Proper Understanding of Scenarios

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Abstract

Scenarios, which are often used in IPCC reports as major outcomes, are useful tools. However, all the scenarios derived through model analyses are too simplified and neglect the large divergences that exist in the real world. In addition, global warming issues have large uncertainties, but most of the scenarios are limited in their treatment. For example, the current energy efficiencies in the marginal abatement costs for several sectors vary widely among countries, and yet, many models do not treat these differences sufficiently. The greenhouse gas emissions shares by country, even in the middle term, will change drastically in the future. Global warming mitigation measures are significantly important; however, mitigation alone will not solve global warming issues. Adaptation measures and socio-economic conditions are significant for better responses to global warming.

Keywords: Climate change, marginal abatement cost, adaptation, emission scenario

1. Introduction

The world is facing multiple challenges that must be solved. Each country has different priorities for these challenges, as well as different objectives. Global warming response measures should harmonize with such multiple objectives in order to increase our current and future welfare as a whole. Computational assessment models and scenarios are useful tools for showing a coherent world. However, both top-down and bottom-up models are too simplified, as compared to the real world, causing the analysis results to sometimes give the wrong implications. The gaps between the scenarios generated by models and the complex real world should be recognized when interpreting scenarios. This paper focuses on diversifications in the real world and supports a better understanding of the global warming response scenarios that are often used by the IPCC, along with better decision making for global warming response measures.

2. Diversification among countries and a different world in the future

Fig. 1 shows the energy efficiencies for basic oxygen furnace steel production in 2000 and 2005. The energy efficiencies in Japan and Korea are around 20% higher than those in the EU and China, and around 30% higher than that in the US. There are large differences in the energy efficiency levels, not only in the iron and steel sectors, but also in other sectors. Different measures are required for different countries. Technology diffusion measures are important in countries that have low efficiency facilities, while technology development activities are important in countries that have high efficiency facilities.

Global greenhouse gas (GHG) emissions in 1990 and 2005 were 32 and 39 $GtCO_2$eq. per year, respectively. According to a non-climate intervention scenario (RITE, 2011a), these emissions will be 55 and 78 $GtCO_2$eq. in 2020 and 2050, respectively. Fig. 2 shows the regional GHG emission shares of the global emissions. The share of Annex I countries was 58% in 1990. However, when excluding the United States, the share of Annex I countries, which have economy-wide emission targets for 2008–2012 based on the Kyoto Protocol, was 27% in 2005. Their share will be 22% and 18% in 2020 and 2050, respectively. The global emission structures have been drastically changed since 1990 and will continue to change toward 2050.

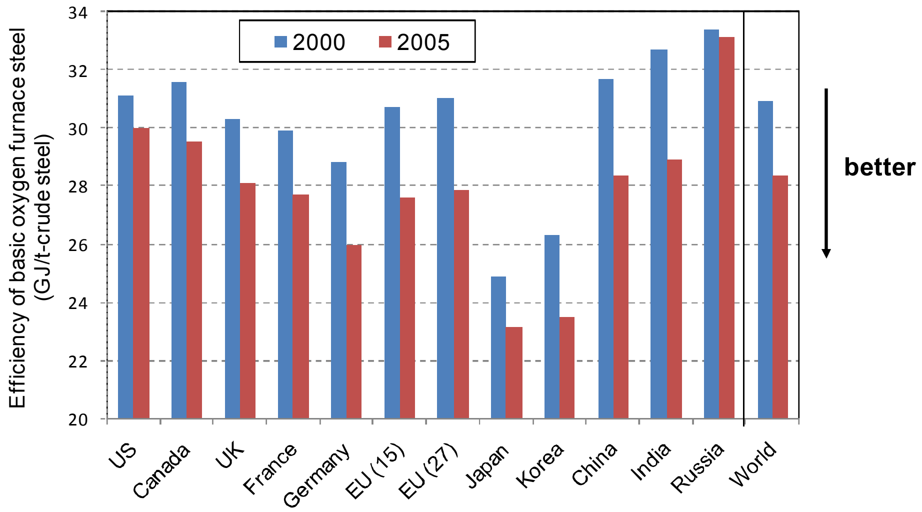

Fig. 1 Energy efficiency for production of basic oxygen furnace steel.

