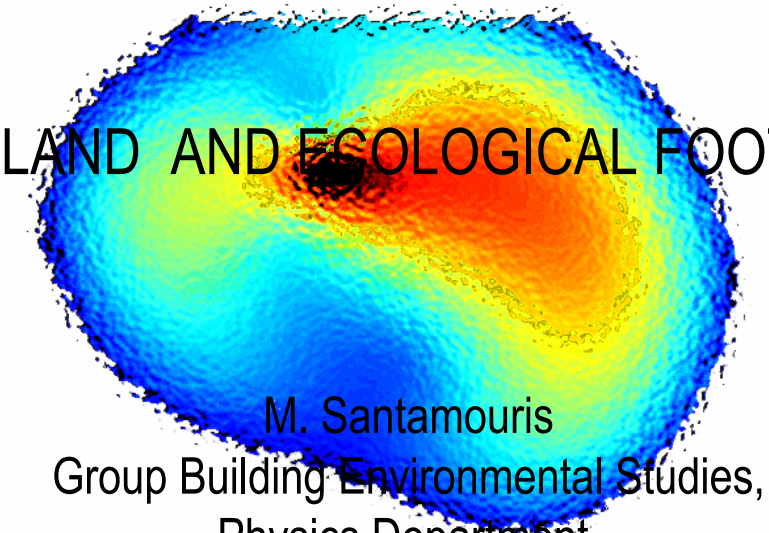
HEAT ISLAND AND ECOLOGICAL FOOTPRINT



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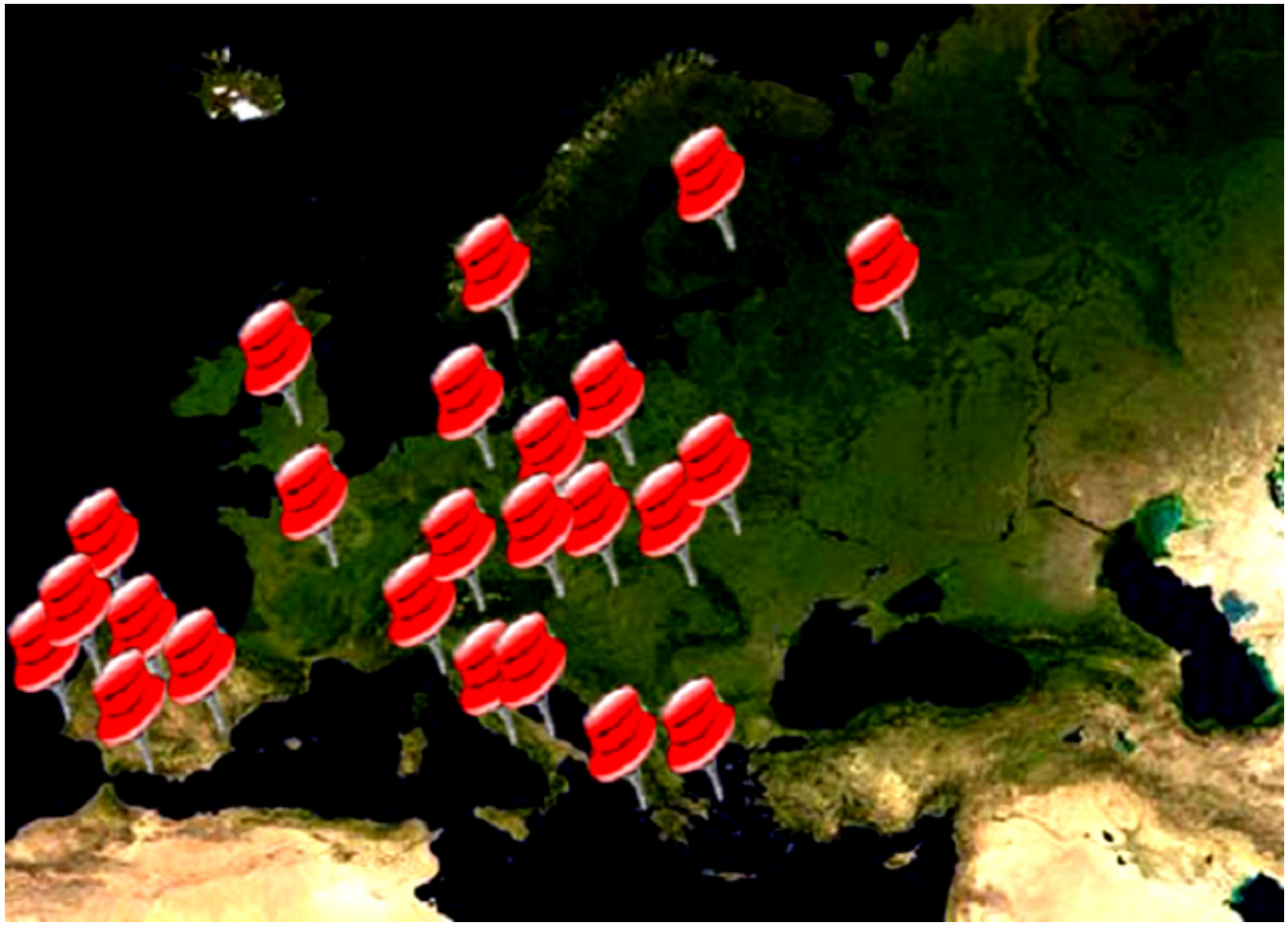
Athens
16 May 2007

HEAT ISLAND INTENSITY OF EUROPEAN CITIES



Cities where Heat Island Studies have been performed

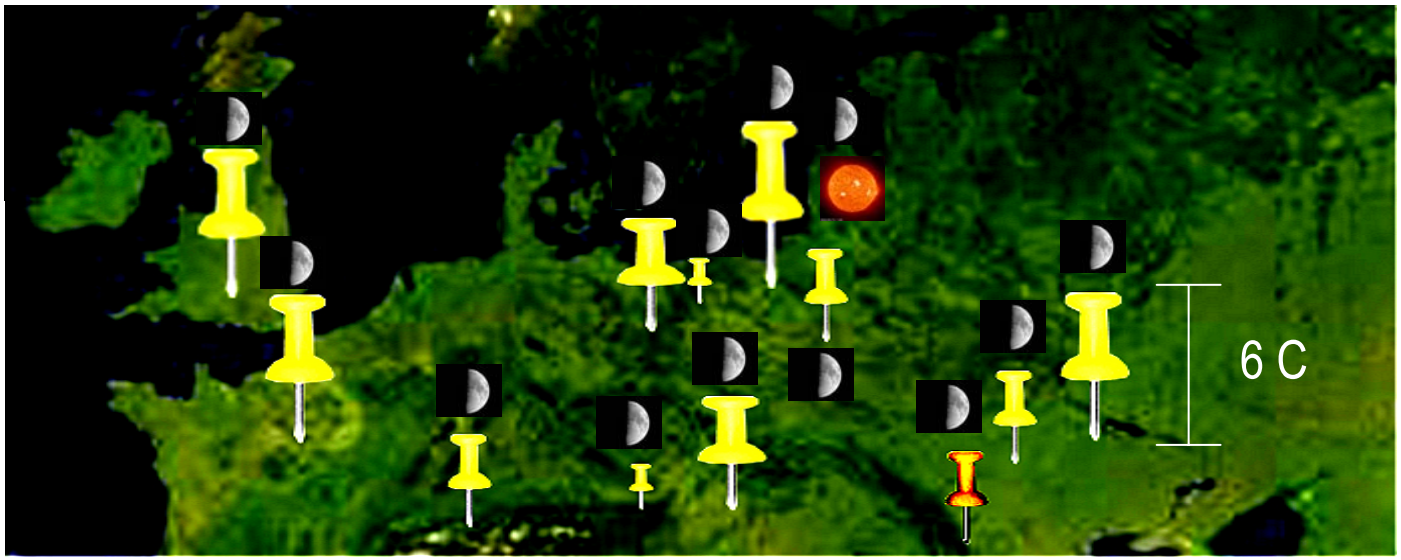
HEAT ISLAND INTENSITY IN SOUTHERN EUROPE

