Interim Report of Criteria (Target-Setting) Team

Japan's GHG Emissions Reduction to be required in 2050

Japan Low Carbon Society towards 2050 Project
Criteria (Target-setting) Team

Japan Low Carbon Society towards 2050 Project
Criteria (Target-setting) Team Member

Norichika Kanie (Team Leader), Tokyo Institute of Technology
Hideo Harasawa, National Institute for Environmental Studies
Yasuko Kameyama, National Institute for Environmental Studies
Izumi Kubota, National Institute for Environmental Studies
Yasuaki Hijioka, National Institute for Environmental Studies
Kiyoshi Takahashi, National Institute for Environmental Studies
Kazuo Matsushita, Kyoto University
Yasuko Matsumoto, Kyoto University
Hiroshi Ohta, Aoyama-Gakuin University

With a support by
Yumi Nishimoto, Kyoto University (Graduate Student)
Kanako Morita, Tokyo Institute of Technology (Graduate Student)
Sho Mizoguchi
Satoko Ido

May 2007
For more information, please contact Norichika KANIE
kanie@valdes.titech.ac.jp

Introduction

The Article 2 of the United Nations Framework Convention of Climate Change (UNFCCC) refers to the objective of the Convention, which is stating that, "The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." However, this statement itself is too abstract and does not demonstrate any specific "target" or concrete measures that should be taken. While various scientific knowledge indicating the dangers and the immediacy for measures to be taken regarding climate change is being accumulated, it is still not clearly indicated where the "goal" for long-term objective can be set. Moreover, we are not sure about the point at which national level "goal" should be set, while taking into consideration the relations with other countries in the world in the era when the nation-state is still the basic "unit" in contemporary international politics even though the globalization is being deepened. The necessity of concrete discussions on long-term goals is even more significant than before with the Kyoto Protocol's entering into force, and when the examination on the future institutional framework for climate change is beginning.

This paper is an interim report of the first three years' work of the target-setting team of the Japan Low-carbon Society 2050 project. We have analyzed possible GHG emissions of Japan in 2050 from various aspects. Our exercises have shown that it would be necessary for Japan to reduce its GHG emissions by between around 65% and more than 80% in 2050 from 1990 level, should we set a long-term goal of climate protection at 2℃ global mean surface temperature increase from pre-industrial level, which corresponds to the stabilization level of 475ppm by a calculation made by the AIM Impact[policy]. This figure is based on various assumptions and calculations. But, even if we consider the scientific uncertainty, it is highly likely that it would be necessary to reduce the emission by 60% or more in order to manage the risks of climate change.

Contents

1. Various Impacts of Global Warming

1.1 Emerging global warming impacts

1.1.1 Introduction

Impacts of global warming have been appearing in a variety of forms throughout the world. The Intergovernmental Panel on Climate Change (IPCC), which is assessing scientific findings on global warming, concluded in its Third Assessment Report that global warming has already begun and impacts have been appearing in various places. In the Fourth Assessment Report (scheduled to be released in 2007), which is currently being prepared, an increasing number of papers and reports describe the emergence of global warming impacts in many fields and regions. The 2003 heat wave in Europe, as well as the heat wave, localized torrential downpours, and 10 typhoon landings that occurred in Japan in 2004, have intensified concerns regarding the relationship between extreme weather events and global warming.

This paper considers cases of global warming impacts observed in Japan and other countries and describes such impacts in Japan, as well as projected future global warming impacts based on the results of research. Various reports on the impacts of global warming on Japan have been published (Harasawa and Nishioka, 2003), and a report compiling the research results of Japan's Global Warming Research Initiative ((Ichikawa, 2003), has also recently been released.

1.1.2 Manifested impacts of global warming (world)

Global warming over the past 50 years is now generally accepted to be attributable to human activity, and its impacts have been appearing in various parts of the world. One of the important findings of the IPCC's Third Assessment Report is the detection of global warming impacts. After compiling and reviewing numerous papers, the report concludes that the impacts of global warming have been appearing in snow and ice as well as in natural ecosystems. Specifically, the phenomena that have been appearing include shrinkage of glaciers; melting of permafrost; shortening of the freezing period of rivers and lakes; prolongation of growing periods in mid- and high-latitude regions; migration of plant and animal habitats toward the poles and to higher elevations; declines in the populations of plant and animal species; and earlier flowering of plants, appearance of insects, and egg laying by birds. In Japan also, impacts are appearing such as earlier flowering of plants and the failure of various trees including beech to seed. Table 1 provides a summary of representative research papers and assessment reports dealing with various findings related to the impacts of global warming that have been published in recent years.

Table 1.1 Recently published reports on impacts of global warming

Field/region	Impacts detected	Projected future impacts	Source
Arctic Circle	Arctic sea ice is melting at an accelerated rate, and the area of sea ice in summer has decreased by 20% over	By the end of this century, the temperature will increase by 4 to 7°C and the area of sea ice in summer will decrease by 50%	ACIA, 2004

	the past 30 years.	or more. Ice in Greenland will also decrease.	
Antarctica	The volume of Antarctic krill has declined by 80% because the area of sea ice, which serves as a refuge for krill from whales and other predators, has decreased due to higher seawater temperatures as a result of global warming.		Atkinson et al., 2004
	Antarctic glacier flows have accelerated. Six glaciers flowing into the Amundsen Sea in West Antarctica have shown faster flow speeds over the past 15 years.		Siegert et al., 2004
Glaciers	Glaciers in the Himalayas and Alaska have significantly receded.		WWF, 2005
Ecosystems	Various impacts have been appearing in the U.S.. Among approximately 150 species of wild plants and animals, half are affected by global warming.		Parmesan et al., 2004
	Impacts have also appeared in ecosystems and animal and plant life throughout the world.		WWF, 2004
		If global warming progresses, 18 to 35% of animal and plant species are in danger of extinction in approximately 50 years.	Thomas1 et al., 2004
Human health	Mortality due to the impacts of global warming has reached 150,000 annually.		WHO, 2003
Industry		Ski resorts in Europe, North America, Australia, and elsewhere will be forced to close due to significant reductions in snowfall as a result of global warming.	Bürki, 2003
General impacts	Impacts of global warming are progressing more rapidly than scientists had previously projected (e.g., impacts on the Arctic Circle; impacts on ecosystems and animal and plant life in the U.S. and elsewhere in the world).	Risks such as melting of the West Antarctic Ice Sheet, shutdown of the thermohaline circulation, etc. are higher than projected in the past.	DEFRA, 2005 (“Avoiding Dangerous Climate Change”: scientific symposium held in the UK)

1.1.3 Actualized impacts of global warming (Japan)

An outline of climate changes that are occurring and the present situation of global warming impacts detected in Japan is given below.

(1) Climate change

1) Temperature change: During the 100 years of the 20th Century, the average temperature in Japan rose by approximately 1°C (world average 0.6°C). Urban areas, especially, are influenced by the heat island effect, and Tokyo, for instance, has experienced an average temperature rise of approximately 2.9°C. Also, the numbers of tropical days and nights are on the increase, especially in urban areas, and the number of cold days has declined (Japan Meteorological Agency, 2002).

2) Rainfall change: Although it differs from area to area, the incidence of heavy rainfall (over 50 mm per hour) is increasing slightly (Japan Meteorological Agency, 2002). Snowfall patterns are also changing. Snowfall change is characterized by wide differences, depending on the region. For example, whereas a tendency toward decreasing snowfall is observed in the Hokuriku Region, snowfall is on the increase in Hokkaido.

3) Sea level change: From 1970 to 2003, the sea level rose by an annual average of 2 mm along the seashores of Japan (Konishi, 2004).

(2) Impacts on the immediate natural environment

Global warming first affects those flora and fauna that are vulnerable to temperature change. In Japan, the following effects are currently becoming apparent.

1) Impacts on alpine plants: At Mt. Apoi in Hokkaido, with the advancement of the Japanese white pine (*Pinus parviflora*) to higher altitudes, the numbers of alpine plants such as *Callianthemum miyabeanum* have decreased and the numbers of dwarf stone pines (*Pinus pumila*) have increased (Masuzawa et al, 2005, Natoi et al, 2003). Around the central mountain area, die-off of the top branches of the dwarf stone pines has been confirmed. It is considered that the decreasing snow coverage caused by global warming is reducing the protective effects provided by the snow (Masuda, 2001).

2) Impacts on timing of plant blooming: The average flowering date of the cherry blossom (Yoshino Cherry, *Prunus yedoensis*) from 1989 to 2000 was 3.2 days earlier than usual (from 1971 to 2000) (at 89 sites) in Japan. The average date on which Japanese maples (*Acer palmatum*) turn red is now about 2 weeks later than the average date from 1953 to 2000 (Japan Meteorological Agency, 2002). These results were analyzed on the basis of phenological data observed since 1953 by the Japan Meteorological Agency. Global warming influences not only climate changes but also human activities. Therefore, the IPCC recommends the collection of observational data for longer periods (e.g. 10 to 20 years or longer) to detect the effects of global warming. The phenological data are valuable, because they have been observed over about 50 years, although they have complex interrelationships

with artificial effects such as those of heat islands.

3) Impacts on insect habitats: The great mormon (Papilio memnon thunbergii), whose northern limit was Kyushu and southern Shikoku in the 1940s, began to be found in Wakayama or Hyogo prefectures in the 1980s, and in the Kanto region from 2000 (Yoshio and Ishii, 2001, Yoshio, 2003). In eastern Japan, southern-bred cicadas (*Cryptotympana japonensis*), which occur from the subtropical zone to the tropical zone, were found in 2001 (Biodiversity Center of Japan, Ministry of the Environment, 2002). Until the 1970s Atypus was found only in western Japan, but in the 1980s it was found in the Kanto region (Harasawa and Nishioka, 2003, Hamaguchi, 2000).

4) Impacts on Animal habitats: Animal habitats have changed because of the progress of global warming. In recent years, for instance, the white-fronted goose (Anser albifrons) has flown in late and started out early (Takeshita, N., 1998). Its wintering places have extended not only to the main island of Japan but also to Hokkaido, and the number of individuals has tended to increase. It has been confirmed that foxes and martens are now inhabiting Mt. Hakusan at an elevation of 2000 meters (Masuda, 2002).

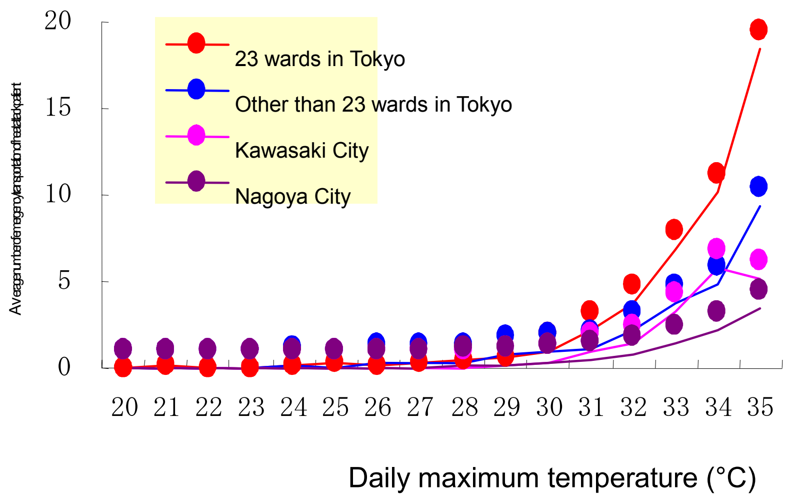
5) Impacts on sea animals and plants: There have been few studies of the effects of global warming on sea animals and plants. However, according to various sources of information, sea turtles are now going further north to deposit their eggs for incubation, and the green turtle (Chelonia mydas), whose northern limit was previously Yakushima Island, has been confirmed to have shifted its sites for egg deposition and incubation to Miyazaki and Kagoshima prefectures. Southern-bred octopuses, crabs and fishes have moved north (Masuda, 2002). In the sea around Motobumachi, in Okinawa Prefecture, coral bleaching has occurred. A species of table coral, Acropora solitaryensis, which previously inhabited the tropical zone, has extended its habitat northward and has been found in the Amakusa region (Ministry of the Environment and Japanese Coral Reef Society, 2004).

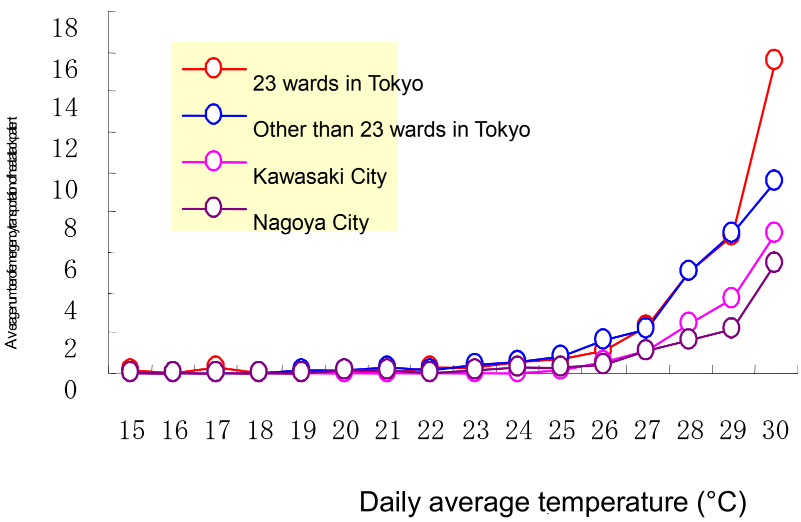
(3) Impacts on civil life

1) Impacts on human health: Centered in large cities, the health effects of extreme heat and heatwaves in summer season have now appeared. In Tokyo, the incidence of heat stress starts to increase on days when the maximum temperature exceeds 30°C, and it tends to increase rapidly when the temperature exceeds 35°C (Ando et al., 2003, Web site for Global Warming and Human health, 2003). In summer 2004, there were 70 tropical days in Tokyo (Otemachi) and 60 in Tsukuba. Both of these numbers were record highs. In big cities, the complicated association of global warming and heat islands cannot be isolated easily. Regardless, people living in cities are definitely suffering from the effects of extreme heat or heatwaves in summer.

The National Institute for Environmental Studies (NIES) has established a system of quick reporting of data, entitled “global warming and health”, which counts on its website the number of emergency transportations to hospital each week. On the basis of records of emergency transportation to hospitals over the past 4 years (2000 to 2003), a fundamental observational study of the occurrence of heat stress has been conducted. In Tokyo, the study was conducted in 23 wards and other municipalities separately. The following data were the result of fundamental observational study of emergency transportation to the hospital of heat stress patients for four years from 2000 to 2003. Figure 1 shows the relationship between daily temperature (average and highest temperatures) and the number of heat stress patients presenting in four districts. In each district, heat stress patients began to present at a daily average temperature of 25°C and maximum temperature of 30°C, and the numbers presenting increased rapidly at a daily average temperature of 30°C and maximum temperature of 35°C. Furthermore, standardization was conducted to account for the different numbers of people in the four districts. After standardization, when the daily average temperature was about 25°C and the daily maximum was about 30°C, heat stress patients started to present. The greater the daily temperature rise, the more the number of heat stress patients increased. There was a correlation between the ambient temperature and the number of heat stress patients. The results of a survey of individual temperature patterns and exposure to heat stress reported that on days of extreme heat (higher than 30°C), temperatures that rose to over 50°C for a short time were observed (Kabuto et al., 2005).

Figure 1.1 Relationship between daily temperature (average and maximum temperature) and average number of heat stress patients (2000–2003)





2) Impacts of local heavy rain, Flood damage: Record local heavy rains and inundation have occurred repeatedly lately. The area damaged by floods has tended to decrease, but the flood damage density (i.e. the amount of damaged general assets per inundation area) has tended to increase (Cabinet Office of Japan, 2002). The maximum water discharge abilities of city sewerage facilities have been designed on the basis of past record amounts of rainfall. Furthermore, the facilities have been improved in assuming that overflows would occur only every few years. The increased number of local heavy rains and the increased degree of rainfall intensity indicate that the design of such facilities now has to be reconsidered.

3) Impacts on urban environment and water environment

Various phenomena can be cited with regard to the urban environment, such as an increase in the number of “tropical nights” (hot nights when the temperature does not fall below 25°C outdoors). The results of surveys on attitudes toward global warming reveal that harmful effects such as sleep disorders due to such tropical nights have been appearing (Committee to Study Impacts of Global Warming on Civic Life, 2003). Increased temperatures are also causing water temperatures to rise in rivers and lakes. This has resulted, for example, in rising water temperature and decreasing concentration of dissolved oxygen in the depths of Lake Biwa, and a trend toward a deterioration in the water quality has been confirmed.

4) Impacts on industry: Various impacts of global warming on industry have appeared, and these have centered on seasonal industry. The rise in temperature has influenced air-conditioning demand by public and business sectors, as well as the energy demand by the industrial sector in terms of the rise and decline of seasonal industries (Ichikawa, 2003). In predicting such seasonal changes in temperature and adjusting production, each business enterprise is considered to treat the effects of global warming in its own way. However, the serious damage caused by the heavy rains and typhoons in 2004 appear to have influenced the management of insurance companies, which have paid out insurance money for the damage.

5) Impacts of extreme weather events or unusual weather on civil life: Considerable impacts on civil life by extreme weather events these days may be caused by the diversification of human habitats as well as by the increasing number of unusual climates. For example, the number of victims, including fatalities, has increased from year to year following an increase in the number of floods. The need for people to live in flood-prone areas because of changes in land use (such as urbanization) or population upsurges can be considered one of the reasons behind the increase in the numbers of flood victims. With diversification of human habitat, the effects of climate on civil life have been become complicated and serious. The effects of extreme weather events, such as floods, continual rain, heavy rain, drought, light rain, heatwaves, hot summers, coldwaves, and cold winters, on civil life are summarized in Table 1.2 The main effects are injury, disease, infection, heat stress/stroke, hypothermia, mental stress, allergy, and death. Needy people, aged people, children, and immunocompromised people commonly tend to be victims of such effects,

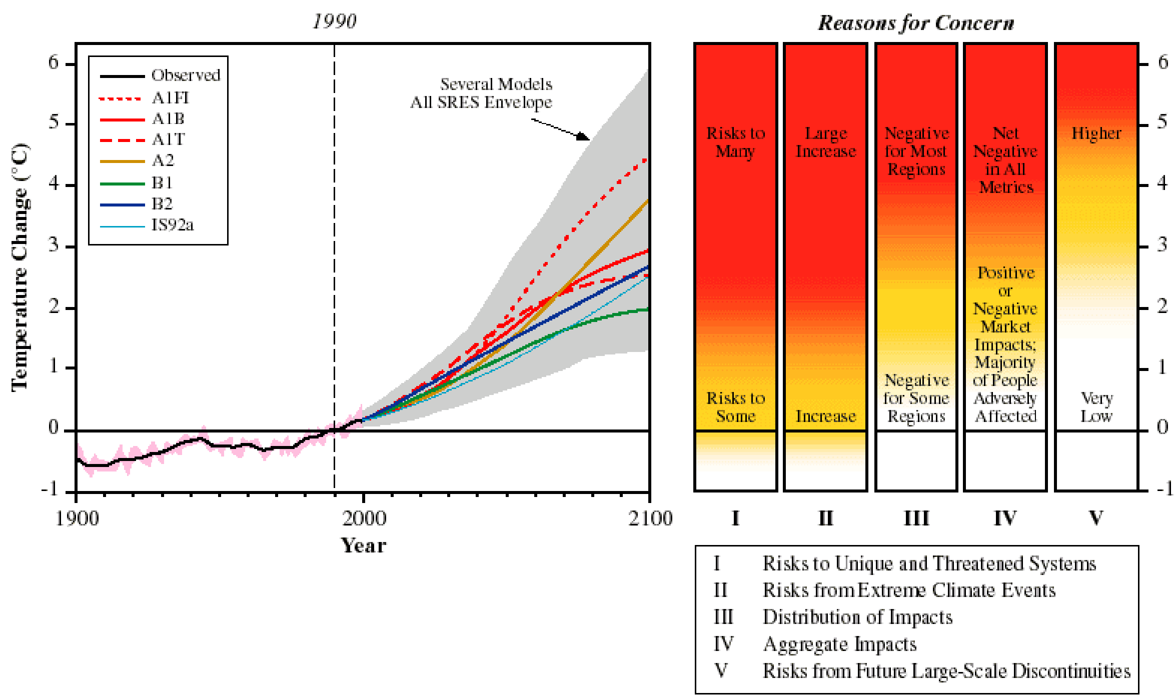
Table 1.2 Examples of effects of extreme weather events on civil life

	Factor	Potential effect
Flood	Rise in streamwaters, Flash floods, Mudslides/mudflows, Landslides	Drowning, Injury
	Inundation	Respiratory disease, hypothermia, Physical/mental fatigue
	Water exposure (water pollution)	Tetanus, Dermatitis, Conjunctivitis, Otorhinolaryngologic infection, Physical/mental fatigue
	Sewage damage, Potable water pollution	Water-borne infections (*E. coli* bacillus, Dysentery bacillus, etc.), Infections such as cholera and salmonella
	Rat plagues	Leptospiral infection
	Contact with rats	Hantavirus pulmonary syndrome (HPS)
	Serious proliferation of mosquitoes	Malaria, Breakbone fever, Yellow fever
	Chemical spills, Industrial waste spills	Injury by contamination with chemical substances
	Loss of life or property	Mental stress
Continual rain, Heavy rain	Soil avalanches	Injury
	Growth in populations of parasitic insects	Infections transmitted by parasitic insects
Drought, shortage of rainfall	Failure of crops	Immune system compromise
	Serious proliferation of mosquitoes	Infection with West Nile fever virus
	Smoke damage by forest fires	Inflammation of eyes, nose and throat, Circulatory system disease
Heatwave, Hot summers	Abnormally high temperatures	Heat stress, Heat stoke, Dehydration, Respiratory affection
	Urban ozone level increase	Asthma, Allergy
Coldwave, Cold winters	Unusually low temperatures	Colds, Pneumonia, Bronchial infections, Circulatory system disease, Hypothermia, Death from cold

1.2 Fields and thresholds of global warming impacts

In a serious global warming situation the effects grow as the temperature rises. Their scopes and magnitudes vary, depending on the targeted effects and the area. For example, it is reported that a water temperature rise of 1°C generates coral reef bleaching, leading to complete extinction of the coral. Figure 1 is a general outline of the effects in the five fields or concerns cited in the third assessment report summarized by the IPCC[1)], as follows. (I) Vulnerable systems such as ecosystems, are influenced by a small temperature rise (1°C or less). (II) Under extreme meteorological phenomena (abnormal climate), even in the early stage of global warming an extreme weather/climate influences the environment. (III) In regard to the distribution of negative effects, although an area with a temperature rise of around 2°C to 3°C will receive some gains (e.g. crop cultivation is possible in northern cold areas), when the temperature increases by this amount or more the adverse effects will stand out. Because developing countries forming small island states or located in coastal areas are affected enormously by even a small sea level rise, a rise of 2°C should be considered a high relative risk. (Ⅳ) If we view the global economy as integrating the effects in individual fields, then the adverse effects stand out, whereas favorable effects can be found in the early stages of global warming in the case of a 2°C to 3°C rise. If a further temperature rise is found, then (Ⅴ) the risk of occurrence of catastrophic phenomenon may not be ignored. For example, although the possibility of occurrence of an extensive phenomenon in the 21st Century, such as the cessation of oceanic general circulation, has been estimated to be small (IPCC, 2001), according to recent research, early global warming increases the probability and risk of this occurring (Rapley, 2006). These days we are focusing on such phenomena with low probabilities of occurrence and enormous eff

Figure 1.2 Five reasons of concerns due to global warming (IPCC, 2001)



Schneider classifies the type of threshold or limit value into two categories, namely, type 1 and type 2 (Schneider and Lane, 2005).

