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6

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1 Introduction

Japan experienced extreme weather events, such as record high temperatures and record rainfall last year and this year. Such extreme weather events have been occurring more frequently around the world, and it is widely acknowledged that climate change is the cause. It is considered that the increase in greenhouse gases (such as carbon dioxide and methane) concentration in the atmosphere contributes to climate change. Atmospheric greenhouse gas concentrations have been increasing during the past 200 years and are expected to rise further, and as such, climate change is likely to accelerate.

Climate change is likely to bring adverse effects to food production, ecosystems, and human health through heat waves and changes in rainfall patterns. To minimize climate change, it is necessary to substantially reduce greenhouse gas emissions, which are causing climate change. The United Nations Framework Convention on Climate Change (UNFCCC) (adopted in 1992) and the Kyoto Protocol (an agreement adopted in 1997 under the UNFCCC) have been seeking ways for countries to reduce greenhouse gases for the past 20 years. However, the burning of fossil fuels produces carbon dioxide (a major greenhouse gas), and since the burning of fossil fuels is closely related to a country's energy use and economic activities, countries are reluctant to substantially reduce their own emissions. Since 2007, countries have been negotiating internationally over a future multilateral agreement including reduction targets for 2020, but the negotiations have been facing serious challenges, and it is unlikely that a consensus will be reached anytime soon.

One of the reasons for the stymied negotiations is that countries do not agree on the required amounts of emission reductions for individual countries. The United States was the world's largest emitter of greenhouse gases until few years ago. However, it decided not to participate in the Kyoto Protocol in 2001 because the country thought that emission reductions would have adverse effects on the economy. With reduction targets imposed by the Protocol, Europe and Japan continue to ask the United States to make equivalent efforts. Developing countries are not required to reduce emissions under the Protocol but are increasingly being asked by developed countries to be responsible due to the rapid increase in their emissions in recent years. Developing countries, however, may wonder why they need to reduce emissions when even the United States is not participating in the Protocol. At international negotiations on climate change, the most deep-rooted disagreements concerning reduction targets for individual countries. Therefore, this article introduces trends in and the substance of the discussion, and aims to explore future developments.

There are two approaches to setting targets for greenhouse gas emission reductions. Aiming to minimize the adverse effects of climate change, the first approach seeks a range of global average temperature increases within which adverse effects are kept to an acceptable level and then estimates atmospheric greenhouse gas concentrations to keep temperature increases within the acceptable range. This approach moves in a counterclockwise rotation from stage 5 to 2 in the climate system illustrated in Figure 1 and proposes the amounts of global greenhouse gas emissions that should be reduced to protect the climate. The second approach estimates reductions attainable through individual measures, such as energy conservation and the introduction of renewables, and, based on the cumulative sum, it proposes reductions for individual countries and the world. This approach moves in a clockwise rotation from stage 1 to 2 in Figure 1 and suggests the amounts that can be reduced through the envisioned measures.