Heat Island Intensity in Southern Europe

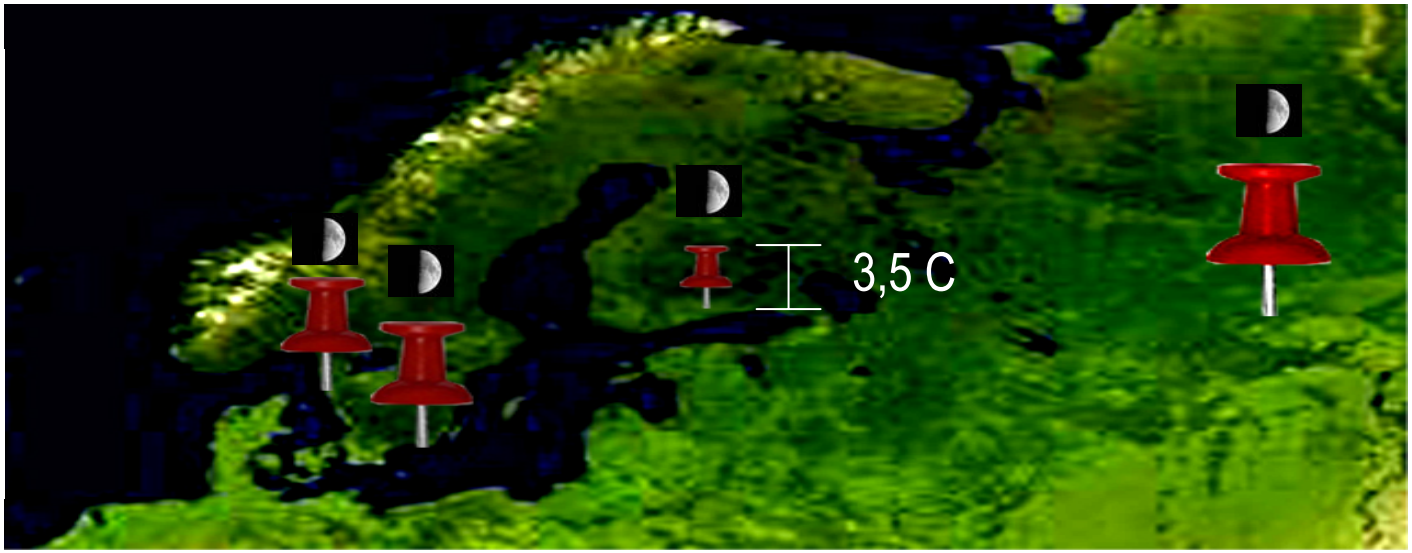
When Heat Island Intensity is higher

HEAT ISLAND INTENSITY IN CENTRAL AND NORTHERN EUROPE

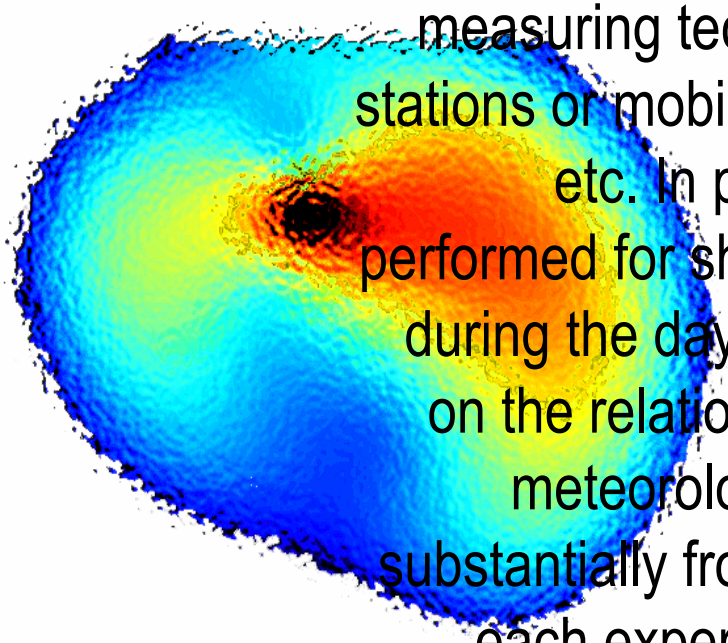
Heat Island Intensity in Central Europe



Heat Island Intensity in North Europe



TYPE OF MEASUREMENTS



Although many data are available on the heat island in Europe, the overall picture is still not very clear. Measurements have been performed using different measuring techniques, either routine meteorological stations or mobile stations, special temperature boxes, etc. In parallel, most of the measurements are performed for short time periods, and some are limited during the day or night period. The reported analysis on the relation of the temperature differences to the meteorological and urban characteristics, varies substantially from paper to paper, as the objectives of each experiment was different. Thus, a very clear comparison of the reported results is not evident.

ENERGY IMPACT OF HEAT ISLAND

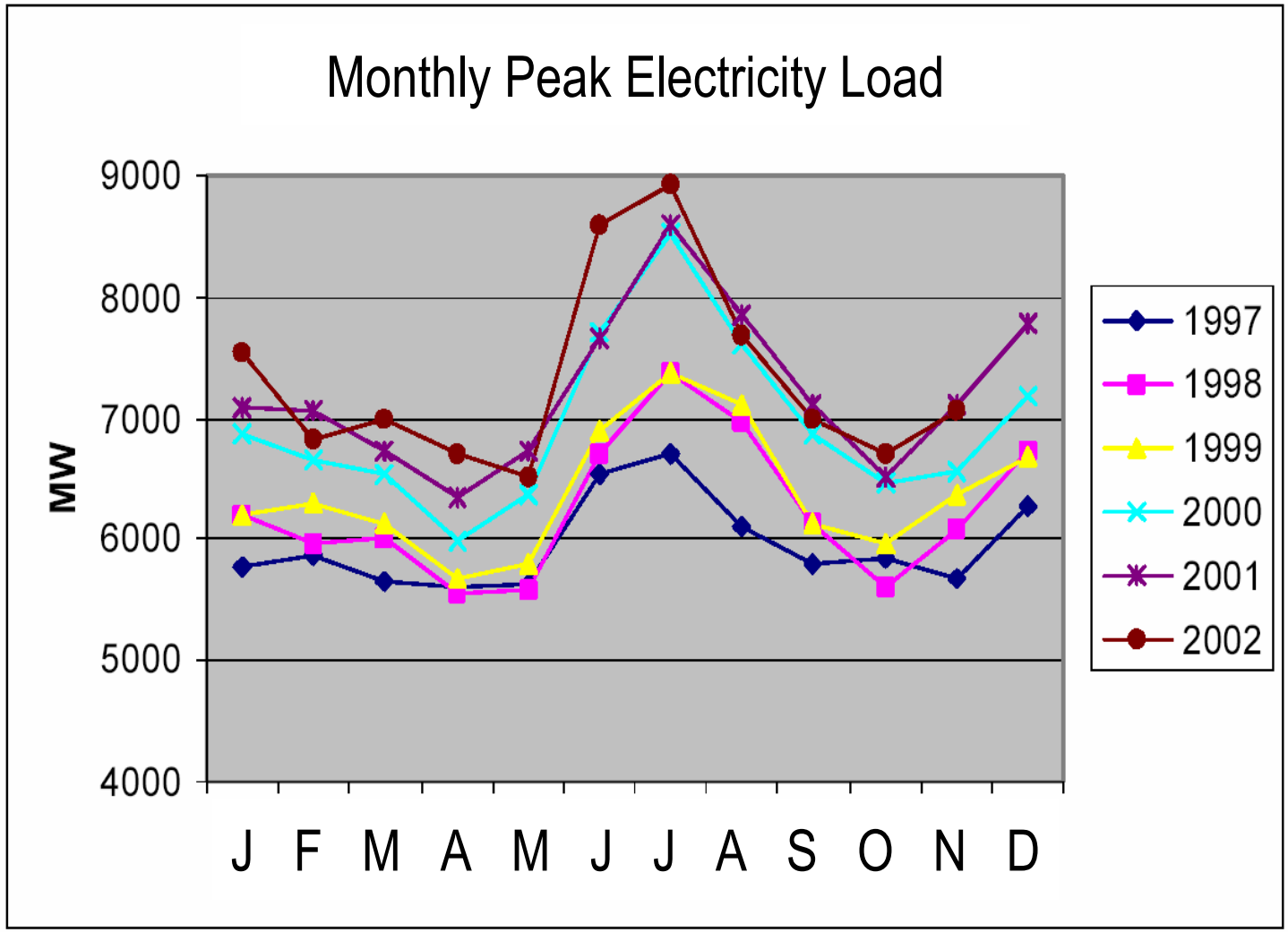
Unit: GWh	1990	1996	2010	2020
Austria	68,6	121,3	235,0	,5
France	331,6	1782,1	5517,2	75,5
Germany	155,9	672,4	1914,0	3197,3
Greece	208,8	1006,6	2281,3	3478,6
Italy	761,0	4494,1	5743	7033,9