・**Type 1 threshold (critical limit associated with socioeconomic effects)**

This value is defined as the value that brings damage unacceptable to policymakers when it exceeds a certain point. The threshold takes the function form of a line or smooth variation.

For example, the admissible uppermost limit for a population exposed to risks such as food shortages, water shortages, health deterioration caused by climate change, and a decreased extent of admissible biodiversity is included. Such examples are found in the range of (Ⅱ), (Ⅲ), and (Ⅳ) in Figure 1.2

・**Type 2 threshold（threshold associated with catastrophic effects）**

To keep the major processes of the climate system stable and express the geophysical and biological limit values, this value should not be exceeded. The function form of this threshold shows changes that are nonlinear or that "jump".

For example, it includes the cessation of thermohaline circulation, which destabilizes the climate system, melting the West Antarctic Ice Sheet and the Greenland Ice Sheet and thus causing irreversible sea level rise. Melting of the permafrost (permanently frozen ground) causes rapid emission of greenhouse gases. Such examples are found in the range of (Ⅰ), part of (Ⅱ), and (Ⅴ) in Figure1. 2

1.3 Projected impacts of global warming (by field)

1.3.1 Projection of global warming impacts by field

(1) **Impacts on ecosystems**

At the scientific symposium held in the UK, participants summarized the effects on ecological systems, including the latest scientific knowledge. According to the report, for example, in coral reefs, a water temperature rise of 1°C would cause bleaching of 82% of corals, and 2°C would cause 97% bleaching. Thus, even a water temperature rise of 1°C causes serious damage. A rise of 1°C would cause a decrease up to 47% in the distribution of animal species; 2°C would cause a 5% to 66% decrease, and 3°C would cause a 7% to 74% decrease. Another case pointed out that the dangerous level of decrease in distribution range is 20% to 30%.

(2) **Impacts on food production**

The third assessment report by the IPCC stated, in regard to the effects on food production, that crop production is adequately ensured even if we consider population increase. However, once the demand and supply of food are unbalanced, developing countries of the tropical and subtropical zones cannot conduct agricultural production. Furthermore, since they cannot purchase crops from the market, it is predicted that they will suffer from famine or starvation. A temperature rise of 2°C to 3°C is predicted to have a positive effect in enabling agricultural production in some areas. In the case of food production, a temperature rise of 2°C to 3°C globally can be considered the dangerous level. In developing countries, since this value may have serious effects, the rise should be limited to 1°C to 2°C.

Table 1.3 Global warming and impacts on food production (WBGU, 2003)

Global mean temperature increase (compared with pre-industrial level)	Impacts (developing countries)	Impacts (industrialized countries)
1.0 to 1.7°C	・ Cereal yields decrease in most tropical and subtropical regions.	・ Cereal yields increase in many high- and mid-latitude

	• Reduced frost damage to some arable crops. • Increased heat damage to some arable crops and animal herds.	regions. • Reduced frost damage to some arable crops. • Increased heat damage to some arable crops and animal herds.
1.4 to 3.2°C	• Stronger decrease of cereal crops in the tropics and subtropics. • Mixed effects in high- and mid-latitude regions.	• Mixed effects upon cereal yields in high- and mid-latitude regions.
1.5 to 2.0°C	• Income of poor farmers declines.	
1.6 to 2.6°C		• Australian crop yields begin to decline after initial increase.
>2.0°C	• Large drops in yield of maize and sugarcane in small island developing states.	• European crop production increases (with some exceptions). • US agriculture suffers losses after previous gains.
2 to 2.5°C	• Crop yield losses in developing countries.	
>3°C	• Crop yield losses in developing countries. A group of 65 countries loses 16% of agricultural GDP.	
2.0 to 6.4°C	• General reduction in cereal yields in most mid-latitude regions. General increase in food prices.	• General reduction in cereal yields in most mid-latitude regions. General increase in food prices.
>2.6°C	• Asia: Net losses in rice production begin.	
>4.2°C		• Entire areas in Australia out of production.

(3) Impacts on water resources

If we take scientific knowledge into consideration with respect to water resources and their relationship with average air temperatures globally, a temperature rise of 1°C to 1.5°C would influence water resources and water supply and demand. A rise of 2°C or more would expand the effects on the water supply and demand and on water quality.

Table 1. 4 Impact of climate change on water resources（WBGU, 2003）

Global mean temperature increase (compared with pre-industrial level)	Impacts
1.0 to 1.7℃	・ Water quality degraded by higher temperatures. ・ Increase in saltwater intrusion into coastal aquifers. ・ Water demand for irrigation will respond to changes in climate. ・ Increased flood damage due to more intense precipitation events. ・ Increased drought frequency. ・ Peak river flow shifts from spring toward winter in basins where snowfall is an important source of water.
1.2 to 3.2℃	・ Water quality degraded by higher temperatures. ・ Water quality changes modified by changes in water flow regime. ・ Water demand effects amplified.
>2.0℃	・ Water supply, demand, and quality effects amplified.
1.5 to 2.0℃	・ The number of people affected by water shortage grows from approx. 600 million to over 2,000 million, with developing countries in Asia particularly severely affected.
>1.5℃	・ Decreases in water supply and quality and an increase of both floods and droughts in regions vulnerable to changes in water resources.

(4) Impacts on health

The population affected by diseases such as malaria and Dengue fever was calculated from the projected expansion in the potential area of malaria caused by global warming. The lower the temperature rise, the lower the effects, since the size of the affected population increases with the global temperature. In regard to direct effects such as heat waves and heat stress in the mid-latitudes, certain temperatures at which mortality increases, decreases, and increases further are said to exist. From the relationship between the effects of heat waves, air temperature, and mortality, the threshold of the effects on health can be taken into account. For example, in a heat wave in Japan, when the daily maximum temperature exceeds 30°C, the number of people presenting to hospitals with heat stress starts to increase, and when the temperature exceeds 35°C the numbers of patients rapidly increases. Because people gradually adapt themselves to heat and can mitigate its effects by using air-conditioners, etc., even if the extreme heat continues, it is difficult to regard the dangerous level of effects on health in terms of global temperature rise only.

(5) Economic impacts

Economic impacts are calculated mostly by lost amounts of GDP. However, temperature rises work entirely differently from economic losses (IPCC, 2001). It is thought that an economic loss of 3% to 5% seriously influences the social economy. However, the power of developed countries is different from that of developing countries, of course, and there are still only a small number of case studies on the economic effects of global warming, because the effects on ecological systems and the damage evaluation are difficult to comprehend.

(6) Impacts on large-scale phenomena

The Third Assessment Report of the IPCC reported that the probability of large-scale changes occurring during the 21st century was considered to be very small, and the level of concern was low. On the other hand, the risk of such changes occurring was considered to be high at a scientific symposium on the stabilization of greenhouse gases (GHGs) entitled "Avoiding Dangerous Climate Change" held in the UK in 2005. Impact studies have thus become necessary with respect to large-scale changes together with those on extreme weather events.

The possibility has been pointed out that climate change may trigger sudden releases of GHGs from oceanic and biospheric carbon sinks. There are concerns over the release of methane due to drastic melting of permafrost as well as from natural gas hydrates in deep oceans and lakes, and the release of other GHGs trapped under hydrate sediments.

1.4 Projected impacts of global warming (by field) （integration）

On the basis of the results of effect studies, the threshold that actualizes the dangerous level and the effects of global warming is examined. Ecosystems (coastal wetlands, animal species, and onshore, forest, and marine ecosystems), agriculture, water resources, human health, energy, and economics are included. There have been studies summarizing global warming in these fields in terms of the dangerous level.

Smith and Hitz (2003) and Hitz and Smith (2004) reviewed studies of the effects of temperature rise according to various fields, thereby proposing that the effect threshold for global warming should be 3°C to 4°C. Parry et al. (2001) studied four main fields—food, flood, water shortage and malaria—showing the relationships between temperature rise and the populations at risk (Figure 1.2). Although the relationships between temperature rise and its effects differ according to the targeted field, for a population at risk of water shortage, when a temperature rise of 1.5°C to 2°C is reached, the risk to the population rapidly increases. Their assumption was that temperature range is a rough indicator of threshold. Hare (2003) devised a system of comparing the effects and risks by expressing them by dark and light colorings ("Burning Embers" diagram.) Schneider and Lane (2006) indicated the thresholds for various fields in a table (Table 1.5). On the basis of recent case studies, they showed effects ranging from those on ecosystems to large-scale phenomena. After reviewing studies of the effects on ecosystems, Leemans and van Vliet (2004) pointed out that 2°C, which the EU set up as the long-range objective to prevent global warming, could not ensure the safety of ecosystems. They indicated that it should be reduced to 1.5°C, and they further insisted that the rate of reduction should be 0.05°C/ decade

.

Table 1.5 Dangerous Anthropogenic Interference (Scheider and Lane, 2006)

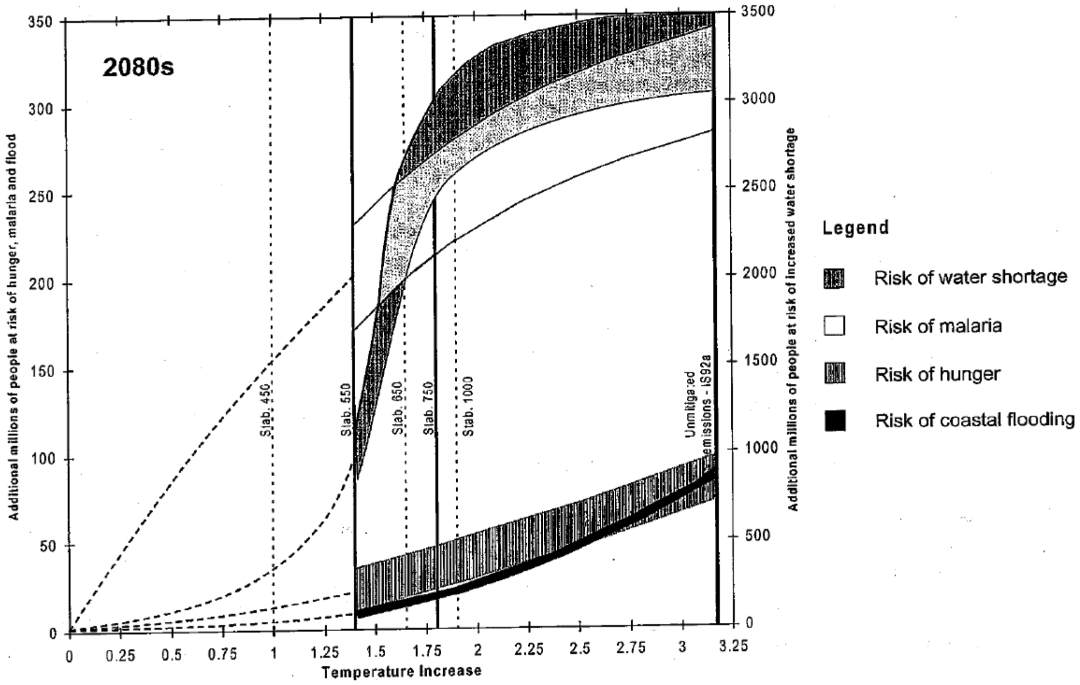


Table 1.6 Dangerous Anthropogenic Interference (Scheider and Lane, 2006)

Vulnerability	Global mean limit	References
Widespread bleaching of coral reefs	＞１℃	Smith et al (2001), O'Neill and Oppenheimer(2002)
Broad ecosystem impacts with limited adaptive capacity (many examples)	１～２℃	Leemans and Eickhout (2004), Hare(2003), Smith et al (2001)
Large increase of persons-at-risk of water shortage in vulnerable regions	450～650ppm	Parry et al. (2001)
Increasingly adverse impacts, most economic sectors	＞３～４℃	Hits and Smith (2004)
Shutdown of thermohaline circulation	3℃(100年)、700ppm CO_2	O'Neil and Oppenheimer (2002), Keller et al. (2005)
Disintegration of West Antarctic ice sheet	２℃、450ppm CO_2 ２～４℃、<550ppm CO_2	O'Neil and Oppenheimer (2002) Oppenheimer and Alley (2004, 2005)
Disintegration of Greenland ice sheet	１℃ １．５℃	Hansen (2004) IPCC(2001)

Table 1.7 Findings concerning impacts on Japan and threshold values

Field	Threshold values of temperature or sea level rise	Specific impacts
Health	33 to 35°C	Increased mortality when the daily maximum temperature exceeds 33 to 35°C (varies according to the region).
	30°C	Occurrence of heatstroke cases at this daily maximum temperature. Sharp increase in heatstroke cases when the daily maximum temperature exceeds 35°C (Tokyo).
Agriculture	35°C	Heat stress when the temperature at the time of rice inflorescence exceeds 35°C.
Ecosystems	+0 to 2°C	Shrinking of the area of alpine vegetation habitats.
	+1 to 2°C	Coral reef bleaching.
	+3.3 to 3.8°C	Virtual disappearance of natural grassland vegetation in subpolar zones. The subtropical zone for natural grassland vegetation expands from the low-lying plains of Kyushu and Shikoku to the southern parts of the Boso and Izu peninsulas (JPCC).
	+3.6°C	About 90% of beech groves disappear.
	+ 4 cm/10 years	Inability of coral reefs to catch up.
	+5 cm/10 years	Mangroves become submerged.
Coastal areas / industries	+30 cm +3°C	57% of sand beaches vanish (90% in the case of 1 m rise). Ski customers decrease by more than 30%.
Water resources	+3°C	Water demand increases by 1.2 to 3.2%.
	+3°C	Decreased flows due to 3°C temperature rise and 10% increase in flows due to increased precipitation are offset at the time of water shortages, but risk of floods increases.
	+1°C	Deterioration of river water quality (BOD 1.01 times, SS 1.05 times, DO -0.1 g/1, pH +0.014).
	+1°C	Increase of COD from 0.8 to 2.0 mg/l and lowering of transparency from 9 to 17 cm in shallow lakes (Kasumigaura).

1.5 Summary of data on dangerous level

Scientific data on global scale effects were collected according to field. On the basis of present data on the amount of temperature rise, the effects and thresholds can be summarized as follows. These values are rough indications at present. In future, additional data will be available for conducting quantitative evaluations of a more definite dangerous level.

" a) Effects on ecosystem

1°C to 1.5°C: Effects on ecosystems
To 1°C: Effects on coral reefs

b) Effects on social economic systems
2°C to 3°C: Food production
To 2°C: Effects on food production in developing countries
To 2°C: Effects on water resources

c) Effects on global systems
1°C to 2°C: Ice sheets of Antarctica and Greenland start to melt
3°C or more: Possibility of oceanic general circulation cessation, etc.

The temperature rises shown here use values from after the industrial revolution. According to the IPCC report, since calculations of future climate are currently made using climate models based on emission scenarios starting in 1990 and effects studies using the above calculations, there are many possible amounts of temperature rise. However, the temperature has already increased by 0.6°C during the 100 years of the 20th Century. If the starting point is determined to be before the industrial revolution, then we have to note that the value deducted by 0.6°C from the amount of temperature rise is available to compare with. We also have to note that in the mid-latitude area, including Japan, the degree of temperature rise has been greater than the average globally.

Reference

Harasawa, H. and S. Nishioka, eds, 2003: Global Warming in Japan – Assessment of Impacts om Nature and Human being, Kokon-shoin, 411pp.

Ichikawa, A., ed., 2003: Global Warming – The Research Challenges A report of Japan's Global warming Initiative, Springer, 161pp.

Japan Meteorological Agency, 2002: Japanese Climate in the 20th Century, Printing Office of the Ministry of Finance, 119p.

Konishi, T., 2004: Long-term Variation of Sea Level, Proceedings of Global Warming Initiative Symposium "Current and Future Strategy of Climate Change Research, 5-7.

Masuzawa, T., H. Mitsuda, M. Tanaka, T. Natori, and S. Watanabe, 2005: Alpine plant community on Mt. Apoi, Hokkaido –Succession of plant community on the ultrabasic soil-, Japanese Journal of Ecology, 55(1), 85-89.

Natoi, T. et al, 2003: Assessment of Alpine ecosystem vulnerability using indices, Final Report of Global Environment Research Fund of the Ministry of Environment. 」 http://www-iam.nies.go.jp/impact/4/index.html

Masuda, K., 2001: Impacts of global warming on flora and fauna in Japan, Journal of Ryukoku University, 23(1), 155-168.

Yoshio, M. and M. Ishii, 2001 : Biophenological study on northward invasion of the great mormon butterfly, Japanese Journal of Ecology, 51, 125-130.

Yoshio, M.,2003: Northward invasions of butterflies and climate warming, Insect and Nature, 37(1), 4-7.

Hamaguchi, T., 2000: Material on Nature History in Kanagawa Prefecture, 21, 89-91.

Takeshita, N., 1998：What will happen to birds? In Doumot, A. and K. Iwatsuki, Living Creatures expelled by Global Warming, Tsukiji-shokan, 413pp.

Masuda, K., 2002: Cases of impacts of global warming on flora and fauna in Japan, Chiri, 47(5), 34-40.

Ministry of the Environment and Japanese Coral Reef Society, 2004: Coral Reefs of Japan, 375p.

Ando, M., S. Yamamoto, and S. Asanuma, 2003: Heat stress and heat stroke caused by global warming, Global Environment, 8(2), 211-220.

Web site for Global Warming and Human health, http://www.nies.go.jp/impact/index.html

Kabuto, M., Y. Honda, and H. Todoroki, 2005: A comparative study of daily maximum and personally exposed temperatures during hot summer days in 3 Japanese cities, Japan Public Health, Japan Jour. Public Health, 52(9), 775-783.

Cabinet Office of Japan, 2002：White Paper on Disaster Prevention, FY. 2002.

IPCC, 2001: Climate Change 2001 Impact, Adaptation and Vulnerability, 1032pp.

Rapley, C. 2006: The Antarctic Ice Sheet and Sea Level Rise, In Schellnfuber H.J. et al. (eds) Avoiding Dangerous Climate Change, Cambridge University Press, 25-27.

