

# Current State and Future Prospects of Cool Roof in Japan

An aerial photograph of Santorini Island, Greece. The image shows a dense cluster of white-washed buildings with blue accents, built on a hillside overlooking the deep blue Aegean Sea. A prominent church with a large blue dome and a bell tower is visible in the center. The background features a rugged, brownish mountain range under a clear sky.

Yasushi Kondo, Musashi Inst. of Tech.

**SANTORINI** Island

# Contents

- (1) Activities of Cool Roof Committee in AIJ
- (2) Private Benefit and Public Benefit of Cool Roof
- (3) Cool Roof Promote Project
- (4) Conclusions

# Contents

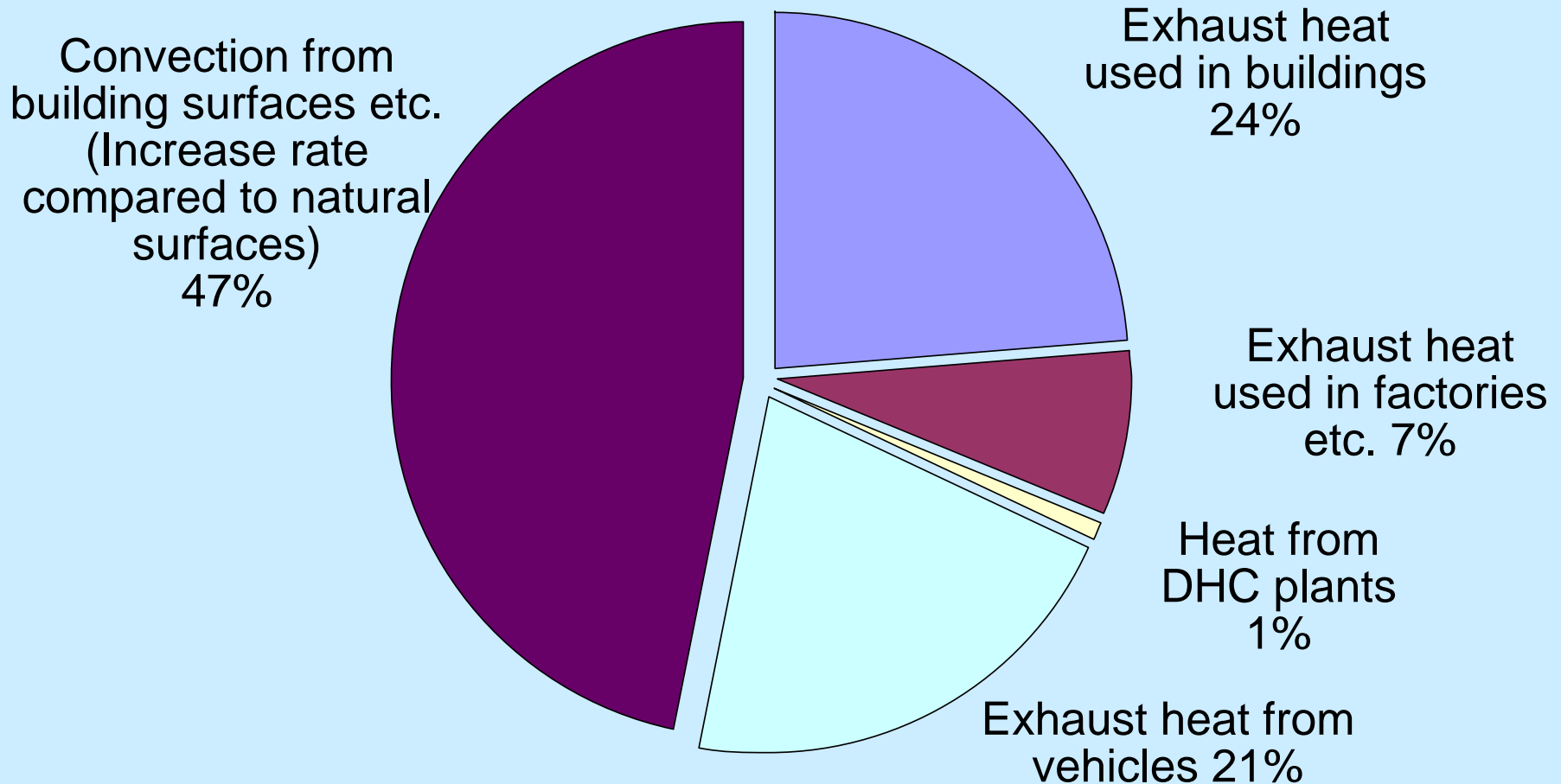
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# Cool Roof Committee of AIJ

