RESEARCH AND DEVELOPMENT OF THE INFORMATION SYSTEM FOR BUILDING-BLOCKS ENVIRONMENTAL EVALUATION

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Abstract

When planning and building low-carbon cities, architectural methods, which take into account global environmental conservation, generally implies reducing the effect of heat load of building. Therefore, we evaluated the reduction of energy consumption that can be achieved by improving models for efficient heating, ventilating, and air conditioning (HVAC) technologies in the office building. We tried to develop an information system for building blocks. In this system we found potential for energy savings. The information on energy savings will be available to residents and energy managers.

Key words: low-carbon city, energy reduction, anthropogenic heat

1. PURPOSE

Japan has a technological potential for reducing its CO_2 emissions by 70% compared to the 1990 level (NIES, 2008), which satisfies the expected demand for energy services in 2050. According to urbanizing in Asia, Asia needs cooling to solve the mechanism of environmental impact.

2. ENVIRONMENT AND ENERGY AROUND BUILDING BLOCKS (EEBB)

We are developing building blocks information system, which we call Environment and Energy around Building Blocks (EEBB). This system has logics based on the optimal control for air conditioning (Yoshida, 2008).

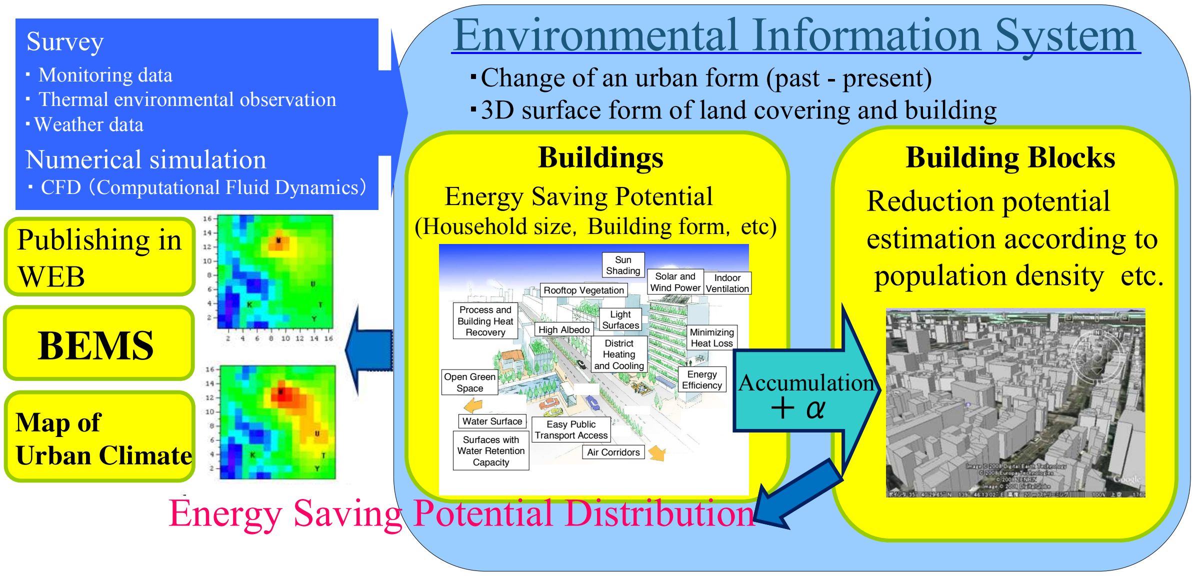

Figure 1: Research flow on EEBB (Yoshida *et al.* 2008, Ichinose *et al.* 2008)

In this system, the energy saving potential is visualized using Google MAP and Google Earth (Figure 1). Obtaining in public is available remote sensing and statistical data helps us to evaluate the simulation accuracy. Appropriate energy saving information should be provided for residents and energy managers, for example, by making use of such data as Automated Meteorological Data Acquisition System (AMeDAS, JMA) measurements delivered in real time.

