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A Study of the Buying Price of Photovoltaic Electricity under a Carbon Tax Regime

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SUMMARY

Assuming that photovoltaic (PV) systems are adopted in residential houses under a carbon tax regime, the economic performance of PV systems is investigated from the standpoint of an electric utility. The economic performance is estimated by using the buying price of PV electricity and the PV economic index, which is defined as the ratio of the buying price to the generation cost of the electric utility. Because these values depend on electric power development and operation, the best mix and the operation of power plants are obtained by linear programming subject to restrictions on power generation. Then, the buying price of PV electricity is calculated from the total cost of the electric utility. The buying price means the upper limit at which the electric utility never suffers a loss. The buying price is also compared with the power generation cost. The parameters are the prevalence attainment ratio of PV systems (0 to 100%), the upper limit of newly developed nuclear power plants (0 to 4 GW/10 y), and the generated energy ratio of coal-fired thermal plants (0 to 15%). Chubu Electric Power Company, Inc. is used as the electric utility. The calculation results show that the buying price of PV electricity increases linearly with increasing carbon tax rate, and its values are 9 and 11.5 yen/kWh when the carbon tax rate is 0 and 25 thousand yen/t-C, respectively, which does not depend on the prevalence attainment ratio of PV systems and the upper limit of newly developed nuclear power plants. It is not the carbon tax rate but the newly developed nuclear power plant that influences the PV economic index. The values of the PV economic index are 1.35 to 1.45 and 1.50 to 1.60 when the newly developed nuclear power plant capacity is 0 and 4 GW/10 y, respectively. These results show that the economic performance of PV systems is increased by developing nuclear power plants at a certain rate and introducing a carbon tax. © 2003 Wiley Periodicals, Inc. Electr Eng Jpn, 143(2): 38–49, 2003;
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Key words: photovoltaic electricity; carbon tax; economic performance; optimal power plant mix; total cost; CO_2 emission; buying price.

1. Introduction

In the light of ever-growing concern over global warming, a number of foreign countries have introduced a carbon tax as a method of reducing CO_2 emissions into the atmosphere. For example, the rate of such a tax in Sweden is 18,000 yen/t-C, in Norway 5400 to 23,000 yen/t-C, and in Denmark 6900 yen/t-C [1]. A serious discussion has also begun regarding implementation of a carbon tax in Japan. According to simulations based on a macroeconomic model, a 20% reduction rate of CO_2 emissions can be achieved in the case of a carbon tax rate of 10,000 yen/t-C, and up to 40% at a tax rate of 30,000 yen/t-C [2].

On the other hand, due to financial support by the state and municipal authorities, the use of photovoltaic (PV) systems has quickly expanded in residential areas of Japan. Thus, by March 2000 about 33,000 buildings had been equipped with such systems, with a total capacity of 121 MW [3]. In June 1998, the Energy Committee of the Ministry of Industry and Trade incorporated new provisions on power supply into the "Long-Term Prospects of Electricity Supply and Demand," which set a goal of boosting this figure to 5000 MW by the year 2010. 121 MW constitutes only 2.4% of that level.

Among the factors that strongly influence the development of PV systems is the selling and buying price of surplus electricity. Under present conditions, the electric power surplus generated by PV systems must be purchased at the same price as regular electricity (16 to 24 yen/kWh).