AIJ: Architectural Institute of Japan

Members:	Y. Kondo,	Musashi Inst. of Tech.
	Y. Ashie,	Building Research Inst.
	H. Shibaike,	Kyoto Inst. of Tech.
	H. Takebayashi,	Kobe Univ.
	H. Namiki,	Taisei Co.
	K. Narita,	Nippon Inst. of Tech.
	H. Narimi,	Osaka Univ.
	M. Nishioka,	Osaka City Univ.
	S. Hashida,	Meiji Univ.
	A. Hoyano,	Tokyo Inst. of Tech.
	Y. Matsuo,	Meiji Univ.
	I. Misaka,	Takenaka Co.
	A. Mochida,	Tohoku Univ.
	M. Moriyama,	Kobe Univ.

# Main Factors on Heat Island Phenomena



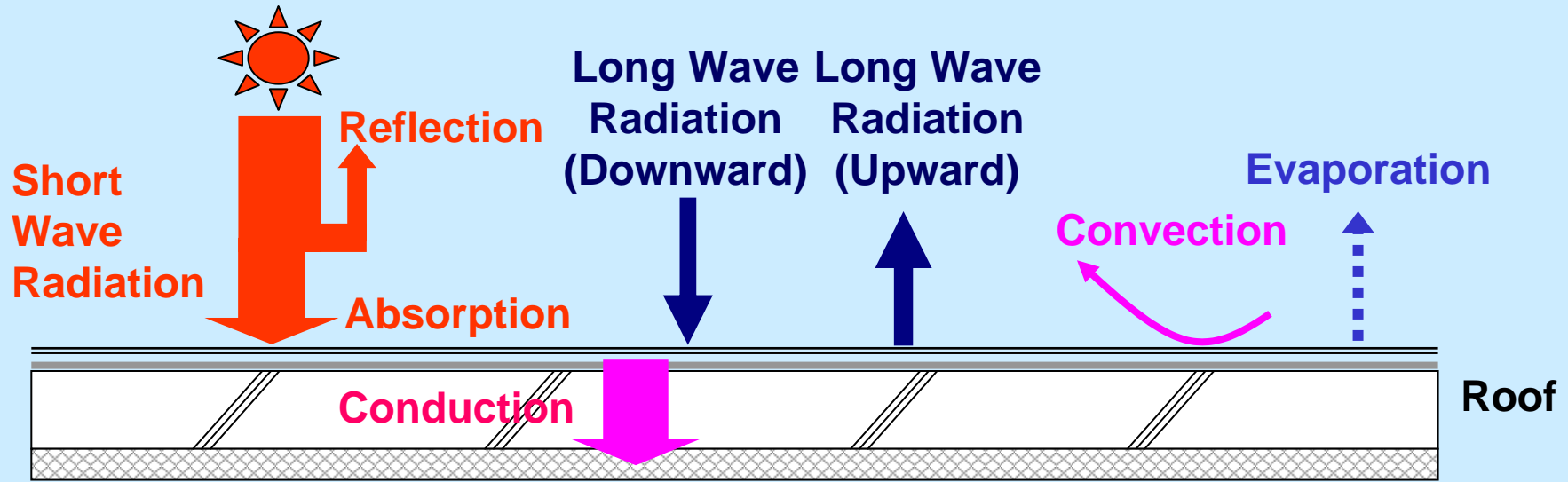
Sensible Heat in Urban Area

(Daily Average in Tokyo, Ministry of the Environment)

Half of the surface of Tokyo is covered with artificial materials. Characteristic of building surface materials effects on urban temperature.



# Heat Balance of Roof



- The surface temperature of a roof can be decreased by controlling several factors affecting the heat balance of a roof.

- The cool roof committee of AIJ discussed latent heat as well as sensible heat.
- Therefore the roof planting and water retentive materials are also studied in the committee.