Portugal	162,4	713,8	1806,8	2552,2
Spain	not av		9366,4	15146,6
UK	120,0	446,0	1135,7	1783,8
Other E.U	1	443,5	1159,1	1897,7
Total E.U	27,9	12176,2	29159,1	44430,2

Two Studies :
- Athens
-- London

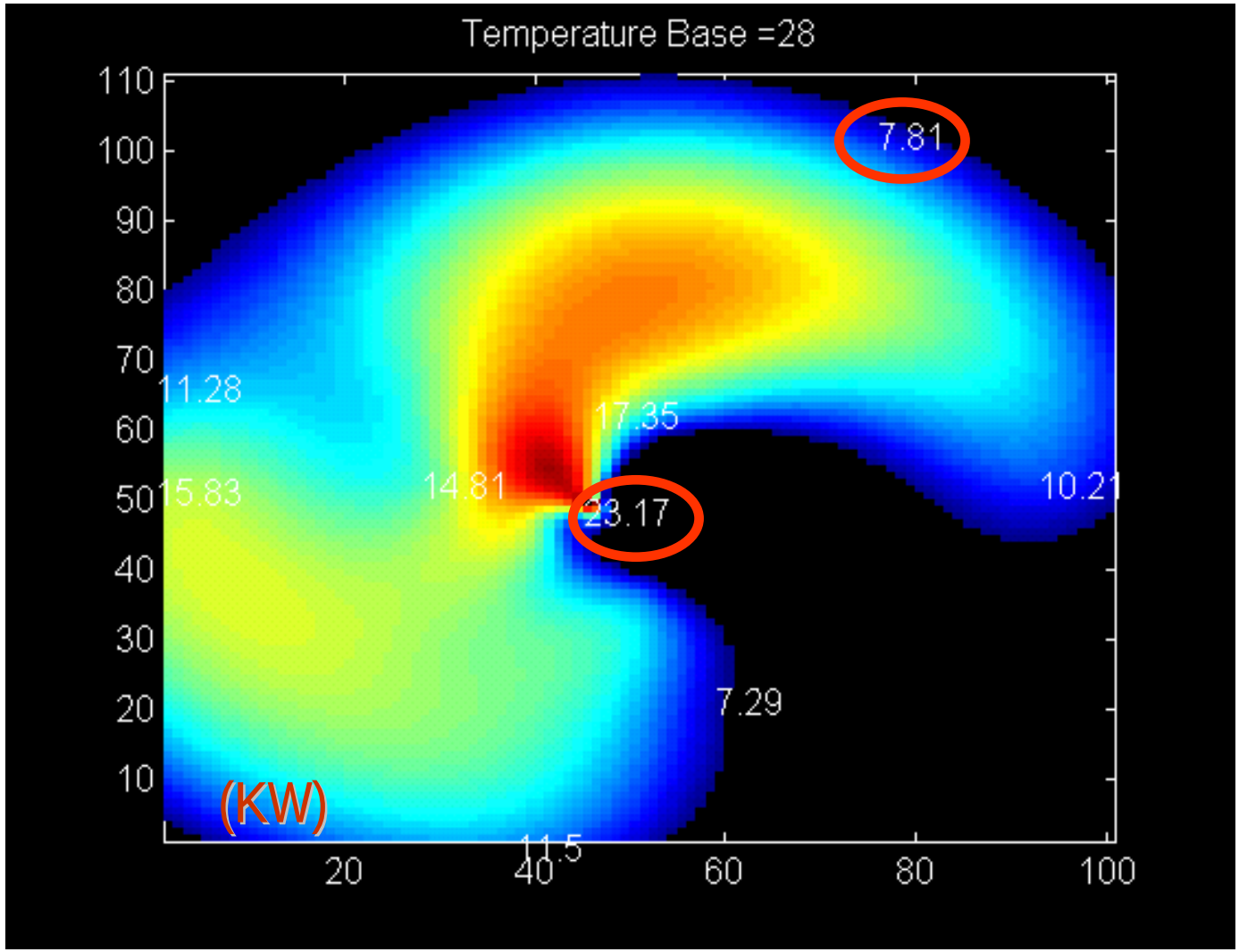
VERY HIGH INCREASE OF PEAK ELECTRICITY DEMAND

Peak Electricity Load in Greece

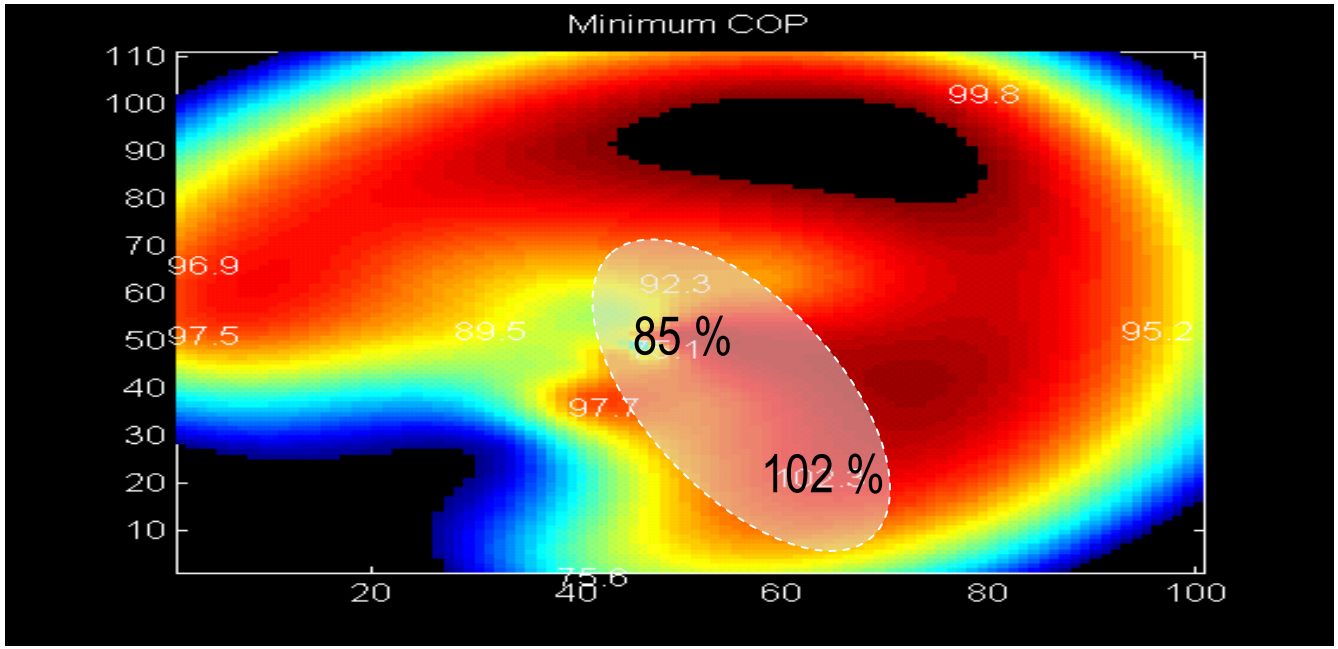


Distribution of Cooling Load in Athens

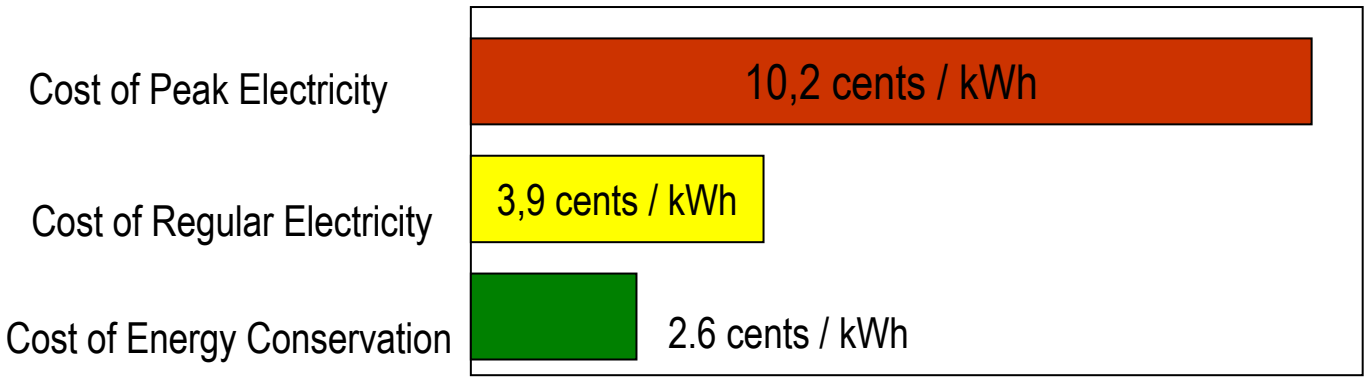
Distribution of Peak Electricity Demand in Athens