A great gap between the amounts that should be

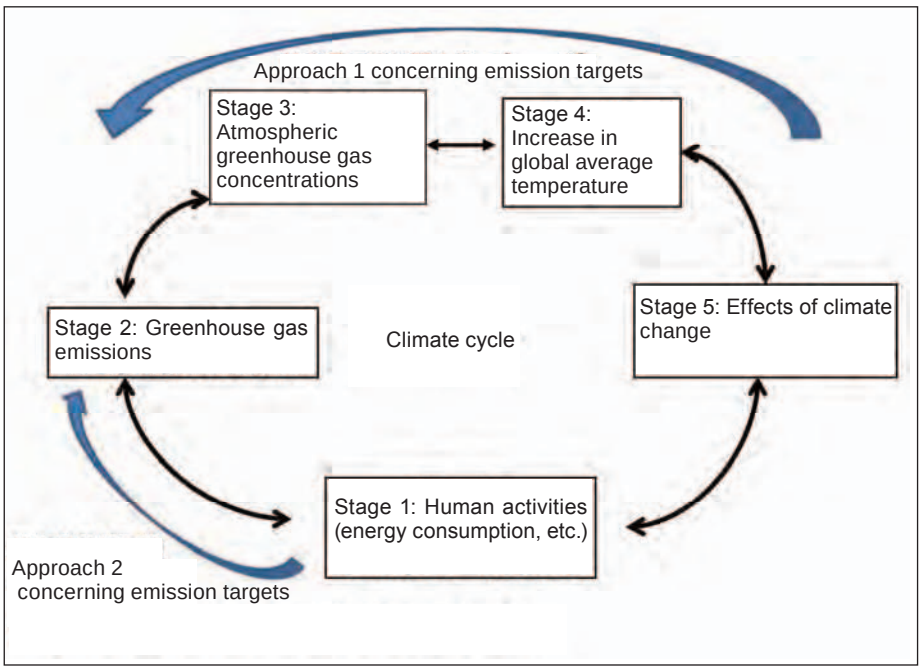


Figure 1: Climate Cycle and Two Approaches for Determining Emission Targets

Source: Adapted from Pershing and Tudela (2003).

reduced to protect the climate and the amounts of reduction that are perceived to be feasible makes it difficult to solve the problem. In Japan, the discussion of reduction targets is often limited to the latter approach and fails to consider the bigger picture, including to what extent emissions need to be reduced to solve the problem. Discussion of the big picture almost never occurs in the policy making process in Japan. This article introduces the basic concepts of the first approach.

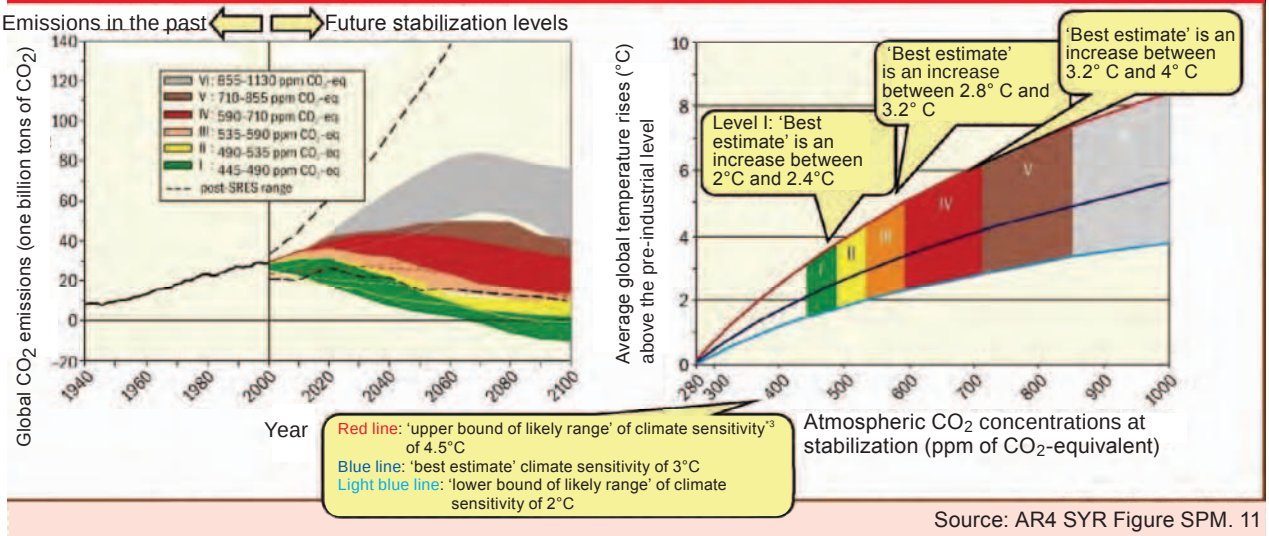
2 Scientifically Required Reductions in Global Emissions