Research Group		Research Subject	Reference
Matsuo Lab.	Meiji Univ.	Reflective Paint	Y. Nishimura et al. (2004)
Ashie Lab.	BRI	Water Retentive Material	
Moriyama Lab.	Kobe Univ.	Various Cool Roofs	S. Nogami et al. (2004)
Hoyano Lab.	Tokyo Inst. of Tech.	Rooftop Lawn-Planting	A. Hoyano et al. (1994) A. Hoyano et al. (2004)
Nishioka Lab.	Osaka City Univ.	Reflective Pavement	S. Wakama et al. (2003)
Mochida Lab.	Tohoku Univ.	CFD on Green Area Ratio	S. Yoshida et al. (2003)
Murakami Lab.	Tokyo Univ.	CFD on Roof Planting	S. Yoshida et al. (2002)
Tokyo Metropolitan Gov. and Japan Testing Center for Construction Materials		Roof Planting and Reflective Paint	T. Fujimoto et al. (2006)
Kondo Lab.	Musashi Inst. of Tech.	Reflective Paint	Y. Kondo et al. (2000) (2006)

# Contents

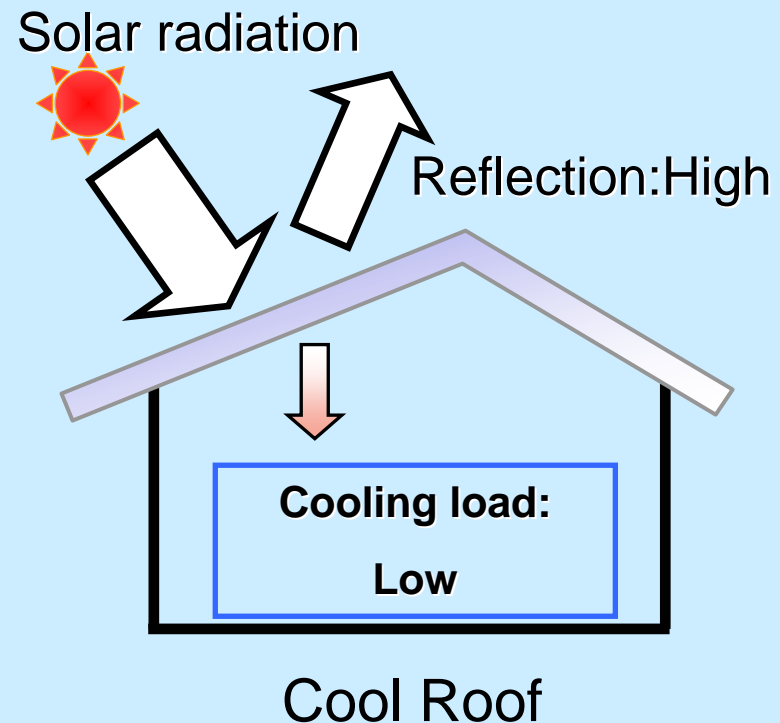
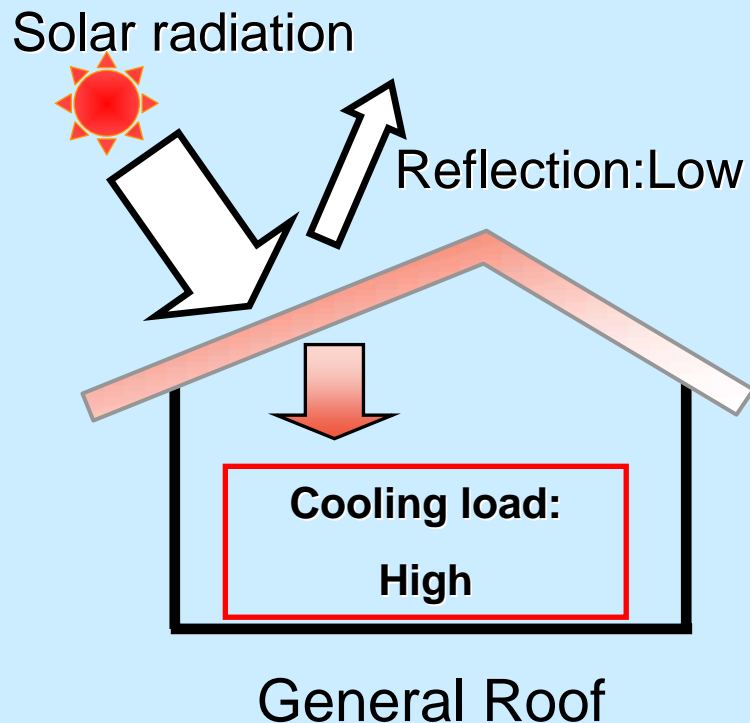
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Cool roof reduce energy consumption for cooling buildings.

