STUDY ON ENERGY CONSERVATION OF “PEFC APARTMENT HOUSE”

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ABSTRACT
For reduction of Green house Gas emission, Polymer Electrolyte Membrane Fuel Cells (PEFC) is promoted by the government in Japan as more efficient co-generation system (CGS). On this study for the purpose of finding the efficient energy supply system with PEFC in the apartment house, first the author proposed “PEFC Apartment House” as more efficient system than the current one (boiler and electric power), which consists of PEFC-CGS, thermal storage tanks, power network and management system. Second, in order to develop the planning method of facilities with PEFC, the author has built up a database of PEFC performance by carrying out measurements at a residential house, and has developed an environmental and economical evaluation system. Third, for prediction of energy conservation and environmental effect of “PEFC Apartment House”, with the evaluation system the author has predicted annual primary energy consumption and carbon dioxide emission at a 30-unit apartment house in Tokyo. As a result, the author estimated about 14% reduction of annual primary energy consumption and about 28% reduction of carbon dioxide emission.

KEYWORDS
Energy conservation, New energy, PEFC, Co-Generation system, Simulation

1. INTRODUCTION
The national government of Japan is diffusing polymer electrolyte membrane fuel cells (PEFC) as a means of more efficient energy use, for reducing greenhouse gas emissions and preserving fossil fuels. PEFC are expected to be employed in buildings and automobiles. This study proposed PEFC-operated apartment houses as an application of PEFC to buildings and simulated their energy saving effect. The results are described in this paper.

2. SYSTEM OUTLINE IN A PEFC-OPERATED APARTMENT HOUSE
The system is composed of a PEFC system (fuel cell stack, reformer, hot water storage tank and supplementary water heater) installed at each apartment and a distribution network connecting PEFC systems. Electric power is shared by apartments and waste heat is used individually by each apartment. PEFC are operated starting at an apartment with lower heat storage. When the capacity of storage is filled to the full, output from the fuel cell stack attached to the storage is discontinued. Then, the efficiency of PEFC operation will be increased; the number of PEFC will be reduced (load factor will be increased) and surplus waste heat will be reduced (more recovered waste heat will be used) through integrated control; and heat loss will be reduced as shorter heat pipes will be required.

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3. EVALUATION OF ENERGY SAVING CAPACITY

The energy saving capacity of PEFC-operated apartment houses was evaluated in terms of reductions of annual primary energy consumption and carbon dioxide emissions.

3.1. Outline of the building

Evaluation was made at an apartment house accommodating 30 80-m² apartments in Tokyo. Power, water heating, and cooling and heating loads were applied for a year (8,760 hours) in increments of one hour using the basic unit [3]. Cooling and heating loads were converted to power load on the assumption of use of air conditioners with COP (coefficient of performance) of 4.9 [4]. Load characteristics were assumed to be the same in all apartments.
3-2. Cases of calculation

Calculations were made in two cases with a conventional apartment house generally available at present and with a PEFC-operated apartment house. In the conventional apartment house, commercial electric power is supplied and hot water is provided using water heaters driven by city gas. The basic units used are listed in Table 4.

Table 3  Specifications for equipment at a conventional apartment house

| Power: Purchasing commercial electric power |
| Hot water: Using water heater (one heater installed per apartment) |
| Fuel for water heater: City gas |
| Capacity of water heater: 803 M/Jh |
| Efficiency of water heater: 83% (HHV) |
Table 4  Basic units used

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>City gas (13A) (low heating value)</td>
<td>MJ/m³(N)</td>
<td>41.66</td>
</tr>
<tr>
<td>Basic unit of carbon dioxide emission from city gas (13A)</td>
<td>kg-CO₂/kWh</td>
<td>0.0013</td>
</tr>
<tr>
<td>Commercial electric power converted to primary energy (17)</td>
<td>MJ/kWh</td>
<td>9.33</td>
</tr>
<tr>
<td>Basic unit of carbon dioxide emission from thermal power generation (8)</td>
<td>kg-CO₂/kWh</td>
<td>9.56</td>
</tr>
</tbody>
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4. RESULTS OF EVALUATION AND DISCUSSION

Figures 4 and 5 show annual consumption of primary energy and carbon dioxide emission in two types of apartment houses, respectively for comparison. It was found that in the PEFC-operated apartment house, annual consumption of primary energy and carbon dioxide emission were lower than in the conventional apartment house by 14.1% and 27.6%, respectively.
Figures 6 through 8 show how PEFC were operated in a PEFC-operated apartment house throughout the day. Findings are described below.

(1) On a winter day (Figure 6), heat demand was higher than in other months, so the hot water storage tank was not filled to the full capacity. Fuel cells stopped operation due to load variations. The number of PEFC in operation at 17:00 hours was less than 20, resulting in power shortage. It was therefore necessary to purchase commercial electricity.

(2) On a spring or autumn day (Figure 7), heat demand was higher than in other months as in winter, so the hot water storage tank was not filled to the full capacity. Power demand was lower than in other months, so PEFC-generated power met the power demand almost completely.

(3) On a summer day (Figure 8), heat demand was lower than in other months, so the hot water storage tank was filled to the full capacity at 11:00 hours. All of the fuel cells stopped operation. As a result, only three units were in operation after 14:00 hours. There occurred power shortage and commercial electricity had to be purchased.
5. CLOSING REMARK
In this study, the energy saving effects of PEFC-operated apartment houses were estimated by simulation. As a result, it was found that less energy was consumed than in conventional apartment houses. It was also revealed that there remains room for optimizing the number of PEFC units and the capacity of heat storage to further increase energy saving capacity. Studies will be made to optimize the number of PEFC units and the capacity of heat storage to further increase energy saving capacity.

REFERENCES
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7) Energy Conservation Act: Annual report, Heat, Table 6 Coefficient of mean daily electric power consumption.
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