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# SIMULARION ANALYSIS OF $CO_2$ REDUCTION SCENARIOS IN JAPAN'S ELECTRICITY SECTOR USING MULTI-REGIONAL OPTIMAL GENERATION PLANNING MODEL

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## Overview

The purpose of this study is to establish multiple $CO_2$ reduction targets for the electricity sector in Japan and, by means of quantitative evaluation based on models, to identify combinations of specific policies and scenarios designed to achieve these targets. In this study, a multi-regional optimal generation planning model was developed, one capable of taking into consideration the power demand for individual prefectures and the power source configuration for individual power companies, and a quantitative determination was made of the combination of reduction measures and the implementation timing in order to achieve specific $CO_2$ reduction targets. Based on the results, a $CO_2$ reduction scenario for the electricity sector in Japan was proposed.

## Methods

In this study, a multi-regional generation operation model (Ashina and Nakata, 2005) was expanded into an optimal generation planning model. Fig. 1 shows the configuration of the multi-regional optimal generation planning model. In this model, Japan was divided by prefecture into 60 regions. In each region, a single demand node representing power demand in that region and multiple power generation nodes representing power plants were established. Between the demand nodes in adjacent regions, hypothetical power transmission lines based on the actual power transmission network were established.

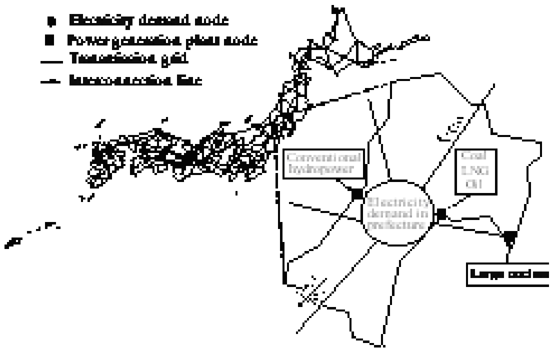


**Fig. 1:** Schematics of the multi-regional optimal generation planning model

## Results

In this study, it was assumed that $CO_2$ reduction target for the electricity sector would be established as 2030, and a multi-regional generation planning model was used to determine an optimal solution for the power source configuration and power generation configuration from 2000 to 2030. First, as the business as usual (BAU) case, a case in which no restrictions are imposed on $CO_2$ emissions in 2030 was established. Next, as a $CO_2$ reduction target for 2030, the range from 120 Mt-C to 50 Mt-C was established in 10 Mt-C increments.

Fig. 2 shows $CO_2$ emissions in the electricity sector from 2000 to 2030 by reduction target. In the BAU case, $CO_2$ emissions continue to increase. From a level of 86.8 Mt-C in 2000, $CO_2$ emissions increase to 137.9 Mt-C in 2030. In the cases in which reduction targets were imposed, $CO_2$ emissions from 2000 to 2005 are unchanged from the BAU case regardless of the target value. From 2010 on, reduction of $CO_2$ emissions progresses as the severity of the reduction target increases. However, in the cases in which the reduction target is up to 90 Mt-C max., there are no differences in $CO_2$ emissions with the exception of the year 2030. This is because in order to reduce $CO_2$ emissions to 90 Mt-C or below, the introduction of CSS-equipped thermal power is indispensable, and equipment costs and operation and maintenance costs are high. Therefore, introduction does not progress to the point at which $CO_2$ reduction targets are imposed.

Fig. 3 shows the relationship between $CO_2$ reduction targets and the power generation configuration in 2030. As the reduction target is made more severe, there is a progressive two-step shift in the changeover of fuel, from coal-fired thermal power to gas combined thermal power, and from gas combined thermal power to CCS-equipped gas combined thermal power. As nuclear power plants and general hydroelectric power plants do not emit $CO_2$ in the process of generating power, these plants generate a uniform quantity of power regardless of the reduction target.

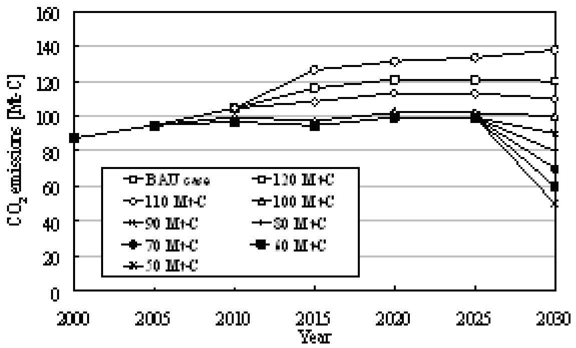


**Fig. 2:** $CO_2$ emissions by reduction target

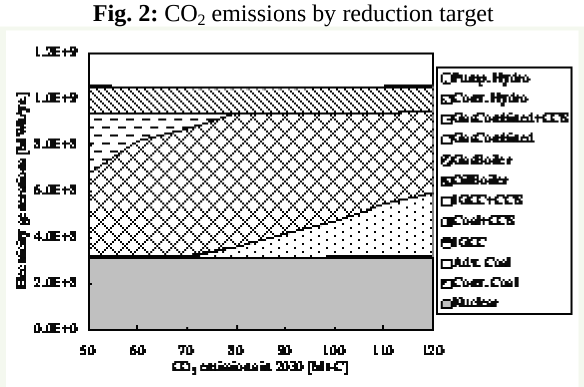

**Fig. 3:** Power source configuration by the targets

## Conclusions

In order to achieve $CO_2$ reductions in the electricity sector, one of the following two scenarios would be effective, depending on the reduction target: (1) Construction of new gas combined thermal power plants, and (2) Introduction of gas combined thermal power facilities that include CCS facilities. Focusing on the timing for the implementation of $CO_2$ reduction measures, under the new gas installation scenario, measures would be implemented in a scheduled manner beginning from 2000 toward the reduction objectives. In contrast, under the CCS scenario, the measures would be implemented only just prior to the imposition of the reduction targets. From the standpoint of rapid reduction of $CO_2$ emissions, the new gas installation scenario would be best. However, through the imposition of $CO_2$ reduction restrictions in a staged manner starting from the present, in the CCS scenario as well, there would be a balance between rapid implementation of measures and large $CO_2$ reductions.

## References

Ashina, S. and Nakata, T. (2005): "Feasibility study of integrated system operation for electricity sector in Japan", *Energy and Resources*, 26(6), 43-49.