Schneider, S. and J. Lane, 2006: An overview of ‘dangerous’ climate change, In Schellnfuber, H.J., W. Cramer, N.Nakicenovic, T. Wigley, and G. Yohe, eds., Avoiding dangerous Climate Change, Cambridge University Press, 367pp, 17-23.

WBGU (German Advisory Council on Global Change), 2003: Climate Protection Strategies for the 21st Century: Kyoto and beyond.

Smith, J. and S. Hitz, 2003: Background paper: estimating global impacts from climate change, OECD Workshop on the Benefits of Climate Policy: Improving Information for Policy Makers, 101pp.

Hits, S. and J. Smith, 2004: Estimating global impacts from climate change, Global Environmental Change, 14, 201-218.

Parry et al. (2001), Millions at risk: defining critical climate change threats and targets, Global Environmental Change, 11, 181-183.

Hare, W., 2003: Assessment of Knowledge on impacts of climate change – Contribution to the specification of Art. 2 of the UNFCCC, 104pp.

Leemans, R. and A. van Vliet, 2004: Extreme Weather] does nature keep up? 56pp.

2. Studies on Atmospheric GHG Concentration Stabilization Targets for Mitigation of Global Warming

2.1 Background of stabilization of concentrations and impact threshold values

2.1.1 Introduction

Discussions on danger points and rates of temperature and sea level rises began in the 1980s. The results of such discussions at various international meetings attended by scientists and policymakers from around the world were embodied into the activities of IPCC and the reflected in the United Nations Framework Convention on Climate Change (UNFCCC). For example, a sea level rise of 20 to 50 cm per decade and a temperature rise of 0.1°C per decade were proposed at the 1988 Bellagio Conference held by the Advisory Group on Greenhouse Gases (AGGG), the predecessor of IPCC. In the same year, AGGG recommended a permissible maximum rate of global mean temperature rise of 0.1°C per decade and a maximum 2°C rise compared with that prior to the industrial revolution. These discussions led to the ultimate setting of targets in the Convention. The developments from that time onward are summarized in Table 2. 1 .

Table 2. 1 **Trends in studies on stabilization of concentrations, temperature rise, and impacts**

Year	Name of meeting	Summary	Remarks (references)
1988	Bellagio Conference	A sea level rise of 20-50 cm/10 years and a temperature rise of 0.1°C/10 years were proposed.	Jager, 1988 (quoted in Agrawala, 1998)
	Advisory Group on Greenhouse Gases (AGGG)	A permissible maximum rate of global mean temperature rise of 0.1°C/10 years and a maximum 2°C rise compared with that prior to the industrial revolution were recommended.	IPCC, 1996
1990	Second World Climate Conference	Vellinga et al. reported on critical values of temperature and sea level rises.	Vellinga et al., 1991
	IPCC First Assessment Report	IPCC, which was established in 1988, released its first report (the First Assessment Report).	IPCC, 1990
1992	United Nations Framework Convention on Climate Change concluded	The stabilization of atmospheric GHG concentrations was prescribed in Article 2 as the ultimate objective for global warming prevention.	
1994	IPCC Fortaleza meeting	Discussions were held on stabilization of concentrations, impacts, and threshold values.	IPCC, 1994
1995	IPCC Second Assessment Report	Analyses showed that in order to maintain the present CO_2 concentration, an immediate 50-70% reduction would be necessary.	IPCC, 1996
1996	Paper published by Wigley et al. on stabilization of concentrations	The paper pointed out that there are innumerable emission pathways leading to the stabilization of concentrations, and that delaying measures to deal with emissions is more beneficial in economic terms.	Wigley et al., 1996
1997	Germany, UK, EU	Reports proposing a temperature rise of 2°C, stabilized concentration of 550 ppm, etc. were released.	WBGU, 1997

	Kyoto Conference (Third Session of the Conference of the Parties (COP3) to the United Nations Framework Convention on Climate Change (UNFCCC))	Industrialized countries agreed on the reduction of GHGs (six gases including CO_2) by 5.2% compared with 1990 in the first commitment period.	
2001	IPCC Third Assessment Report	Scenarios to achieve stabilization were presented (Post-SRES).	IPCC, 2001
2003	IPCC Expert Meeting on Levels of Greenhouse Gases in the Atmosphere Preventing Dangerous Anthropogenic Interference with Climate System	Specialists from various fields gathered to discuss dangerous levels in relation to climate change. Preparation of an IPCC report was entrusted to the plenary session, but the report was not prepared after all.	IPCC, 2003
2004	IPCC Expert Meeting on the Science to Address UNFCCC Article 2 including Key Vulnerability Report	Discussions were held on the ultimate objective prescribed in Article 2 of UNFCCC, in relation to stabilization of GHG concentrations in the atmosphere and temperature rise, impacts, and emission pathways.	IPCC, 2004
2005	Scientific symposium on stabilization of greenhouse gases	A symposium entitled "Avoiding Dangerous Climate Change" was held at the Hadley Centre of the Met Office, UK.	DEFRA, 2005

2.1.2 Views of Vellinga et al.

Vellinga and Swart (1991) proposed tolerable levels taking into account the vulnerability to global warming of ecosystems, agriculture, and economies. Critical loads used in discussions on acid rain in Europe at that time seem to have been taken into consideration. Temperature and sea level rise were studied in terms of absolute values and rates of change as long-term targets related to climate change, and the dangerous levels were classified by red, yellow, and green signals (Table 2.2). However, the boundaries of each classification were not altogether clear and there were no quantitative scientific findings on risks leading to instability of global systems. The limitations on tolerances of ecosystems to climate change were nevertheless supported by many scientific societies.

Table 2.2 Classification of critical temperatures and sea level rise

	Temperature	Sea level rise	Impacts
Red ○	$\Delta T > 0.2$°C/10 years Max. $\Delta T = 2$°C	SLR > 0.05 m/10 years Max. SLR = 0.5 m	Socioeconomic collapse; high risk of instability of global systems.
Yellow ○	$0.1 < \Delta T < 0.2$°C/10 years Max. $\Delta T = 1$°C	0.02 < SLR < 0.05 m/10 years Max. SLR = 0.2 m	Extensive losses of ecosystems; medium risk of instability of global systems.
Green	$\Delta T < 0.1$°C/10 years	SLR < 0.02 m/10 years	Partial losses of ecosystems;

○	Max. ΔT < 1°C (from pre-industrial level)	Max. SLR < 0.2 m（from present）	low risk of instability of global systems.

2.1.3 IPCC S profile and WRE profile

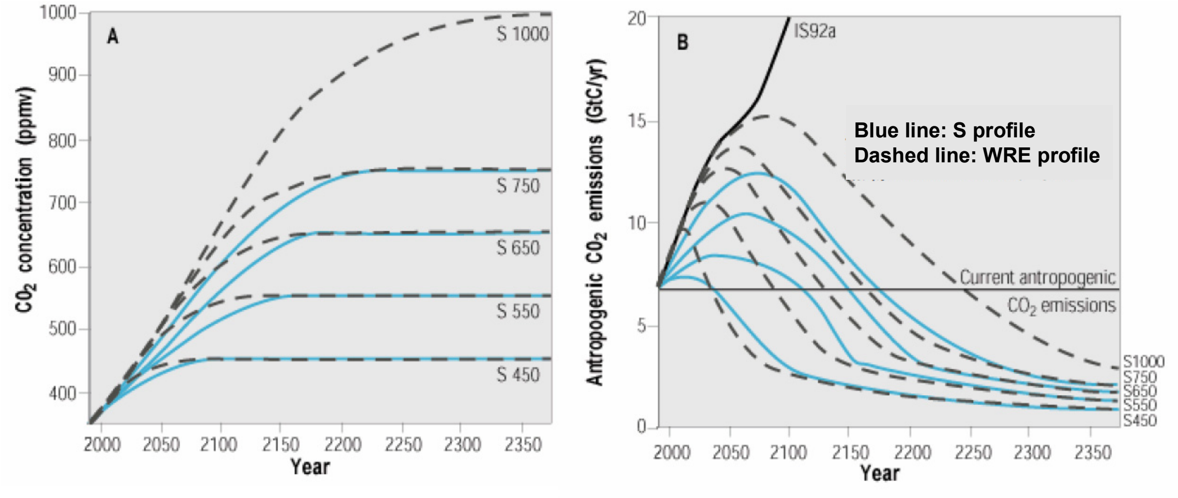
IPCC released its First Assessment Report in 1990, followed by the Supplementary Report in 1992. Subsequently, as proposed by Martin Parry who is currently cochairman of the Second Working Group of IPCC, as well as others in the UK, a conference on impact threshold values was held in Fortaleza, Brazil (IPCC, 1994). Discussions at this conference centered around summarizing concepts such as vulnerability, resilience, etc. and examining the threshold values of impacts of global warming such as specific increases in temperature that would be dangerous. This work raised the awareness of IPCC and impact researchers concerning dangerous levels of impacts and the related stabilization of concentrations and emissions.

The Second Assessment Report was released in 1995, dealing with the stabilization of carbon dioxide as a major topic. In the Summaries for Policymakers of the Synthesis Report (1996), it was concluded that "Carbon cycle models show that immediate stabilization of the concentration of carbon dioxide at its present level could only be achieved through an immediate reduction in its emission of 50 to 70% and further reductions thereafter." Figure 2.1 shows carbon dioxide emission pathways for CO_2 stabilization levels of 450, 550, 650, 750, and 1,000 ppm. Carbon cycle models were used for these calculations. IPCC's pathways to reach stabilized concentrations are referred to as "S profiles."

Among the discussions on the stabilization of CO_2, Wigley et al. published a paper suggesting that there are many pathways to achieve the stabilization of concentrations and that the optimum pathway from an economic perspective would be to allow emissions to continue for some time, and then to drastically reduce them at a certain point using new technologies that would result in the same stabilization of concentrations (Wigley et al., 1996). On the other hand, IPCC's S profiles regard immediate emission reductions to be necessary. The pathways described by Wigley et al. are referred to as the "WRE profiles," from the first letters of the names of authors Wigley, Richels, and Edmonds. A characteristic of the WRE profiles is that although they show economically optimum pathways, they do not take into consideration the impacts when emissions increase further and temperatures continue to rise.

From such analyses, the following findings concerning dangerous levels and stabilization of concentrations, are summarized in IPCC's Second Assessment Report: (1) stabilization of atmospheric GHGs will require a period from 100 years to several hundred years (the time of stabilization will vary according to different stabilized concentrations; (2) even when the stabilization of concentrations and permissible limit of total emissions are determined, more than one permissible emission pathway to achieve the stabilization of concentrations will exist; and (3) in order to stabilize concentrations at the current level, an immediate reduction of 50 to 70% is necessary.

Figure 1.1　S and WRE profiles (IPCC, 1996)



2.1.4 Views of Germany and the EU

Germany, the UK, and the EU as a whole have been promoting research on the stabilization of concentrations as well as emissions and impacts from an early stage.

● German Advisory Council on Global Change (WBGU) reports

WBGU released reports in 1995, 1997, and 2003. These reports basically study two principles: (1) preservation of ecosystems, and (2) stabilization of concentrations and permissible limits of temperature rise based on preventing excessive costs.

- **Total global mean temperature change not exceeding 2°C (relative to pre-industrial level between 1861 and 1890)**

Since the highest range of global mean temperature rise during the present Quaternary period (over the past several hundred thousand years), which has shaped today's climate and the development of humankind, was 1.5°C higher than the pre-industrial level, the Council added 0.5°C to account for improved adaptive capacity and set a 2°C upper limit on temperature rise. As the global mean temperature has already risen by 0.6°C, the leeway is only 1.4°C. The Council concluded that a temperature rise exceeding 2°C could lead to intolerable changes in the composition and functioning of ecosystems, and that impacts could already be expected below this limit.

- **Rate of temperature rise of 0.2°C per decade**

A rate of temperature rise of 0.2°C per decade is the limit that is tolerable in terms of costs (including recovery from impact damage) to adapt to climate change calculated on the basis of 5% of GDP. The global tropospheric mean temperature is currently rising at a rate of 0.22°C per decade, which has already exceeded this limit. However this average was calculated over a short period, and the rate of change should become smaller as the period is lengthened to several decades.

The 2003 report stated that it was necessary to limit the rise in global mean temperature to a maximum of 2°C (not more than 0.2°C per decade) relative to the pre-industrial level, and to limit CO_2 concentration to 450 ppm (equivalent concentration including other GHGs). In order to achieve this, the Council concluded that emissions of GHGs including CO_2 would have to be reduced by 45 to 60% from the 1990 levels by 2050, and that industrialized countries must reduce emissions by at least 20% by 2020.

● **Efforts by the EU**

On the other hand, the EU agreed on the figure of 2°C and stabilization of 550 ppm (CO_2) at a Meeting of the Council of Ministers in 1996. This was based on the IPCC's Second Assessment Report, which summarized the latest scientific findings available at that time. The Council concluded that (1) for stabilization at 550 ppm, current emissions must be reduced to below 50%, and (2) the global mean temperature would consequently rise by 2°C compared with the pre-industrial level. It was determined that the stabilization of all GHGs (particularly CH_4 and N_2O) was necessary, and that the preventive principle should be applied in the case of uncertainty.

According to a recently released report by the Commission of the European Communities (2005), the rise in global mean temperature should be stabilized at not more than 2°C and the atmospheric concentration of GHGs at significantly lower than 550 ppm (CO_2 equivalent concentrations, hereafter expressed as CO_2-eq) compared with the pre-industrial levels. The probability of achieving the target (within 2°C) is two in three in the case of a concentration of 425 ppm, one in six in the case of 550 ppm, and one in 16 in the case of 650 ppm (all concentrations in CO_2-eq). The report therefore concludes that it is necessary to stabilize the concentration at a much lower level of 550 ppm (CO_2-eq) in order to limit the temperature rise to 2°C. Moreover, recent findings support the values of 2°C and 550 ppm (CO_2-eq), with 1 to 2°C being the threshold value for ecosystems and water resources. If the temperature rise exceeds 2°C, serious impacts can be expected to appear on ecosystems, food production, and water supplies, and irreversible destructive phenomena may occur.

2.1.5 Findings reported at scientific meetings in the UK

The UK has also been conducting studies on the stabilization of GHG concentrations. The 2003 Energy White Paper (British Trade and Industry, 2003) and other reports (DEFRA, 2003a and 2003b) acknowledged that a global mean temperature rise of not more than 2°C (since pre-industrialization) and a CO_2 concentration not exceeding 550 ppm (double the pre-industrial level) would be necessary to prevent most of the damage resulting from climate change. IPCC (2001) formulated an energy plan based on the finding that stabilizing the atmospheric concentration of CO_2 at a maximum of 550 ppm would limit the economic loss suffered by industrialized countries in 2050 to an average of 1%. The Royal Commission on Environmental Pollution of the UK (2000) also recommended a level of 550 ppm, and the judgment of the UK government is that adopting a concentration stabilization target exceeding 550 ppm would invite criticism, particularly from environmental preservation groups, the EU, and the governments of developing countries.

In February 2005, the UK government sponsored a scientific symposium on the stabilization of GHGs at the Met Office in Exeter. Under the theme of "Avoiding Dangerous Climate Change," the symposium was held with the aim of summarizing the latest scientific findings on climate change-related issues, which is one of the themes of the G8 meeting to be held in the UK in July 2007. About 200 scientists and specialists from some 30 countries participated in the symposium, and reports on the following three research topics were presented and discussed (DEFRA, 2005).

(1) Various levels of global warming impacts

Compared with the IPCC's Third Assessment Report (2001), understanding of the assessment of climate change impacts has been further clarified and uncertainties have decreased. However it has become apparent that the risk of impacts is more serious than previously thought. For example, a regional temperature rise of 2.7°C (equivalent to a 1.5°C rise in the global mean) might trigger melting of permanent ice caps, and an increase of approximately 1°C in global temperature is likely to lead to extensive coral bleaching. It has been found that, in general, damage increases if the global temperature rises by 1 to 3°C. Reports were presented showing that if the temperature rises above 3°C, there is increased risk of serious large-scale impacts occurring such as a shutdown of the thermohaline circulation, reversal of land carbon sinks, and destabilization of the Antarctic ice sheets.

(2) Stabilization of GHG concentrations and emission pathways to avoid dangerous global warming

With regard to GHG emission pathways, different models suggest that when reduction measures are delayed, greater measures are required later to achieve the same temperature target. Even a delay of five years could make a significant difference, and if action to reduce emissions is delayed by 20 years, rates of emission reduction thereafter may need to be three to seven times greater.

(3) Technological options to achieve stabilization of GHGs

As regards technological options for stabilizing GHGs, technological measures for reducing emissions over the long term already exist. Moreover, the possibility of lowering reduction costs by the effective use of various technologies has been shown. All measures for stabilization of GHGs need to be promoted including strong technology development and diffusion, emission trading, etc. Major investment is needed now in both mitigation (reduction) and adaptation. The first is necessary to minimize future impacts, after which adaptation to unavoidable impacts becomes important.

2.2 Preconditions in studies on stabilization of concentrations

Some cases were described earlier in section 2. When making comparative studies, however, attention needs to be paid to the fact that preconditions differ for each case. For example, CO_2 was the only target in IPCC's initial work on the stabilization of concentrations, but in fact the overall situation of global warming cannot be grasped unless GHGs other than CO_2 are also taken into account. Various means have therefore been utilized in recent studies, such as expressing values taking radiative forcings of GHGs other than CO_2 and aerosols, etc. into account and converting them to CO_2-equivalent concentrations. Preconditions when studying dangerous levels are summarized below.

2.2.1 Preconditions

When studying long-term targets, it is necessary to gain an understanding of the “when,” “where,” and “how” of climate change impacts. In concrete terms, the following preconditions must first be clarified.

Targeted gases (gases that are the objective of the study concerned)
Starting point of assessment (the time used as a base in discussions)
Indicators for judgment of dangerous levels (which indicators are to be used in discussions)
Spatial scale of assessment (global or regional level)

•Targeted gases

Kyoto Protocol targets the six main GHGs for reduction; namely carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). There are, however, many more substances that contribute to global warming. These include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), ozone (precursors related to ozone generation in the stratosphere and troposphere: volatile organic compounds (VOCs), carbon monoxide (CO), nitrogen oxides (NOx)), and aerosols (sulfate, black carbon, organic carbon). Although these GHGs and other substances are emitted as a result of human activity, natural factors are also connected to global warming. One natural factor that can be cited is changes in albedo caused by variations in solar radiation, volcanic activity, and land use. Figure 4 shows the magnitudes of global mean radiative forcing of the climate system due to these anthropogenic and natural factors. GHGs such as CO_2 act as a force contributing to global warming, whereas aerosols such as sulfate have a cooling effect. The figure shows the cumulative effects of these global warming and cooling factors for the year 2000 relative to 1750.

In the past, analyses were conducted only on CO_2. However, emissions of other GHGs are also large, with CFCs and HCFCs in particular having a very strong greenhouse effect. Studies on the stabilization of concentrations have therefore begun taking these gases into consideration. With regard to natural factors such as variations in solar activity, although the majority of studies do not take them into account, some assign them certain pre-industrial values. The types of GHGs investigated also differ from study to study. Table 2.3 shows the GHGs targeted by various studies for comparison.