**=>Private Benefit**

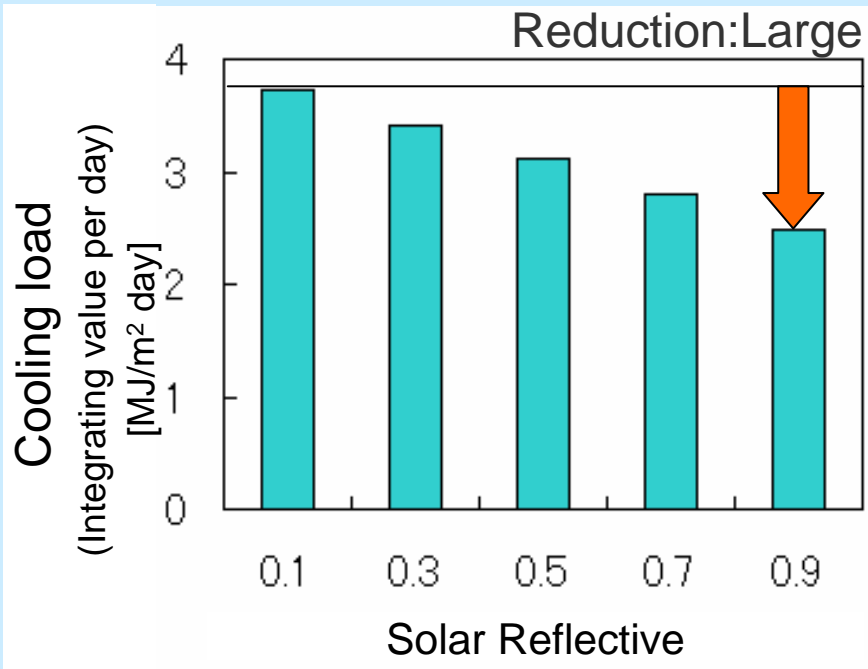
Cool roof reduce sensible heat flux from roofs to the atmosphere.

**=>Public Benefit**



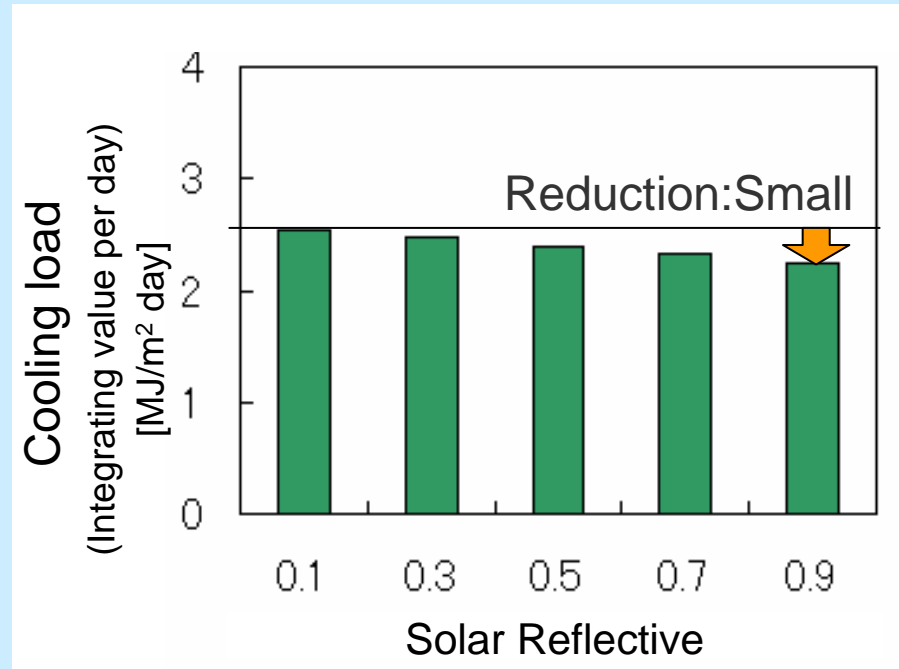
# Relationship Between Cool Roof and Cooling Load

(Simulation results of summer condition in Tokyo)



( $R = 0.51 \text{ m}^2\text{K/W}$ )