The Fourth Assessment Report (AR4) (released in 2007) of the Intergovernmental Panel on Climate Change (IPCC) suggests that if a global temperature rise is limited to less than 2°C above the average temperature before the industrial revolution (when the use of fossil fuels began at the end of the 18th century), many regions will face adverse impact of climate change while some other regions on earth could experience favorable effects, including growth in cereal yields due to higher temperatures. However, the report also suggests that if the temperature rises around 4°C, all regions on earth will experience more adverse effects than favorable effects (IPCC, 2007). In response to this report, ongoing international negotiations under the UNFCCC propose that the ultimate global temperature rise should be stabilized within 2°C above the pre-industrial average.

Scientific studies have made clearer the relationship between the different stages in Figure 1 (the process from stages 5 to 4 to 3 to 2) (Figure 2). The right-hand panel in Figure 2 illustrates the relationship between temperature rises and atmospheric greenhouse gas concentrations. The left-hand panel shows the relationship between the concentrations and global emissions. For example, as discussed earlier, if the goal is to limit the global average temperature rise to within 2°C above the pre-industrial level, the right-hand panel in Figure 2 shows that this goal is in Category I. To suppress atmospheric greenhouse gas concentrations within Category I, we must control global carbon dioxide emissions within the range of Category I on the left-hand panel. In other words, to reach the target of 2°C, there will be hardly any room for the world to be able to increase CO_2 emissions.

3 Expressions of Concerns and Discussion of Equity: What is Each Country's "Fair Share" of the Burden?

As illustrated in the previous chapter, levels of global emissions required to mitigate climate change can be estimated by knowledge of natural sciences. However, natural science alone cannot find solutions concerning the ranges of reductions required for individual countries in order to achieve the goal, because not all



Source: AR4 SYR Figure SPM. 11

*1 Emission ranges of the stabilization scenarios (shown in colored shadings in the left-hand panel) comprise CO_2-only as well as multi-gas scenarios, and correspond to the 10th to 90th percentile of the full scenario distribution.
*2 Approaching equilibrium can take several centuries, especially for scenarios with higher levels of stabilization.
*3 It shows changes in temperature in the case where atmospheric CO_2 concentrations rise to twice the pre-industrial level.
*4 CO_2 emissions in most models do not include emissions from the decay of above ground biomass that remains after logging and deforestation, or those from peat fires and drained peat soil.

Figure 2: Relationship between Long-term Targets and Greenhouse Gas Emissions
This author made modifications to the material prepared by the Ministry of the Environment based on the figure in the IPCC

countries agree on a specific allocation method.

Atmospheric concentrations of greenhouse gases are calculated by subtracting amounts absorbed (by forests, etc.) from amounts released through the burning of fossil fuels, etc. To avoid further increases in greenhouse gas concentrations, it is essential to both reduce emissions and increase absorption. Forests have been decreasing in size due to land-use policies of developing countries, and thus different approaches are being explored. It is also not realistic to ask developing countries (which are currently aiming to realize economic development) to reduce emissions, and therefore, developed countries need to substantially reduce current emissions.

There are two types of assessment criteria when individual countries set up their targets: equity (*koheisei* in Japanese) and cost effectiveness (Figure 3). Equity means that allocations differ depending on the circumstances of the participants. (The word 'fairness' [also *koheisei* in Japanese but written with different characters] is used when participants in the same circumstances receive the same treatment.) Cost effectiveness means that it is desirable to achieve the same goal at a lower cost. However, these terms are not usually used under such strict distinction. In Japan, *koheisei* may be written phonetically (so there is no distinction in meaning) and is often used interchangeably.

In addition, indicators to measure equity can be categorized into two groups. The first group is based on degree of responsibility. The Polluters-Pay Principle (PPP) has been long proposed over the discussion on costs to cover compensations for damage caused by pollution, etc. This is a policy principle where the more environmentally harmful substances a polluting party produces, the larger costs it needs to pay. For example, equalizing per capita emissions and proposing reductions based on accumulated historical emissions are categorized into this group.