Note: Electricity is converted by using 1 MWh = 0.086/0.33 toe. Source: Estimates by RITE based on IEA statistics, worldsteel data, etc.

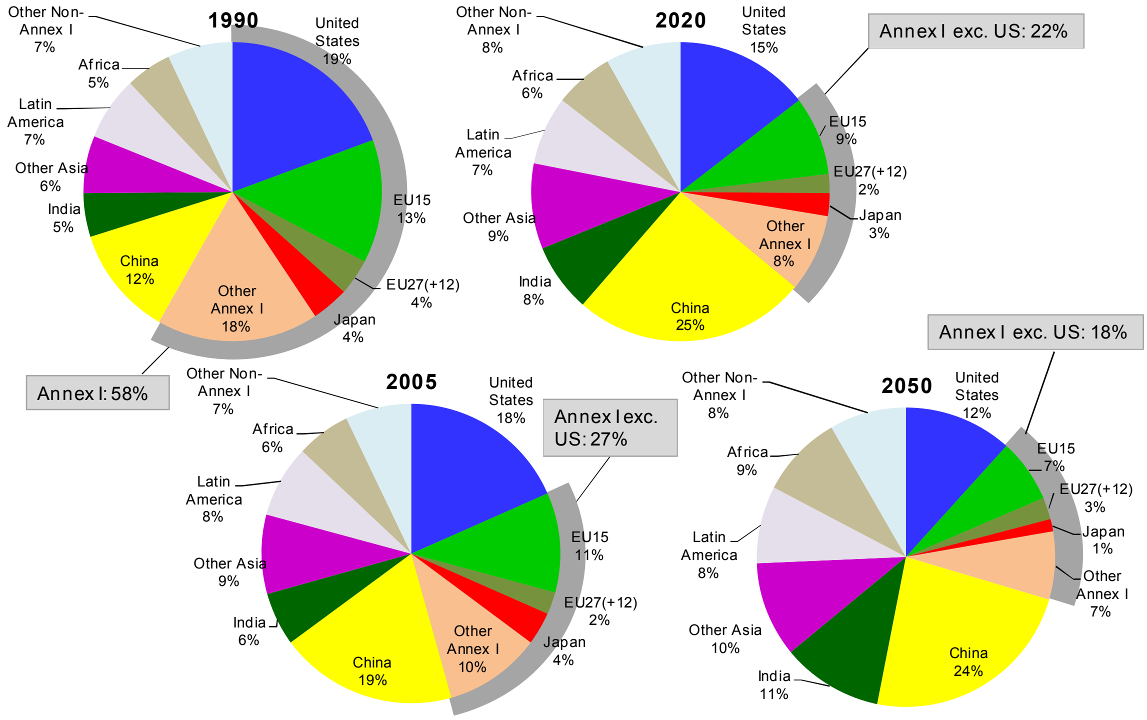

Fig. 2 Historical and outlook data for green house gas emissions by region.

Note: LULUCF emissions are excluded.

Fig. 3 shows the marginal abatement cost (MAC) curves for 2020 for major countries, as estimated by a detailed technology-oriented model, DNE21+, which was developed by RITE (e.g., Akimoto et al., 2008). The MAC curve shapes for 2020 differ considerably between countries. The baseline emissions of China and India will drastically increase in 2020, as compared with those in 2005, because of rapid economic growth. However, there are large emission reduction potentials with relatively lower costs, e.g., below 50 \$/tCO_2eq. In Japan, on the other hand, there are only small potentials, even when considering costs below 100 \$/tCO_2eq., because high energy efficiency technologies have already been adopted in many energy-intensive sectors. Japan's baseline emission growth rate in 2020 is relatively low as compared to those of other countries, and almost equivalent to the rate in 2005. However, even if all of the measures below 50 and 100 \$/tCO_2eq. are achieved, the expected emissions will be -5% and -10%, respectively, as compared to 2005, which corresponds to +1% and -4% in comparison with 1990.