Roof without insulation



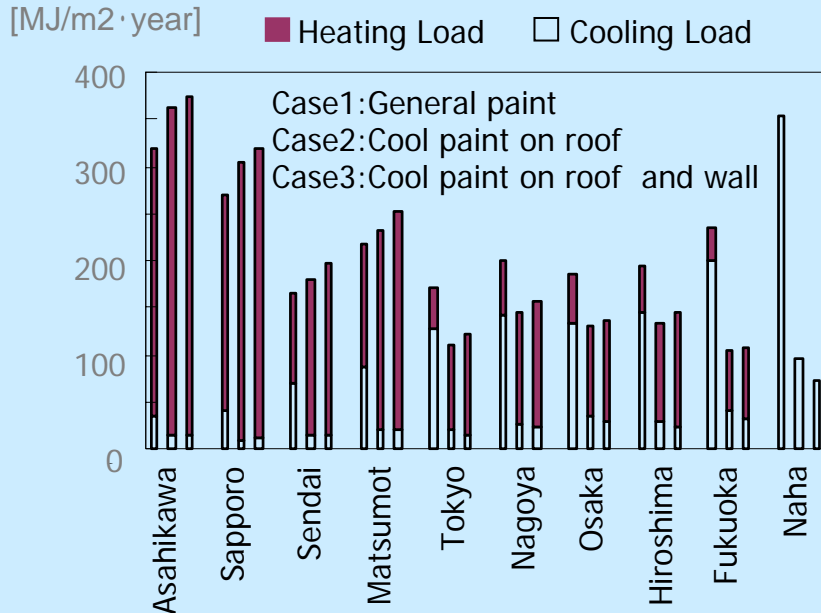
( $R = 2.29 \text{ m}^2\text{K/W}$ )

Well insulated roof

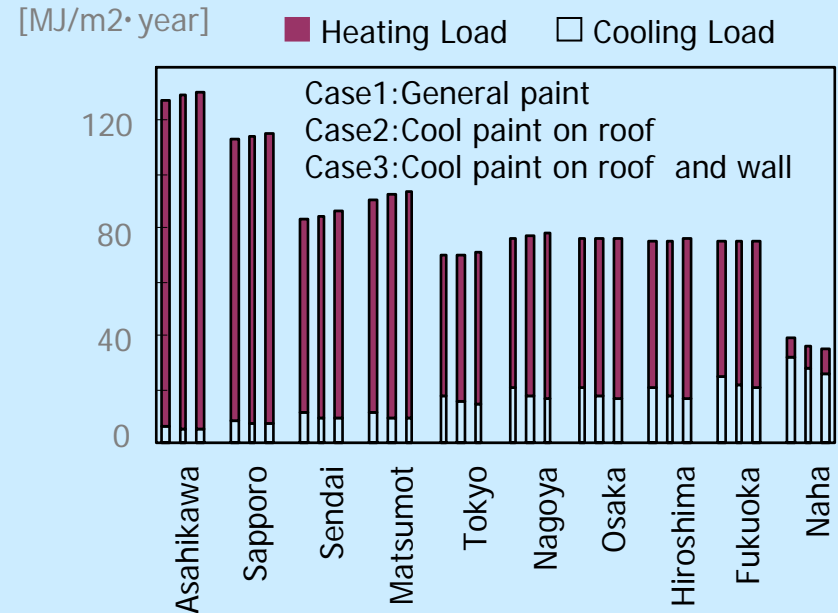
When the roof is not well insulated, cooling load and/or indoor temperature can be decreased by increasing the rooftop reflectivity

# Relationship Between Cool Roof and Local Climate (Ref. 1)

## Total Air-conditioning Load (Heating Load + Cooling Load)



(1) Warehouse



(2) House

- The total load can only be reduced in hot areas. The effect of high reflective paint on the air-conditioning load depends on the local climate.

# How much sensible heat from urban surfaces can be reduced ?



(a) Commercial area  
Shinjuku ward



(b) Residential area  
Setagaya ward



(c) Industrial area  
Shinagawa ward

## Decrease of Sensible Heat in applying Cool Roof (Ref. 7)

	Gross building coverage ratio	<b>A</b> Decreased sensible heat	<b>B</b> Anthropogenic exhaustion heat (Ref. 11)	<b>A/B</b>
	[%]	[MJ/m <sup>2</sup> · day]	[MJ/m <sup>2</sup> · day]	[%]
Shinjuku ward	36.0	0.95	3.70	25.7
Setagaya ward	30.0	0.79	1.62	48.7
Shinagawa ward	29.2	0.77	3.86	19.9

- Cool roof can reduce the cooling load of buildings with low insulation.

**=> Private Benefit**

- Cool roof is effective in decreasing urban area temperature in summer.