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3. POSSIBILITY FOR ENERGY REDUCTION

In Japan, the structure of energy consumption in buildings has a ratio of the air conditioning for about 40% and the ratio of the lighting and the electrical outlets for about 30%. At the National Institute for Environmental Studies (NIES) we built an office building Climate Change Research Hall (CCRH) building: ferroconcrete, 3 floors, 4900 m² total floor space., When this office building was designed, the possibility of energy reduction was calculated and the results showed that the effect of window type on cooling was about 10%, natural ventilation reduced the need for cooling by about 40% and the roof planting had little effect (Chikada, *et al.*, 2001). In the office building, mainly the Air Handling Unit (AHU) uses the chilled water in summer and the hot water is used by Fan Coil Unit (FCU) in winter (Yoshida, 2006). We collected large amount of data on the energy consumption, heating, ventilating and air conditioning (HVAC), weather using the Building and Energy Monitoring System (BEMS).

3.1. Energy saving mode for air conditioning

In the office building the reduction in energy consumption was achieved by improving the HVAC technologies and by using the natural ventilation in the office building (Figure 2). The results of monitoring showed a large possibility for energy minimization in seasonal terms.

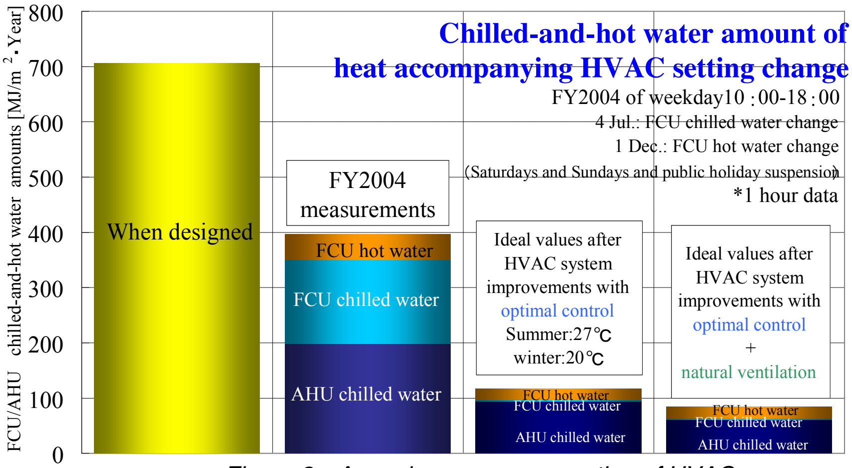
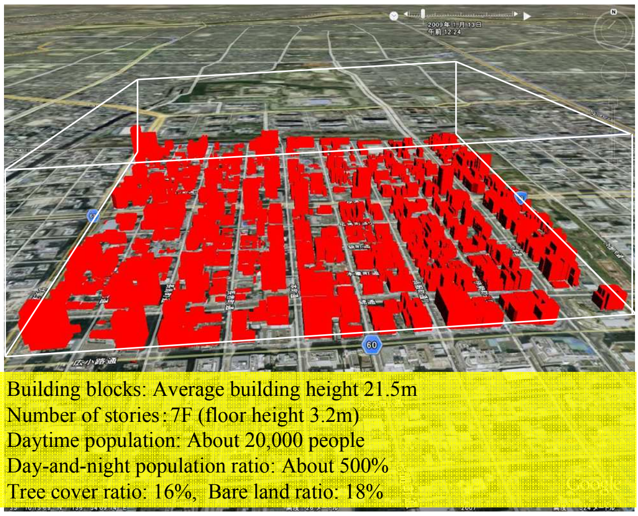


Figure 2 Annual energy consumption of HVAC

3.2. Nagoya case study on the building block types

We attempt to adapt the energy saving logic for many places. Therefore, we conducted our first study on the quality of building blocks environment in Nagoya using the weather data and the building arrangements.
Firstly, we used laser point data provided by Kokusai Kogyo corp. to build the 3D-model (Figure 3), which used building-blocks with 7F-buildings (floor height 3.2m). The average building height was 21.5m. Inside the building-blocks we set the sky view factor (SVF) of 20% using CanopOn2 tool (Takenaka, 2006), and the width of the roads equal 8m (Figure 4).