Figure 2.2 Antropogenic and natural forcing of the climate for the year 2000, relative to 1750 (IPCC, 2001)

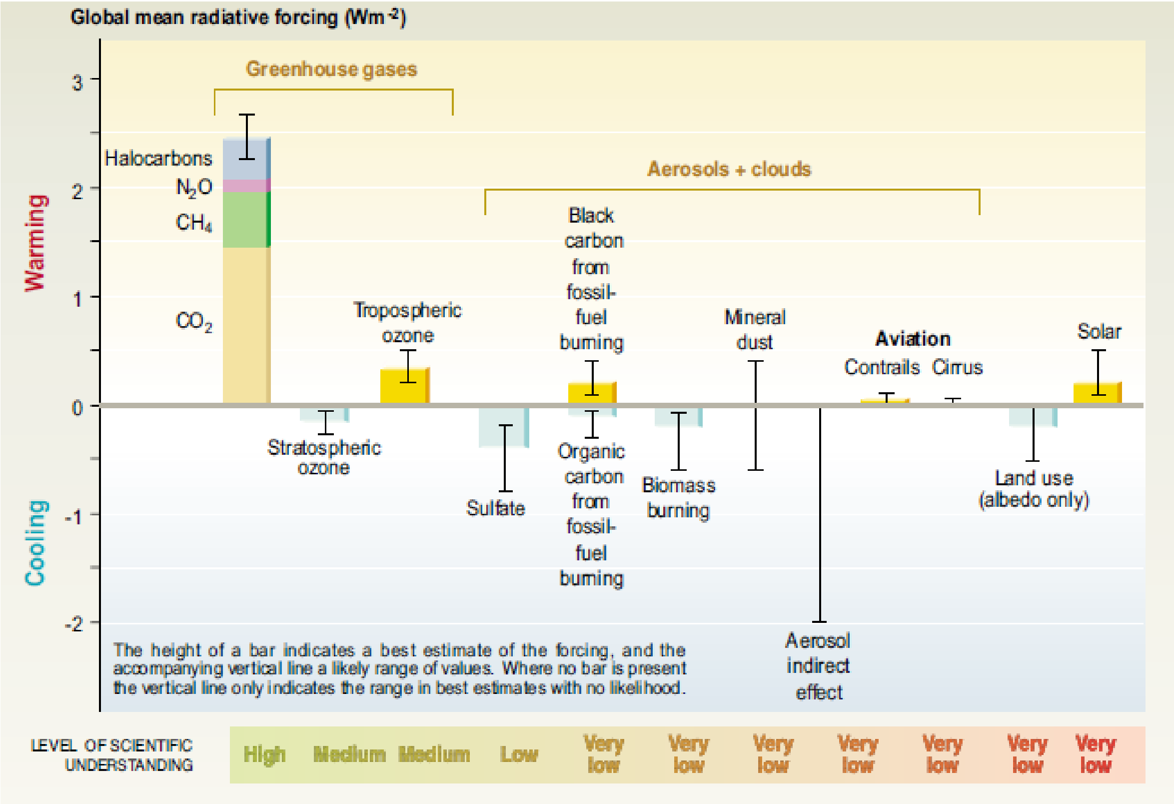


Table2. 3 Examples of GHGs and aerosols targeted in studies on stabilization of concentrations and temperature rise

	Targeted GHGs and aerosols	Remarks	References
1) Hare et. al	- CO_2 (fossil CO_2 and land use CO_2), CH_4, N_2O, HFCs, PFCs, SF_6 - Ozone precursors (VOCs, CO, NOx) - Aerosols (SO_2)	CFCs not taken into account. Natural radiative forcings not investigated.	Hare and Meinshausen, 2004; den Elzen and Meinshausen, 2005; Meinshausen, 2005
2) Commission of the European Communities	- CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 - Tropospheric ozone	Quoted the research results of 1). No particular quantitative analysis.	Commission of the European Communities, 2005
3) German Advisory Council on Global Change (WBGU)	- CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 - CFCs and HCFCs - Tropospheric ozone precursors (CO, NOx, VOCs) - Aerosols, black carbon	Analyzed using ECLIPS of PIK.	WBGU, 1997 and 2003
4) AIM Model	- CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 - CFCs, HCFCs - Ozone (stratosphere, troposphere) - Water vapor (troposphere) - Aerosols (originating from SO_2, fossil fuels, and biomass) - Changes in solar radiation and land use (albedo)	Natural radiative forcing taken into account (however, solar radiation assumed to be fixed since pre-industrial time).	Hijioka et al., 2005

•Starting point of assessment

The question arises as to where to position the starting point of temperature rise. Since the IPCC established future GHG emissions with 1990 as the starting point (Special Report on Emissions Scenarios (SRES), etc.), future temperature rise and impacts have been assessed by climate models using these emissions scenarios as conditions. On the other hand, in view of the temperature rise of 0.6°C that has already occurred over the past 100 years, there are studies that take the industrial revolution (around 1750) or the pre-industrial period (around 1850) as starting points, and these are becoming the mainstream. In particular, studies by the EU, Germany, and the Netherlands use the pre-industrial period (1861 to 1890, based on the rationale that results of observations by thermometer from 1860 onwards are available).

• Indicators for judgment of dangerous levels and spatial scale of assessment

Absolute values of temperature rise and sea level rise and their rates of change are often used as indicators to measure dangerous levels. Precipitation should also be used as an indicator in view of its connection to droughts and flooding. However, projections of precipitation by climate models are not as accurate as projections of temperature, and the cumulative number of precipitation-related impact studies is much smaller than those dealing with temperature and sea level rises. As a result, temperature and sea level rises have been chosen as indicators rather than precipitation. With regard to temperature, global mean temperature is used as an indicator and the values are quantified in terms of impact damage.

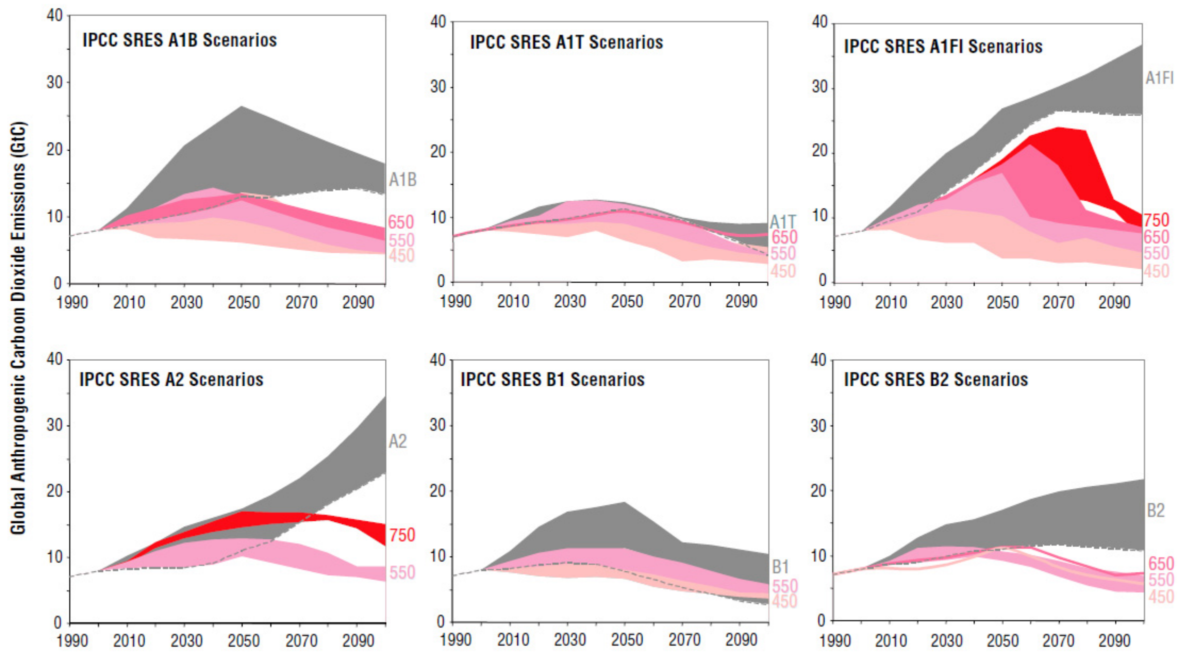
The reasons for the use of global mean temperature as an indicator are set forth in chapter 19 of IPCC's TAR (2001). Although there are advantages in studying dangerous levels by summarizing global warming in terms of a single indicator for the entire planet, since temperature increases differ according to the region, such an approach should only be positioned as an indicator to grasp the overall picture. Impact studies on global warming can be expected to progress at the regional level in the future, so this indicator can be expected to be subdivided into regional-level judgment indicators from now on.

2.3 Stabilization scenario

2.3.1 Post-SRES

The Post-SRES CO_2 stabilization scenarios are mitigation scenarios that were formulated based on the Special Report on Emissions Scenarios (SRES) (Swart *et al.*, 2002) released in 2000 by IPCC. In the Post-SRES scenarios, atmospheric CO_2 stabilization concentrations are set at 450, 550, 650, and 750 ppm, and the timing and degree of the necessary mitigation measures are quantitatively shown under six future development assumptions described by the SRES (A1B, A1F1, A1T, A2, B1, and B2). Figure 6 shows anthropogenic CO_2 emission pathways by future development pathways according to the SRES, and CO_2 emission pathways when CO_2 concentration stabilization constraints are imposed. The CO_2 emission pathways when CO_2 concentration stabilization constraints are imposed clearly show larger differentiations due to the differences in constraints than to the differences in future world scenarios. On the other hand, when these results are compared with the case in which concentration stabilization constraints are not imposed, the amounts of reduction show large variations according to the future world, suggesting that the difficulty of achieving climate stabilization will differ greatly depending on the differences in the future world.

Figure 2.3 Comparison of SRES and post-SRES scenario ranges in total global CO_2 emissions (Morita et al., 2001)



2.3.2 Equal Quantile Walk (EQW) (Meinshausen et al., 2004,

Meinshausen has studied the relationship between GHG stabilization concentration and global mean temperature increase taking uncertainty into consideration (Meinshausen, 2005). The temperature rise at the time of GHG concentration stabilization is estimated by Eq. (1) and (2) below:

$$\Delta Q = \alpha * \ln(C/C_0) \qquad (2.1)$$

$$\Delta T = \Delta Q * (\Delta T_{2xCO2}/\alpha * \ln(2)) \qquad (2.2)$$

where ΔQ: radiative forcing, α: coefficient, C: CO_2 equivalent concentration,
C_0: CO_2 concentration prior to the industrial revolution, ΔT: global mean temperature increase (compared to that prior to the industrial revolution), and ΔT_{2xCO2}: climate sensitivity.

As shown in Eq. (2), global mean temperature increase is determined by radiative forcing and climate sensitivity. Climate sensitivity indicates long-term (equilibrium) variations in the global mean temperature when atmospheric CO_2 concentration doubles. Global mean temperature increase, a parameter that comprehensively indicates the uncertainty of physical processes and interactions contained in a climate model, is estimated at 1.7 to 4.2°C in the Third Assessment Report of IPCC (Cubacsch *et al.*, 2001)[)]. With regard to the uncertainties of climate sensitivity, the probability density distribution approach has been proposed using various methods (Forest et al., 2002, Gregory et al., 2002, Kerr, 2004, Murphy et al., 2004).

Using the probability density distribution function of climate sensitivity reported in the existing studies shown in Figure 7, Meinshausen et al. (2004) clarified the relationship between stabilization concentration (radiative forcing) and global mean temperature increase in terms of the probability of overshooting the target values for global mean temperature increase (1.5, 2.0, 2.5, 3.0, and 4.0°C), with the temperature prior to the industrial revolution as the base (Figure 2.7). According to Figure 2.4, for example, it can be seen that in the case of 450 ppm GHG concentration stabilization, the probability of overshooting 2°C is 47% on average, with minimum and maximum values of 26% and 78%, respectively. In this way, Meinshausen attempted to achieve analysis with a higher degree of reliability by using the probability distribution of climate sensitivity to express targeted GHG stabilization concentrations and global mean temperature increase in terms of a range of probability.

In EQW, which is targeted at GHGs and aerosols, detailed studies are conducted on the relationships between stabilization concentrations and emission pathways. Figure 8 shows changes in GHG concentrations and emission pathways for three GHG stabilization concentration targets (GHG concentrations of 550, 475, and 400 ppm). In the case of the 550 ppm stabilization scenario, it is estimated that emissions in 2050 of the gases targeted for reduction in the Kyoto Protocol (hereafter referred as “Kyoto gases”) will need to be reduced by approximately 10% from the 1990 levels. In the case of the 475 ppm and 400 ppm (peak concentration 475 ppm) stabilization scenarios, on the other hand, a considerable reduction of approximately 50% in Kyoto gas emissions in 2050 compared to the 1990 levels is estimated to be necessary. In these scenarios, CO_2 emissions originating from land use change are assumed to have a negative value (i.e., absorption source). Hence, when CO_2 emissions originating from land use change have a high value, as in the present situation, it is found that even more severe reductions in emissions are required. Moreover, studies of various mitigation measures under the 400 ppm GHG concentration stabilization target (peak concentration 475 ppm) have concluded that considerable efforts will be required if mitigation is delayed.

Under the EQW approach, therefore, quantitative analyses of various GHG concentration stabilization targets have been conducted taking differences in reduction starting times into consideration in order to determine the future course that should be taken, particularly in terms of mitigation measures.

Figure2. 4 The risk of overshooting 2.0°C global mean equilibrium warming for different CO_2 equivalent stabilization levels (Meinshausen, 2005)

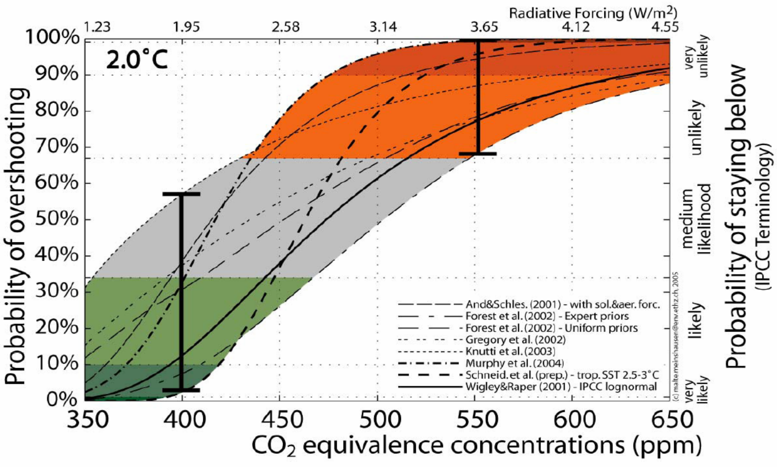
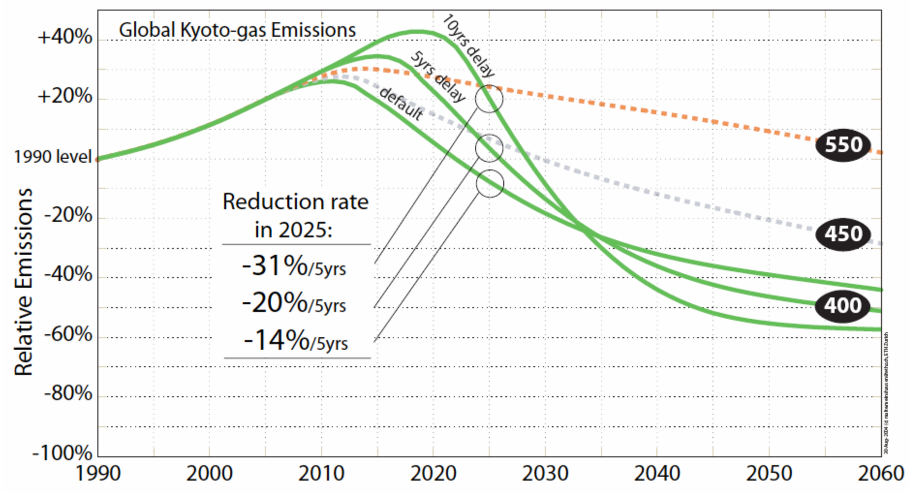


Figure2.5 Global Kyoto-gas emissions for stabilization at 550, 475 and 400ppm CO_2eq (Meinshausen, 2005)



2.4 Outline of AIM/Impact[Policy]

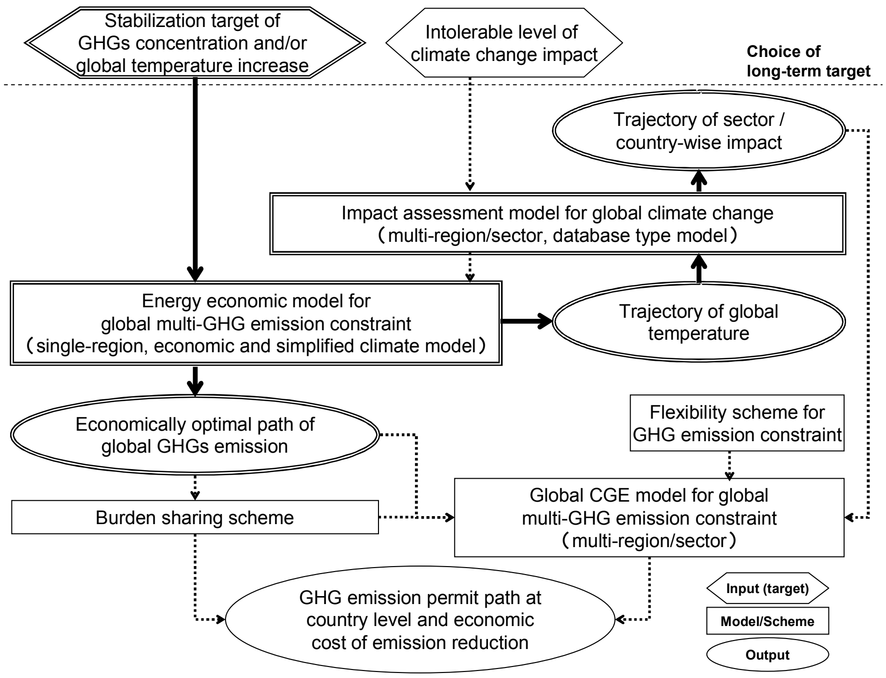
2.4.1 What is AIM/Impact[Policy]?

In the present study, we are developing AIM/Impact[Policy] (Hijioka et al., 2006), a policy support tool to assist in achieving climate stabilization targets by comprehensively analyzing and assessing GHG concentration stabilization and mitigation measures as well as impacts and risks under the targets (Figure2.9). The objective of the development of AIM/Impact[Policy] is to provide an integrated approach for the analysis of dangerous levels of global warming impacts by connecting the knowledge obtained from sectoral climate change impact studies with GHG stabilization targets.

In establishing future targets for global mean temperature, sea level rise, atmospheric GHG concentrations, and so on, AIM/Impact[Policy] functions to (1) project the optimal GHG emissions path and GHG reduction burden by region, and (2) show the scale of the warming impact by country and sector under this GHG emissions path, and provide materials to investigate whether or not the established future targets are sufficient to avoid "dangerous impacts" (i.e., to determine the validity of future targets). This will be highly useful for formulating specific future targets for global warming response policies.

AIM/Impact[Policy] consists of multiple models. These are classified into models to simulate GHG emissions under the global warming control targets (an energy economic model, a burden sharing model to estimate the GHG reduction burden by country, and a global economic model to assess economic impacts resulting from the implementation of global warming response policies), and a model to simulate the global warming impact anticipated to occur under the global warming control targets (impact assessment and adaptation model) (Figure 2.6). The energy economy model contained in Figure2.6 is used to simulate the optimum GHG emission pathway in terms of economic efficiency for an assumed climate stabilization target, and to quantitatively assess the impacts of global climate change and sea level rise.

Figure2. 6 Outline of AIM/Impact[Policy]



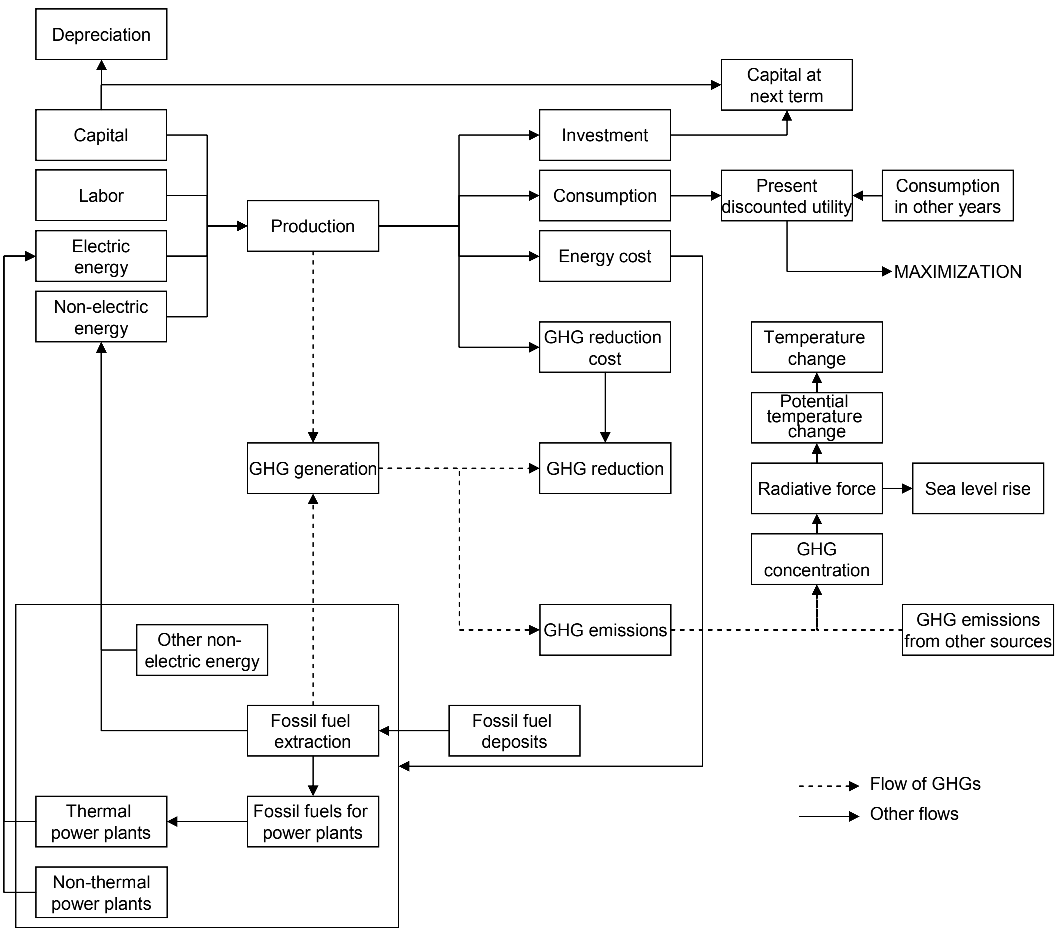
2.4.2 Outline of energy economic model

The energy economic model was adopted as a dynamic optimization model to simultaneously predict very long-term economic activities and climate changes (Figure 2.7).