ENERGY IMPACT OF HEAT ISLAND



Distribution of Minimum COP of A/C in Athens



ENERGY IMPACT OF HEAT ISLAND

Year	1997	1998
Athens' heat island energy cost (kWh/m^2)	38.2	29.0
Total Athens' heat island energy cost (GWh)	1772.5	1345.6
CO_2 emissions (tn)	5317440	4036800
Ecological footprint of the Athens' heat island (ha)	1036901	787176

Increase of the Ecological Footprint in Athens

The results show given the actual penetration of air conditioning in the country, the ecological footprint because of the heat island ranges 1.5-2 times the city's political area that have to be reserved every year to compensate the additional CO2 emissions caused by the presence of the heat island effect while the maximum potential ecological footprint provided that all buildings are air conditioned is almost 110000 hectares.

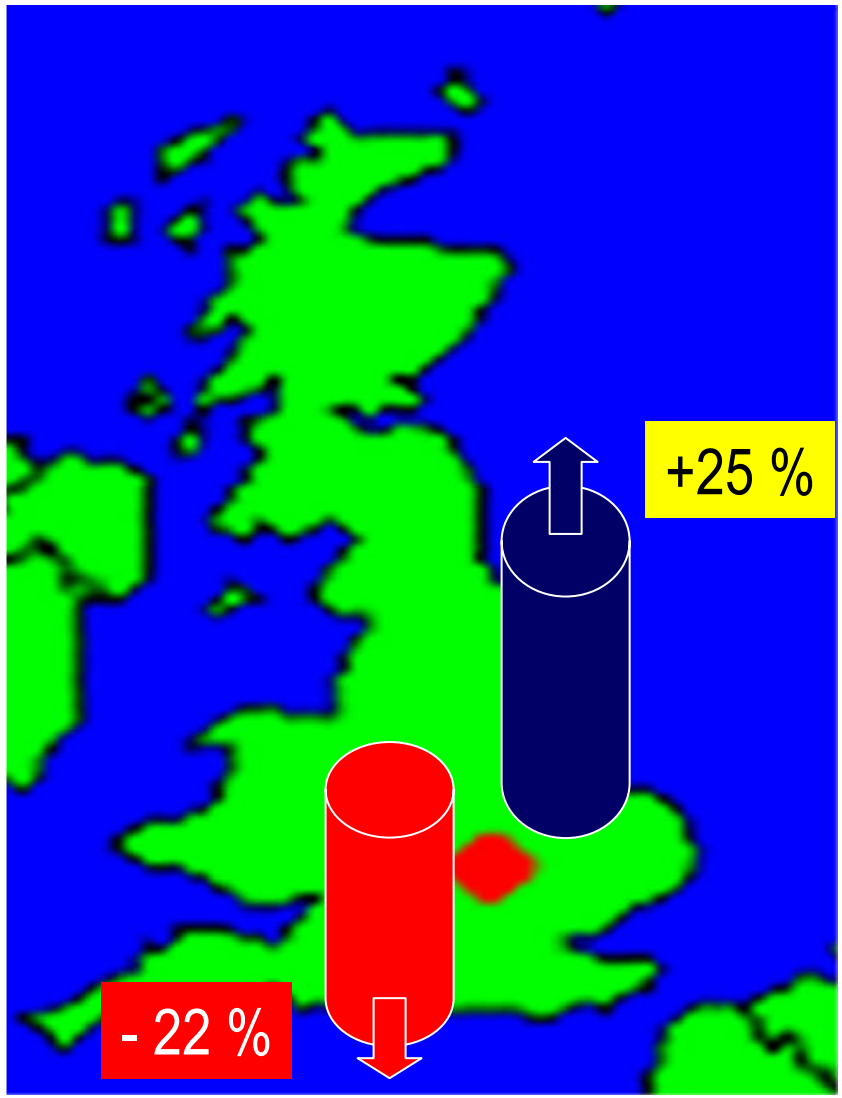
Economic Cost of Heat Island in Athens

Based on the measured temperature data the additional energy spend for cooling purposes to counterbalance heat island effect in the major Western Athens area is calculated. The difference between the energy consumption of buildings and the one they would had the climate been similar to the one of reference station is equal to 41.3 GWh.

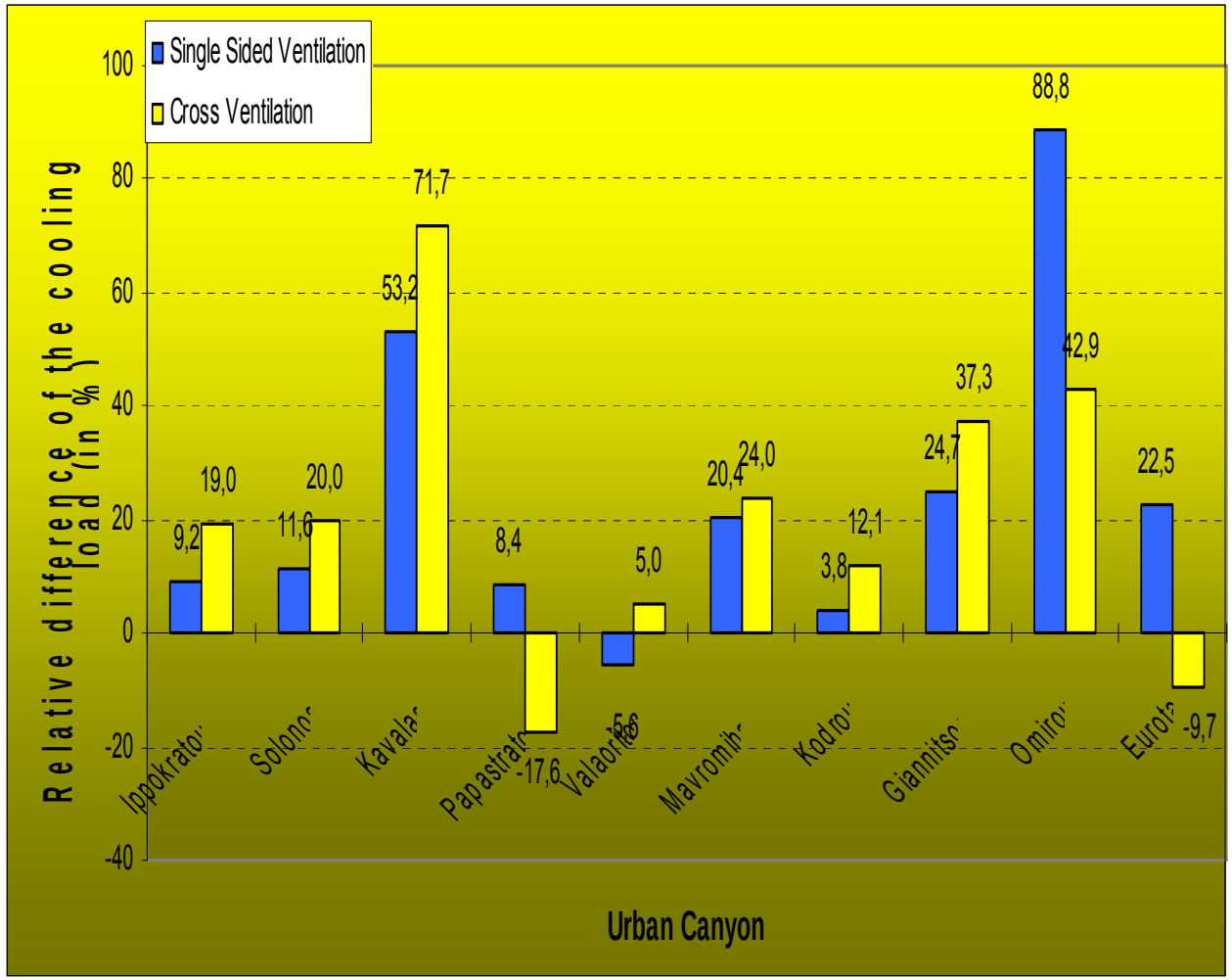
The cost to compensate the heat island is calculated close to 4.13 MEuros/year or 164 Euro's per household. The additional peak cooling electrical load to compensate the heat island is 82.4 MW, which is 25 MW more than the figure of the area almost not affected by the heat island. According to the calculations, in the grid equal to 1000 Euros, this gives an investment of 20 MEuros in generation and distribution equipment.