The second group determines reductions based on ability to pay and is called the ability–to-pay principle. According to this principle, relatively wealthier parties should pay more than relatively poorer parties. Systems like the cumulative taxation system are based on this principle. Per capita GDP and a country's total GDP are categorized into this group.

The Japanese people often say, "Why does Japan need to further reduce emissions when the country is conducting so much effort to conserve energy?" However, based on the categorization above, this discussion is not about equity, it is about cost effectiveness. From an outside point of view, it can be explained that relatively stringent reduction

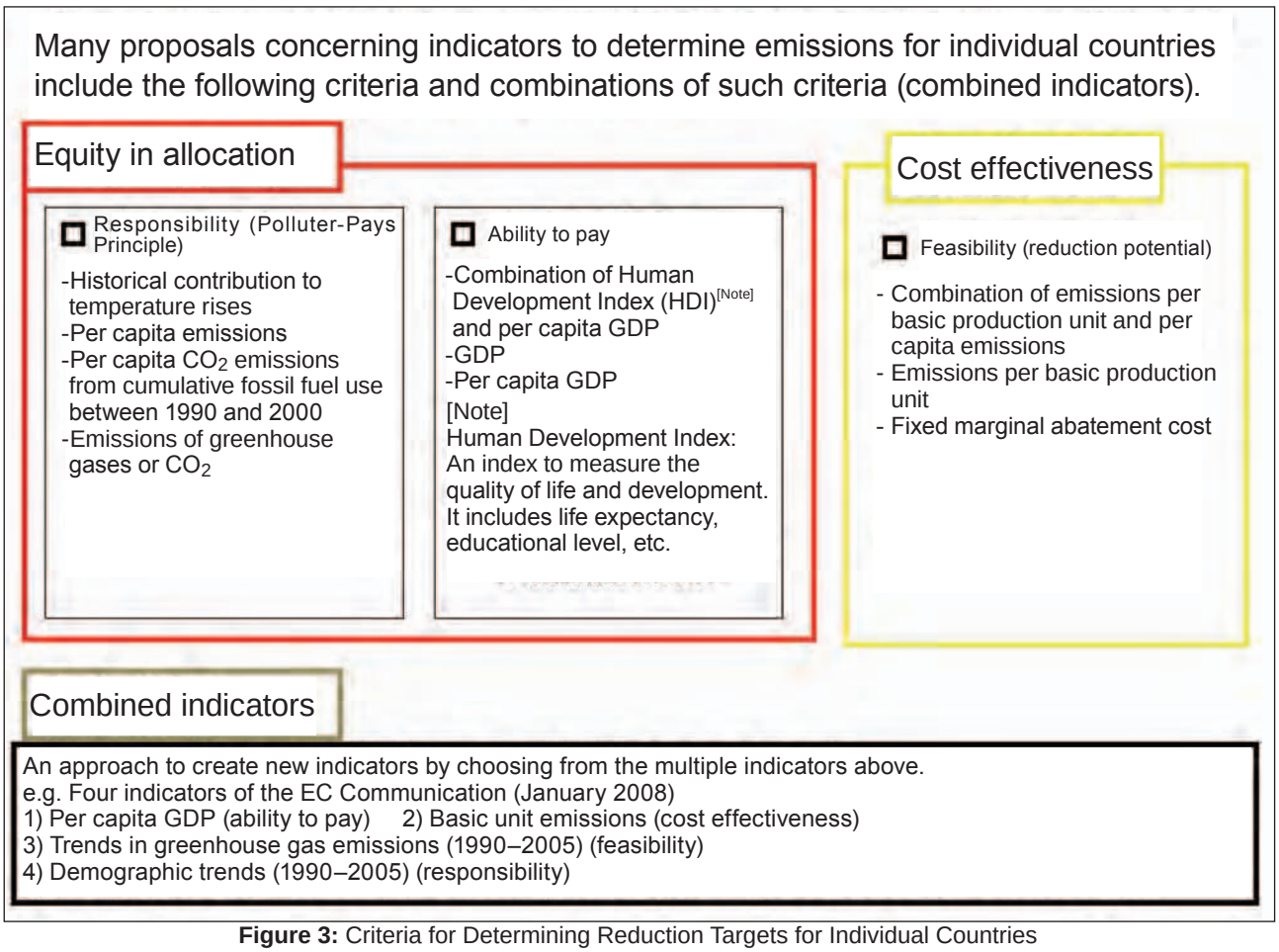


Figure 3: Criteria for Determining Reduction Targets for Individual Countries

targets are imposed on Japan because the country's per capita emissions are large (at least compared to the world average) and the country is wealthy. In particular, when using systems like the Kyoto Protocol's emissions trading schemes and offset schemes, whereby reducing emissions overseas at relatively lower costs can be counted towards a country's reductions, the country does not necessarily need to reduce domestic emissions. In such cases, the country's cost effectiveness indicators do not mean anything, and the ability-to-pay indicators are more justifiable. As such, indicators should be chosen depending on systems that can be used to achieve goals.

Paying attention to such differences in the indicators, the European Union (EU) created combined indicators using multiple indicators from different indicator groups to achieve consensus among countries.

4 Provision of Information to Reduction Target Estimates for Individual Countries

While there are many different indicators, what are valid reduction targets for Japan and other countries to propose from an equity point of view? Figure 4 reviews countries' various proposals on how to set emission reduction targets and illustrates estimated reduction targets for individual countries based on some major proposals. Some estimates show that, by 2020, developed countries (Annex I) should aim to decrease their total emissions by 25% compared to 1990 levels in order to control the temperature increase within 2°C. The multi-stage indicator (in the "existing research" section in Figure 4) illustrates a combined indicator created from several indicators concerning equity and cost effectiveness, and it is an approach to determine the levels of severity of action for country groups at different stages of economic growth (developed, emerging, and developing countries). The Contraction and Convergence (C&C) strategy sets a target for, for example, 2050 and 2100 so that per