This model is a nonlinear optimization model indicating the optimum developmental process in the global economy, and provides a framework for quantitatively assessing various climate change policies. This model consolidates the world into a single region, and consists of four basic modules (economic/energy module, greenhouse gas emissions module, climate module, and sea level rise module). It allows policy targets to be quantitatively assessed by identifying optimal paths of economic development under various constraints; namely, (1) GHG concentration constraints, (2) global mean temperature constraints, (3) temperature change rate constraints, and (4) sea level constraints. These constraints can be set simultaneously, and the time that the constraints are applied can also be set freely, from a single point to multiple points in time.

In this model, in addition to changes in radiative forcing resulting from GHG and SO_2 emissions, changes in radiative forcing due to ozone (stratospheric and tropospheric), variations in stratospheric water vapor, soot originating from fossil fuels, and soot originating from biomass combustion are also modeled. Values for GHG concentration are expressed by converting the sum of these radiative forcing values into CO_2 concentration.

Figure2. 7 Structure of energy economic model



2.5 Analysis of GHG emissions control policy for climate stabilization

Calculations were performed under business as usual (BaU) conditions and the following two constraints to assess the impacts of global warming under GHG stabilization conditions.

① BaU: Business as usual
② GHG-475ppm: 475 ppmv cap on total GHG concentrations
③ GHG-550ppm: 550 ppmv cap on total GHG concentrations
④ GHG-650ppm: 650 ppmv cap on total GHG concentrations

Constraint optimization calculations in which CO_2 and GHG concentrations did not exceed the constraint between the years 1990 and 2200 were carried out. The SRES B2 scenario prepared by the IPCC was used for future population and future economic growth. A discount rate of 4%, reduction ratio of GHG/energy production ratio of 0.85, and climate sensitivity of 2.6°C were applied. Figure2.8 (a)-(d) show rises in average global temperatures, GHG concentrations, GHG emissions and rises in sea level until 2150.

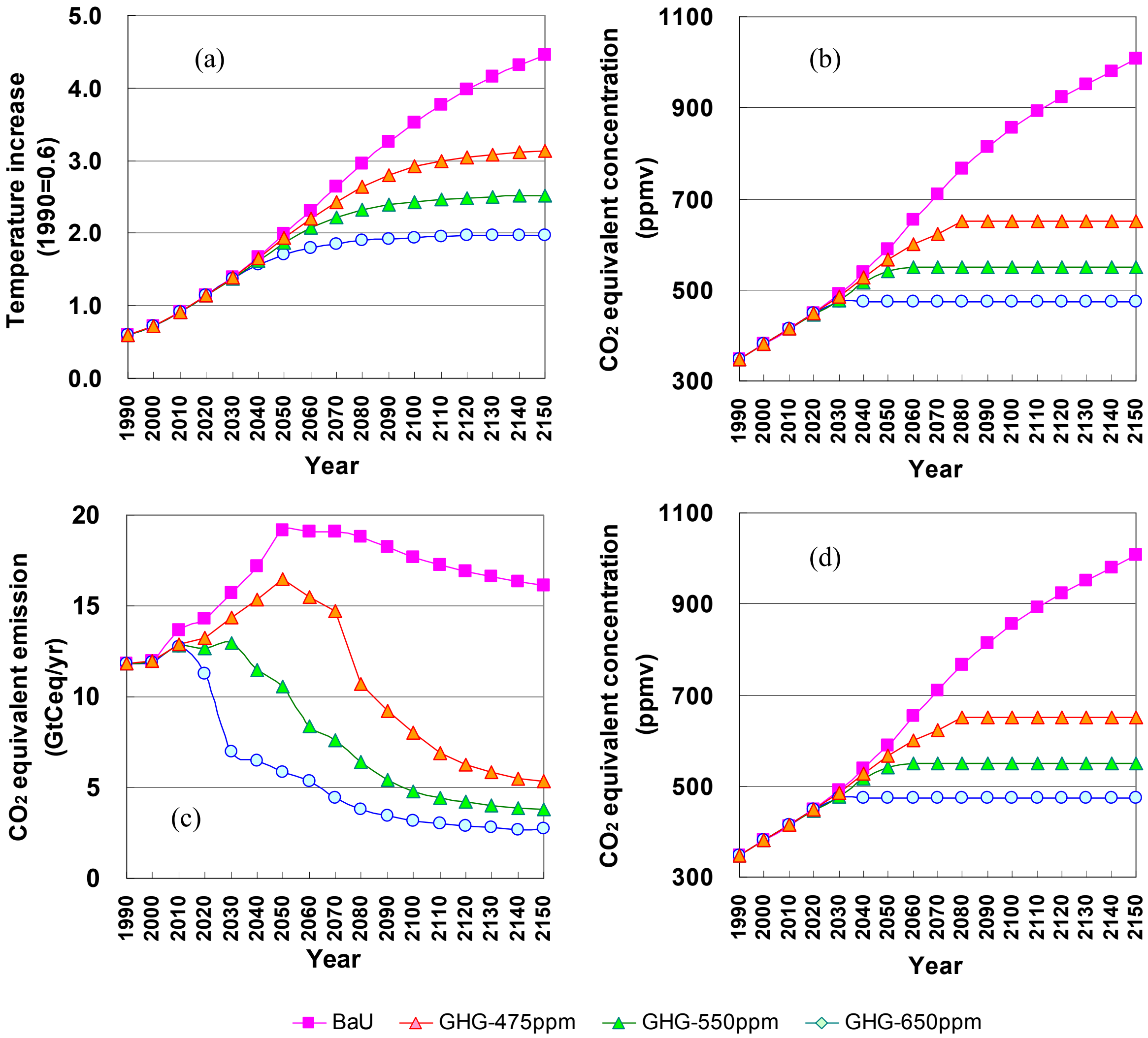
In the BaU case, GHG emissions continue to rise until 2050, and by 2150 GHG concentrations will have increased to about 3.0 times the 1990 level. The average global temperature will rise 3.5°C by 2100, and 4.5°C by 2150. Judging from the projected temperature changes in 2150, the increase will greatly exceed 2°C in all cases except for when GHG concentrations are restricted to 475 ppmv. With regard to rises in sea level, the projected rise is 0.16 m by 2100 and 0.22 m by 2150 in the case of GHG-475ppm. These rises are 0.7 and 0.5 times, respectively, those projected for the BaU scenario. Under conditions of GHG-550ppm and GHG-600ppm, the rises in sea level by 2150 are 0.26 m and 0.31 m, respectively. These figures are 1.2 and 1.4 times, respectively, those projected in the case of GHG-475ppm. With regard to rises in sea level, the projected rise is 0.16 m by 2100 and 0.22 m by 2150 in the case of GHG-475ppm. These rises are 0.7 and 0.5 times, respectively, those projected for the BaU scenario. Under conditions of GHG-550ppm and GHG-600ppm, the rises in sea level by 2150 are 0.26 m and 0.31 m, respectively. These figures are 1.2 and 1.4 times, respectively, those projected in the case of GHG-475ppm

Focusing on GHG emissions, in the case of GHG-475ppm, reductions of approximately 10% and 50% in GHG emissions need to be achieved by 2020 and 2050, respectively, compared to the 1990 level, indicating the urgent need for a full-scale reduction system. GHG emissions after 2010 are consistently lower than the 1990 level when the GHG concentration is capped at 475 ppm, confirming the need for a strict emissions control policy.

To summarize the analysis results, temperature rises and adverse impacts are mitigated in the GHG-475ppm and GHG-550ppm cases in comparison with the BaU case. However, even in the GHG-475ppm case, which requires severe reductions in emissions (approximately 10% reduction in 2020 and 50% reduction in 2050 compared to 1990), impacts of climate change cannot be avoided. Measures against global warming integrating both mitigation and adaptation measures are therefore essential.

In order to mitigate the impacts of global warming, it is necessary to establish targets that incorporate stabilization concentrations, temperature rises, and mitigation measures in an integrated way taking impact threshold values into consideration. We carried out a quantitative assessment of the GHG emissions paths necessary to achieve GHG concentrations stabilization targets. The results showed that to avoid average global temperature increases above 2°C, a stabilization target for GHG concentrations of less than GHG 475 ppmv is needed, and that to achieve this broad-based target, emissions reductions are necessary in the near future.

Figure2. 8 GHG concentrations (a), GHG emissions (b), Global mean temperature increase (c), Sea level rise (d), under three GHG concentration constraints



2.6 Summary

In this paper, we have summarized the existing GHG stabilization scenarios and reported the results of analyses of global mean temperature increase and GHG emission pathways as well as global warming impacts under GHG concentration stabilization constraints using the

AIM/Impact[Policy] policy support tool. Our results indicate that (1) a GHG concentration stabilization target not exceeding 475 ppm is necessary to suppress the rise in global mean temperature to 2°C compared to the level prior to the industrial revolution, requiring a significant reduction in emissions at an early stage; and (2) the impacts of global warming cannot be avoided even if GHG concentrations are stabilized at 475 ppm or less, making global warming response measures integrating both mitigation and adaptation measures essential.

Reference

Agrawala, S., 1998: Context and early origins of the intergovernmental panel on climate change, Climate Change , 39, 605-620.

IPCC, 1996: Climate Change Synthesis Report.

Vellinga, P. and R.J. Swart, 1991: The Greenhouse marthon: A proposal for a global strategy, 18, vii-xii.

IPCC, 1990: Climate Change The IPCC Scientific Assessment, 365pp.

IPCC, 1994: IPCC Special Workshop Article 2 of the United Nations Framework Convention on Climate Change, 39pp.

Wigley, T.M.L., R. Richels, and J.A. Edomongs, 1996: Economic and environmental choices in the stabilization of CO2 concentrations: choosing the ‘right’ emissions pathway. Nature, 379, 240-243.

WBGU(German Advisory Council on Global Change), 1997: Targets for Climate Protection, 1997.

IPCC, 2001: Climate Change 2001 Mitigation, 752pp.

IPCC, 2003: Report of the IPCC Expert Meeting, Levels of Greenhouse Gases in the Atmosphere Preventing Dangerous Anthropogenic Interference with Climate System, Geneva, 21 – 22 January 2003.

IPCC, 2004: Report of the IPCC Expert Meeting on The Science to Address UNFCCC Article 2 including Key Vulnerability Report. Buenos Aires, Argentina 18-20 May 2004.

DEFRA(UK Department of Environment, Food and Rural Affairs), 2005: Summary of the Science Symposium on Stabilization of Climate Change “Avoiding Dangerous Climate Change”, UK Exeter, 1-3 February 2005.

Vellinga, P. and R.J. Swart, 1991: The Greenhouse marthon: A proposal for a global strategy, 18, vii-xii.

IPCC, 1994: IPCC Special Workshop Article 2 of the United Nations Framework Convention on Climate Change, 39pp.

WBGU(German Advisory Council on Global Change), 1995: Scenario for the derivation of global CO2 reduction targets and implementation strategies, 40pp.

WBGU(German Advisory Council on Global Change), 1997: Targets for Climate Protection, 1997.

WBGU (German Advisory Council on Global Change), 2003: Climate Protection Strategies for the 21st Century: Kyoto and beyond.

Commission of the European Communities, 2005: Winning the battle against global climate change, Commission staff working paper.

British Trade and Industry, 2003: Energy White Paper. Our energy future - creating a low carbon economy. 138pp.

DEFRA, 2003a: The Scientific case for setting a long-term emission reduction target.

DEFRA, 2003b: Ancillary effects of greenhouse gas mitigation policies.

IPCC, 2001: Climate Change 2001 Mitigation, 752pp.

DEFRA, 2005: Summary of the Science Symposium on Stabilization of Climate Change.

IPCC (1996) Climate Change 1995, The Science of Climate Change, J. T. Houghton et al. ed., Cambridge University Press, Cambridge, 572pp.

Swart R, Mitchell J, Morita T, and Raper S (2002) Stabilisation scenarios for climate impact assessment. *Global Environmental Change* 12(3), 155-165.

Morita T, Robinson J, Adegbulugbe A, Alcamo J, Lebre La Rovere E, Nakicenovic N, Pitcher H, Raskin P, Sokolov V, de Vries B, Zhou D (2001) Greenhouse gas emission mitigation scenarios and implications. In: Davidson O, Metz B, Swart R (Eds), Climate Change 2001: Mitigation. Cambridge University Press, Cambridge, UK, pp.115-166.

Meinshausen M (2005) On the Risk of Overshooting 2°C, Avoiding Dangerous Climate Change. Exeter, UK.

Cubacsch U, Meehl GA, Boer GJ, Stouffer RJ, Dix M, Noda A, Senior CA, Raper S, and Yap KS (2001) Projections of Future Climate Change. In: Houghton JT, Ding Y, Griggs DJ, Noguer M, van der Linden PJ, Dai X, Maskell K, and Jonson CA (eds.), *Climate Change 2001—The Scientific Basis.* Cambridge University Press, Cambridge, pp. 695-738.

Forest CE, Stone PH, Sokolov A, Allen MR, and Webster MD (2002) Quantifying Uncertainties in Climate System Properties with the Use of Recent Climate Observations. *Science* 295, 113-117.

Gregory JM, Stouffer RJ, Raper SCB, Stott PA, and Rayner NA (2002) An observationally based estimate of the climate sensitivity. *Journal of Climate* 15, 3117-3121.

Kerr RA (2004) Climate change—Three degrees of consensus. *Science* 305, 932-934.

Murphy JM, Sexton DMH, Barnett DN, Jones GS, Webb MJ, Collins M, and Stainforth DA (2004) Quantification of modelling uncertainties in a large ensemble of climate change simulations. *Nature* 430, 768-772.

Meinshausen M, Hare B, Wigley TML, van Vuuren D, den Elzen MGJ and Swart R (2004) Multi-gas emission pathways to meet arbitrary climate targets. *Climatic Change* (submitted).

Hijioka, Y., T. Masui, K. Takahashi, Y. Matsuoka, H. Harasawa：Development of a support tool for greenhouse gas emissions control policy to help mitigate the impact of global warming, Environmental Economics and Policy Studies, Vol.7, No.3, pp.331-345，2006.

3. Climate Change Policy Beyond 2013: A Basic Approach to the Scenarios of Long-Term International Political Change

3.1Introduction

This chapter discusses research commissioned by the National Institute for Environmental Studies as part of the "Studies on Multidimensional Criteria for Evaluating Policies on Global Warming" project sponsored by the Global Environment Research Fund of the Japanese Environment Ministry. My contribution to the project, of which the present chapter represents an interim report, will provide a basic approach to possible scenarios for long-term international political change up to the year 2050. Other research associates will then quantify these scenarios and calculate the amount of greenhouse gas reduction required under each so as to be able to determine possible frameworks for sharing this burden among the countries and regions of the world.

3.2 The Major Factors of Long-Term International Political Change

The overarching premise to envision the scenarios of long-term international political change is that such change is the collective result of the responses taken by the major countries and regions of the world to relevant long-term factors and trends at both global and domestic levels. Another assumption is that the world faces many long-term issues that lie beyond the control of any one state or region. In other words, the outlook for international political change depends on a combination, not only of measures pursued separately by the major countries (e.g., China, India, the United States, Japan), country blocs (NIES, BRIC), and regions (the European Union, sub-Saharan Africa) of the world in response to global and internal trends, but also of international efforts to address issues of worldwide import. Chief among these issues are such concerns as population growth, food production and supply, development of and access to new technology, economic globalization, environmental change (deforestation, global warming, species extinction, drought), and the root causes of international conflict (poverty, hunger, resource depletion). These long-term world trends are greatly affected by specific national and regional trends as well as by responses taken to such conditions at both domestic and international levels. These national, regional, and international policies all directly affect long-term global trends (as related to population growth, food production, energy, and the like), thus ultimately determining the path of international political change.

The leading countries and regions of the world do not necessarily have clearly articulated strategies on global issues, but the factors shaping their responses include education (e.g., literacy rate, school enrollment), food production (food self-sufficiency), development of and access to agricultural and industrial technology (genetic engineering, production automation), economic, fiscal, and employment conditions, the environment (deforestation, global warming), and national and regional social stability. (Of these, this study is most concerned with population, economic growth, technology, and energy.) The characteristics of the long-term policies adopted by each state or region prescribe the possibilities for, and effectiveness of, cooperation at the regional and global levels by determining the framework under which this cooperation takes place, who assumes the central role, and how. Any conjectures we make about the future of such international trends must go beyond analysis of mere surface phenomena and seek a long-term outlook at the level of perceptions, ideas, and values.

The ever-spreading, ever-accelerating movement of people, goods, money, services, and information across the globe—not to mention the social erosion brought on as a result—has been among the most powerful forces shaping the world in the post-Cold War era. The rapid and wide-ranging changes induced by globalization have torn apart preexisting social institutions, threatening those privileged under the political and economic systems of the past, severing the traditional bonds between individuals and society, and bringing forth a resurgence of nationalism, cultural reaction, and religious fundamentalism. On the other hand, we cannot ignore the movements that acknowledge the benefits of globalization instead of responding in a reactionary and inward-looking manner. These efforts seek ways to coexist with globalization and control it so as to promote the good of the state and local community and nurture the healthy development of humankind. This "liberalism" is in the tradition of eighteenth-century Enlightenment thinking. Another kind of social movement is being spearheaded by international NGOs and other advocates of "cosmopolitanism" committed to respecting people as members of the human race rather than of a particular state, ethnic group, or social stratum.[1] The chief targets of criticism by this movement are international private capital and multinational corporations (MNCs). While large-scale financiers, MNC executives, and other international businesspeople who jet around the globe in pursuit of their own grand designs may perhaps be called cosmopolitan in the sense that they possess highly developed international sensibilities and profess no strong feelings of affiliation to any particular country or locale, the fact that they are more interested in advancing market globalization than in achieving the good of humanity as a whole or securing universal human rights and equality makes them agents of "market economism" (to be discussed in more detail in the next section) rather than cosmopolitans in the true sense of the term. Finally, there are those who carry on the cosmopolitan thinking of the eighteenth century in pursuing the ideal of world government, believing that the ultimate solution to such global issues as human rights and the environment is through the establishment of a centralized international governing body.

3.3 Four Paradigms of International Political Change[2]

3.3.1 Market Economism

Market economism, or a strong support of and faith in economic globalization, is by far the dominant paradigm in today's world, shaping not only long-term national, regional, and international trends but also attempts by the major countries and regions of the world to deal with such trends (Ohmae 1990; Wolf 2004). Market economism has its root in liberalism,

[1] Although radical labor unions occasionally also participate in this movement, as they did for example during the 1999 protests against the WTO in Seattle, such groups should be considered protectionists acting to preserve their own interests rather than cosmopolitans proper.

[2] A paradigm, as defined by Thomas Kuhn (1970), denotes an overarching theoretical framework for formulating and investigating scientific queries that dominates any given discipline at a time between the previous scientific revolution (i.e., a shift in such paradigms) and the next, for example, geocentric (Ptolemaic) versus heliocentric (Copernican) theories in astronomy. For the purposes of this discussion, however, the term is used more broadly in the sense of a basic way of looking at and thinking about things that is widely accepted at a particular point in time.

particularly utilitarianism and libertarianism (a philosophy that espouses granting individuals the greatest freedom possible while minimizing the role of the state; see Nozick 1974), and is frequently associated with economic liberalism and laissez-faire and free-market capitalism. The advocates of market economism, or globalists believe in perpetuation of the consumption-based model of economic development and are skeptical of the possibility of resource depletion, placing their confidence in the ability of human intellect and technology to overcome all such obstacles (Simon 1996). They also favor deregulation of financial markets and promote the activities of the MNCs.

Such people moreover tend to show little attachment to a particular country or region (community), instead traveling the world over in search of ever more revenue and bigger and better markets while being driven solely by the need to expand profits and produce returns for investors. Although their focus thus lies mostly on raising short-term gains, in the long term they typically work to lift restrictions on business and research and development and to promote small government, privatization, reliance on the market mechanism, and other such practices in the interests of efficient business, relying on technology to solve every kind of problem. On one hand, market economism gives rise to a class of financiers, MNC executives, lawyers, engineers, and other highly educated professional elites who, as the "winners" in the new world order, are able to fully enjoy the fruits of economic globalization; on the other hand, however, it also levels wages for simple and unskilled laborers across the globe and swells the ranks of those who have been left unemployed by new technology or who have become dropouts in the race for success (i.e., NEETs or "freeters," as young low-income part-timers are known in Japan), elements that threaten healthy economic development and social stability. This lack of regard for the long-term welfare of society is also shared by MNCs, most of which show little concern either for global concerns such as hunger or the environment or for the educational, employment, and social conditions of the countries and regions in which they do business, instead moving on to other places when profits begin to fall.