Energy Impact of Heat Island in London (BRE)

Because of Heat Island in London, cooling load increases by 25 % while the heating load is reduced by 22 %.
Also the cooling potential of night ventilation techniques is reduced by 55 %



IMPACT OF HEAT ISLAND ON THE POTENTIAL OF PASSIVE COOLING TECHNIQUES



European Research on Heat Island Mitigation Techniques concentrates on :

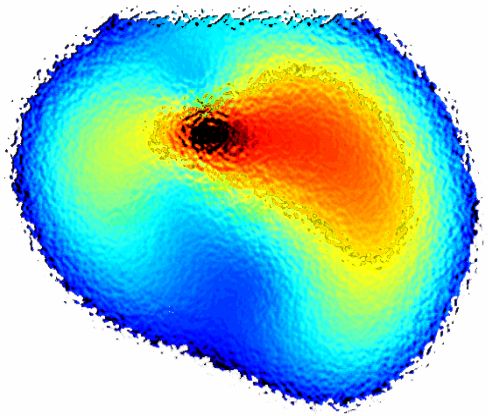
- the increased use of green areas,

-the use of appropriate materials, in particular of white and colored high reflective coatings,

- decrease of anthropogenic heat

- use of cool sinks for heat dissipation,

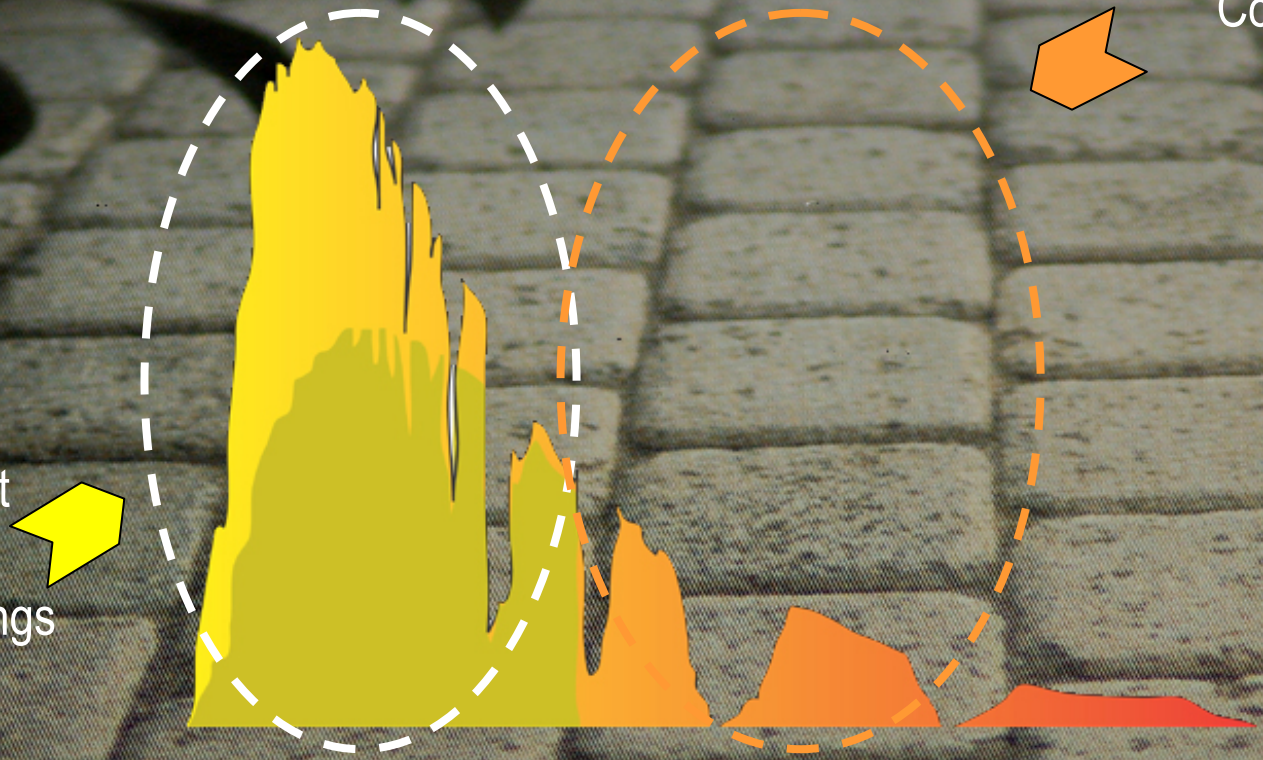
- appropriate layout of urban canopies involving the use of solar control, techniques to enhance air flow, etc.



DEVELOPMENT AND TESTING OF HIGH REFLECTIVE COATINGS

Phase 1 : Testing of the Thermal Performance of Natural Materials for Pavements

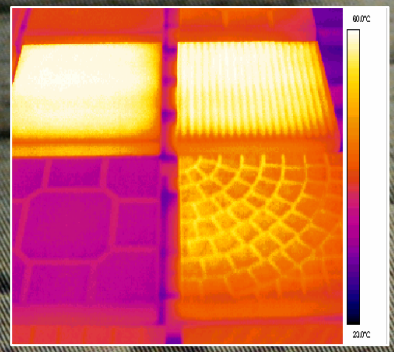
Phase 2 : Development and Testing of High Reflective Colored Coatings

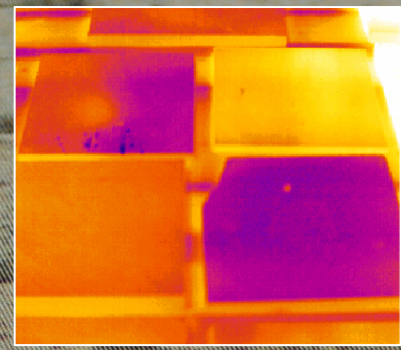


Phase 2 : Development and Testing of High Reflective White Coatings

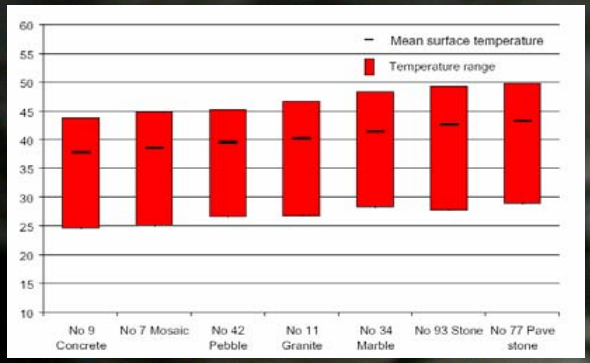
TESTING OF NATURAL MATERIALS FOR PAVEMENTS

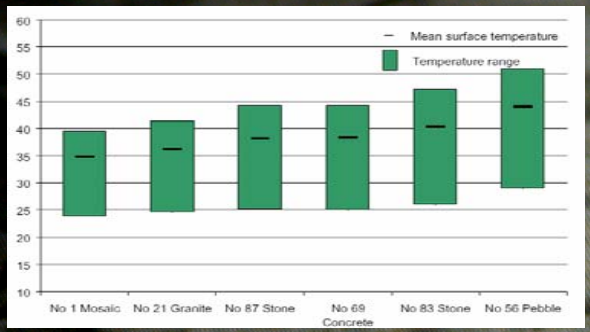
The study involved 93 commonly used pavement materials and was performed during a complete summer period. The thermal performance of the materials was measured in detail

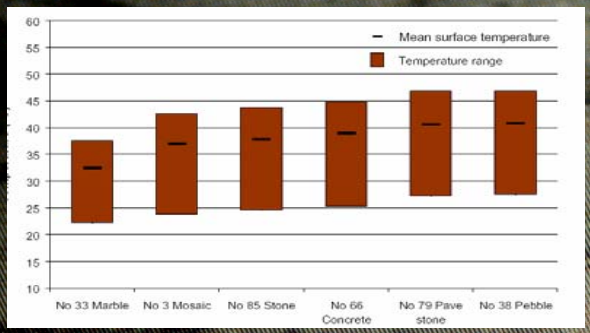




TESTING OF NATURAL MATERIALS FOR PAVEMENTS







For black surface colored materials the lowest temperatures were observed at those made of mosaic, concrete and marble.

