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Influence of System Operation Method on CO_2 Emissions of PV/Solar Heat/Cogeneration System

SHINICHIRO OKE,[1] YOSHISHIGE KEMMOKU,[2] HIROFUMI TAKIKAWA,[1] and TATEKI SAKAKIBARA[1]
[1]Toyohashi University of Technology, Japan
[2]Toyohashi Sozo College, Japan

SUMMARY

A PV/solar heat/cogeneration system is assumed to be installed in a hotel. The system is operated with various operation methods: CO_2 minimum operation, fees minimum operation, seasonal operation, daytime operation, and heat demand following operation. Of these five operations, the former two are virtual operations that are operated with the dynamic programming method, and the latter three are actual operations. Computer simulation is implemented using hourly data of solar radiation intensity, atmospheric temperature, electric, cooling, heating, and hot water supply demands for one year, and the life-cycle CO_2 emission and the total cost are calculated for every operation. The calculation results show that the two virtual and the three actual operations reduce the life-cycle CO_2 emission by 21% and 13% compared with the conventional system, respectively. In regard to both the CO_2 emission and the cost, there is no significant difference between the two virtual operation methods or among the three actual operation methods. © 2008 Wiley Periodicals, Inc. Electr Eng Jpn, 164(2): 54–63, 2008; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/eej.20414

Key words: PV/solar heat/cogeneration system; life-cycle CO_2 emissions; hotel; actual operation method; dynamic programming.

1. Introduction

With global warming and depletion of fossil fuels having become worldwide problems, there is a great demand for reduction of CO_2 emissions and energy consumption. But in Japan, CO_2 emissions and energy consumption are continuously growing in the civilian sector. Aiming at reduction of CO_2 emissions in the civilian sector, the introduction of renewable energy systems and cogeneration systems has been proposed, but it is now clear that the implementation of individual systems of this sort cannot produce a sufficient effect.

In cogeneration systems using absorption refrigerators based on exhaust heat for cooling, CO_2 emissions increase rather than decrease [1, 2]. However, a reduction of CO_2 emissions is reported when heat pump air-conditioners are employed instead of absorption refrigerators [3].

On the other hand, in photovoltaic (PV) power systems and solar heat collection systems, the output varies with weather conditions, which requires the combined use with power grids and auxiliary heat sources [4, 5]. In addition, when PV and solar heat systems are operated in combination with gas/diesel engine cogeneration, the performance depends strongly on the method of operation of the cogeneration system [6]. In combined PV and diesel power generation, methods for predicting the PV output have been proposed to realize optimal operation, but sufficient prediction accuracy has not been achieved [7].

The authors have proposed the introduction of combined PV/solar heat/cogeneration systems in the civilian sector, and have studied life-cycle CO_2 emissions (including not only operation but also manufacture and construction) [8–10]. We found that in such systems too, using heat pumps instead of absorption refrigerators for cooling allows reduction of CO_2 emissions [11].

In the aforementioned reports, CO_2 emissions and costs were analyzed assuming the introduction of PV/solar heat/cogeneration systems into hotels (heat/power ratio: 1.3) and hospitals (heat/power ratio: 0.8). The results indicated that the proposed systems would be efficient for facilities with high heat/power ratios such as hotels: in these facilities, CO_2 emissions decrease by 20% compared to

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