

Principal Research Results

Impacts of Large-scale Penetration of CHP Systems and Heat Pump Water Heaters through Generation Mix on CO₂ Emission in Japan

Background

The energy efficiency improvement and the CO₂ emission reduction are expected by a large penetration of the cogeneration or CHP (combined heat and power) system including fuel cells. In the previous studies on CO₂ emission evaluation, the substituted thermal power technology is exogenously assumed, and the presumption of the effect of the reduction might give bias to the CO₂ reduction measures selection in the future. It is necessary to analyze the effect of the CO₂ emission reduction for the energy system of the entire country that puts a decentralized power supply and the power supply from the grid together, and to clarify a technological condition of a decentralized power supply to contribute to the CO₂ reduction.

Objectives

This report presents a quantitative evaluation of CO₂ emission from grid power systems and heat source systems including CHP and the heat pump water heaters in residential and commercial buildings in Japan.

Principal Results

We estimated CO₂ emission using an optimal generation planning model. Through quantitative simulation runs, the authors obtained the following results:

- (1) The installed capacity and the operation pattern of non-industrial cogeneration systems were assumed referring to the Ministry of Economy, Trade and Industry's long-term energy outlook. The installed capacity of CHP is expanded respectively by 10.85 GW in fiscal year 2020 and 12.39 GW in fiscal year 2030 in the CHP promotion scenario compared with a reference scenario without the additional policy. We assume two cases for additional nuclear power; 17 units as a high case, and 4 units during 2000-2010 and upper limit of 7 units during 2010-20 as a low case. CHP will defer high-efficiency AGCC, and suppress generation from new AGCC. CHP will increase existing gas-fired and oil-fired power plants whose thermal efficiency is relatively low. Introduction of CHP bring a small impact on CO₂ emission (Figure 1).
- (2) The purchased power from the electric power grid decreases by the CHP installation. The marginal emission factor of CO₂ for each amount of the cogeneration power generation that replaces this bypassed demand decreases according to the improvement of the power generation efficiency of CHP (Figure 2). The generation efficiency of a commercial CHP is requested when this marginal CO₂ emission factor is compared with the average CO₂ emission factor of the grid power (about 90g-C/kWh in fiscal year 2010) and it is requested to improve to about 50% or more (solid oxide fuel cell level) for the customer with a low heat demand ratio such as offices with about 37% or more in hospitals.
- (3) CO₂ heat pump water heater is also recognized as one of the key demand-side technologies to reduce carbon emissions from the Japanese residential sector. According to the governmental report on Japanese energy outlook toward 2030, cumulative units of the CO₂ heat pump water heaters installed are expected to reach 5.2 million by FY2010 and 20 million by FY2030, respectively, through further technology developments. The amount of the introduction of nuclear power generation expands from an economic side in the generation mix as a base power supply if it can be expected for technology of heat pump water heater development to progress steadily, and to spread surely, and restricts neither the location nor the system operation, and the effect of the CO₂ reduction is large in fiscal year 2030 with 10.74 million t-C. The effect of supply-side CO₂ emission reduction by heat pump water heater driven by induced demand growth will be twice as much compared with its direct reduction on the demand-side. However, it is assumption in this to pay the maximum CO₂ reduction effort on both sides of supply and demand.

Future Developments

The energy system including distributed energy resources will be analyzed according to the technological progress and the fuel price fluctuation of a decentralized power supply and the system power supply while considering the customers' benefits to clarify the technological development target that contributes to the environmental improvement of the entire country.

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Reference

H.Asano, et.al., 2006, "Impacts of Large-scale Penetration of Cogeneration Systems and Heat Pump Water Heaters through Generation Mix on CO₂ Emission in Japan", CRIEPI Report Y05014 (in Japanese)

