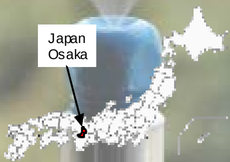
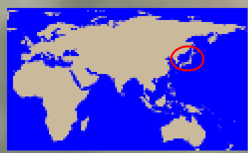
Effect of evaporative cooling techniques by spraying mist water on energy saving in apartment house





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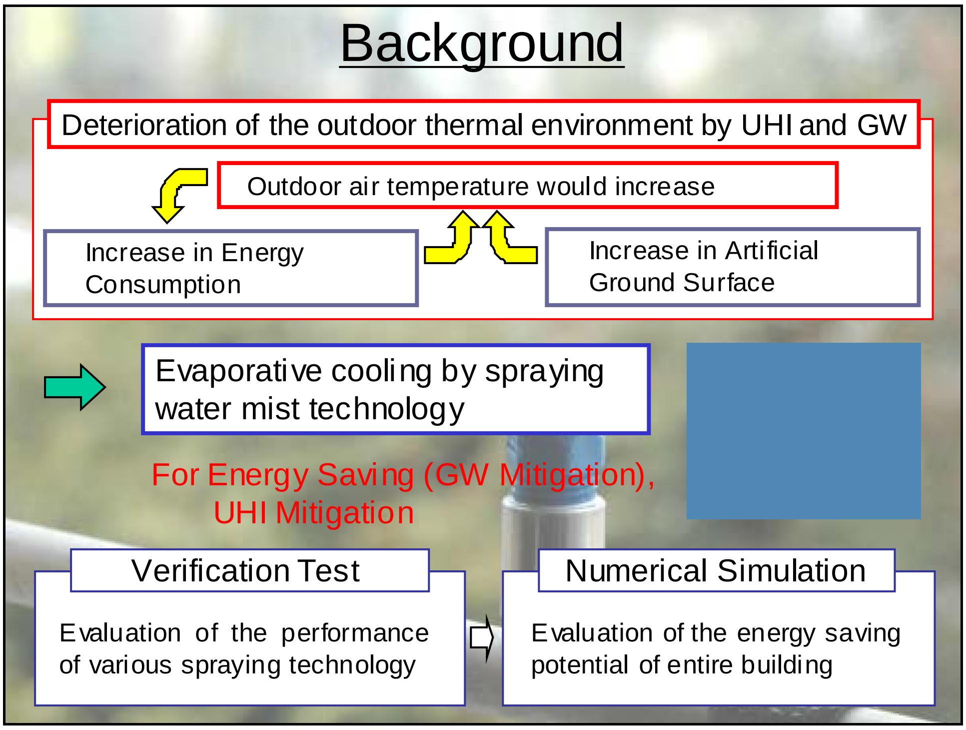
Background


Background
Deterioration of the outdoor thermal environment by UHI and GW
Outdoor air temperature would increase
Increase in Energy Consumption
Increase in Artificial Ground Surface
Evaporative cooling by spraying water mist technology
For Energy Saving (GW Mitigation), UHI Mitigation
Verification Test
Evaluation of the performance of various spraying technology
Numerical Simulation
Evaluation of the energy saving potential of entire building

Verification tests

Test building

Fig. : Overall View of the Targeted Apartment House

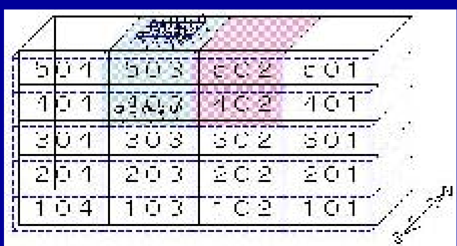


Fig. : Outline of the Targeted Apartment House

An apartment house in Osaka City was used as the verification test building in an investigation of the energy reduction effect of four types of spraying water mist technology.

Rooftop spraying (Sidewall),
Veranda spraying,
Outdoor unit of AC spraying

This building was a 5-story, 42-year-old building of reinforced concrete construction.

This has 20 dwelling units and all units have the same floor plan.

