Zero-Energy House With Introducing EVs and Verification Of Radiation Cooling in Bangkok, Thailand

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Introduction

Air pollution due to rapid motorization is becoming serious at urban area in Bangkok, Thailand.

Therefore, clean energy vehicles that do not emit greenhouse gases are expected.

EVs can be used as batteries as well as reducing emissions.

In Thailand, where economic development is remarkable, by proposing zero-energy housing by introducing EVs and PVs, we can promote the introduction of EVs and reduce primary energy consumption.

Although there are many reinforced concrete houses in Bangkok, cooling is frequently used due to the warm weather throughout the year.

On the other hand, wooden houses are the mainstream in Japan, have low heat capacity and can maintain room temperature

In recent years, radiation cooling is expected because of high comfort.

Evaluate the comfort and energy saving of radiant cooling in an existing Japanese wooden model house

In this research, we introduce a high-performance wooden house in Thailand and aim to realize a zero-energy house by installing an EV and PV.

Overview

<Actual Survey>
to evaluate the comfort and energy-saving with using radiation cooling.

<Energy Simulation>
To compare the results with actual survey and evaluate validity.

<Analysis >
to verify the feasibility of Zero-Energy House with using EV and PVs.

<Conclusion>

Methods/Actual Survey

Figure 1 the model house in Nara

Figure 2 radiation panel and PMV meter

Figure 3 the condition of experiment (left: dehumidification amount,, right: room temperature)

Table 1 measurement outline

Experiment period	From 28th, July to 6th, August
Location	Mitsuemura, Nara Prefecture, Japan
Building Type	Detached house
Building structure	Wooden house, 2-storied
Cycle of Cooling period	24h (17:00 to 17:00)
Preset Temperature	26 degrees

AC and RC and OU are sharing refrigerant through piping.
It is possible to switch the valves and stop sending refrigerant to specific machine

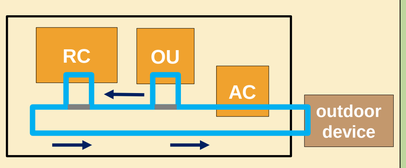

Figure 4 the image of switching valves

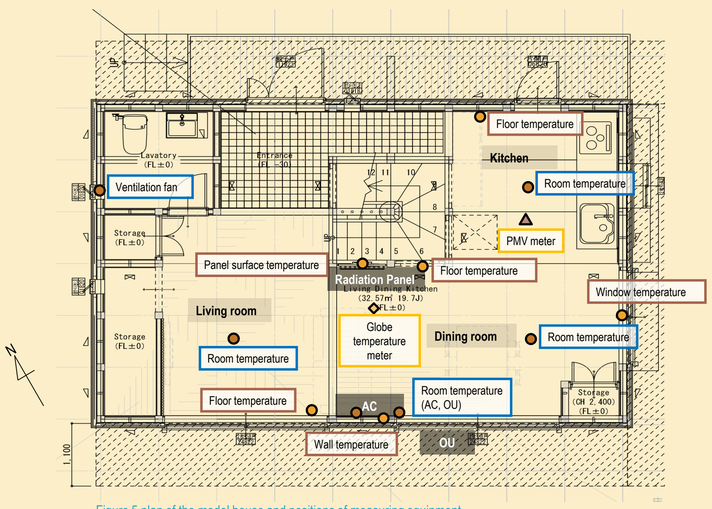

Figure 5 plan of the model house and positions of measuring equipment

<Comfort>
Temperature recorder
temperature 50mm, 1100mm, 2400mm
outside temperature balcony 2nd floor
<Dehumidification>
Electronic balance
connect plastic tanks to drains
measure the weight of plastic tanks with **electronic balance**
<Power Consumption>
Watt meter
clump the wiring inside the switchboard

