Priority Subjects — **Establishment of Optimal Risk Management**

Scientifically and Economically Rational Scenarios to Reduce CO_2 Emissions

Background and Objective

Although we do not have a clear outlook for the national energy policy, the reduction of CO_2 emissions is a major issue in an international framework as it was before the Great East Japan Earthquake. We therefore need to show appropriate direction for the development of low-carbon technologies, leading to emissions reduction, based on the latest trend of technologies and their potential risks.

This study aims to forecast restrictions on world CO_2 emissions with technology basis and economical rationality, and to contribute to establishment of long-term national energy policy. We also conduct preliminary assessment of environmental risks regarding CO_2 capture and storage (CCS) in order to discuss the future introduction of CCS technology.

Main results

1 A rational and feasible pathway of CO_2 emissions reduction based on a new concept of climate stabilization

We have presented a CO_2 emissions pathway, termed Z650*1, designed on the basis of a new climate stabilization concept, and discussed its consequences and issues from a viewpoint of feasible measures to mitigate global warming (V12007). The amount of CO_2 emissions in 2050 for Z650 is 74% of 2000 levels, which is much greater than the 34% required for a conventional pathway (Fig. 1). The Z650 pathway is recognized as a flexible alternative toward the 2°C-target*2, providing more room for reaching an agreeable compromise between developed and developing countries. However, Z650 would see a relatively large increase in temperature during the 21st century (comparison between dotted and solid lines in Fig. 1), necessitating adaptation measures to climate change. Regarding adaptation issues, we have surveyed examples of recent and ongoing strategies and initiatives in leading overseas countries and summarized the general outlook for electric industry in Japan (V12008).

2 Long-term analysis of CO_2 reduction technologies by an integrated assessment model (BET)

BET, developed in FY2011, is our integrated assessment model that includes components of energy, environment (climate), and economy in order to evaluate the importance of CO_2 reduction technologies and their economic impacts. A defining feature of BET, compared with the other models, is that it is superior in handling various end-use technologies that convert final energy into energy service. In FY2012, we have evaluated CO_2 reduction technologies with BET under greenhouse gas constraints and showed that a combination of electrification and advanced end-use technologies (such as heat pump water heater and electric vehicles) would be one of the rational measures to reduce greenhouse gases in the long term (Fig. 2). Also, to have the BET outcome recognized in international modeling communities, we have joined the Energy Modeling Forum 27 modeling exercise (EMF27), which facilitates inter-comparison of over 10 integrated assessment models. The results of EMF27 will be cited in the fifth assessment report of the IPCC published in 2013-2014.

3 Analysis of potential environmental risk by introducing CCS technology

Although CCS technology is one of the important mitigation measures for global warming, scientific understanding of environmental and health risks caused by CCS is not sufficient in Japan. To evaluate the potential environmental impact of CCS technology, we have performed a life cycle assessment (LCA) regarding a pulverized coal power plant in Japan. The results suggest that, while widespread CCS technology decreases global warming impact through the substantial reduction of CO_2 emissions, the use of monoethanolamine (MEA) solvent increases environmental impact, which occurs in processes of MEA production and CO_2 capture (Fig. 3) (V12012).

*1 A CO_2 emissions pathway that allows cumulative total of 650 GtC during 21st century and aims to attain zero in the middle of the 22nd century.
*2 An aspiration goal to limit the global mean temperature to 2°C above preindustrial (around 1750) levels.

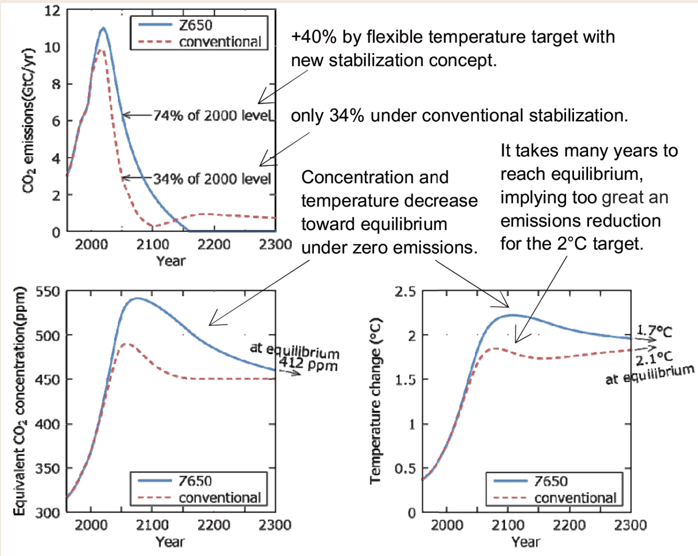

Fig. 1: Comparison between new zero-emissions stabilization (Z650) and conventional concentration stabilization

Results from calculation with our simple climate model (SEEPLUS). Equivalent CO_2 concentrations in the lower left panel represents concentrations converted from the total forcings including non-CO_2 agents. The conventional stabilization toward a constant concentration of 450 ppm, corresponding to 2°C warming, requires substantial emissions reductions during the 21st century. In contrast, Z650 allows more emissions during the 21st century due to a long-term decrease in concentrations resulted from zero emissions after the middle of the 22nd century.