B. Creation of integrated energy service

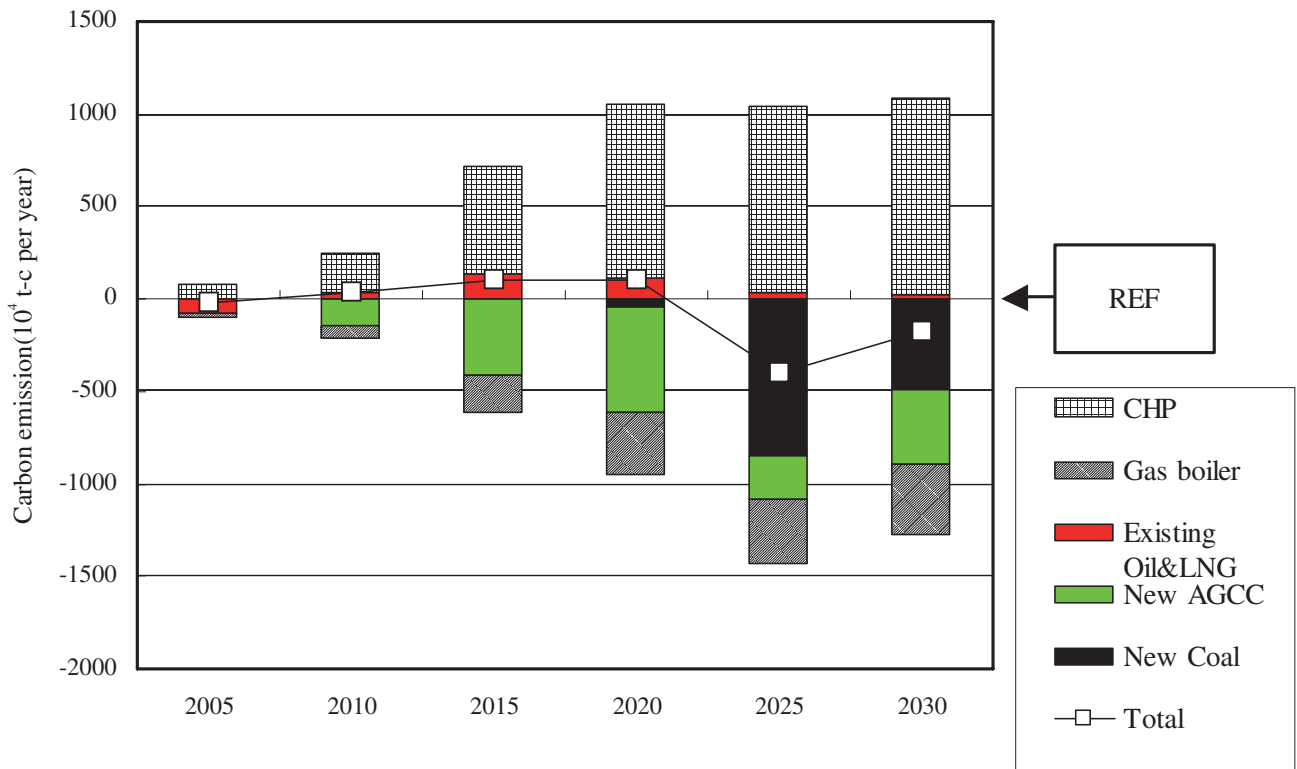


Fig.1 Changes in CO₂ emission and generation mix by CHP penetration: High nuclear case

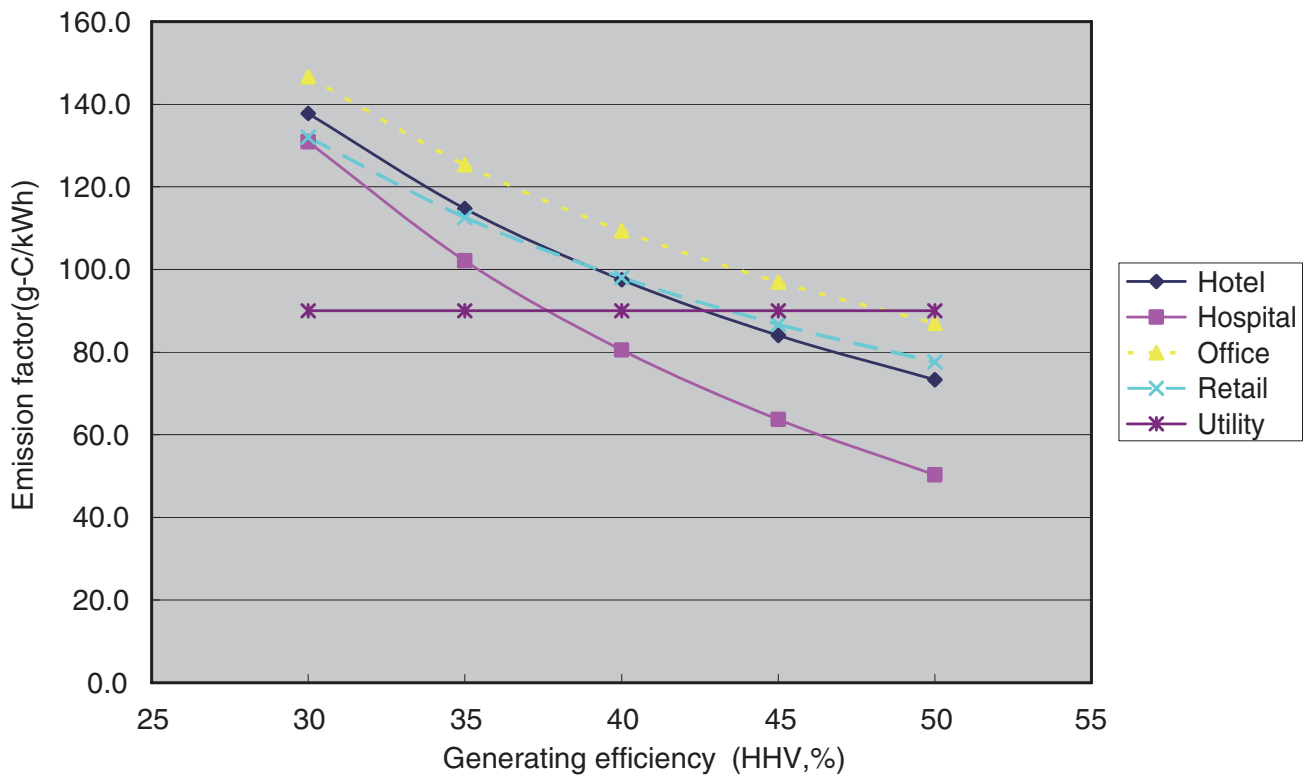


Fig.2 Marginal CO₂ emission factor of CHP