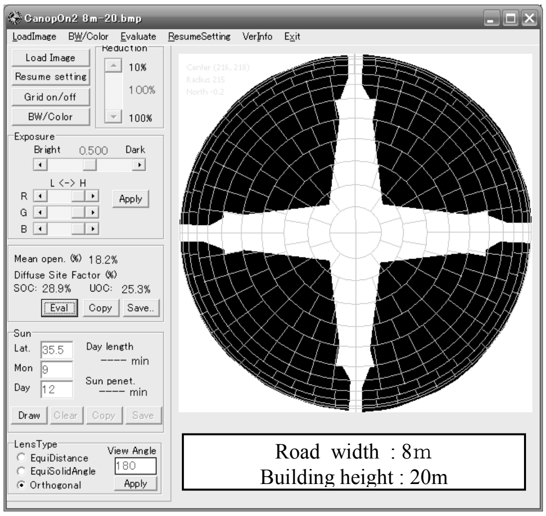


Figure 3 3D-CAD model of Nagoya in 2005 (Using Google Earth) *Figure 4 SVF on 3D- model of Canopy*

When generating blocks, using the 3D-model, we set 5 values of the Predicted Mean Vote (PMV) index, for 5 values of wind velocity, which were 0, 0.5, 1, 1.5 and 2m/s (Figure 5). When the wind velocity decreased, the PMV value also decreased reducing the thermal stress. When we changed the width of roads to 4m, the effect of wind change of was not significant.

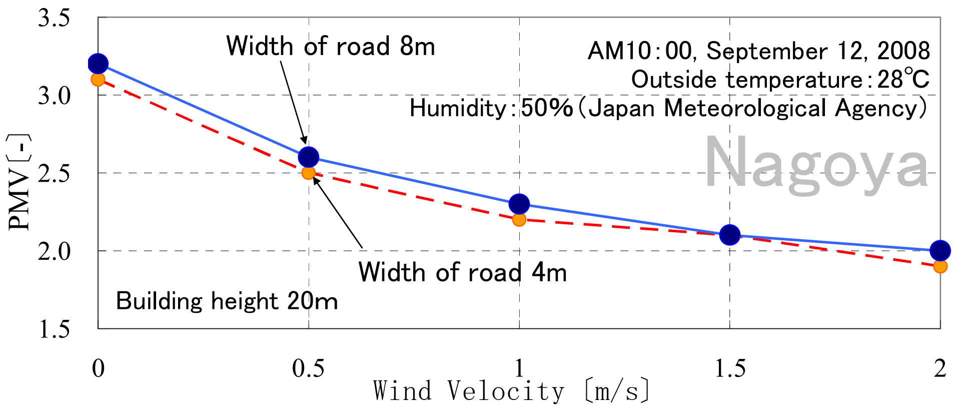


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Figure 5 PMV and wind velocity of Nagoya in 2005

In terms of building block types, it is easy to set an indicator using SVF. When changing the width of road to wider, the sky view factor becomes larger and PMV exceeds 3.0 (Figure 6) reaching the level of extreme physiological thermal stress (Fanger, 1972)
In order to build the low-carbon cities, we need to reach a level for comfort in wind values. When planning the building blocks in Nagoya we found that the values of SVF less than 50% are appropriate.