For white surface colored materials at those made of mosaic, concrete, granite, pebble and marble

For gray surface colored materials all of them except for those made of pebble and pave stone presented low temperatures.

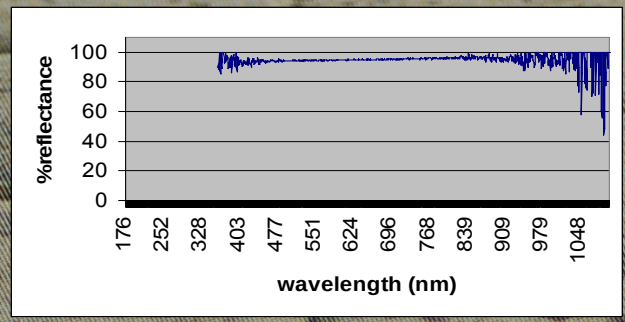
For green surface colored materials at those made of mosaic and granite.

For brown surface colored materials at those made of mosaic and stone

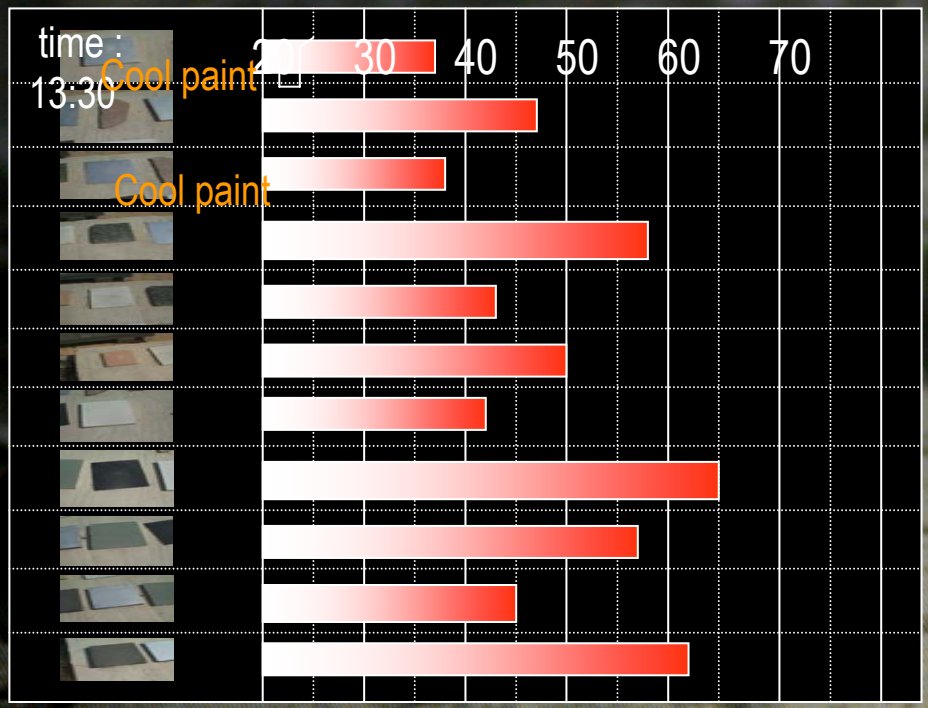
DEVELOPMENT AND TESTING OF HIGHLY REFLECTIVE WHITE COATINGS

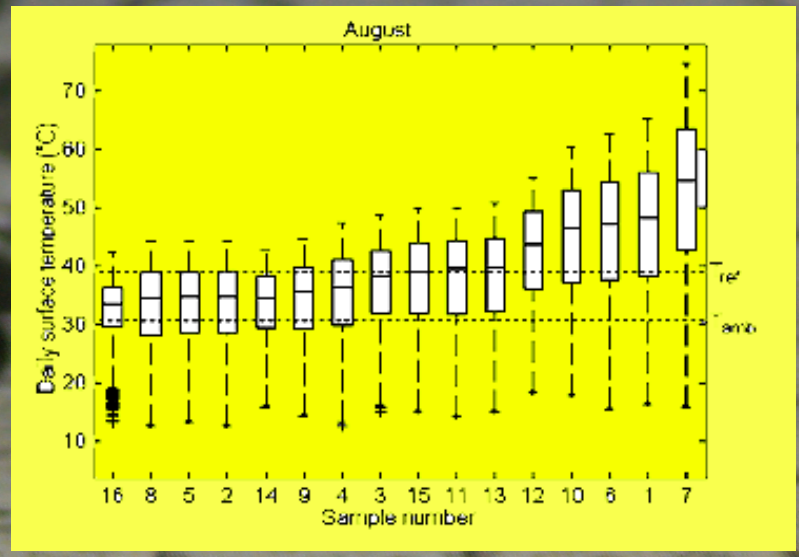
Sample description	Sample colour
Aluminum pigmented acrylic coating	Silver gray
Acrylic, ceramic coating	White
Acrylic, elastomeric coating	White
Acrylic, elastomeric coating	White
Alkyd, chlorine rubber coating	White
Aluminum pigmented, alkyd coating	Silver gray
Emulsion paint	Black
Acryl-polymer emulsion paint	White
Acrylic latex	White
Aluminum pigmented coating	Silver
Acrylic insulating paint	White
Aluminum pigmented acrylic coating	Silver
Epoxy polyamide coating	White
Acrylic paint	White
Uncoated tile (reference)	White
Acrylic elastomeric coating	White

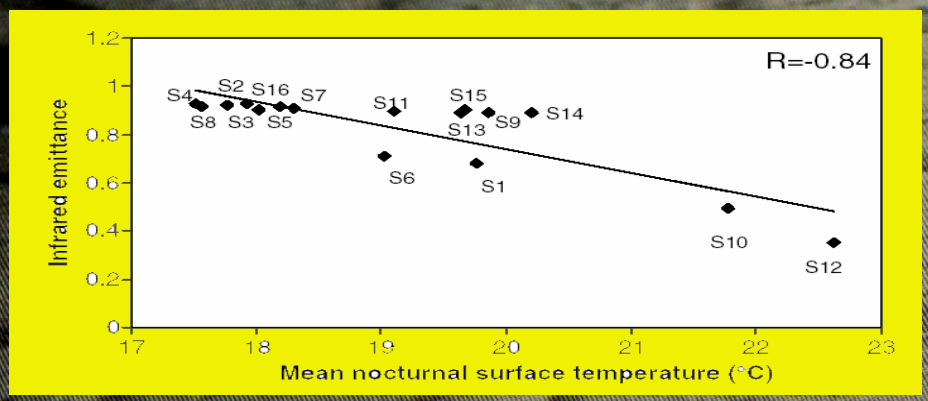
The study involved the development of high reflective coatings and a comparative testing of 16 high reflective white coatings during the whole summer period