**=> Public Benefit**

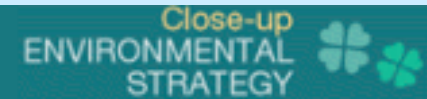
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# Environment Bureau of Tokyo Metropolitan Government

## Rooftops and Wall Greenery Measures



Since April 2001 Tokyo Metropolitan Government has required greening rooftops and wall surfaces for new grounds and buildings that have a ground surface of over 1,000m<sup>2</sup> (250m<sup>2</sup> for public facilities).

54.5ha of rooftops have been greened as of January 1, 2005.



## Cool Roof Promote Project started in 2005

<http://www2.kankyo.metro.tokyo.jp/heat/coolroof/coolroofpress.pdf>

## Committee to Promote Cool Roof

<http://www.coolroof.jp/>

### Members:

Environment Bureau of Tokyo Metropolitan Government

Several Tokyo wards: Chiyoda ward, minato ward, shinjyuku ward etc.

Japan Paint Manufactures Association

Center for environmental Information Science

NPO Roof development research center

■ The building owners who apply rooftop greening or high reflective paint can get a grant from Ministry of the Environment, if they meet the requirements.

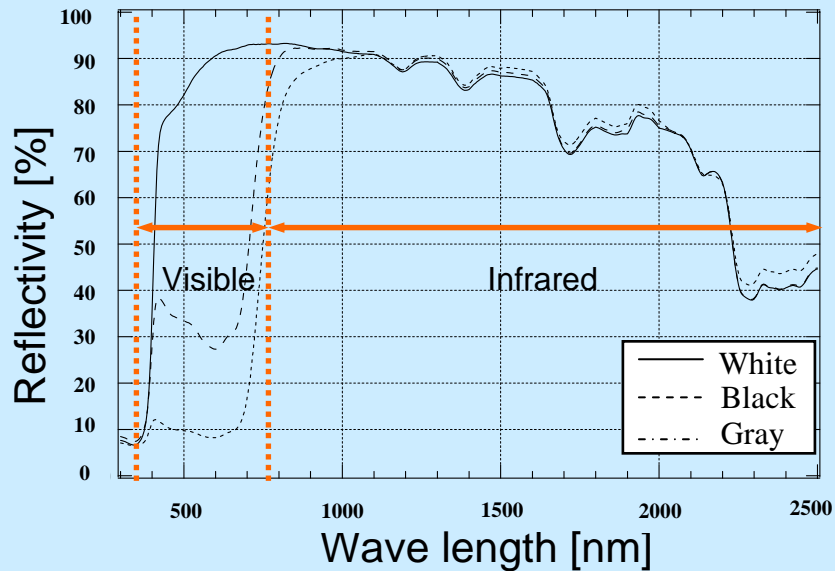
- Many high reflective paint products are distributed in the Japan market.

However there is no authorized standard for performance of high reflective paints in Japan.

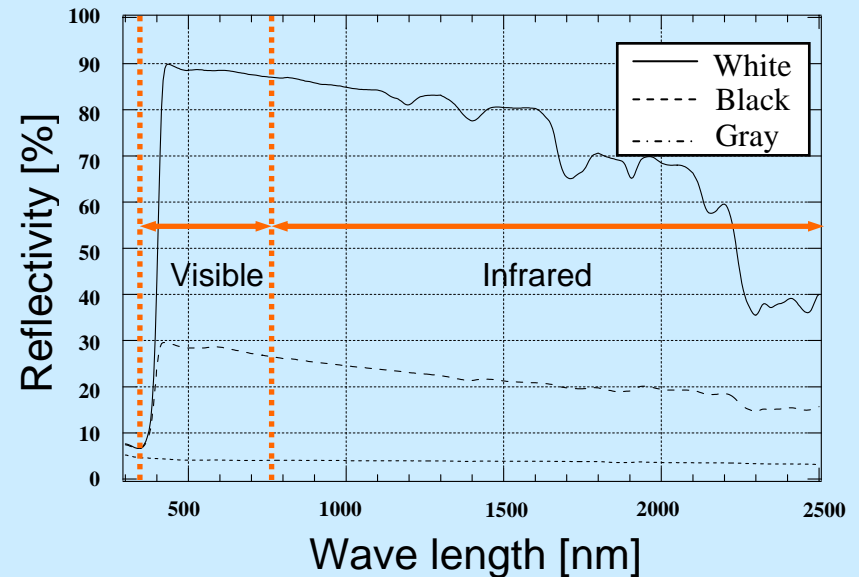
- A standard or qualification system should be considered in Japan.