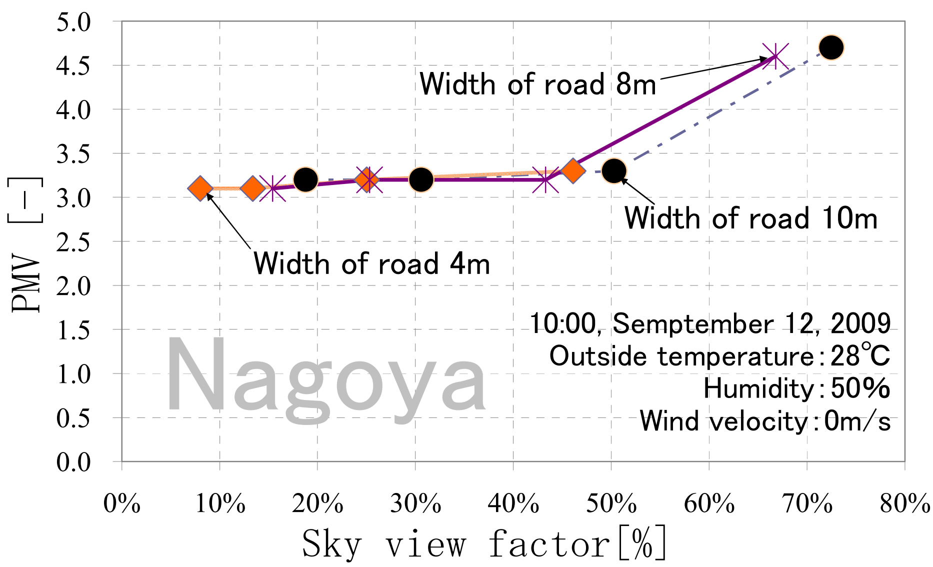

Figure 6 PMV and sky view factor of Nagoya in 2005

We analyzed the distribution of air temperature in the average blocks using Computational Fluid Dynamics software (CFD2000). We set the parameters as follows: wind direction was set to the westward, wind velocity to 2.0m/s, outside air temperature to 35℃, wall surface temperature to 35℃, roof surface temperature to 45℃, road surface temperature to 45℃. The building height was set to 20m. The standard k-ε model with X:200m ×Y:200m×Z:100m was accounted for the effect of turbulence.
Depending on the road widths the model provided different parameters of turbulence for different monitoring points. Table 1 shows predictions of air temperature inside building blocks using CFD simulation for different road widths and monitoring point heights.

Table 1 Prediction of air temperature inside building blocks using CFD

Road width	Building's side	Monitoring point heights			
		1.2m	5m	10m	20m
4m	Windward	40℃	38℃	38℃	40℃
	Leeward	48℃	50℃	52℃	54℃
8m	Windward	39℃	38℃	38℃	39℃
	Leeward	52℃	53℃	54℃	55℃
10m	Windward	40℃	38℃	38℃	38℃
	Leeward	48℃	52℃	54℃	56℃

When we set the road width to 4m and monitoring point height to 1.2m, the CFD simulation of air temperature inside the blocks resulted in 40℃ in windward and 48℃ in leeward of the buildings. Increasing the height of monitoring points from 1.2m to 20m showed the rise in air temperature by 6℃ in leeward of buildings. On the other hand in windward of the buildings temperature slightly dropped at the monitoring points set 5m and 10m above the road. Therefore, depending on the wind direction, each building had different condition for the effective use of natural ventilation.

When we changed the road width to 8m, the influence of outside environment was similar to the example of 4m road width. This model showed that building blocks with 8m road width can use outside air effectively when building heights are 5m or 10m.

As following, when we increased the road width to 10m, we observed higher air temperature than in two previous examples. Around monitoring points set 5m and 10m height, we can use the outside air to effectively cool the air inside the buildings. When monitoring points were at the roof level of the buildings (20m height), we found hot zones, which is probably a result of the heat transfer from roads and roofs. Therefore, this model should not be used for exploring the natural ventilation.

The result above provide an idea on how to reduce the energy consumption for cooling using natural ventilation, they were optimized how it can be planning for further studies.

4. CONCLUSION

To realize low carbon cities, Asia needs energy reduction of cooling. According to our results, which showed that depends on the weather data and building arrangement, we can control air conditioning efficiently. For example, in the case study of Nagoya, the sky view factor was set 50% or less. Using the CFD simulations of air temperature around the buildings, we could achieve the comfortable level of temperature by setting the building height to 10m. The heat balance for cooling reduction is compared to determine whether natural ventilation can be used or not.

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