3.3.2 Nationalism: Balance versus Dispersal of Power

The next two paradigms we will consider are characterized by anti-globalistic nationalism. While nationalism is extremely diffuse and hard to define (Kedourie 1993), its way of viewing and considering the world is founded on political realism (hereafter simply "realism"). "Balance of power" is one of the leading forms of realism recognized in the world, and the discussion of nationalist paradigms in this chapter will be based on this perspective. Under the balance-of-power paradigm, in which nationalism driven by ethnic, state, and/or religious loyalties becomes the dominant force behind international political change, a kind of closed regionalism will take over as the world splits into separate, mutually exclusive regional economic blocs. Alternatively, should narrower forms of nationalism based on extreme sectarianism or fundamentalism prevail, then a dispersal-of-power paradigm marked by decentralization and fragmentation will take hold. Such a world will lie somewhere between the two extreme poles of "antagonistic" and "tolerant/symbiotic." The latter type may be described as one in which each faction, while rejecting centralized authority in favor of regionalism and local autonomy, nevertheless accepts the existence of groups beside its own and works to promote cultural diversity rather than incite conflict.

As already discussed, nationalism has its root in realism (Bull 1977; Carr 1951; Morgenthau 1972) and neo-realism (Gilpin 2003; Waltz 1979). It supports a wide range of political systems, from democracy to theocracy to one-party dictatorship. Typical economic policies include protectionism (neo-mercantilism) as well as state-controlled capitalism and regulated free markets. Generally speaking, the scenario is one in which the state, together with the major industries, interest groups, and other vested interests within the country, strives to maintain the status quo as much as possible while pursuing short-term gains.

Should the balance-of-power paradigm prevail, the world (in contrast to the world based on multilateralism and international cooperation to be described in the next section) will be fraught with tension as a few superpowers struggle for dominance against each other or against alliances of states formed in rivalry to them, in much the same way that the United States and Soviet Union divided the world between them during the Cold War. The United States may ultimately emerge as the unilateral leader of the world, although a scenario in which the world splits again into two poles as the United States and China vie with each other for hegemony is perhaps more likely. Alternatively, the rise of countries such as China or India could spur neighboring states to rally together, thereby breaking up the world into various regional blocs (NIC 2004).

The dispersal-of-power paradigm is one in which power is broadly dispersed. Two very different futures, namely the "antagonistic" versus the "tolerant/symbiotic," are possible under this situation.

To begin with the first possibility, in The Anarchical Society (1977) Hedley Bull argues that the world, although "anarchical" in the sense that it is not regulated by a formal centralized government, still possesses an international order imposed through the abovementioned balance of power among nations. The dispersal-of-power scenario, however, predicts a world in which power is so scattered so as to rule out the emergence of one, two, or even several dominant groups. Eruption of conflict in such a world will quickly cause each faction to retreat into sectarianism and fundamentalism, resulting in utter chaos as the world descends into violent struggles for natural resources and succumbs to narrow-minded and truculent forms of nationalism and fundamentalism that reject all possibility of harmony with others. Each state, region, ethnic group, or religious organization will demand that only its own rights and claims be recognized, doing completely away with international order and, in the worst case, leading to the "clash of civilizations" described by Huntington (1996).

Present-day examples of the nationalist paradigm of international political change include OPEC—an oil cartel founded on resource nationalism—as well as China, India, and many other developing countries both large and small.[3] Developing countries typically face many pressing

[3] It is hard to say where the United States belongs at this point, given the huge influence exerted on its internal and external policies by domestic interest groups (e.g., local constituencies, the defense industry) on one hand versus by advocates of market economism and its offspring, MNCs, on the other. In terms of its aggressiveness in opening up foreign markets to genetic modification technology, for example, the United States may be said to represent the interests of multinational agribusiness and therefore to be acting on behalf of market economism and maximization of profits for the commercial sector; at the same time, the country's stance on abortion, regenerative medicine, and other such issues that clash with fundamentalist Christian doctrine, not to mention its deference to the industrial sector in matters to do with energy conservation, would seem to put it in the nationalist camp. The question of whether any state subscribes to one ideology or another is largely a matter of degree, and the United States seems to be a case in which the different forces are particularly closely matched, although its policies do appear to be quite globalist on such topics as

issues including overpopulation, hunger, income disparity, and environmental destruction. In order to prevent public dissatisfaction over these problems from destabilizing society or erupting into antigovernment protests, each government must continually strive to modernize agriculture and industry, generate employment, and otherwise maintain high rates of economic growth. Thus these states are constantly under pressure to scramble for their own interests in any way that they can, massively exporting products in which they have a comparative advantage to gain foreign currency for securing food, water, energy, and other resources. The result is a situation in which international conflicts over such limited goods may flare up at any moment (Klare 2001). Should problems with the economy, resources, or the environment ever grow worse enough to incite civil war and political breakdown in areas such as sub-Saharan Africa or south Asia or in populous countries such as China or India, then neighboring states will be faced with the prospect of massive numbers of refugees flowing into their borders (Homer-Dixon 1999). The situation could be made even worse should individual parties retreat into sectarianism or fundamentalism, plunging whole nations and regions into anarchy and confusion (Bok 1989).

As for the second possibility, that of tolerance/symbiosis, advocates of this kind of world share among them a distrust of centralized governing systems and belief in local autonomy. They aim for a world that is compartmentalized into the smallest possible administrative units each governed under the principles of subsidiarity[4] and local independence with minimal interference from central authority (Daly and Cobb 1994). They favor many of the same values as communitarianism (to be discussed in the next section) while also encouraging such practices as promotion of local industry, local cultivation and consumption of organic produce, use of locally sustainable energy, and preservation or reintroduction of lifestyles to fit the culture and customs of each individual country or region through adherence to "appropriate technology" or "slow life" philosophies (Schumacher 1973; Petrini 2003).

Despite the international status of some movements associated with the tolerance/symbiosis model, for example the Slow Food campaign, the ideas of this paradigm depart significantly from communitarianism and its emphasis on international cooperation in that they generally advocate noninterference rather than confederation among different parts of the world. In developing countries, environmental measures conducted under this model will likely involve efforts to attain sustainability in accordance with the U.N. Local Agenda 21 action plan. Developed countries with already advanced environmental policies will meanwhile tend toward "ecological modernization" (Martin 1992 and 1993; Weizäcker, A. Lovins and L. Lovins 1997) consisting of a two-pronged approach in which government measures aimed to promote local production and consumption, encourage recycling, and otherwise achieve a conservation-oriented, environmentally friendly society are combined with private ecobusiness designed to pursue profit and the environment all at the same time.

3.3.3 Communitarianism: A World Founded on International Cooperation

One hopeful alternative to untrammeled market economism on one hand and internal and

---

deregulation of trade and financial markets.

[4] The idea that centralized authority should take on only those functions that cannot be efficiently performed by lower or more local governing bodies.

worldwide strife engendered by nationalism and fundamentalism on the other is international cooperation based on communitarian thinking, as seen in the European Union (EU) with its commitment to "open regionalism." Unlike the symbiotic/tolerant dispersal-of-power paradigm, communitarianism actively seeks solutions to international problems. Largely social democractic in orientation, it upholds political liberalism and equality, democracy, the rule of law, fairness and social justice, community solidarity, realization of an efficient but restrained market economy, and adherence to international standards and international law. Although part of the liberalist tradition, it tends to emphasize equality (fairness, social justice) over freedom and argues for preservation of the public good even at the partial expense of individual liberties (McGrew 2003). For the purposes of this discussion, both liberalist movements that call for the creation of social welfare states based on Rawlsian principles of equality (Rawls 1971) as well as anti-liberalist communitarian ideologies that argue for limiting individual choices in the name of the common good (MacIntyre 1981; Sandel 1982) will be classified as falling within the communitarian paradigm, although political philosophy makes rigorous distinctions between the two schools of thought.

For advocates of this paradigm, the above-described principles and values are the best prescription for dealing with global issues. They seek, in other words, to achieve such goals as enforcing the rule of law within the international community, guaranteeing transparency, accountability, and democratic decision-making in policies addressing worldwide concerns, realizing a world founded on fairness and social justice in which everyone is accorded an equal chance to live,[5] maintaining or restoring societal bonds at all levels of the community, ensuring public regulation of global trade and finance, and providing for the involvement of leading stakeholders in decisions having to do with corporate governance (Held 2004).

Concrete examples of the communitarian paradigm in today's world include the social democratic governments of Scandinavia and western Europe, traditionally committed to promoting such values as social welfare, workers' rights, and equal social participation for men and women. British/U.S.-style free competition and deregulation introduced through globalization have, however, begun to force shifts in these European labor and welfare policies. Threatened by losses to domestic industry and interests and faced with the related fear (both actual and perceived) of unemployment posed by the influx of cheap labor from the newly included eastern European member states, the region is becoming increasingly prey to antiglobalization and nationalistic reaction, as revealed by the recent rejection of the EU constitutional treaty in French and Dutch popular referendums held in 2005. Not all EU policies are entirely "open"; European market integration was accomplished largely to counter U.S. and Japanese economic strength, for example, and the primary goal of the Common Agricultural Policy (CAP) is to protect agriculture in the region. The European Union nevertheless represents a purposeful effort to integrate sovereign states politically and economically that is unparalleled in modern history and that will foster movements toward open regionalism in other areas of the world. Indeed, European countries such as Germany, the Netherlands, and the Scandinavian nations now stand at the helm of attempts to deal with global concerns (Scandinavian ODA is valued at over 0.7% of the total national incomes of those countries, for example), working together with international bodies to address issues including

[5] In other words, a world that allows the greatest number of people to live out their lives as fully as possible freed from fear of harm or want for basic needs.

overpopulation, development, the environment, regional conflict. Well educated and highly sensitive to concerns having to do with human rights, development, and environment conservation, these Europeans will, through their commitment to political liberalism (Held 1995, 2004) as well as to open regionalism and the development of a global community, will greatly help bring the world together toward the accomplishment of such objectives as the U.N. Millennium Development Goals.[6]

3.3.4 Cosmopolitanism

Globalization brings with it rapid and far-reaching changes in existing political, economic, and social systems that deeply threaten those unable to cope with such upheaval. At the same time that this threat begets nationalism, cultural reaction, religious fundamentalism, and other such backward-looking responses, it also inspires others to search for new political, economic, and social frameworks on which to rely. The world now faces an increasing number of issues that both developing and already developed countries are equally powerless to resolve on their own, be it enormous foreign direct investment, excessive interference by MNCs in small- and middle-sized countries, international drug syndicates, genetically modified organisms (GMOs), bovine spongiform encephalopathy (BSE), HIV/AIDS, or global warming. In urging people to look beyond the traditional nation-state in thinking about and dealing with the world, cosmopolitanism offers one possible ideological framework under which the international community may join together to overcome such shared concerns.

The greatest aim of cosmopolitanism is the realization and preservation of universal human rights. Important ideas include allegiance to humankind as a whole, global citizenship, equal rights regardless of culture, ethnicity, and gender, and responsibilities for the satisfaction of basic human needs (Held 2003). The cosmopolitan view of the ideal global community goes beyond anything imagined by political realism or by the current U.N. system founded on the principle of national sovereignty. This view calls instead for a world where everyone can be free and equal regardless of religion, creed, ethnicity, nationality, or any other affiliation. Although several past agreements including the 1948 Universal Declaration of Human Rights and the 1966 International Covenants on Human Rights have succeeded in incorporating some cosmopolitan ideals, on the whole the movement still faces many obstacles, among them questions over how to achieve its ideals within the present-day international framework based on national sovereignty, how to establish the notion of "environmental rights" within the international community, and how (and under whose responsibility) to correct the economic gaps forming between developing and developed countries as a result of rapidly spreading globalization. Some theorists argue for the need to establish a world government through which to deal with unemployment, the environment, and other worldwide issues that threaten to worsen as globalization progresses (Biermann and Bauer 2005).

The above discussion may be summarized as in figure 3.1, which diagrams the different ideological stances informing international political change as falling into two pairs of opposite

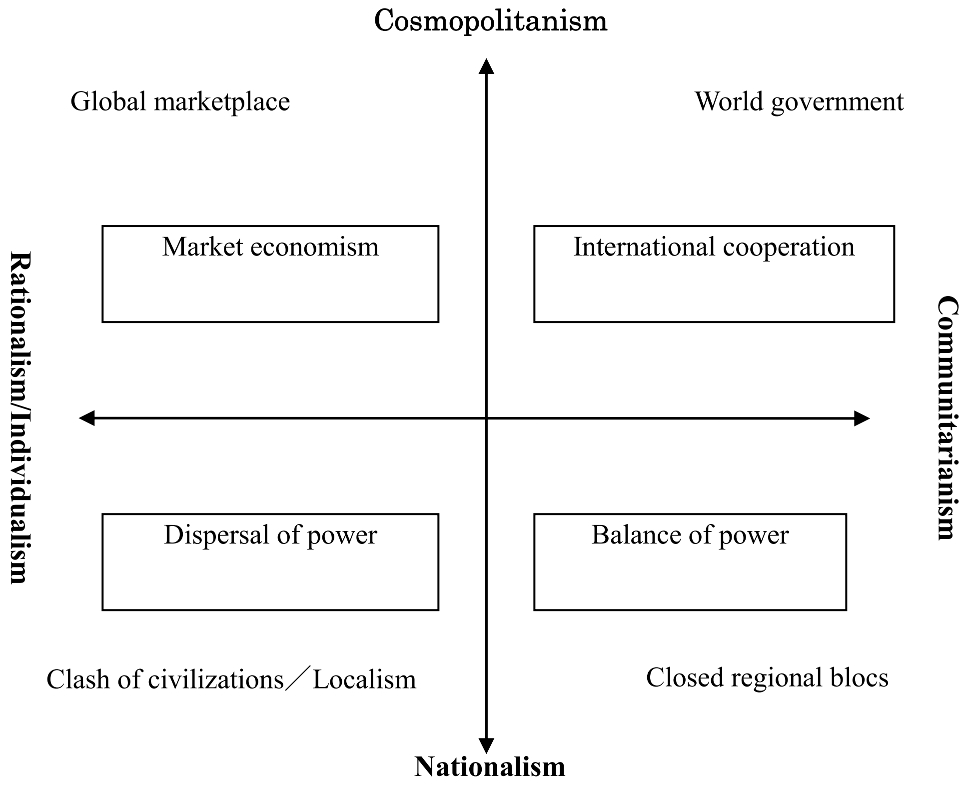
[6] Whether the European Union can truly assume such a role will, however, also depend on whether it can develop a more pluralistic identity, for example through the inclusion of nearby Islamic nations such as Turkey.

(or perhaps complementary) poles, the first being cosmopolitanism versus nationalism (sectarianism, fundamentalism, localism) and the second, rationalism/individualism versus communitarianism. The two sets of pairs are positioned along the vertical and horizontal axes of the diagram, respectively, so that the vertical axis measures the degree of relationship between individual states or regions to the rest of the world, while the horizontal axis indicates the closeness of individuals to their societies. Each paradigm taken up so far is assigned to a quadrant depending on where it falls along these two scales—international cooperation (communitarianism) in quadrant I (top right), market economism in quadrant II (top left), dispersal-of-power in quadrant III (bottom left), and balance-of-power in quadrant IV (bottom right). I consider these four to be the four basic paradigms of international political change. At the furthest corner of each quadrant is assigned the most extreme outcome possible under that basic paradigm, whether it be a single world government, a global market, localism/clash of cultures, or a world split into closed regional blocs.

The opposition between cosmopolitanism and nationalism (the vertical axis) corresponds to the longstanding dichotomy between idealism and realism in international political theory. The push and pull between rationalism/individualism and communitarianism (the horizontal axis) likewise corresponds to the stand-off between liberalism and its critics (i.e., socialist-oriented thinking); the former values personal liberty and places the good of the individual above that of society as a whole, while the latter emphasizes fairness and equality over freedom and considers society as coming before the individual.[7] In light of the above, figure3. 2 recasts the model presented earlier by reinterpreting the vertical axis as indicating differences in epistemological stance (i.e., idealistic versus realist) and the horizontal axis as showing degree of priority given to individual freedom on one hand and fairness and equality on the other. The balance achieved between these two sets of opposing forces within any given society affects the particular attributes of that society. Within the international community, too, the question of which paradigm will most influence the future largely depends on which of these pairs comes to claim relative precedence out of all the ideological attitudes and values professed by its constituents.

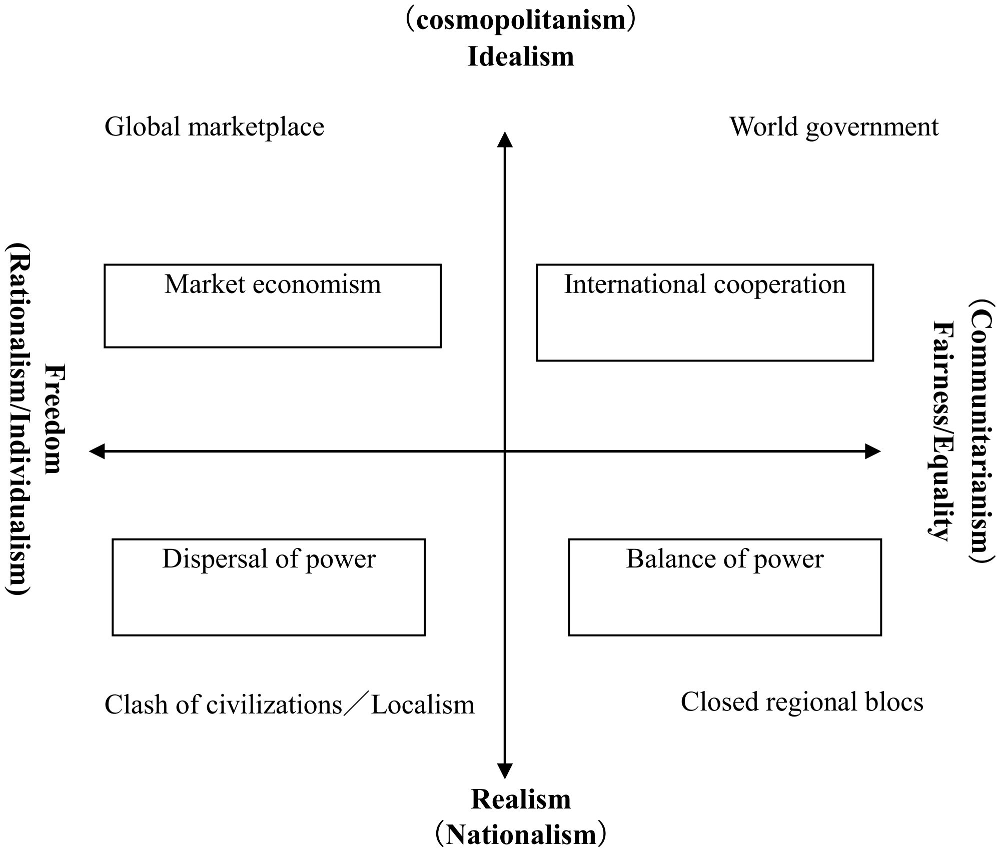
[7] Although it goes without saying that liberalism and realism, too, may be considered ideological opposites in many respects, such differences will be ignored here for the sake of simplicity.

Fiugre 3.1. Paradigms of international political change according to ideological stances



In this way, figures 3.1 and3. 2 together outline the defining ideological characteristics of the four basic paradigms as well as of their radical variants. The other diagrams classify the four basic paradigms in terms of their differences as regards primary international political structures (figure 3.3), attitudes toward international cooperation (figure3. 4), and available climate change policy options (figure 3.5). Before moving on to predict the scenarios of international political change up to 2050 possible under these paradigms, the discussion will briefly turn to the ideas taken up in figures 3–5 so as to provide some further guideposts in projecting scenario details and developing feasible formulas for burden sharing. Given the special relevance of the concept of a single world government (characterized in the figures as being a special variant of the international cooperation paradigm) to questions having to do with climate change policy, however, the discussion will actually treat a total of five, not four, paradigms of international political change.

Figure3. 2. Paradigms of international political change as classified according to different epistemological stances and values



To begin first with this idea of a single world government, there can be no doubt that the emergence of such a centralized international governing system would be greatly beneficial as far as climate change and other global-scale problems are concerned. A global government would enable policy coordination and efficiency throughout the world while also guaranteeing international cooperation in setting, implementing, and overseeing binding goals toward realizing these policies. Not only would it be able to efficiently allocate resources for development of new technology, but it would also have a wide variety of comprehensive policy options at its disposal, including direct regulation, reliance on market mechanisms, and research into technological solutions. Given the current state of affairs in the world, however, there is little chance that a centralized global government will come into being anytime soon, although there has been some discussion regarding the possibility of setting up a Global Environment Organization (GEO) or World Environment Organization (WEO) specialized to deal with environmental concerns (Biermann and Bauer 2005). In any case, such a formal centralized governing body, however achieved, will represent the constitutional system in its state of ultimate evolution.