Fig. 4 shows the global MACs for 2020 and 2030. With the same MAC, the emission reduction potentials in 2030 are around 10% higher than those in 2020. Decision-making with reference to a longer time span is a key to lowering the emission reduction costs.

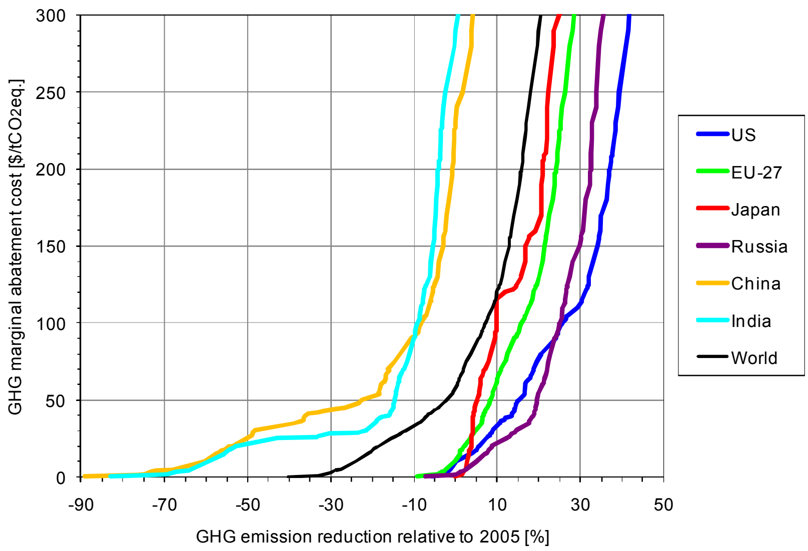

Fig. 3 Marginal abatement cost curves in 2020 for major countries.

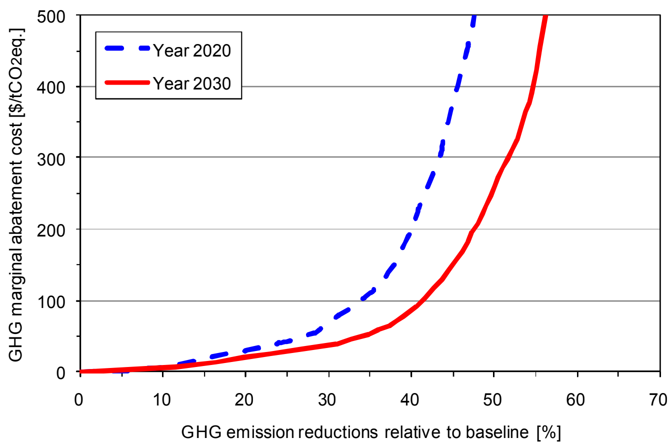

Fig. 4 Comparison between marginal abatement cost curves in 2020 and 2030 for the world.

Futures conditions, as described in the contexts of global warming scenarios, i.e., long term, will be very different from those at present. Scenarios can help with an understanding of consistent future conditions that will be very different from those at present. The world is greatly diversified. However, simplified scenarios sometimes tend to neglect such large diversification. Therefore, we have to recognize the inevitable gap between such scenarios and the actual world.

3. Better understanding of the numbers in IPCC AR4

In 2007, by referring to only 6 scenarios, the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) determined that 2000–2015 would be the peak years of global GHG emissions, which would stabilize at 450 ppm CO_2eq. However, according to a recent study, 2010–2020 will have the same level, based on many recently reported scenarios (van Vuuren and Riahi, 2011).

