THE CHANGES IN ENERGY TECHNOLOGIES FOR LONG-TERM CO_2 EMISSION REDUCTION IN JAPAN UNDER NUCLEAR STAGNATION

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Overview

After the Fukushina disaster in March 2011, the discussion about future dependence on nuclear power has not yet been converged in Japan. However, the availability of nuclear power has serious impacts on emission reduction of energy-origin CO_2 emissions. We developed the Japanese Regional Energy Model (J-REM) and analyzed the differences in the choice of energy technologies towards 2050 under various CO_2 emission constraints and available combination of energy technologies (Nagata and Mori (2012)). This study focuses on the impacts of nuclear stagnation on the choice of energy technologies for the long-term CO_2 emission reduction in Japan by using this model.

Methods

The structure of J-REM is shown in Figure 1. The net energy demand in the industrial and transportation sector (except for car) and the energy service demand in the transportation (automobiles only) and buildings sectors are exogenously given. This model covers various energy conversion technologies (fuel conversion, power generation, and technology employed in vehicles), including hydrogen and fuel cell technologies. The introduction and utilization of these technologies that will minimize the discounted present value of total expenditure in energy supply for various constraints, such as the maximum primary energy supply (reserves of fossil fuels), energy balance, electricity load curve, and CO_2 emissions, will be determined by using linear programming techniques. The amounts of 15 kinds of primary energy and CO_2 emissions are calculated simultaneously. This model focuses on the differences in energy use by climate, population density, and availability of locally distributed gas (city gas) infrastructure. According to them, Japan is divided into seven regions.

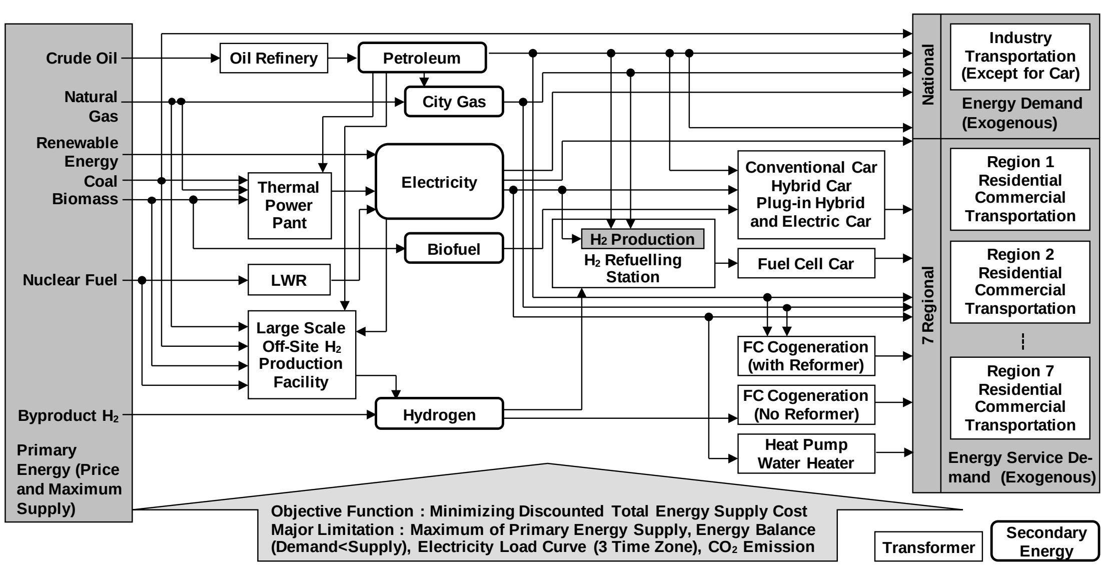

Figure 1. Structure of Japanese Regional Energy Model (J-REM)

Results

As for nuclear, two scenarios are set; (1) keep half capacity level in 2010, and (2) fade out (Figure 2). In the keep half scenario, new plants will be constructed to maintain the capccity after 2035. On the other hand, the lifetime of extsting power plants is assumed to be 40 years and total capacity will be zero in 2050 in the fade out scenario because no new construction is assumed.