capita emissions around the world will be the same in the distant future and determines linear emission pathways towards the goal. Different estimates used different preconditions, including the world's emission reductions, and so it is not easy to make comparisons, but generally speaking, indicators that emphasize equity propose stricter reduction targets for developed countries that have relatively larger per capita emissions. In contrast, many developed countries have relatively more advanced technology and tend to use indicators that emphasize cost effectiveness and, as a result, smaller amounts of reductions are estimated by cost-effectiveness indicators. For example, if Japan uses an indicator emphasizing equity, it will be required to propose reductions of approximately 30% compared to 1990 levels by 2020. In contrast, if the country uses an indicator emphasizing cost effectiveness, no reductions will be necessary compared to 1990 levels. Japan has been arguing that this is the case since it is more advantageous to use an indicator emphasizing cost effectiveness. However, current negotiations have shown that other countries are not convinced by this argument, believing it is not equitable.

Due to immigration and other effects, the United States has a relatively high rate of population growth compared to other developed countries and is expected to maintain that high level. Therefore, even though per capita emissions in the United States are higher than other developed countries, the emissions reductions required of the United States are not large, based on a rule aiming to equalize per capita emissions. However, as the population grows, energy consumption also increases, and it is not easy to achieve a target even if the range of reductions is small. Given the current American economy and politics, any range of reductions is hard to accept, as has been shown by the country's attitudes.

Among emerging countries, the Chinese economy is rapidly developing, and its reduction targets have characteristics that are more similar to other developed countries than to other developing countries. India is recognized as an emerging country, but in many ways, the country remains at the level of a developing country. As such, an indicator emphasizing per capita emissions in particular shows that India will be allowed to have an increase that is more than twice as large as the 1990 level.

