analysis of the same buildings with a number of variants (comparison analysis will be performed towards other urban heat island mitigation techniques, i.e green roofs).

The following buildings have been selected:

- Cooled 800 m^2 office building in a school campus in Trapani, Sicily, Italy.
- Cooled 50 m^2 laboratory in Chania, Crete, Greece.
- One not-cooled elementary school buildings in Kessariani, Greece.
- Not-cooled laboratory in London, England.
- Not-cooled 100 m^2 residential unit in La Rochelle, France.

Moreover, a tool-kit dedicated to a simplified evaluation of the potential benefit of cool roof has been developed (first version of the tool already available), which allows the evaluation on the basis of the following parameters:

- Climatic data.
- Main thermo-physical properties of the roof.
- Energy system type, fuel and costs

The main outcome is the energy and economic assessment of the cool roof applications.

Finally, a technical guidelines Handbook will be developed and will be continuously updated during the project's lifetime. The contents of the handbook are:

1. Introduction to the heat island problem and overview of cool roofs characteristics and technical aspects
2. Cool Roofs materials state of the art
3. Implementation of cool roofs in the framework of this project
4. Tool-kit description and operational recommendations
5. Cool Roofs in the EU

All the results described above will be available on line at the project web site.

Marketing aspect

In the market axis the objective is to fight the “lack of awareness” and “skepticism” in the field of cool roofs. Therefore the marketing plan will have a twofold target: (a) to inform the key players regarding the existence and the innovative technologies for cool roofs and (b) to trigger them. In this scope, a report regarding the main cool roof products features has been created. This report includes a general description of cool roof products, their major benefits and the technical characteristics per product category. Furthermore, a detailed description is given on the distribution system and ordering, the pricing and delivery, and the promotion, branding and labeling of cool roofs products.

Additionally, the definition of the target market and strategy to be used to reach targeted customers will be done. A list of the “key players” in the market transformation has been created. The list contains two major categories of key players: a) Target groups: Market actors in the field of roofs, end users, building engineers, scientists and experts and local and EU policies stake holders. b) Key actors: scientific organizations, International institutions. For these categories the contact information (name, address, phone, email, fax etc.) has been gathered for the project countries (GR, FR, BELGIUM, IT), for other EU countries, USA, Japan, other countries in the world and international (referring to organizations that can not be locally defined). The list contains currently more than 1000 contacts. This list will be available on line on the project web site.

The next step that is currently under way is the evaluation of how the target groups perceive the cool roofs in relation to other solutions as well as the target market’s attitude regarding the cool roofs products will be performed. For this, a questionnaire has been developed and will be distributed to the key players list in order to have a quantitative measure on the potential of incorporating cool roofs. The questionnaire’s recipients are professional institutes, private companies, free lance engineers, building owners, contractors, etc. This questionnaire Interviews will be released to public and private building sector end users. In addition, historical analysis of the market trends for the last 10 years in comparison with US figures will be elaborated and a strategic plan for overcoming the already known market barriers, i.e. lack of awareness for the construction companies, buildings' contractors, technicians and skepticism for the manufacturing companies in the field, will be developed.

Based on these results, a marketing plan will be also developed to maximise the promotion of cool roofs. It will include advertising, investigation of the role of public relations and incentives and it will set the methods for promotion in the market.

Policy aspect

The aim of the policy axis is the analysis of the policy framework in the EU and in particular Member States and to recommend clear and concrete policy measures and initiatives that can assist the overall work of the Cool Roofs Action Plan. A situation analysis of existing policies in EU, Member States and international context as well as any relevant scenario planning for upcoming policy changes/trends will be created through: a) Study of the existing regulations in the EU and Member States that are relevant and affect the introduction of Cool roof technology. b) Assessment of the level (low-medium-high) of the impact of those regulations to the cool roofs technology, prioritizing the relevant regulations mentioned above according to the level of potential positive or negative effects to the accelerated market

penetration of the technology, c) Identification of successful international policies that facilitate the introduction of the cool roof technology in the respective countries/regions.

Furthermore, recommendations as to how to incorporate cool roof benefits and facts into EU policies will be developed. The advocacy opportunity will be assessed and a contact programme and advocacy work at EU level will be developed. The relevant EU, Member States or international stakeholders that can positively influence EU policies to facilitate the introduction of cool roof technology will be mapped and identified. This will happen via interviewing key stakeholders, via the "key players" list as well as via desk research. An action plan to create synergies with those relevant stakeholders (form coalition) will be recommended. Moreover, **e**xisting networks and experiences from EU, individual Member States, international level, will be used as appropriate. An action plan to leverage this network will be recommended. The action plan will be drawn to foster the synergies and network of stakeholders (that has been created as described above), utilize the previous success stories from other regions and address the "hot policy issues"/priority policy areas for Cool Roofs.