In addition, the IPCC AR4 also summarized that GHG emission reductions of 25%–40% by 2020 relative to 1990 levels would be required for Annex I countries to stabilize at 450 ppm CO_2eq. However, most of the studies that these reduction ratios were based on adopted equal per-capita emissions as a basis for their emission reduction criterion and included many subjective assumptions. It would be more appropriate for Annex I countries to attain 10%–30% reductions by 2020, when equitable greenhouse gas emission allocations between Annex I and Non-Annex I countries are considered for stabilizing atmospheric GHG concentrations at 450 ppm CO_2eq. under the criteria of equal per-capita GHG emissions, per-GDP costs, and marginal abatement costs.

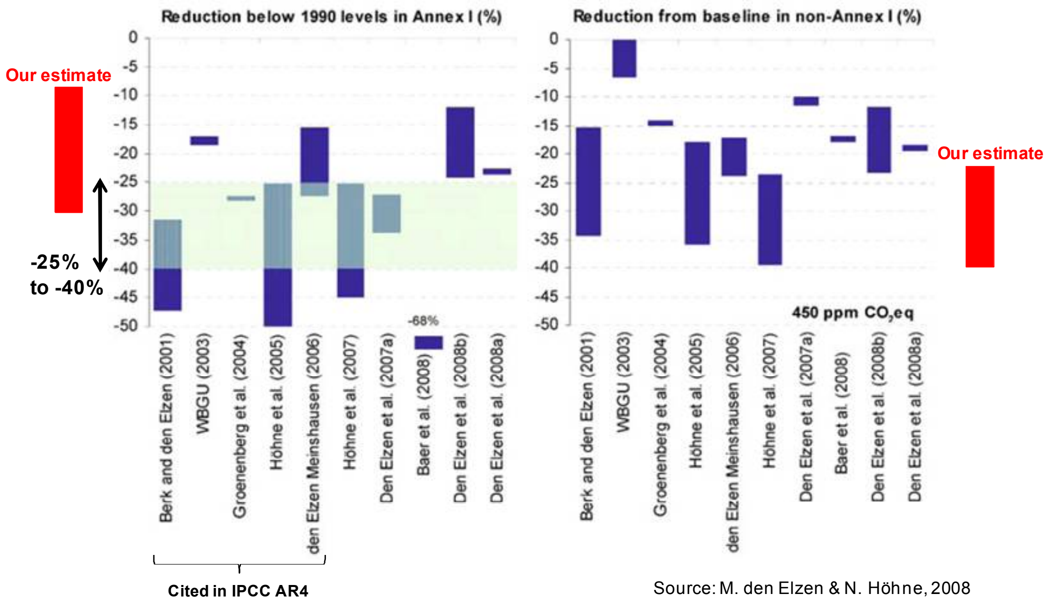

Fig. 5 Emission reductions in 2020 in Annex I and Non-Annex I countries for stabilization at 450 ppm-CO_2eq. (Source: Akimoto et al., 2011; den Elzen and Hohne, 2008; IPCC, 2007).

There is greater flexibility for the transition pathways and emission allocations among countries than those shown in the IPCC AR4. IPCC only summarizes the reported scenarios or transition pathways. Some of these are the results of very limited studies or include scenarios with ad hoc subjective or convenient assumptions and neglect some conditions that have already been fixed, e.g., the model base year is 2000, but we are already in 2011. Unfortunately, some of the IPCC AR4 information that contains misunderstandings has contributed to deadlocks in international negotiations and domestic decision making on global warming.

4. Importance of integrated measures for mitigation and adaptation

Figs. 6 and 7 show scenarios for the agricultural land area and population under water stress, respectively. Both of these analyses show the effects of mitigation levels, adaptation measures, and socio-economic conditions. Halving global emissions by 2050 will reduce global warming and crop production damage, and the required area for crops will be reduced. However, the effects of socio-economic conditions are much larger than those of the mitigation, and adaptation measures also have a certain level of effects. The analyses for a population under water stress also have implications similar to those for the agricultural land area, as seen in Fig. 7. However, the effect on the population under water stress will be small compared with the case of the agricultural land area, even if halving global emissions is achieved. The global warming damages vary, not only by the emission reduction levels, but also by the socio-economic conditions and adaptation measures. Integrated assessments of the mitigations and adaptations are important.