Results/Actual Survey

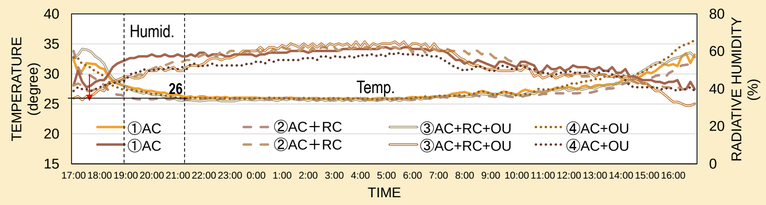

Figure 6 Comparison by each equipment pattern room temperature and relative humidity)

Every patterns maintained around 25 degrees after 4 hours.
②AC+RC go down its temperature faster than other 3 patterns in first 2 hours.

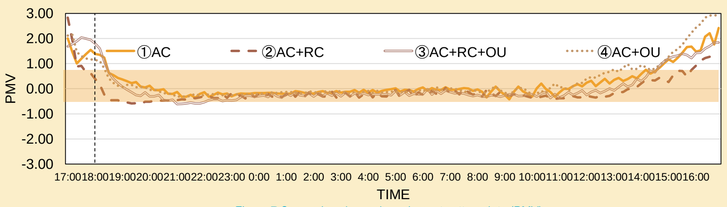

Figure 7 Comparison by each equipment pattern data (PMV)

②AC+RC had dropped PMV the fastest and it had already in a range of ±0.5 at 18:00.

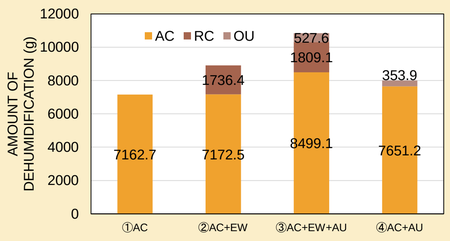

Figure 8 Comparison by each equipment pattern (amount of dehumidification)

The amount of dehumidification by AC became the **largest** in all patterns.

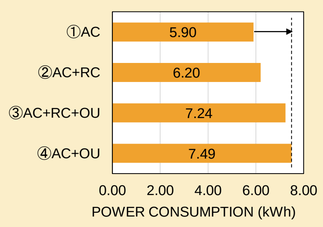

Figure 9 Comparison by each equipment pattern (power consumption)

④AC+OU **+1.59kWh** >①AC,
③AC+RC+OU **+1.34kWh** > ①AC.
→As the number of facilities increased the amount of electricity also increased

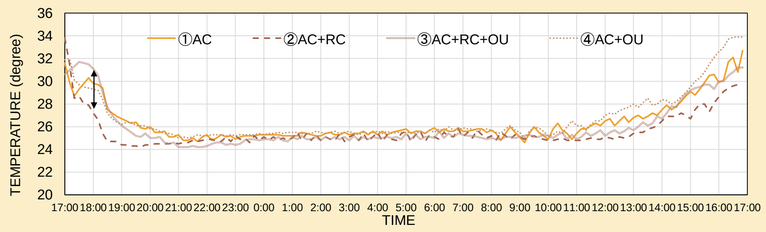

Figure 10 Comparison by each equipment pattern (globe temperature)

When comparing ①AC and ②AC+RC, the globe temperature of ② was 27.2 degrees, though ① was 29.8 degree
→**RC is effective in lowering globe temperature**.

Energy Simulation

Table 2 Simulation outline

Experiment period	From 29th, July to 4th, August
Weather data	Tsu, Mie prefecture, Japan, EPW
Analysis software	BEST-H (IBEC)
Cooling Capacity	5.5 kW
Rated power consumption	1.8 kW
Measurement interval	10 min.