Test building

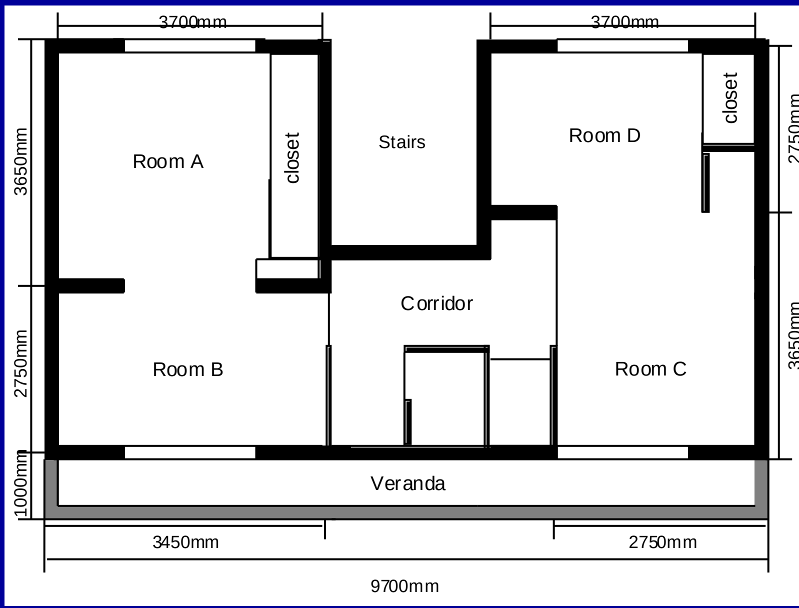


Fig. :Floor Plan (One dw elling Unit)

Spraying apparatus

Nozzle A
(0.2MPa)

Nozzle B
(1.8MPa)

Pump(60W)

Two types of single-flow nozzle were used for water spraying.

Nozzle A sprayed relatively large water droplets (particle size approximately 300 µm) under water mains pressure of around 0.2MPa (without pump), while nozzle B sprayed fine mist water droplets (particle size approximately 40 µm) under pump pressure of around 1.8 MPa.

Rooftop spraying

Fig. : View of the Rooftop Spraying

Rooftop spraying was intended to improve the thermal environment of the top floor by spraying water onto the roof surface using nozzle A (without pump).

Spraying time was set from 9 a.m. to 5 p.m. and interval of the spraying was set for 15 seconds, then stopped for 7 minutes.

Under this spraying condition the estimated volume of water sprayed was 261 L/(day house).

Rooftop spraying

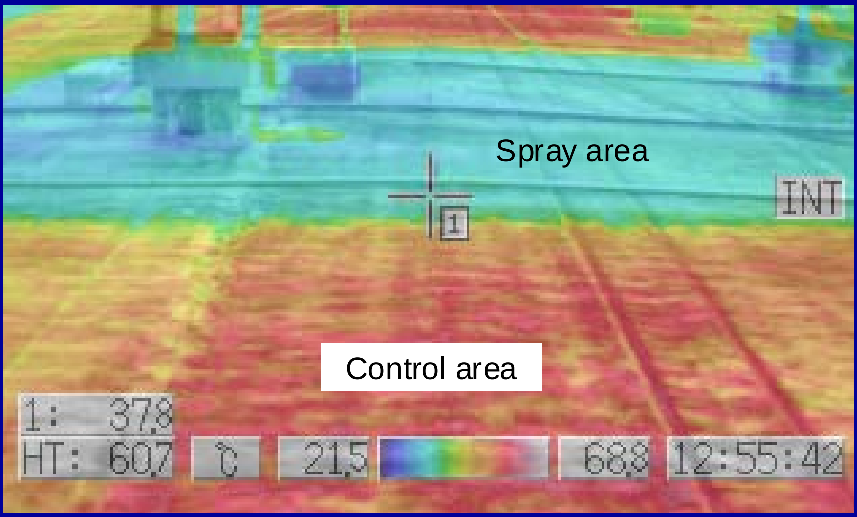


Fig. : Thermal Image of the Surface Temp. Reduction by Use of the Mist Water Spray at Rooftop (August 16)

Rooftop spraying

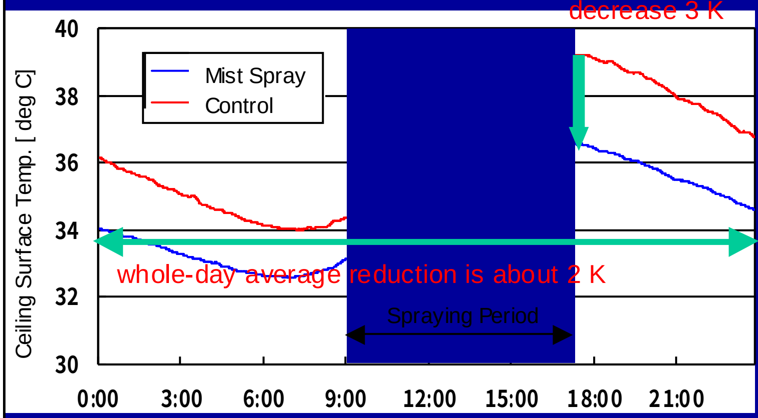


Fig. : Variation with Time of Ceiling (Indoor) Surface Temp. by Use of the Mist Water Spray at Rooftop (August 16)

Veranda spraying

For veranda spraying, nozzle B with pump was used to spray a fine mist of water droplets at the outside of the room.