Figure 4 suggests that, as the world aims for 2°C, Japan's current target to reduce emissions by 25% compared to 1990 levels by 2020 is reasonable in order to show that the country accepts its fair share from an equity point of view. In other words, if Japan fails to meet this reduction target, the country will lose its moral authority to demand other countries to follow suit. According to Figure 2 (prepared by the IPCC), it is also clear that Japan needs to reduce emissions continuously between 2020 and 2050. It is, of course, essential to discuss specifically how to achieve the target (the second approach mentioned in the introduction), but it is also important to be aware how much effort is required to solve climate change.

5 Need for Structural Shift in Negotiations

As discussed in the introduction, since 2007, there have been ongoing negotiations on international cooperation to tackle climate change, but progress has not been made. One of the reasons for stalled negotiations seems that the United States (which used to be the world's largest emitter of greenhouse gases until recently) has not accepted the approach of international "cap and trade" as under the Kyoto Protocol. As long as countries see emission reductions as a burden and continue to negotiate over the allocation of the burden, the United States is not likely to accept the approach, and as long as the United States does not accept it, countries are not likely to reach an international consensus on how to solve climate change.

Rather, the solution for the deadlock is to change the negotiation structure. What is needed is a structural shift away from negotiations concerning burden allocation and toward competition for gain (e.g., Barret 2008, and Bodansky and Diringer 2010). It is essential to incorporate, into the current international system, a structure where countries and companies will reap economic benefits from being the first to develop technology to reduce emissions.

This trend has already been seen. Global competition has been fierce in new businesses to contribute to reducing CO_2 emissions, such as solar power systems, wind power generators, hybrid cars, electric cars, and bio fuel-related products. In order for companies to acquire global competitiveness, it is important for a government to create policies to help such new industries grow. For example,

(As of 2020, compared to the 1990 levels) Equity Cost effectiveness Combined

Emission reduction percentages by country & region for 2020 (compared to 1990)		Japan	U.S.	EU25	Russia	Annex I countries (total)	Reference. China	India	Non Annex I countries	World
Existing research (e.g. for stabilizing CO_2 at 450 ppm) Höhne, N., D. Phylipsen, Moltmann, S., 2007: Factors underpinning future action 2007 update, for the Department for Environment, Food and Rural Affairs (DEFRA), UK	Multi-stage (combined indicator)[1]	-31%	-38%	-36%	-52%	-41%	62%	235%	89%	9%
	Contraction and Convergence (C&C) (responsibility)[2]	-31%	-18%	-34%	-48%	-32%	62%	168%	76%	10%
	Common but differentiated convergence (CDC) (responsibility)[3]	-33%	-9%	-35%	-47%	-29%	48%	180%	72%	10%
	Triptych (combined)[4]	-29%	-8%	-31%	-45%	-26%	65%	103%	69%	10%
The Mid-term Target Committee (2009) Analysis by NIES & RITE	Equal MAC (cost effectiveness)[5),10)]	+1 ~-5%	-19% ~-24%	-23% ~-27%	-32% ~-47%	-25%	-	-	-	-
	Equal cost/GDP (capability)[6),10)]	-8% ~-17%	-7% ~-18%	-30 ~-31%	-31% ~-54%	-25%	-	-	-	-
Estimate by NIES, Kyoto University, & Tokyo Institute of Technology	Equal cost/GDP converge (cost effectiveness)[7),10)]	- 3%	-10%	-26%	-52%	-25%	114%	65%	74%	14%
	C&C (responsibility)[8),10)]	-16%	-13%	-26%	-46%	-25%	72%	98%	74%	14%
	Emission/GDP equal rate reduction (cost effectiveness)[9),10)]	-30%	-19%	-33%	-21%	-25%	160%	81%	74%	14%