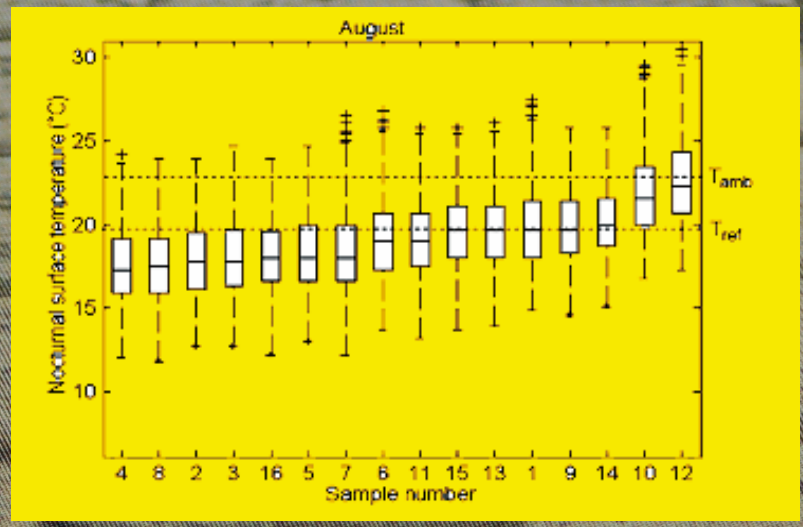


DEVELOPMENT AND TESTING OF HIGHLY REFLECTIVE WHITE COATINGS



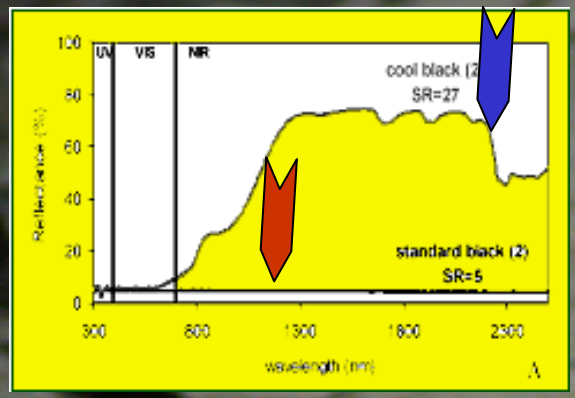


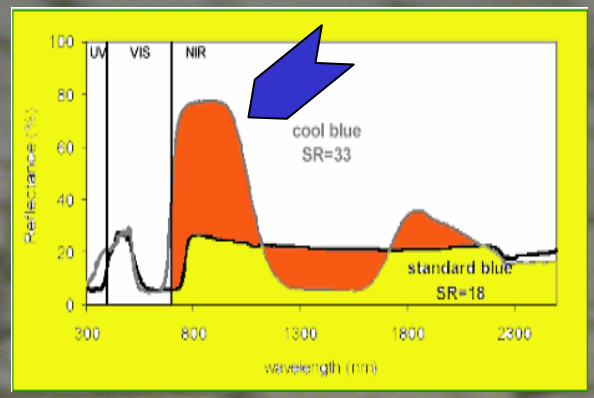


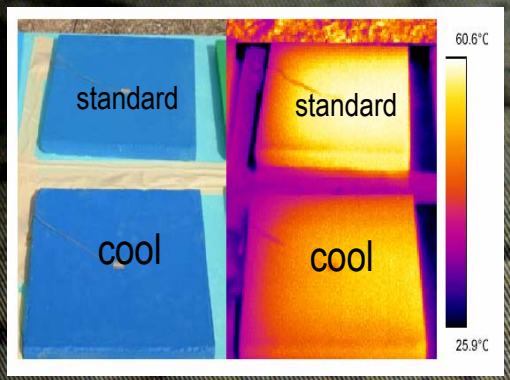


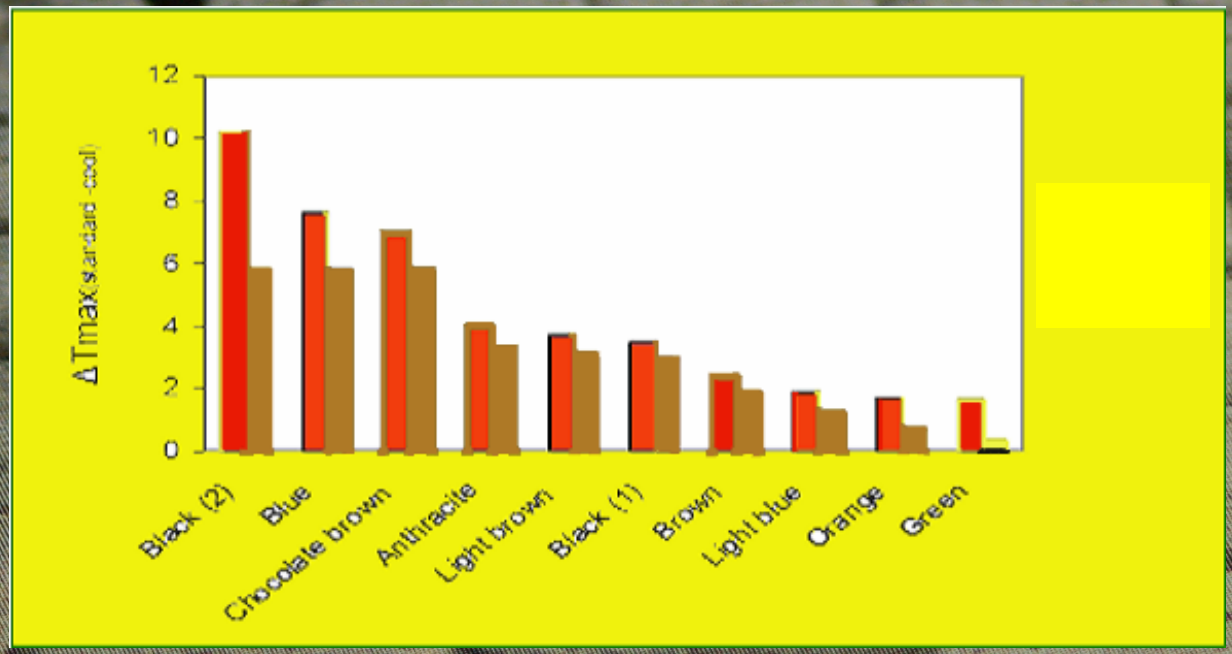
DEVELOPMENT AND TESTING OF REFLECTIVE COLORED COATINGS

Standard	Cool	Standard	Cool
Orange		Anthracite	
Light blue		Brown	
Blue		Chocolate brown	
Green		Light brown	
Black (1)		Black (2)	