End users aspect

The main target of the end users axis is the wider projection of results of the proposed work. The activities of publicity that will be materialized are categorized based on the project characteristics and the characteristics of the urban planning sector are:

• Initial Actions: Those include the determination of the project and EU-CRC ID that will accompany all diffusion actions.

• Actions of Informing. The project's and EU-CRC web site will be used for a) assisting dissemination and diffusion activities – on project, partnership, events, news, results and outputs b) assisting an expert feedback on an iterative basis, so outputs reflect the response of the scientific sector to the project results c) Inter-linking with, and provide additional support to, market actors, stakeholders, etc. related to project outputs. Additionally the COOL ROOFS project will develop: publications of hardcopy and electronic brochures, newsletters of briefing and information and a multimedia spot on the benefits of cool roofs.

• Actions of Publicity and Projection. The COOL ROOFS project will publish related articles and announcements in printed publications, local magazines and electronic publications.

• Actions of Promotion. These actions include: a) Organization of local workshops and seminars b) participation to EU Conference with distribution of brochures and an oral presentation c) Participation in an International Exhibition.

Main results and target groups of the Cool Roofs project

The main results of the cool roofs project are summarized below:

- The creation of EU Cool Roofs Council (EU CRC) as well as the development of the EU CRC's Action Plan and strategic plan.
- Five cool roofs pilot studies to serve as examples of cool roofs benefits, a database of cool roofing materials and manufacturers, a handbook and a toolkit to assist the better understanding of the technical aspects of cool roofs technology

- A market promotion plan for the market aspect of cool roofs that will be based on the mapping of key players in the field and the analysis of the existing market situation in EU.
- A proposal for a successful strategy to overcome possible policy barriers and engage with key stakeholders who could support and accelerate the creation of an EU policy and regulatory friendly environment to Cool roofs.
- The organization of workshops and seminars and participation to an EU Conference and an exhibition to disseminate the results of the project. Creation of a web portal providing visitors with information about the Cool Roof project: http://www.coolroofs-eu.eu/ and the EU-CRC: http://coolroofs-eu-crc.eu/.

The key players for the successful implementation of the COOL ROOFS project can be divided in two categories: a) target groups including:
- Market actors in the field of roofs (e.g. Roofing contractors and construction, Paints manufacturers and retailers, construction companies)

- End-users (Building owners and renters, Consulting and Real Estate Companies, Municipalities and local energy agencies, Public housing organizations and companies etc.)

- Building engineers, scientists and experts (Designers and architects, Civil Engineers, Urban planners, Building auditors involved in Certification activities etc.)

- Local and EU policy stakeholders (Ministries of Environment, Urban Planning, Prefectures and municipalities, Regional Agencies and regional planners)

b) Key Actors: for the achievement of the project's results and according to the four aspects defined: Scientific Organizations (technical axis), International Institutions and Organizations as well as local stakeholders (end users axis), Market actors (market axis), Environmental and Energy policy players (policy axis).

Conclusions

The work and results of an ongoing project called Cool Roofs focusing on the promotion of cool roofs technology in the European Union have been presented. The basic aspects of Cool Roofs technology have been analyzed pointing out its main benefits. In the framework of this project the EU Cool Roofs council has been founded with important participations from the industry and other relevant stake holders. A database of cool roofing materials has been created and is available on line on the cool roof project web site. Five demo projects, a handbook and a toolkit will help demonstrate the benefits of cool roof technology. The market promotion plan that will be developed will contribute to overcoming cool roof market barriers. The work on the policy axis will help understand the mechanisms for incentives in EU and local level for the promotion and adoption of cool roofs. The outcomes of the project will be communicated to the target groups through an extensive information campaign.

It is expected that the outcome of the project will clearly demonstrate the benefits of cool roofs technology in terms of energy savings, indoor thermal comfort improvement and financial viability. Cool roofs technology will be promoted through integration in EU and state policies, relevant financial incentives and the increase of cool roof market share in the EU.

References

Akbari H., Menon S. and Rosenfeld A. (2009), Global cooling: increasing world-wide urban albedos to offset CO_2, Climatic Change (2009) 94:275–286, DOI 10.1007/s10584-008-9515-9.

Akbari, H., Bretz, S., Taha, H., Kurn, D., Hanford, J., 1997. Peak power and cooling energy savings of high albedo roofs. Energy and Buildings – Special Issue on Urban Heat Islands and Cool Communities 25 (2), 117–126.

Akbari H., Davis S., Dorsano S., Huang J., and Winert S., Eds., 1992: Cooling Our Communities—A Guidebook on Tree Planting and Light-Colored Surfacing. U.S. Environmental Protection Agency, Office of Policy Analysis, Climate Change Division, 217 pp.