1) Commitment levels are divided into four stages. The strictest stage determines absolute reductions depending on per capita emissions.
2) Equalizing global per capita emissions by 2050.
3) Growth of Non-Annex I countries is added to C&C. Annex I countries will converge per capita emission by 2050. Non-Annex I countries are allowed to increase emissions up to a threshold and will later converge, taking the same amount of time.
4) Domestic emissions are divided into three sectors: electricity, industry, and domestic, and each sector reduces emissions based on a different standard.
5) Analysis (2): Calculated result by NIES (AIM global technology model) and RITE (RITE global model) for equal MAC (marginal abatement cost) cases.
6) Analysis (4): Calculated result by NIES (AIM global technology model) and RITE (RITE global model) for equal cost/GDP cases.
7) Emission/GDP will be the same globally by 2050. Assumes world emissions are halved by 2050.
8) Same as 3), but assumes world emissions are halved by 2050.
9) Emission/GDP will be improved at a certain rate for all countries. Halving global emissions by 2050 is required. This indicator requests developing countries (other than China and India) to substantially reduce emissions.
10) The base year emissions specified by the Kyoto Protocol (1990 for CO_2, CH_4, and N_2O; 1995 for HFC_s, PFC_s, and SF_6) are used to calculate reductions compared to the 1990 levels. All Annex I countries are required to reduce emissions by 25% compared to the base years.

Figure 4: Emission Reduction Targets for Major Countries by Different Indicator

Sub-committee for Mid- and Long-term Roadmap toward Low-carbon Japan, Global Environment Committee, Central Environment Council

Germany was eager to adopt feed-in-tariff (FIT) for the renewable energy , not only because of the environmental reasons to reduce CO_2 emissions but also for the purpose of cultivating German industries (Wada 2003). China became the world's top producer of solar panels in 2009 (PV News 2011), and boosting the Chinese makers is the driving force for the Chinese government to request developed countries to set stricter reduction targets. The United States is planning to keep using coal-fired power generation and swiftly develop clean coal technology (especially carbon capture and storage, CCS) and sell the technology to China and India, which are planning to continue using coal.

There have been some proposals, at least at the expert level, to create an international system that emphasizes promoting such competition (Barrett 2003, Victor 2011). These proposals include methods to establish international technology standards and energy efficiency standards by type of business. However, the greatest weakness of these proposals is that they put so much emphasis on promoting competition that they neglect the first approach discussed in the introduction (i.e. verifying gross emissions required to minimize climate change). In particular, Victor even finds a solution in geoengineering (e.g. artificially blocking sunlight by scattering particles in the stratosphere). We should not abandon our efforts to control emissions. It will be necessary both to promote competition and to maintain the current UNFCCC and Kyoto Protocol as a way to verify gross emissions.

Japan has been increasingly interested in a bilateral credit system as a trial to change the structure. In the system, Japan and developing countries have technology partnerships. When Japan helps a developing country with its technology, part of the reductions achieved in the country will be counted as Japan's reductions. This is basically the same as the CDM under the Kyoto Protocol, but it is advantageous because it can avoid complicated procedures, which have been a problem of the CDM. By using such

mechanism and adopting technology from developed countries, developing countries can become low carbon societies. At the same time, Japanese companies can develop markets overseas.

6 Conclusion

International cooperation for tackling climate change is at a crossroads. On one hand, even though a substantial amount of emission reductions is required, governments are reluctant to accept strict reduction targets. On the other hand, based on the vision to create low-carbon societies in the long term, companies have been conducting technological innovation and product development. If private technological innovation, product development, and their popularization make progress at a rate faster than expected, governments may become willing to accept the substantial reduction targets that they now hesitate to agree on.

At the same time, it is essential to better understand climate change in order to increase public interest and understanding. Constant and steadfast efforts are required depending on the role of each individual and party.

To solve climate change, we cannot avoid the process of international consensus building. Experts in international negotiations or in natural sciences alone cannot achieve this. The establishment of a domestic system where specialists from various fields, including natural sciences, humanities, and social sciences, gather, is the precondition for successful international negotiations.

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Profile

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