# Reflectance Spectra of Various Reflective Paint Products

(Ref. 6)



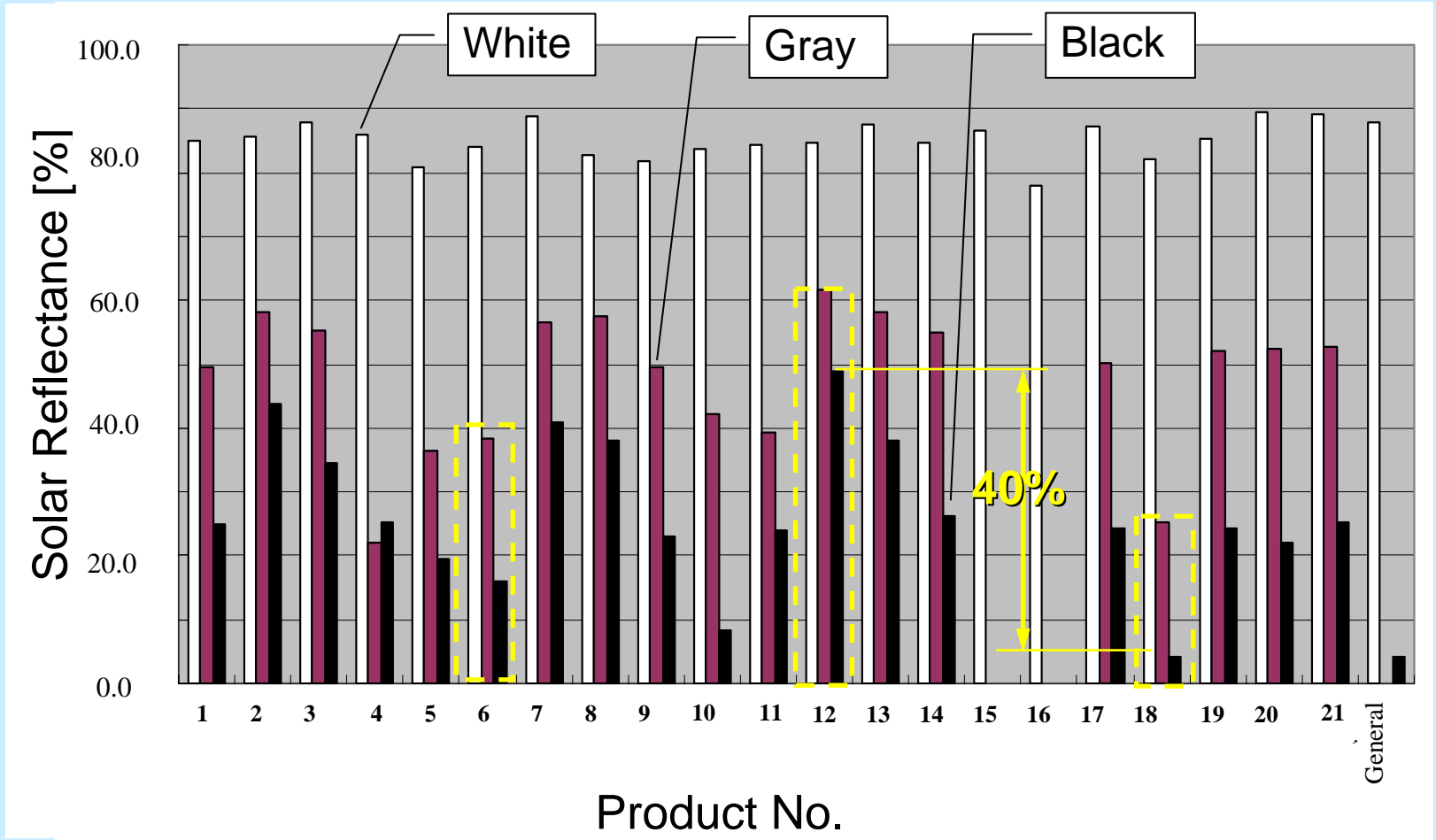
Product No. 12



Product No. 18

## Measured Reflectance Spectra

The performance of 21 reflective paints was examined.