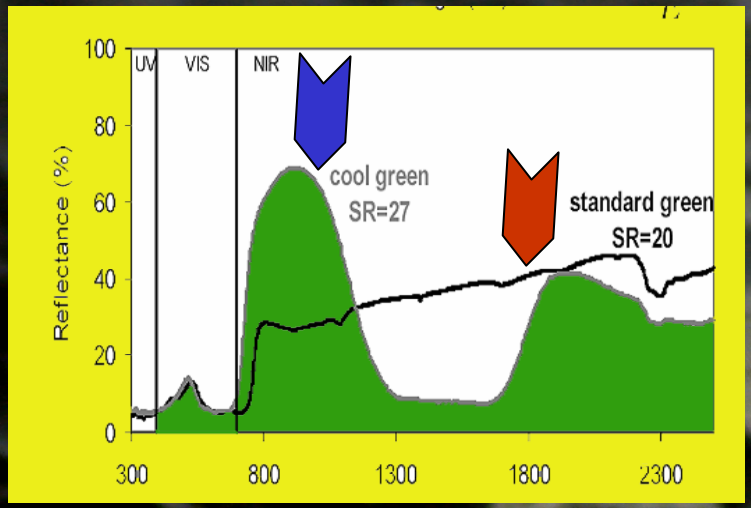


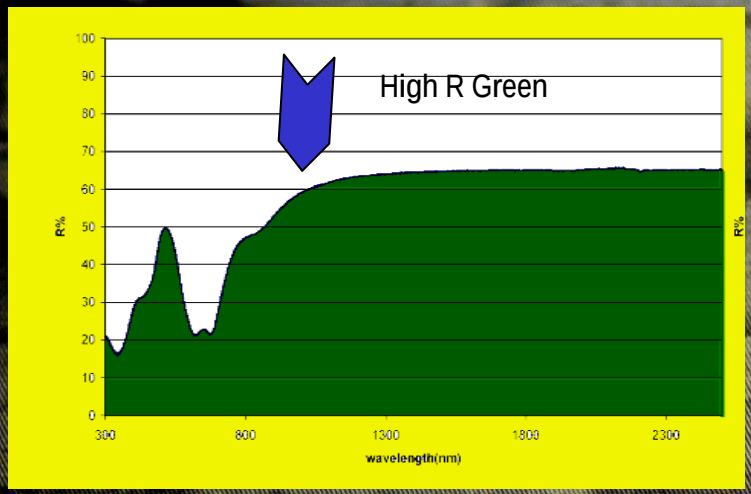


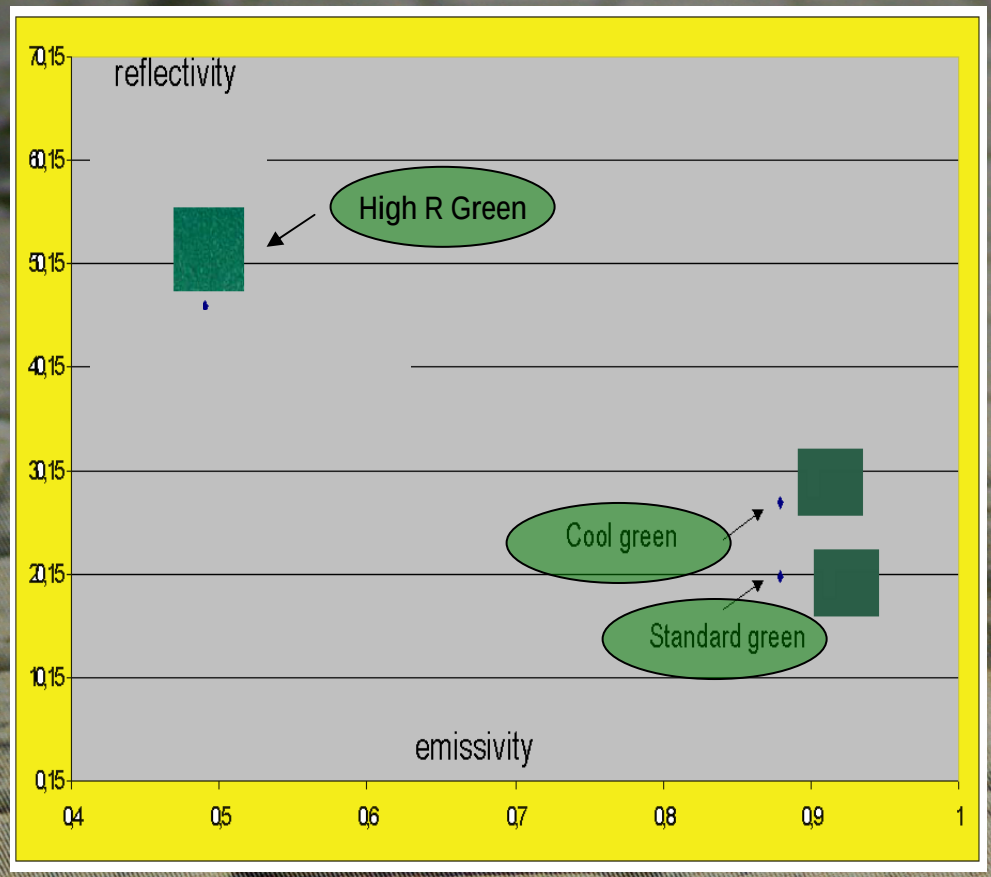




DEVELOPMENT AND TESTING OF REFLECTIVE COLORED COATINGS







ENERGY IMPACT OF REFLECTIVE COATINGS

	Residential Building		Office Building	
	Insulated	Non Insulated	Insulated	Non Insulated
Athens	1.8 C	5.1	1.9 C	4.6 C

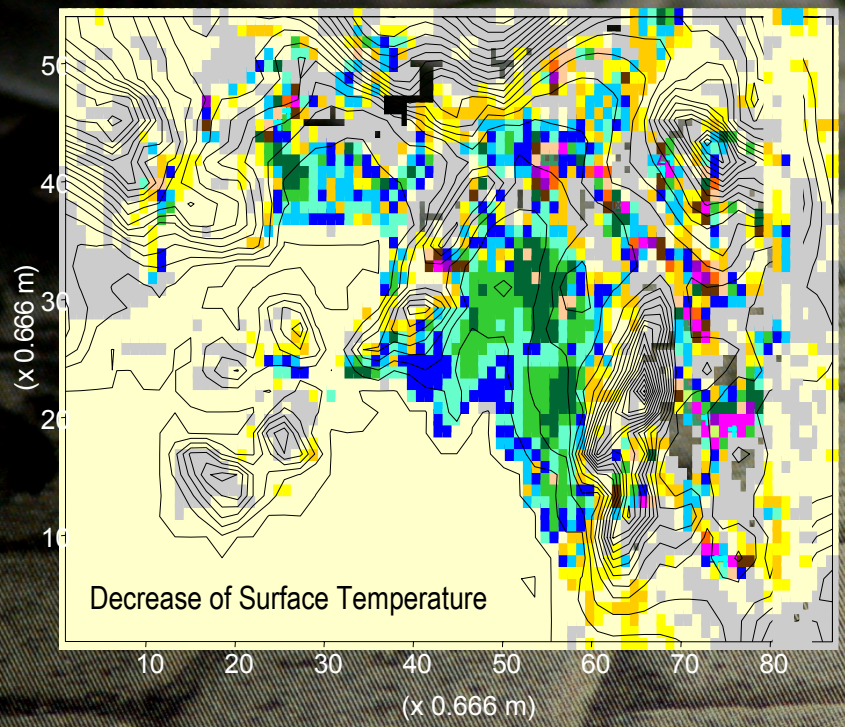
Free Floating Buildings. Reduction of the peak indoor temperature

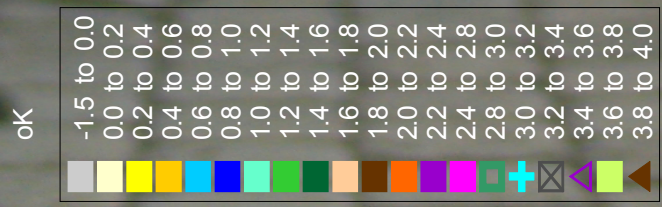
A/C Building Buildings. Reduction of the Cooling Load

	Residential Building		Office Building	
	Insulated	Non Insulated	Insulated	Non Insulated
Dubai	13 %	31 %	8 %	25 %

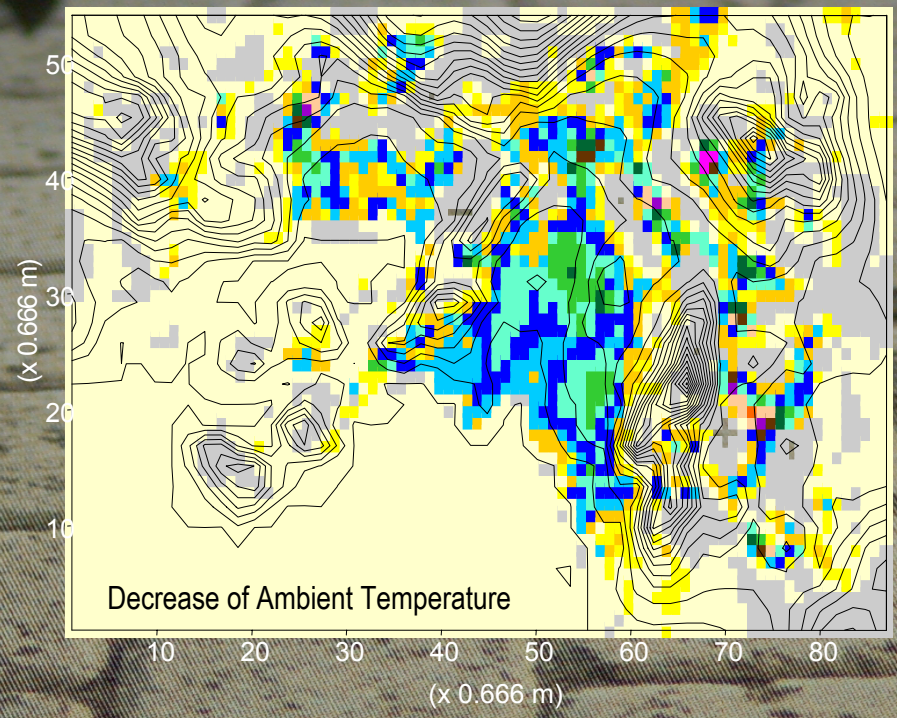
ENVIRONMENTAL IMPACT OF COLORED REFLECTIVE COATINGS

12:00 LST





12:00 LST



Heat island is a important climatic effect in Europe and is present in all geographic zones of the continent. Heat Island has an important impact on energy demand during the summer period and studies in Athens and London have shown that UHI is associated with much higher cooling loads for buildings, increase of the peak electricity demand and decrease of the performance of the air conditioners, while it decreases seriously the cooling potential of natural and night ventilation techniques. In parallel, UHI has an important global environmental impact as it increases the ecological footprint of the cities.

In parallel, important research has been carried out aiming to mitigate heat island. Research focuses on the understanding of the impact of urban green areas as well as on the development of appropriate materials for the urban environment.

In particular, white and colored cool materials have been developed and tested.

It has been found that cool materials present much lower surface temperatures that common materials and this can contribute highly to decrease urban ambient temperatures and mitigate heat islands in Europe. .