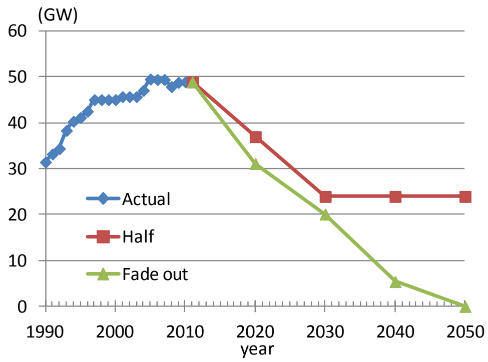

Figure 2. Scenario of Nuclear Capacity

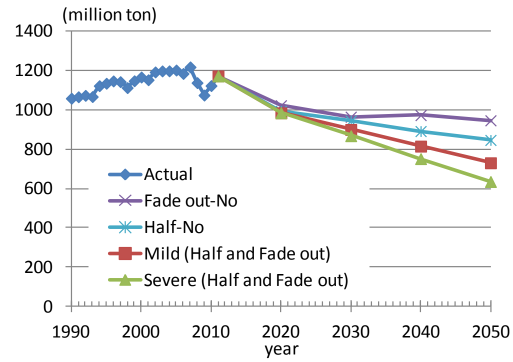

Figure 3. Energy-Origin CO_2 Emission

Figure 3 shows energy-origin CO_2 emissions. Nuclear stagnation will delay its reduction and the difference in 2050 will reach 100 million ton without CO_2 constraint cases. The reduction in the Half-No case from the current level is achieved mainly by feed-in tariff and some cost-effective and efficient energy utilizing technologies (hybrid vehicles, biofuels, stationary fuel cell cogeneration (FC-CGS), and heat pump water heater). Figure 4 compares the differences in technology choice in the passenger car. No difference is observed until the mild CO_2 constraint in passenger car selection. Interestingly, selected technologies under the severe CO_2 constraint will be different according to the nuclear scenario. EV will be chosen in the Half-Severe Case, however, FCV will be chosen in the nuclear fade out case. Hydrogen for FCVs will be produced by reforming biomass and the construction of expensive hydrogen supply infrastructure will be required.

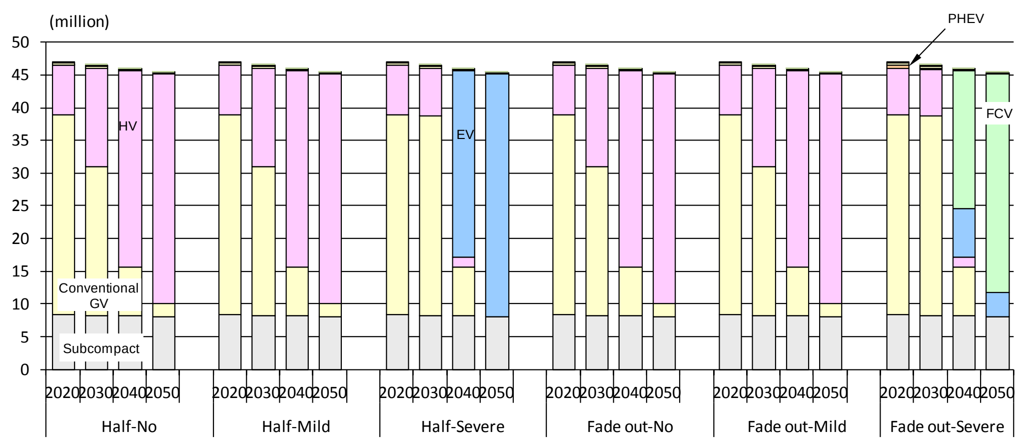

Figure 4. Number of Passenger Cars under Nuclear Scenarios and CO_2 Constraints

Heat pump technology plays an important role for CO_2 emission reduction from hot water supply. It consumes electricity, but no difference is observed in the introduction of this technology according to the nuclear scenario and it will overcome even FC-CGS. This is because of its high efficiency. The efficiency of heat pump is measured by COP (coefficient of performance) and will reach 400% in near future in warm climate region. This superiority of heat pump in CO_2 emission reduction will overwhelm the increased CO_2 emission unit in 2050 by nuclear stagnation (from 87.7g/kWh to 105.9g/kWh).

Conclusions

This study analyzed the cost and effectiveness of various advanced energy conversion and utilizing technologies in reducing CO_2 emissions toward 2050 by employing the Japanese Regional Energy Model (J-REM). The results of this study confirmed the importance of the combination with nuclear power and electrification end-use technologies for CO_2 reduction in Japan. It is expected that revising process of safety standards of nuclear power by the government will take time, however, maintaining a certain dependence on nuclear power in future will important not only for CO_2 reduction but also for improving energy security and keeping bargaining power in purchasing fossil fuels.

References

Nagata, Y. Mori, Y. (2012), “Regional Differences in the Choice of Energy Technologies for Long-Term CO_2 Emission Reduction in Japan,” Presented at the 35th Annual IAEE International Conference, Perth, Australia.