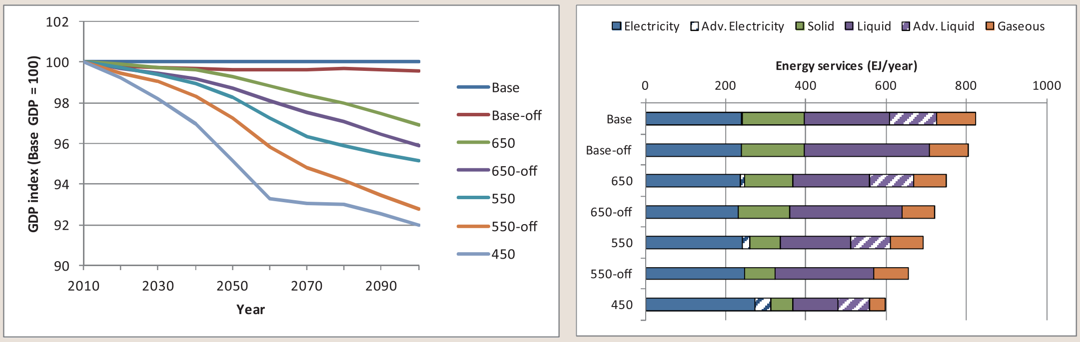

Fig. 2: Global GDP changes and energy service demands in 2050 under constraints of greenhouse gas (GHG) emissions

Results from calculation with our integrated assessment model (BET). "Base" means the case without GHG constraints, numbers in labels, such as 650, indicate constraints of GHG concentration in ppm in CO_2 equivalent, and "off" indicates the results without advanced end-use technologies, such as heat pump water heater, electric passenger vehicles, and hybrid freight vehicles. The stricter the GHG constraints are, the larger the GDP losses are; the GDP losses are mitigated by the advanced end-use technologies (left panel). When the GHG constrains are strict, the energy service demands decrease but the electricity demands are stable in contrast (right panel). "Solid", "Liquid", and "Gaseous" mean the forms of secondary energy.

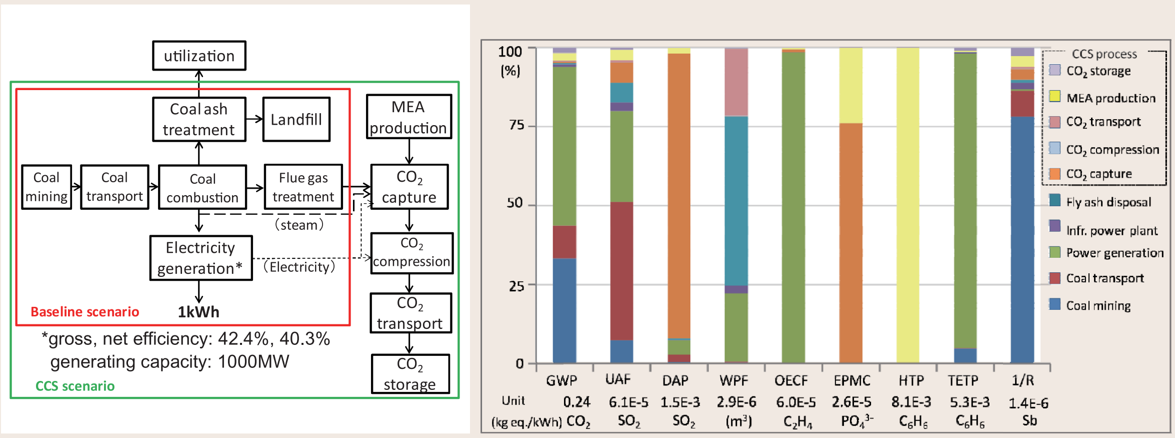

Fig. 3: LCA of a pulverized coal-fired power generation with CCS technology in Japan

The left panel shows LCA system boundaries for base and CCS cases. Dashed/dotted arrows show steam/electricity flow from power plant to CO_2 capture and compression processes. The right panel shows the magnitude of impact in terms of reference substances and its breakdown by processes, categorized into 9 environmental areas: global warming, urban air pollution, acidification, waste, photochemical oxidant, eutrophication, toxic chemical, biological toxicity on terrestrial, and resource consumption, labeled by GWP, UAF, DAP, WPF, OECF, EPMC, HTP, TETP, and 1/R. Introducing CCS technology results in a relative increase in impact caused by MEA production and CO_2 capture processes.