Turning now to each of the four basic paradigms, international cooperation as it stands today operates on a framework developed following the end of World War II. The twin pillars of this framework are the United Nations system established for world peace on the one hand (Held 1995) and the Bretton Woods system instituted to govern international finance and free trade on the other. What distinguishes this framework from the centralized constitutional world government described above is that the former recognizes no authority higher than that of the state. The U.N. Charter, for example, guarantees members political and territorial autonomy as well as noninterference in domestic affairs based on an understanding of the nation-state as the fundamental compositional unit of the international community.

More recently, however, this state-centered framework has come to be challenged by the increasingly greater roles assumed by NGOs (both non-profit and otherwise) in dealing with such global issues as the environment or human rights. International bodies, central and local governments, corporations, NGOs, NPOs, and other multiple stakeholders are now joining together to address worldwide concerns and conduct international affairs in a way that transcends the traditional distinctions between nation-states. Also underway are efforts to unite the countries of a single region in accordance with the ideals of "open regionalism" described earlier, as Europe is now doing through its (so far unsuccessful) attempts to establish an EU constitution. EU member states already cooperate in a wide variety of policy areas including climate change, working together to develop market and technological strategies, encourage environmental oversight and ecolabeling, and introduce regulation binding throughout the entire region (albeit with some minor adjustments from country to country). Should other regions of the world also one day follow suit with such measures, then international cooperation will become more far-reaching and effective than it is now.

The balance-of-power paradigm posits a world divided into one, two, or multiple spheres of influence. Unlike in the international cooperation paradigm, here the great powers of the world actively vie with each other for global and regional dominance. Many present-day international alliances, whether multilateral (e.g., NATO) or bilateral (e.g., between Japan and the United States), exist purely for the sake of joining forces against other opposing factions, for example. Indeed, it must be admitted that even the European Union, for all its commitment to international cooperation, went ahead with market integration at least partly to collectively counter the economic power of NAFTA (led by the United States) and Japan. In Asia, meanwhile, the impending rise of China and India threatens to unleash balance-of-power struggles throughout the region as China, India, Japan, the United States, and South Korea, not to mention the ASEAN nations, all compete for regional hegemony.

It is sometimes possible for environmental technology to advance even under the balance-of-power paradigm and its focus on competition, as happened for example when the Muskie Act, intended to reduce air pollution in the United States, galvanized Japanese automobile manufacturer efforts to develop cleaner and more efficient engines. Although passage of this bill regulating automobile emissions was initially delayed in the United States, its introduction into Congress sparked concern among Japanese automakers, for whom success in the U.S. market was crucial. Japan immediately responded by passing legislation similar to the bill and launching efforts to develop new technology for cleaner air sponsored by the public and private sectors alike. As a result, Japanese automakers were able to significantly enhance engine efficiency while also reducing the emission of sulfur oxides and other harmful gases, greatly cutting into the U.S. market in the process. On the whole, however, such positive examples remain the exception than the rule. Under the balance-of-power paradigm, rivalry generally precludes the possibility of coordinated international action on the environment, leaving economic incentives (e.g., subsidies) and development of new technology the two main recourses available for pursuing climate change policy and other basic environmental goals.

Like the international cooperation and balance-of-power paradigms, the dispersal-of-power paradigm tends toward decentralization in the sense that it does not envision the establishment of a single world government. But unlike the other two, which allow for some form of international governance, dispersal-of-power deliberately avoids any form of active alliance between the different parts of the world, whether it be for promoting international cooperation or for establishing spheres of influence. Of the two futures possible under this paradigm, the antagonistic model foreshadows a fractured and leaderless world where separate states, religions, ethnic groups, corporations, NGOs, and terrorist groups cling chauvinistically and selfishly to their own sectarian or fundamentalist doctrines. Each country, group, or region will put its own concerns above those of its country or the world at large. As far as climate change policy is concerned, none of these entities will take it upon themselves to introduce any sort of reform, simply waiting to hitch a free ride on others' efforts or decrying the past responsibility of others while refusing to rein in their own greenhouse gas emissions. The result will be a complete breakdown in global warming policy likely to be worse than the B-a-U, or "business as usual," approach of not trying to do anything at all.

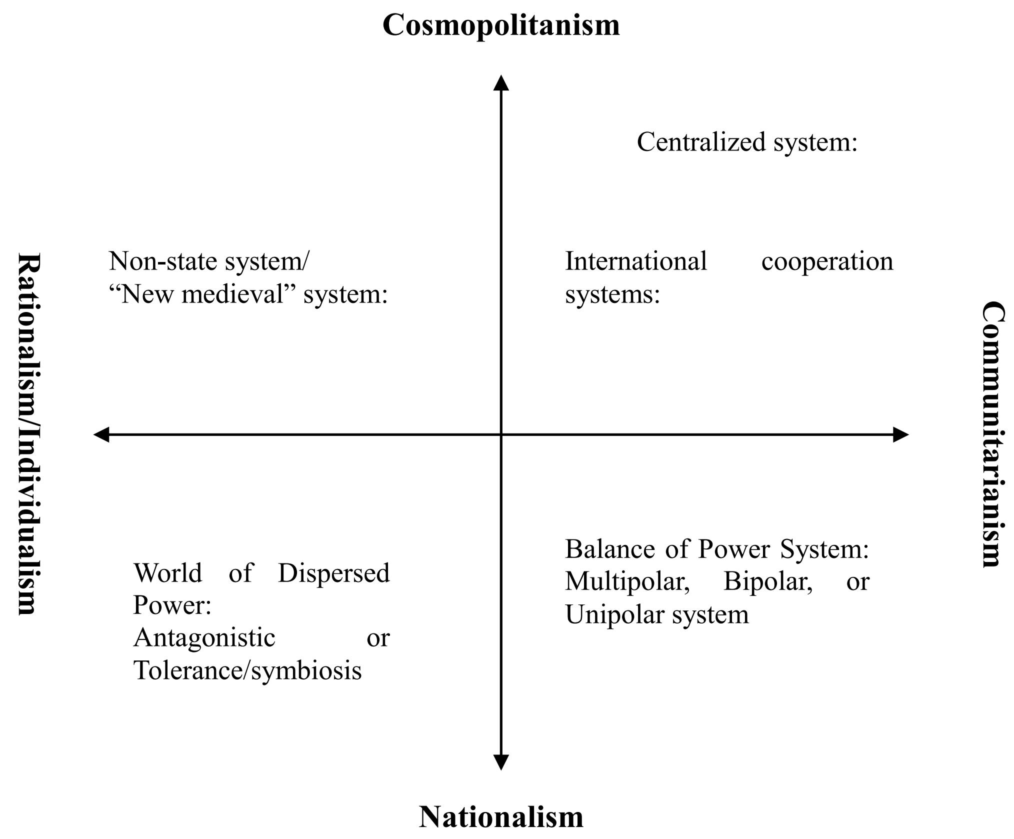
Under the tolerant/symbiotic model, however, things would be quite different. Although individual groups will still tend to place local interests above those of the country or the international community, locally initiated efforts on behalf of the environment will spread sustainable appropriate technology in developing countries while promoting technological advancement and ecological modernization in developed ones, adding up altogether to help ease climate change. The overall effectiveness of such efforts will be hard to predict, however, given their dependence on sporadic isolated measures carried out by individual parties without reference to an overarching and coordinated international action plan.

Finally, the market economism (or globalist) paradigm—as captured in such characterizations as "the retreat of the state" (Strange 1996) or "the borderless world" (Ohmae 1990)—posits a world where the main actors in international politics are no longer sovereign nation-states but rather business interests as represented by global market forces and MNCs. Under this paradigm, the private sector works on governments to establish WTO and other international trade rules of advantage to MNCs (e.g., deregulation of trade and finance or protection of intellectual property rights). The term "new Middle Age" occasionally heard nowadays compares the influence exercised not by states but by MNCs, international NGOs, and other nongovernmental entities over present-day international relations to the power once wielded by religion in maintaining the medieval world order (Gilpin 2003).

Advocates of market economism typically favor small government, campaigning for less or no legal restrictions on corporate and social endeavors and encouraging stimulation of private enterprise through transfer of as much power from the public to private sector as possible at both the national and international levels. In terms of environmental policy they argue against direct regulation, preferring to rely on voluntary effort and technological remedies instead. Thus climate change policy under the globalist paradigm will consist largely of nonbinding market strategies combined with the search for new technological solutions. While market competition may very well turn out to be the best way to efficiently and effectively allocate resources and inspire new technology toward preventing global warming, it is equally possible that over-reliance on market mechanisms will only end up concentrating wealth and technical know-how in the hands of a select few MNCs and large-scale investors without doing anything for the environment at all.

Figures 3.3, 3.4, and3. 5 summarize the above discussion of the four basic paradigms of international political change (and one variant thereof), using the analysis of their ideological foundations set out in figures 3.1 and3.2 to make assertions about their differences as regards systems of international governance,[8] attitudes toward international cooperation, and strategies for dealing with climate change, respectively. With this background in mind, the final section will outline the scenarios of international political change most likely to take place under these four basic paradigms.

Figure 3.3 Paradigms of international political change as classified according to primary international political structures



[8] Alternatively, it may also be possible for the institution of a certain system of governance to determine the nature of the paradigm that will become predominant under that system.

Figuren 3.4 Paradigms of international political change as classified according to approaches toward international cooperation

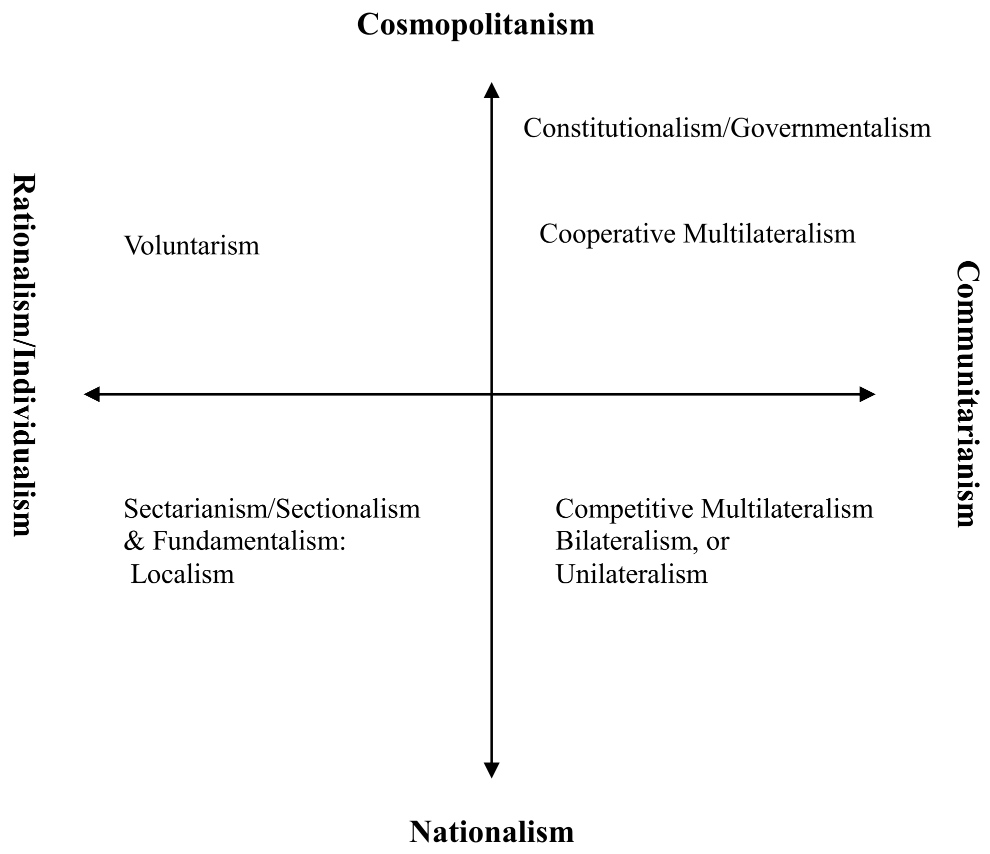


Figure3.5 Paradigms of international political change as classified according to climate change policy option

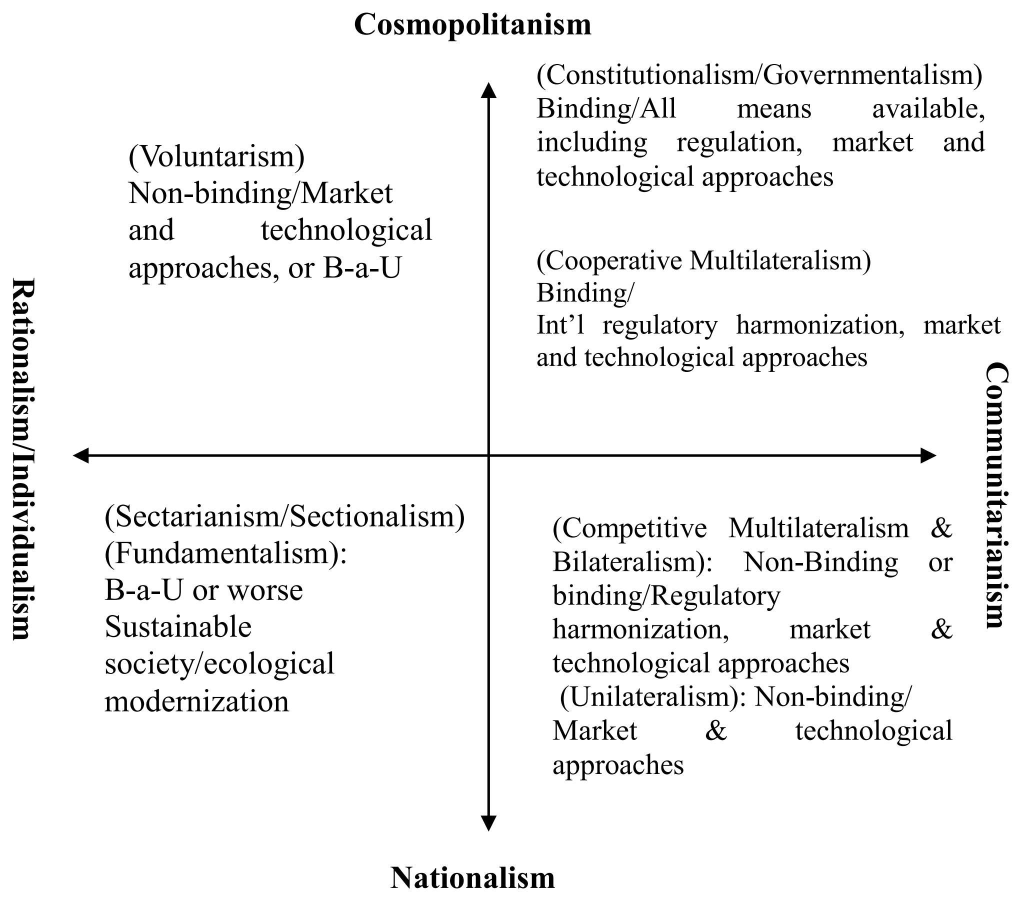
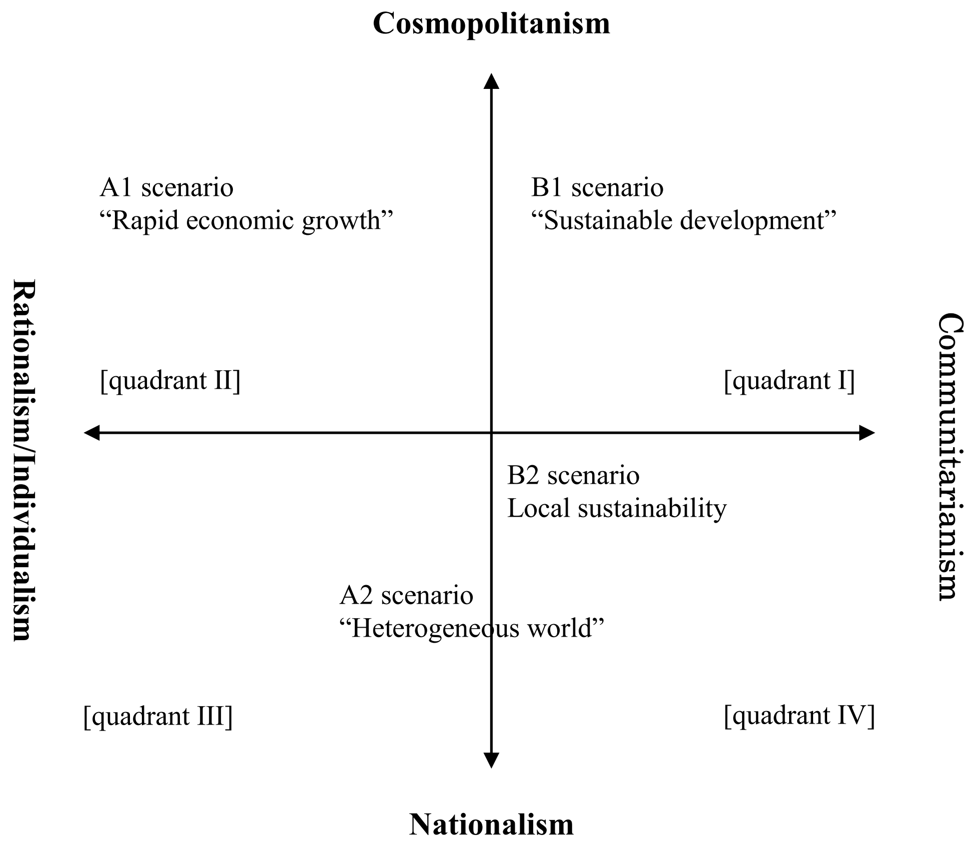


Figure 3.6 Paradigms of international political change as compared to climate change



3.4 In Lieu of Conclusion: Storylines for Four Basic Scenarios of International Political Change

Of the four basic paradigms, market economism is by far the most prevalent in the world today. In accordance with this trend, the market economism scenario projects that the present-day consumer societies of the West and Japan will continue to spread throughout the world, leading to an extension of current long-term trends (i.e., B-a-U, although with market strategies and technological advancement opening up the possibility of some improvement of environmental conditions). MNCs will come to assert greater and greater influence over trade, communications, and finance, overtaking all but the OECD, NIES, and BRIC nations in economic scale. As a result, the world will continue to suffer from the effects of both environmental degradation and global warming.

The international cooperation scenario, meanwhile, predicts that the world will eventually come to correct the economic and social inequities caused by market economism through adherence to the principles of communitarianism and open regionalism. Committed to liberalism but with an even deeper dedication to equality, fairness, and social justice, the world will cooperate in realizing such goals as preserving and restoring local identities, ensuring social justice and the public good at the national level, and jointly protecting the international politico-economic order, global climate, and other assets recognized as being the humankind's common heritage. The international community will move actively to support new technologies for sustainable agriculture, energy conservation, and environmental protection while also working toward the U.N. Millennium Development Goals, making this the preferred scenario as far as climate change policy is concerned.

The balance-of-power scenario envisions a world in which resistance to market economism fuels heightened nationalism, sparking frequent clashes over water, energy, and other such limited resources. The result may be a bilateral world split between the two superpowers of China and the United States, or perhaps a multilateral one in which the United States, European Union, Japan, and BRIC each have some say in international politics. Rivalry among states will make it extremely difficult to guarantee fair allocation of resources or to secure international cooperation in developing new technology, despite the urgent need for such technology in producing enough food, goods, and energy to support all the people of the world. Thus under this scenario, conditions of climate change will only worsen.

Two different futures are possible under the dispersal-of-power scenario. The antagonistic model forecasts that dissatisfaction with market economism, mass migration of refugees across international borders, and other factors leading to social instability will open the way toward extreme sectarian or fundamentalist movements that call for violent social change and exclusion of alien cultures and ethnic groups. At best the world will only carry on business-as-usual and global warming will increase at current rates; more likely, however, spreading deforestation and dearth of new technology could lead to even worse damage than currently projected. The result will be a vicious circle in which the suffering imposed on the less powerful regions or elements of society begets even harsher forms of sectarianism and fundamentalism.

By contrast, the tolerance/symbiosis model projects general improvement in conservation and environmental preservation throughout the world based on the incremental effects of efforts to introduce sustainability into developing countries on the one hand combined with promotion of ecological modernization and recycling in some developed parts of the world on the other. But the sporadic and uncoordinated nature of these efforts carried out separately across the world makes it difficult to ascertain exactly how effective they will be in dealing with global climate change.