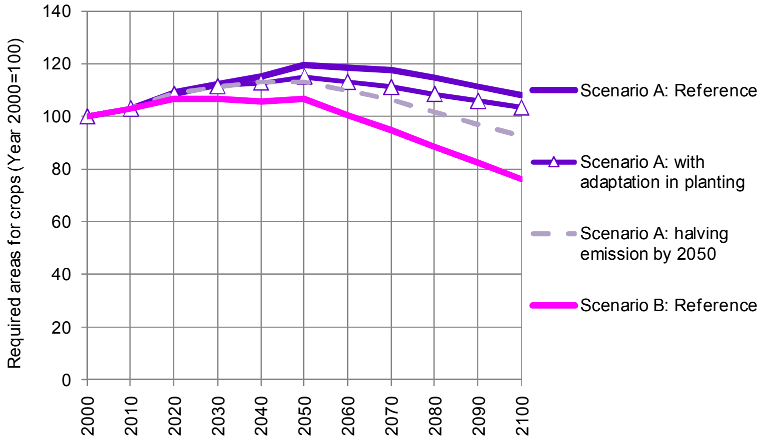

Fig. 6 Scenarios for agricultural land area. (RITE, 2011c)

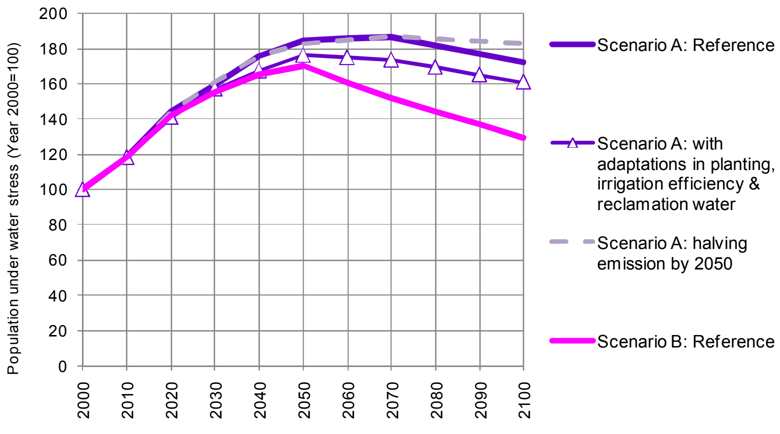

Fig. 7 Scenarios for population under water stress. (RITE, 2011c)

5. Conclusion

The real world is facing multiple challenges that must be solved. Global warming response measures should harmonize with these multiple objectives. Multiple views, including trade-offs and synergy effects, will be required to evaluate scenarios. In addition, the distribution and equity issues are significant in the real world; however, models sometimes neglect these issues for simplicity. Models and scenarios are powerful and useful tools, but scenarios should be recognized and interpreted with an understanding of the gaps between the models/scenarios and the real world to avoiding confusion in real-world politics.

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Appendix Socio-economic scenarios

RITE has been developing a comprehensive scenario for climate change control and sustainable development in a project named alternative pathways toward sustainable development and climate stabilization (ALPS). The development of this comprehensive scenario for climate change control and a sustainable economy includes a formulation of the long-term prospects for population and economic growth. Two scenarios are being developed. Scenario A assumes medium technology improvements, in which economic growth slows down, particularly in developed countries, while Scenario B assumes high technology improvements, inducing continuous high economic growth.

Fig. A-1 shows the world population scenarios (the population scenarios for each country are also available (RITE, 2011b)). In Scenario A, the world population is assumed to have a medium growth rate and the medium variant scenario of the 2008 Revision developed by the United Nations is adopted. After growing to 9.1 billion in 2050, the world population grows steadily to 9.3 billion by the year 2100. In Scenario B, the world population is assumed to have a low growth rate.