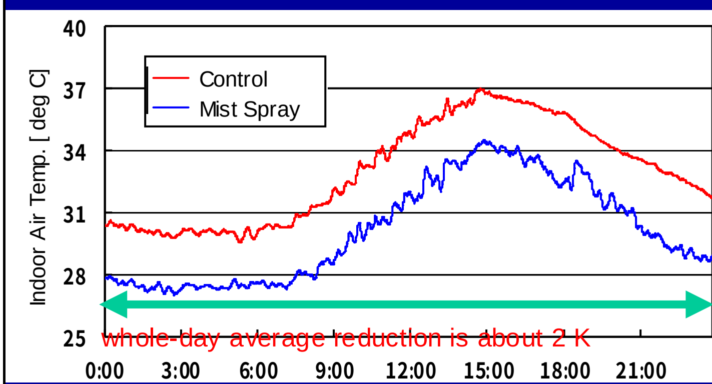
And cooled outside air would enter the room by through the natural ventilation.

Spraying was continuous a whole day.

Under this spraying condition the estimated volume of water sprayed was 322 L/(day house).

Fig. : View of the Veranda Spraying

Veranda spraying



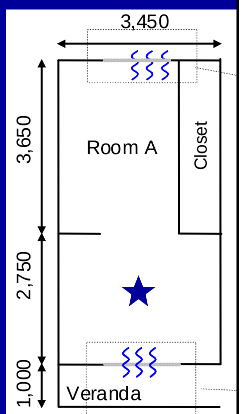
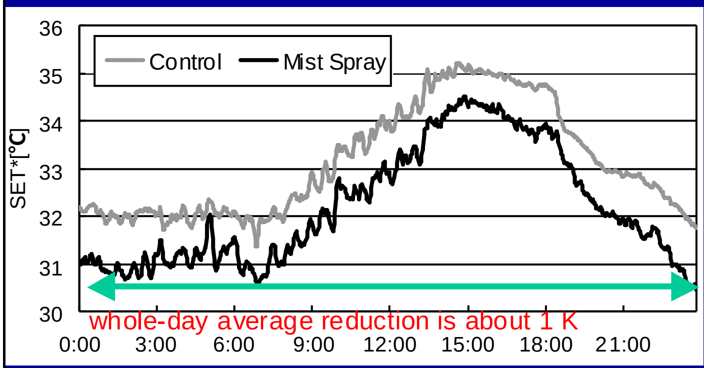


Fig. : Comparison of Variation with Time of Indoor Air Temp. by Use of the Mist Water Spray at Veranda (August 16)

Increase in humidity would be expected to have a negative impact on thermal comfort.

Veranda spraying



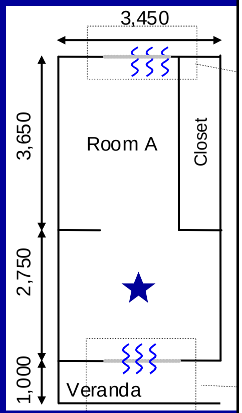


Fig. : Comparison of Variation with Time of SET* by Use of the Mist Water Spray at Veranda (August 16)

Positive Impact to the thermal comfort

Spraying to the outdoor unit of room AC

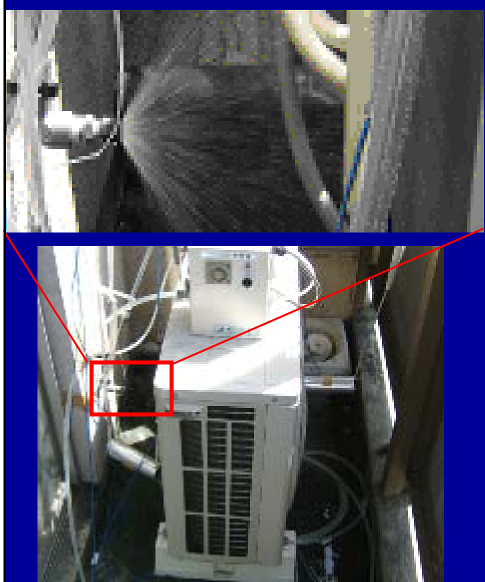


Fig. : View of Spraying to the Outdoor Unit of Room Air Conditioner

For spraying to the outdoor unit, temperature of supply air to the unit and heat exchange fins would lower and it would improve air-conditioning efficiency.

A single nozzle A (without pump) was installed in the air inlet of an outdoor unit, and spraying a whole day with a cycle of 1 second spraying followed by 29 seconds cessation.

Under this spraying condition the estimated volume of water sprayed was 66 L/(day unit).

