# The Assessment of Technology Options on Large-Scale $CO_2$ Emission Reduction toward 2050 in Japan

## Background

The development of various innovative energy technologies has been in progress to realize the low-carbon society in the long-term. However, a lot of budget is required to develop many kinds of technologies at the same time, and since these technologies have a competitive relationship for their introduction, some portions of the effect of reducing the Green House Gases (GHGs) emissions will be offset. Therefore, it is desirable to conduct a systematic analysis to evaluate the effect and cost of reducing GHG emissions in the case where each technology will be made practicable and to select the technologies that should be given higher priority.

## Objectives

The purpose of this study is to modify the Japanese Hydrogen Energy Model (J-HEM), which the authors developed in the previous study, and to analyze total energy supply cost (including the cost of preparing energy supply infrastructure) toward 2050 and the quantitative effect of $CO_2$ emissions reduction if various energy technologies will be made practicable at the same time or individually.

## Principal Results

### 1. Improvement in the Japanese Hydrogen Energy Model (J-HEM)

Various innovative energy supply and utilizing technologies, e.g., heat-pump water heaters and other end-use apparatus, electric and other alternative vehicles, fuel cells, hydrogen-related technologies, biofuels, carbon capture and storage (CCS), and energy conservation options are incorporated in the Japanese Hydrogen Energy Model (J-HEM) to analyze the competition for $CO_2$ emissions reduction between them. This model minimizes net expenditure in energy supply and utilization by the year 2050 under the various constraints, such as the primary energy supply, energy balance, electricity load curve, introduction of new technologies, and $CO_2$ emissions, and selects the optimal technology options (Fig. 1).

### 2. The relationship between the introduced technologies and $CO_2$ emission constraints

The energy supply and utilization technologies that will be introduced by 2050 were analyzed based on the recent presuppositions. Even in the BAU (business as usual) case, where $CO_2$ emission constraints will not be applied, IGCC, heat-pump water heaters, stationary fuel cell cogeneration systems, and biofuels for transportation will be introduced. However, it is expected that the progress in improvement in energy supply and utilization remains slow. If the constraint of reducing energy-related $CO_2$ emissions in 2050 to half the level in 2000 will be imposed, various other technologies e.g., CCS, biomass generation, and in particular, next generation vehicles (fuel cell passenger cars and trucks (FCVs), electric vehicles (EVs), plug-in hybrid vehicles (PHEVs)) in the vehicle transportation sector will be needed to minimize the additional cost of $CO_2$ reduction (Fig. 2).

### 3. The effect of available technology options on reduction cost

The average and marginal costs to achieve the $CO_2$-half target mentioned above will be 5,000 and 20,000 yen/t-$CO_2$ respectively in 2050. If technology options will be limited, energy supply costs have to increase. In the case that next generation vehicles except for hybrid vehicles (HVs), biofuels for transportation and CCS technologies will not be available, total cost of energy supply in 2050 will increase by 18.5%, 7.4 trillion yen annually, compared with the case where all of these innovative technologies will be available (Fig.3, the difference between the CO2-Ltd case and the CO2-All case). It can be considered that this difference is the benefit realized by developing these technologies.

## Future Developments

The analysis of the medium-term, in which available technology options are limited, will be performed. Then, a model that focuses on the differences in population density and energy utilization between city center and suburban or rural area, and in the cost of preparing energy supply infrastructure due to them will be developed, and a desirable role sharing of energy supply and utilizing technologies will be analyzed.

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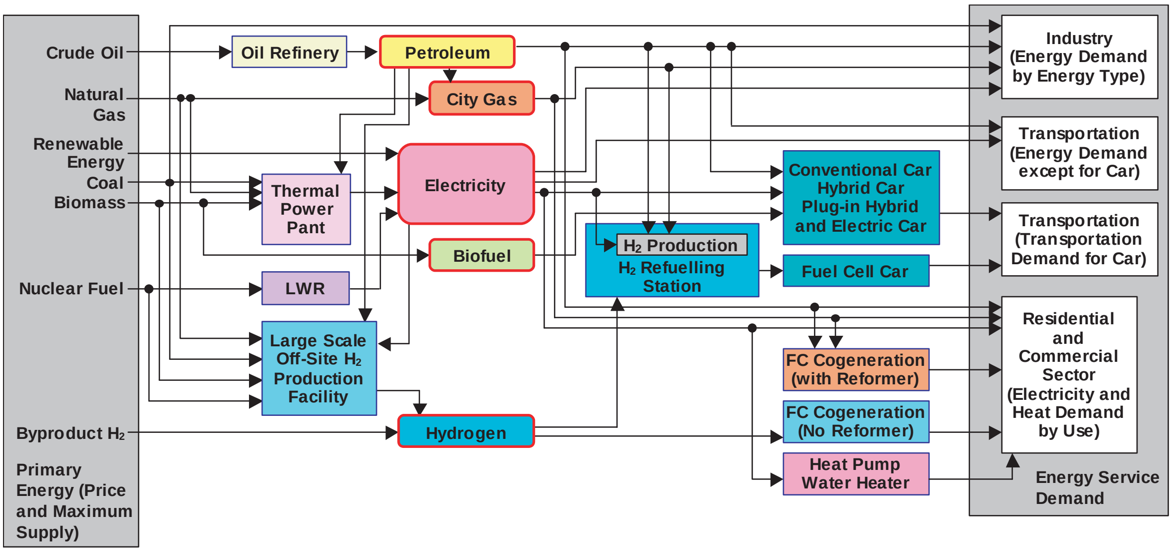
***Reference***