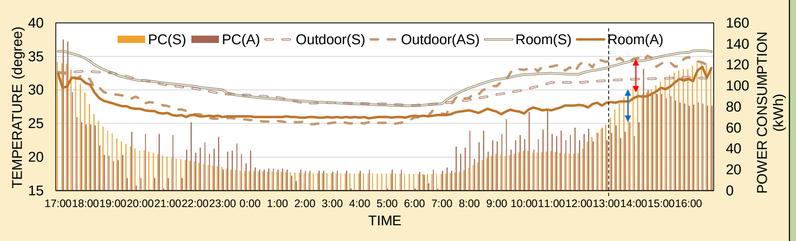

Figure 11 Comparison with experimental data (temperature and power consumption)

After 13 o'clock, the actual measurement result has a higher outside air temperature than the simulation result, but the power consumption was smaller and the room temperature was lower than simulation results.

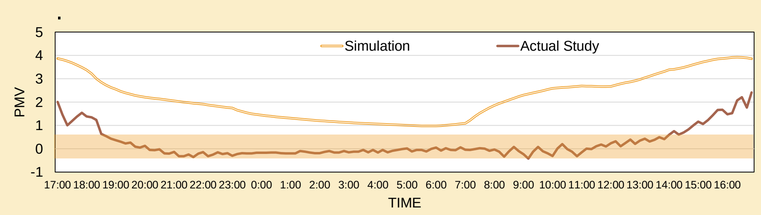

Figure 12 Comparison by each equipment pattern (PMV)

Simulation results were up to 2 larger than experimental results.
→The difference in outdoor temperature
→ the actual model house had high insulation performance and was easy to cool.

Discussion

1) Feasibility of zero-energy house

・PV panel generates power and Power Conditioner converts DC to AC.
・V2H connects Power Conditioner and EV
→ charge electric power generated from PV to EV

Table 3 Performance of each facility

Battery Capacity (EV)	40kWh
Discharge Lower Limit (V to H)	10%
System Capacity (PV)	0.25kW
Power Conditioner Efficiency (PV)	96%
Maximum number of panels	20 PVs

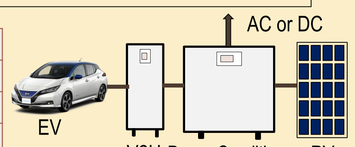

Figure 13 System of using EV as a battery

I assumed a house with one car (EV), and then calculated the minimum number of PV panels to cover daily power consumption.

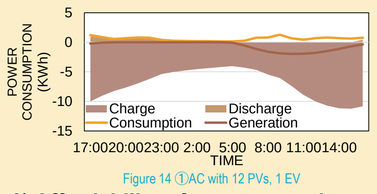

Figure 14 ①AC with 12 PVs, 1 EV

It is possible to cover power consumption with PV and EV
→EV should always parked at home and works as a storage battery.

2) Affordability of zero-energy house

・People in Bangkok who commute by car drive 23.2km/day
→Assume a mileage of 6000 km/year and **estimate car costs**

General House (Gasoline Car)
Mileage 6000 km ÷ Fuel Efficiency 14.4km/L × Gasoline Price 26.5 Baht = Total 11041Baht

80% cost saving

Zero-Energy-House (EV)
Mileage 6000 km ÷ Efficiency 10km/kWh × Electricity Price 3.8 Baht = Total 2280Baht

・Annual power consumption per person is 2700kwh, and assume 4 people per household
→**estimate the payback period for equipment installation costs**

General House (Electricity Price)
Electricity Price 3.8 Baht/kWh × Power Consumption 10,800 kwh/Y + Car Cost 11,041 Baht = Total 52,081 Baht/Y

29.4year

Zero-Energy-House (Equipment Installation Cost)
1.5million Baht (Electricity charge is assumed to be free to use private power generation)

Conclusion

Findings

1.Radiative cooling system is effective to lower glove temperature
2.Wooden house with high insulation can be cooled effectively
3.It is hard to achieve zero-energy house with 1 EV, because EV is most used as a car during the day when power generation is large
4. Replacing gasoline vehicles with EVs will reduce gasoline costs by 80%, but it will take about 30 years to recover equipment installations, so households of the middle class or higher may afford this system.

Further Study

1.Verify zero-energy district with sharing PVs and EVs in the region.
2.Set temperature with using RC may be lower and it can reduce energy consumption.

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