Spraying to the outdoor unit of room AC

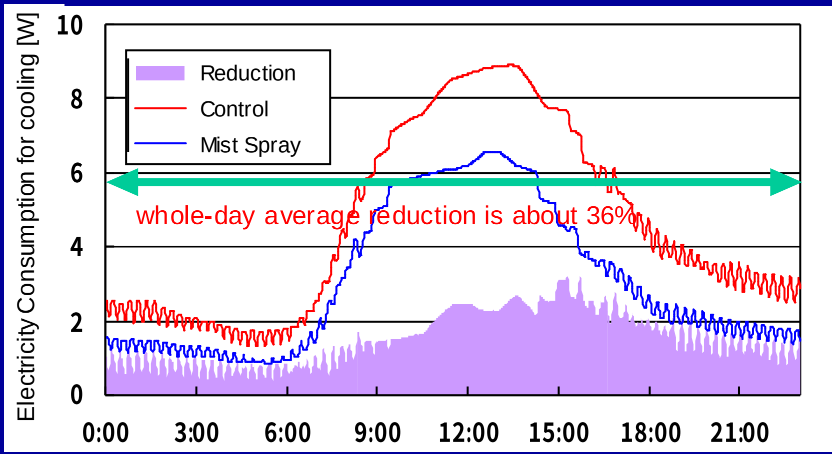


Fig. : Comparison of Variation with Time of the Electricity Consumption for Cooling and it's Reduction by Use of Mist Water Spray to the Outdoor Unit of Air Conditioner (September 22)

Numerical Simulation

The verification tests confirmed the effectiveness of various mist water spraying used independently, in a part of the building.

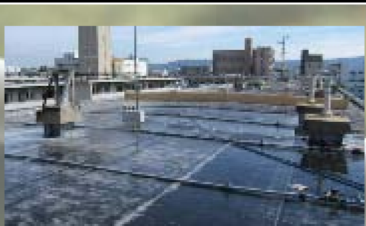
The numerical simulation used to evaluate the effect by applying these spraying methods to the entire building.

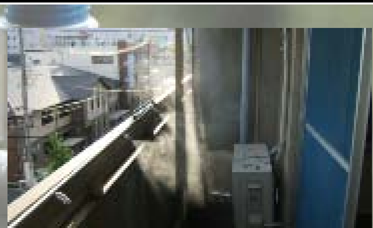
For this investigation, the air-conditioning thermal (cooling) load calculation program (SMASH) was used, and the whole building (all 20 dwelling units) was modeled.

Each dwelling units was assumed to be occupied by a family of four persons (2 adults, 2 children).

Experimental Cases of the Simulation

Case	Calculation Method
Rooftop	Using effective solar absorption for evaporation at rooftop (Control case:93%, Spray:30%)
Veranda	Decreasing -2K of the air temp. from control case
Outdoor Unit	Reducing 36% of energy consumption for cooling from control case
Sidewall	Using effective solar absorption for evaporation at rooftop (Control case:93%, Spray:30%)
All	All spraying method mentioned above
Control	No spraying method





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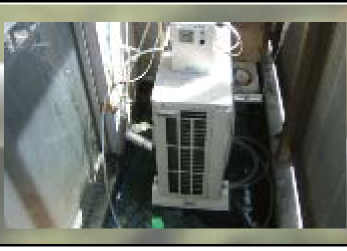

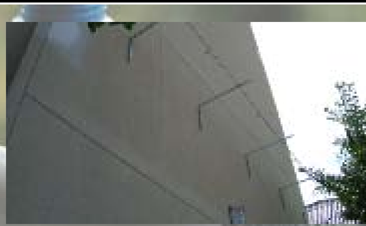

Simulation Results

Table : Average Energy Consumption Reduction Rates for cooling on Each Floor

Case	Energy Consumption Reduction Rates [%]				
	1F	2F	3F	4F	5F
Rooftop	0	0	0	1	22
Veranda	65	65	65	65	51
Outdoor Unit	36	36	36	36	36
Sidewall	5	5	5	4	4
All	79	79	79	79	80

"Veranda" showed the largest effect. The second is "Outdoor Unit"

In the case of "All", it can reduce 80% of energy consumption for cooling.

Simulation Results

Table : Summary for the Effect of “All” Case (Monthly Average)

Evaluation Items		Jul.	Aug.	Sep.
Energy Saving for Cooling [%]		85	74	89
Reducing Using Time of Room Air Conditioner [%]		85	68	90
Whole Energy Saving of each dwelling units [%]		13	14	13
Monthly Total Electricity Saving [kWh]		544	1111	435
Monthly Total Electricity Necessary for Mist Spraying [kWh]	Pump:60W	280	477	267
	Pump:30W (in the future)	178	290	169
Monthly Total Water Necessary for Mist Spraying [m^3/month]		166	227	158

Summary

Verification tests and numerical simulations were conducted in order to investigate the effect of misting technology on energy saving.

We could confirm mist cooling had the effect of reducing usage time of the air-conditioning, improving air-conditioning efficiency and reducing the energy.

In the future, we would test the other negative (-) or positive (+) effects of mist spraying such as effect on the building materials (+), risk for mould (-) and so on.