Y. Nagata, 2009, “The Effectiveness of Technology Options on Large-Scale $CO_2$ Emission Reduction toward 2050 in Japan”, CRIEPI Report Y08013 (in Japanese).




The J-HEM analyzes the optimal combination of the technologies quantitatively that minimizes discounted total energy supply cost under various constraints such as primary energy supply or $CO_2$ emissions.

**Fig.1** Overall Structure of Japanese Hydrogen Energy Model (J-HEM)

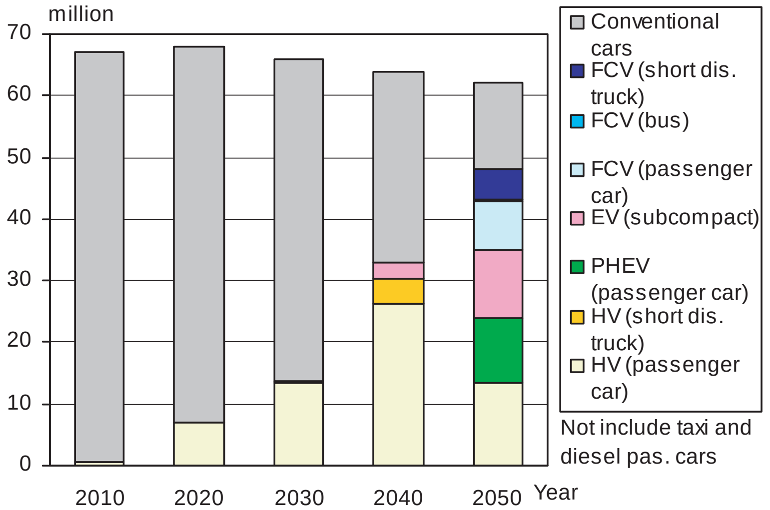



**Fig.2** Number of vehicles (in the case where all technology options are available under the $CO_2$ emission constraint in 2050 to half the level in 2000)

| Case | $CO_2$ Const-raint | Buildings | Transportation | | | | Gene-ration |
|---|---|---|---|---|---|---|---|
| | | HP water heater, FC-CGS | HV | EV, PHEV | FCV | Biofuel | IGCC with CCS |
| BAU | No | O | O | O | O | O | O |
| CO2-All | Yes Start in 2010 and strength-ened to the half level of 2000 in 2050 | O | O | O | O | O | O |
| CO2-Ltd | | O | O | X | X | X | X |
| CO2-Ele | | O | O | O | X | X | X |
| CO2-H2 | | O | O | X | O | X | X |
| CO2-Bio | | O | O | X | X | O | X |
| CO2 -noCCS | | O | O | O | O | O | X |

(Note) O: That technology is available, X: Not available.

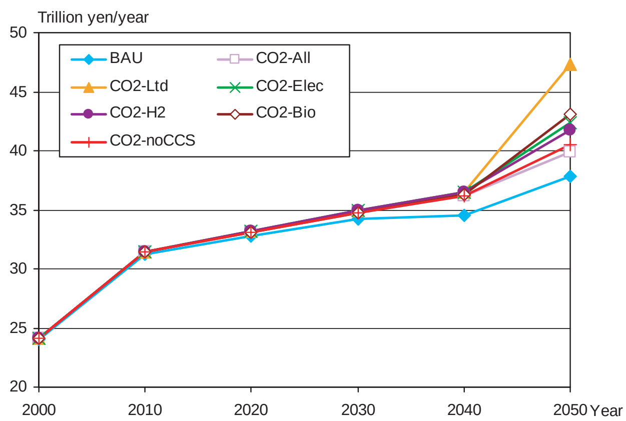



**Fig.3** Relationship between the combination of available technology options and energy supply cost