This scenario is roughly equivalent to the average of the UN medium variant and low variant scenarios for the world population. The world population grows slowly from 6.1 billion in 2000. After peaking at 8.6 billion around 2050, it declines to 7.4 billion by the year 2100.

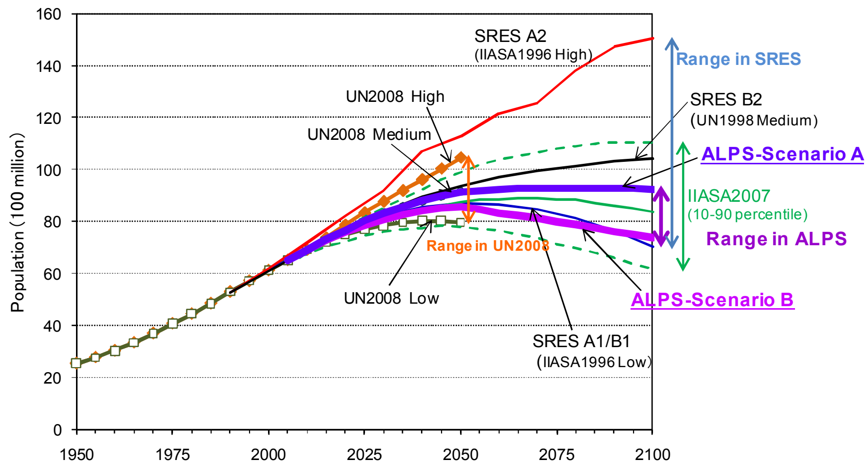

Fig. A-1 World population scenarios.

Note: Statistics up to 2008, RITE projections from 2009.

Fig. A-2 shows the world GDP scenarios (the GDP scenarios for each country are also available (RITE, 2011b)). The potential GDP grows at a higher rate in Scenario B than in Scenario A. The higher GDP per capita growth rate of Scenario B makes the population smaller than the population in Scenario A. The world average for GDP annual growth is assumed to be 2.0% per year in Scenario A and 2.3% per year in Scenario B from 2000 to 2100.

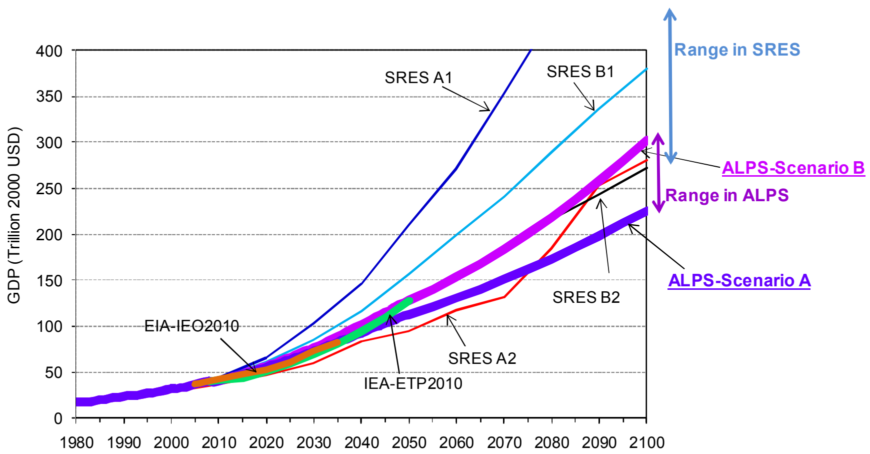

Fig. A-2 World GDP scenarios.

Note: Historical data to 2008 and RITE projection after 2009. We adjusted the data using the prices in the year 2000 because the IPCC Special Report on Emissions Scenarios (SRES) is based on the prices in the year 1990. The DOE/EIA-IEO 2010 data at 2005 prices was also aligned with the base year. The PPP-based IEA-ETP 2010 was converted into MER accounts in accordance with the global average ratio of PPP/MER under the assumptions of ALPS Scenario A.