Comparison of Solar Reflectance in Various Products

# Ageing of Reflective Paints by Exposure Testing

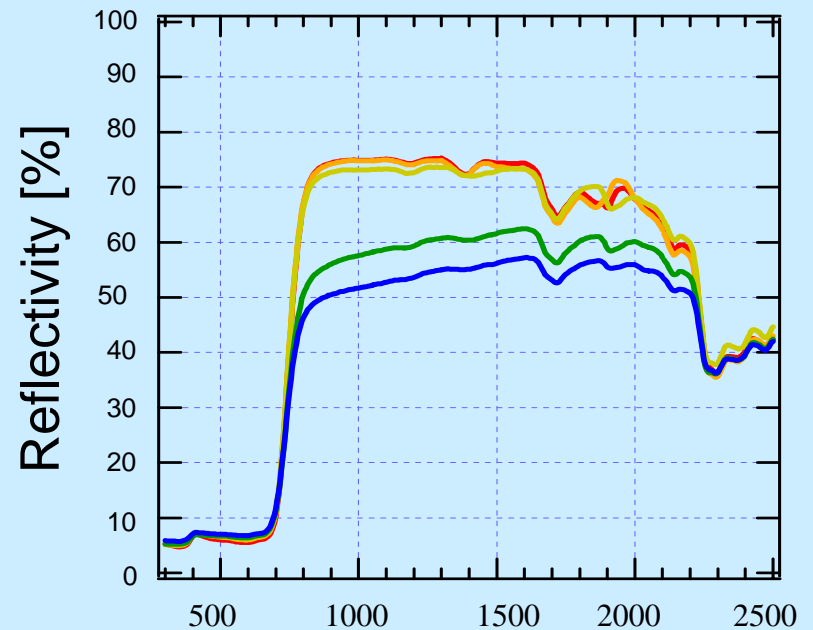
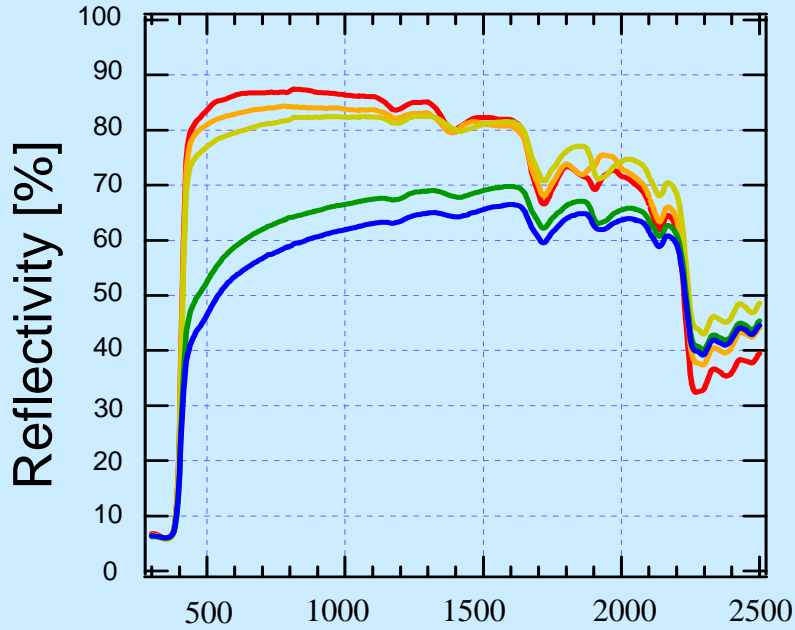
16 white paints

14 gray paints

14 black paints



Tokyo Metropolitan Gov., Japan Testing Center for Construction Materials  
and Kondo Lab. Musashi Inst. of Tech.



— Not exposed   
 — 121 days later   
 — 197 days later   
 — 342 days later   
 — 571 days later

White (Product No.13)

Black (Product No.13)

## Results of Ageing Test on Reflective Performance

## Example (Product No.13)

	Solar Reflectance [%]		Visible Ray Reflectance [%]		Infrared Ray Reflectance [%]	
	Not exposed	571 days later	Not exposed	571 days later	Not exposed	571 days later
White	80.8 →	54.8	85.2 →	50.4	82.1 →	61.4
Black	40.4 →	30.7	5.8 →	6.9	71.2 →	51.5

- When high reflective paint is applied, the ageing of performance should be considered.  
The recovery method of performance should be studied.



## (4) Conclusions

- [1] The research studies on cool roof in Japan are shown.
  - [2] Private benefit and public benefit of cool roof are shown.
  - [3] An example of cool roof promote project is introduced.  
Some problems to promote the application of cool roof are discussed.
- The designers and owners of building should recognize the private benefit of cool roof properly and apply it.
  - The policy maker should recognize the public benefit of cool roof properly and promote it.

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- 3) <http://www.coolroof.jp/faq/index.html>

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### Roof Greening

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