ASHRAE Standard 90.1 (2004 edition) Energy Standard for Buildings Except Low-Rise Residential Buildings, section 5.3.1.1.

ASHRAE Standard 90.2 (2004 edition) Energy Efficient Design of Low-Rise Residential Buildings, section 5.5

ASTM Standard E1980-01 Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces

ASTM E408-71(2002) Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques

ASTM Standard E903-96. Standard Test Method for Solar Absorptance, Reflectance and Transmittance of materials using integrating spheres.

ASTM Standard G159-91. Standard Tables for References Solar Spectral Irradiance at Air Mass 1.5: Direct Normal and Hemispherical for a 37° Tilted Surface. (in compliance with ISO 9845-1:1992)

Bretz, S., Akbari, H., 1997. Long-term performance of high albedo roof coatings. Energy and Buildings 25, 159–167.

California's Title 24: www.energy.ca.gov/title24/

Cartalis, C., Synodinou, A., Proedrou, M., Tsangrasoulis, A., Santamouris, M., 2001. Modifications in energy demand in urban areas as a result of climate changes: an assessment for the Southeast Mediterranean region. Energy Conversion and Management 42 (14), 1647–1656.

Chicago energy conservation code: City of Chicago: http://egov.cityofchicago.org

Clarke J. F., 1972, Some effects of the urban structure on heat mortality. Environmental Research Volume 5, Issue 1, March 1972, Pages 93-104. doi:10.1016/0013-9351(72)90023-0

Cool Roof Rating Council: http://www.coolroofs.org

Energy Star: http://www.energystar.gov/index.cfm?c=roof_prods.pr_roof_products

EPA 2009a, Reducing Urban Heat Islands: Compendium of Strategies Urban Heat Island Basics, Available on line at: http://www.epa.gov/hiri/resources/compendium.htm

EPA 2009b, Reducing Urban Heat Islands: Compendium of Strategies Cool roofs, Available on line at: http://www.epa.gov/hiri/resources/compendium.htm

Konopacki, S., Akbari, H., 2001. Measured energy savings and demand reduction from a reflective roof membrane on a large retail store in Austin. Lawrence Berkley Laboratory Report No. LBNL-47149, CA.

Konopacki, S., H. Akbari, M. Pomerantz, S. Gabersek, and L. Gartland. 1997. Cooling Energy Savings Potential of Light-Colored Roofs for Residential and Commercial Buildings in 11 U.S. Metropolitan Areas. Paper LBNL-39433. Lawrence Berkeley National Laboratory, Berkeley, CA

LBNL Heat Island Group: http://heatisland.lbl.gov/ (publications)

LEED® (by USGBC) www.usgbc.org

Levinson R., Akbari H., Reilly J.C (2007). Cooler tile-roofed buildings with near-infrared-reflective non-white coatings. Building and Environment, 42 (7), pp. 2591-2605.

Oke, T.R., D.G. Johnson, D.G. Steyn, and I.D. Watson, 1991: Simulation of surface urban heat island under 'ideal' conditions at night – Part 2 : Diagnosis and Causation. Bound.- Layer Meteor., 56, 339-358

Rosenfeld, A.H., Akbari, H., Pomerantz, M., Taha, H., Romm, J.J., 1996. Policies to reduce heat islands: magnitudes of benefits and incentives to achieve them. In: Proc. 1996 ACEEE Summer Study on Energy Efficiency in Buildings 9.

Santamouris, M., 2007. *Heat island research in Europe - State of the art.* Advances Building Energy Research 1. pp. 123-150

Santamouris, M. (Ed.), 2001. Energy and Climate in the Urban Built Environment. James and James Science Publishers, London.

Synnefa, A; Dandou, A; Santamouris, M; Tombrou, M; Soulakellis, N (2008), On the Use of Cool Materials as a Heat Island Mitigation Strategy, Journal of Applied Meteorology and Climatology 47.

Synnefa A., Santamouris M., and K. Apostolakis, 2007: On the development, optical properties and thermal performance of cool colored coatings for the urban environment. Sol. Energy, 81, 488–497

Taha H., (1997a), Urban climates and heat islands: Albedo, evapotranspiration, and anthropogenic heat. Energy Build., 27 (1007), 99–103

Taha H., 1997b: Modeling the impacts of large-scale albedo changes on ozone air quality in the South Coast Air Basin. Atmos. Environ., 31, 1667–1676.

Taha H., 2005: Urban surface modification as a potential ozone airquality improvement strategy in California—Phase one: Initial mesoscale modeling. Altostratus Inc. for the California Energy Commission, PIER Energy-Related Environmental Research Rep. CEC-500-2005-128