Based on the above, the present paper will close with a table briefly characterizing the four basic scenarios in terms of their optimal (or most extreme) possible outcomes, long-term outlooks on population, economic growth, technology, and energy issues, and comparison to SRES predictions(See Table 3.1 and Figure 3.6).[9] The preliminary nature of this outline will, however, require that further refinements be made before its predictions can be satisfactorily quantified.

---

[9] SRES, short for "Special Report on Emissions Scenarios," scenarios developed by the Intergovernmental Panel on Climate Change to predict worldwide trends in greenhouse gas emissions (IPCC 2000).

References

Biermann, Frank, and Steffen Bauer. 2005. A World Environment Organization: Solution or Threat for Effective International Environmental Governance? Hants, UK: Ashgate.

Bok, Sissela. 1989. A Strategy for Peace: Human Values and the Threat of War. New York: Pantheon.

Bull, Hedley. 1977. The Anarchical Society: A Study of Order in World Politics. New York: Columbia University Press.

Carr, E. H. 1951. The Twenty-Years' Crisis, 1919–1939. 2nd edition. London: Macmillan.

Daly, Herman E. , and John B. Cobb, Jr. 1994. For the Common Good: Redirecting the Economy toward Community, the Environment, and a Sustainable Future. Boston: Beacon Press.

Gilpin, Robert. 2003. "A Realist Perspective on International Governance." In Held and McGrew 2003, 237–48.

Held, David. 1995. Democracy and the Global Order: From the Modern State to Cosmopolitan Governance. Stanford: Stanford University Press.

_____. 2003. "Cosmopolitanism: Ideas, Realities and Deficits." In Held and McGrew 2003, 305–24.

_____. 2004. Global Covenant: The Social Democratic Alternative to the Washington Consensus. Cambridge: Polity.

Held, David and Anthony McGrew, eds. 2003. Governing Globalization: Power, Authority and Global Governance. Cambridge: Polity.

Hawken, Paul, Amory Lovins, and L. Hunter Lovins. 1999. Natural Capitalism: Creating the Next Industrial Revolution. Boston: Little, Brown and Company.

Homer-Dixon, Thomas F. 1999. Environment, Scarcity, and Violence. Princeton: Princeton University Press.

Huntington, Samuel P. 1996. The Clash of Civilizations and the Remaking of World Order. New York: Touchstone.

Intergovernmental Panel on Climate Change (IPCC). 2000. IPCC Special Report on Emission Scenarios. Cambridge: Cambridge University Press.

Jänicke, Martin. 1992. "Conditions for Environmental Policy Success: An International Comparison." The Environmentalist 1(12): 47–58.

_____. 1996. "Democracy as a Condition for Environmental Policy Success: The Importance of Non-Institutional Factors." In Democracy and the Environment: Problems and Prospects, ed. William M. Laffery and James Meadowcroft. Cheltenham, UK: Edward Elgar.

Kedourie, Elie. 1993. Nationalism. 4th edition. Oxford: Blackwell.

Kennedy, Paul. 1993. Preparing for the Twenty-First Century. New York: Random House.

Klare, Michael T. 2001. Resource Wars: The New Landscape of Global Conflict. New York: Owl Books.

Kuhn, Thomas S. 1970. The Structure of Scientific Revolutions. Chicago: University of Chicago Press.

MacIntyre, Alasdair. 1984. After Virtue: A Study in Moral Theory. 2nd edition. Notre Dame: University of Notre Dame Press.

McGrew, Anthony. 2003. "Liberal Internationalism: Between Realism and Cosmopolitanism." In Held and McGrew 2003, 267–89.

Morgenthau, Hans J. 1972. Politics among Nations. New York: Knopf.

National Intelligence Council (NIC). 2004. Mapping the Global Future: Report of the National Intelligence Council's 2020 Project. Washington, DC: Government Printing Office.

Nozick, Robert. 1974. Anarchy, State, and Utopia. New York: Basic Books.

Ohmae, Kenichi. 1990. The Borderless World: Management Lessons in the New Logic of the Global Marketplace. New York: HarperCollins.

Petrini, Carlo. 2003. Slow Food: The Case for Taste. Trans. William McCuaig. New York: Columbia University Press.

Sandel, Michael. 1998. Liberalism and the Limits of Justice. 2nd edition. Cambridge: Cambridge University Press.

Schumacher, Ernst Friedrich. 1973. Small Is Beautiful: Economics as If People Mattered. New York: Harper & Row.

Simon, Julian L. 1996. The Ultimate Resource 2. Princeton: Princeton University Press.

Strange, Susan. 1996. The Retreat of the State. Cambridge: Cambridge University Press.

Waltz, Kenneth N. 1979. Theory of International Politics. Reading, MA: Addison-Wesley.

Von Weizäcker, E. U., Amory Lovins, and L. Hunter Lovins. 1997. Factor Four: Doubling Wealth, Halving Resource Use. London: Earthscan.

Wolf, Martin. 2004. Why Globalization Works. New Haven: Yale University Press.

4. Japan's Permitted GHG Emissions Reduction Range in 2050

4.1. Differentiation schemes and International Political Change Scenario

Alongside the long to mid term GHG emissions reduction policy targets at various levels of the government, which are presented in chapter five, there have been scientific studies on differentiating GHG reductions across countries. For example, ECOFYS has presented its report on the result of the calculation of the differentiation of CO_2 emission using the IMAGE model, based on the SRES A1B scenario of IPCC (Hone et al 2004). Similarly, the Dutch research institute RIVM has conducted calculations of differentiation on the CO_2 emission equivalency of the emission of the six greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) included in the Kyoto Protocol using IMAGE model, based on the SRES A2 scenario (den Elzen and Berk 2004). Differentiation formulas in the existing studies are principle oriented, i.e. all people on the Earth should have the same right to emit GHGs. The major ideas of the existing studies are introduced below.

4.1.1 Contraction and Convergence (C&C or Per Capita Convergence)

This is one of the simpler and clearer calculation rules, and therefore, many policy-oriented researches, such as GCI, RIVM and ECOFYS, use this approach in order to draw a country-based GHG reduction target. In this approach it is estimated that a global emission concentration stabilization level, such as 450ppm or 550ppm, would be agreed upon and the path to realize such stabilization level would also be agreed upon at the global level, including for both industrialized and developing countries. The differentiation of emissions is made based on a rule in which per capita emissions converge on the global level in a specific year, such as 2050.

4.1.2 Common but Differentiated Convergence (CDC)

This is an applied model of the C&C, based on the same kind of differentiation rule, but a different rule is applied for developing countries in that they may reach the same target as the developed countries at some later point in time and conditional to the developed countries' actions. Therefore, the convergence of developing countries begins when a country's emission reaches to the global average per capita emissions. The amount of time necessary to reach the level of convergence would be the same for both developed and developing countries.

4.1.3 Multistage Approach

Countries gradually move through several stages of emission target in terms of stringency. The stringency of the emission reduction is increased as the economy develops. A certain level of threshold is set for countries to move on to the next stage. Usually stages are divided into three or four, as opposed to the Kyoto Protocol's two stages of Annex-I and Non-Annex I, in a manner such as this:

a) Absolute emission reduction stage
b) Stabilization stage
c) Intensity target stage (emission per GDP)
d) No commitments stage

4.1.4 Brazilian Proposal (or historical responsibility)

An approach based on a proposal originally submitted by the Brazilian government for emission differentiation before the Kyoto Conference. It attributes emission responsibilities to the impact of a country's historical contributions to surface temperature change. The approach requires very complex analysis to identify historic emissions and their contributions to temperature change. Further research has been done as a MATCH project.[1]

4.1.5 Triptych Approach

The triptych approach distinguishes three emission sectors: the power sector, the energy-intensive sector and the domestic sector (including the residential and the transport sectors). The emission of each sector is treated by different calculation method, and then each sector's emission is added up for a national emission allowance. Therefore, one target is set for one country, and no sector targets are set. For the electricity production and the industrial production sectors, growth in physical production and production efficiency are assumed, taking into account the need for economic development. They would eventually converge into a certain level throughout the world. The domestic sector is calculated to converge per capita emission in a particular year (Hohne et al. 2004).

4.1.6 Multi-sector Convergence

A similar approach to the Triptych Approach, but has seven sectors as opposed to the three sectors of the Triptych Approach.

Looking at these proposals in terms of the International Political Change scenario, which was introduced in the chapter 3, most of the approaches fall under the "multilateral target-setting scenario", where cosmopolitanism and communitarianism prevail. Others go under the globalization paradigm and fall into the "prioritize economic globalization scenario". The above-mentioned proposals are allocated on the International Political Change scenario, described in the previous chapter, in Figure 1.

1 http://www.match-info.net

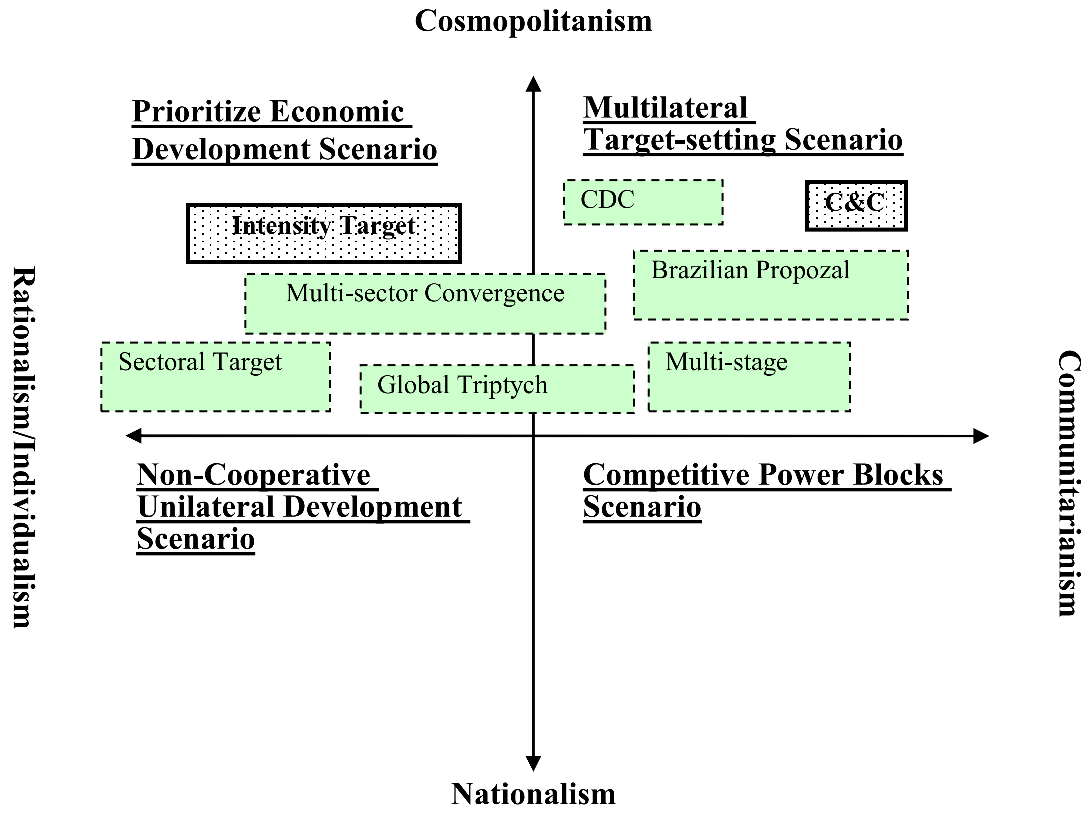


Figure 1. International Political Change Scenario and Existing Approaches

4.2 Japan's GHG emissions reduction in 2050

Table 1 shows the results from two existing studies of the 2050 emissions reduction required for Japan. All figures are the reduction from 1990 levels.

CO_2

	Multi-stage	C&C	Common but Differentiated Convergence (CDC)	Triptych
400ppm	-84.05%	-77.34%	-88.31%	-84.06%
450ppm	-81.45%	-71.67%	-77.68%	-69.10%
550ppm	-62.65%	-45.23%	-52.16%	-46.47%

Source: Original, based on Hohne et al (2004)

GHG

	Multi-stage	C&C	Brazilian Proposal	Triptych
550ppm	-70.63%	-74.35%	-74.08%	-65.26%
650ppm	-45.33%	-55.30%	-61.87%	-23.27%

Source: Original, based on den Elzen and Berk (2004)

Table 1. Japan's Emission in 2050 Calculated for Different Stabilization Levels and Different Differentiation Approaches

As these figures show that Japan's GHG emissions reduction required in 2050 is fairly high, especially taking into consideration the level of GHG emissions reduction in order to avoid a dangerous level of climate change, as presented in chapters 1 and 2.

Still, there might still be skeptics of climate change and people who would like to find reasons not to introduce any measures that may change the current business as usual practices, accusing the scientific uncertainties involved in the science of climate change. In fact, as Pershing and Tudela described, there are at least five stages in the science of climate change where scientific uncertainty can come into place (Pershing and Tudela 2003).

In this study our team attempts to take scientific uncertainty into consideration in calculating the GHG emissions reduction needed by 2050. In other words, in this way we will be able to show the range of the level of GHG emissions reduction in a more robust manner. The calculation is based on the climate change policy support tool AIM/Impact[Policy]. In doing so, we have introduced three sets of scientific uncertainties that could be included in the calculations. The three uncertainties considered here are as follows.

First, we have a variation in the level of allowed temperature increase. As we saw earlier in chapter 1, it becomes increasingly clear that the risk of climate change gets higher if the Earth's surface temperature increases more than 2℃ above pre-industrial level. However, still there is room for uncertainty both scientifically and in terms of the values or the senses of human beings. That is, ultimately the dangerous level of climate change may be determined by the personal values of each citizen or their political judgment. For example, whether the level at which a dangerous level is considered to have been reached is dependent upon an increase in human or economic damage caused by the growing magnitude of typhoons or hurricanes, or a loss in biological diversity, depends on one's individual living or working environment, or on political or economic circumstances. It may also depend on individual experience. It is true that a precautionary approach is important for such an issue as climate change, where many impacts are currently under scientific investigation. That said, perspectives on risks could be different from person to person, or from organization to organization. Therefore, societal decision-making as an accumulated sum of individual decision-making, although there could be the effects of collective decision-making, may ultimately be subject to change due to values. Thus, we included 2.2℃ and 2.5℃ increase of temperature cases (above the pre-industrial level), in addition to a 2.0℃ increase case, in our examination. According to AIM Impact[policy], these correspond to 500ppm, 550ppm and 475ppm GHG concentration levels respectively.

The second factor taken into consideration is climate sensitivity in the model, because the GHG reduction path changes due to climate sensitivity. In the case of 2.0℃ stabilization, for instance, a GHG concentration level of 560ppm corresponds to it if the climate sensitivity is 2.0℃. However, it becomes 440ppm if climate sensitivity is 3.0℃. Thus, we use three different climate sensitivity levels here, namely 2. 0℃, 2. 6℃ and 3. 0℃.

The third factor is global differentiation. As mentioned earlier, there have already been some proposals of differentiation schemes. Taking those approaches into consideration, and having international political change scenarios in mind, we used six ways of differentiation that may be useful for looking at a range of levels of GHG emissions reduction in 2050. As for international political change, we analyze that the current political situation has led to two directions, one is a world envisaged by a "multilateral target-setting scenario" led by the

Kyoto Protocol and its parties, and the other one is the one envisaged by an "economic development first scenario" led by the US and other parties that are interested mostly in economic development in the first place. For this study we have to focus on these two scenarios, leaving examination of the other two scenarios for further study in the future.

As described in chapter 3, a "multilateral target-setting scenario" considers equity, equality and justice as important values. It further believes in a multilateral system for the management of international public good. This way of thinking is affinitive to a Contraction and Convergence (C&C) approach, as it seeks eventual equal per capita emissions. We have chosen this approach as representing this scenario. The year of convergence may not necessarily be 2050, however. Therefore, we set the converging year to three; 2050, 2070 and 2100.

The "economic development first scenario" considers climate policy in conjunction with economic development. Like a reduction target by the Bush administration, GHG emissions reduction may also be measured in relation to economic activities. GHG emissions reduction considered in relation to economic activities is affinitive to an intensity-based approach when one is to set a limit on emissions. For the middle to long term, measuring GHG emissions reduction in relation to GDP can be undertaken in two ways. One is the convergence of per GDP emissions throughout the states in the world. Different from C&C, this approach does not secure the equal right to emit per person; however, it may secure equity of the impact of GHG emissions reduction to economic activities measured by GDP in a certain year. Bearing in mind that the current gap of intensity among countries is big (meaning that shorter-term convergence requires a huge emissions reduction for a particular country), the converging year for these cases are set at 2070 and 2100 for the current study. Another approach is that of an equal intensity improvement level throughout the world. This approach also fits with a sector based approach, but we do not deal with it here because of a problem of data availability.

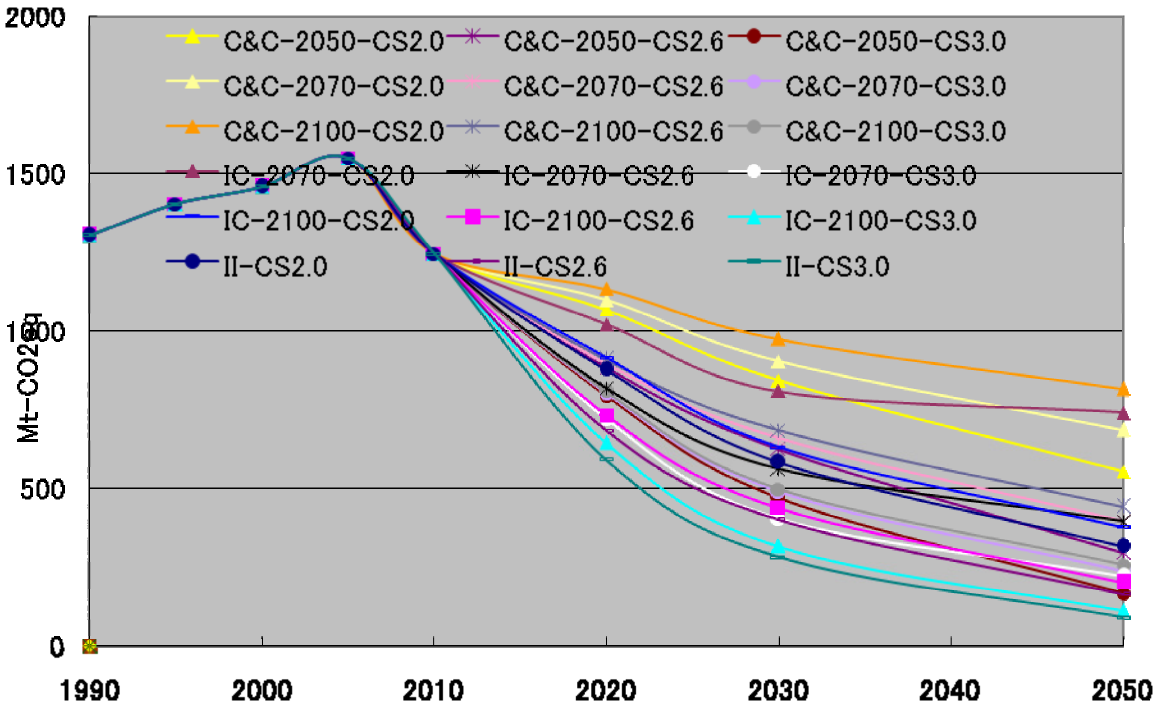
Each differentiation approach is considered in reference to an international political change scenario, and therefore they represent an extreme picture of the world in a sense. It is likely that reality is a more modest picture and comes into place in-between extreme pictures of the world. This is, however, a positive sign for the purpose of this chapter, because the range of GHG emissions reduction is made clear by looking at extreme cases. A modest scenario should fit in somewhere between the extreme cases.

4.3 Results of calculation

As 2 ℃ is a point of departure for discussion about dangerous levels of climate change, we would first like to present the fixed level of a 2 ℃ target and consider the scientific uncertainties of climate sensitivity and international differentiation. The result of the calculation is presented below.

Differentiation approach	Climate sensitivity		
	2.0	2.6	3.0
C&C 2050	57	77	87
C&C 2070	47	70	82
C&C 2100	37	66	80
Intensity Convergence 2070	43	70	83
Intensity Convergence 2100	71	85	91
Equal Intensity Improvement	76	87	93

Table. Japan's necessary GHG emissions reduction in 2050 for stabilization of 2□ temperature increase (from 1990 level)



14 cases out of 18 samples represent a 60-90% reduction. There are also cases where Japan's emissions reduction is around 50% from 1990 level when low climate sensitivity is combined with differentiations that require a lower emission reduction for Japan. Given that the average climate sensitivity is 3.0℃ in the IPCC Fourth Assessment Report, however, that is an exceptional scenario. In fact, even the lowest Japanese emissions reduction is 80% when climate sensitivity is 3.0.

Emissions reductions for other countries are shown below.

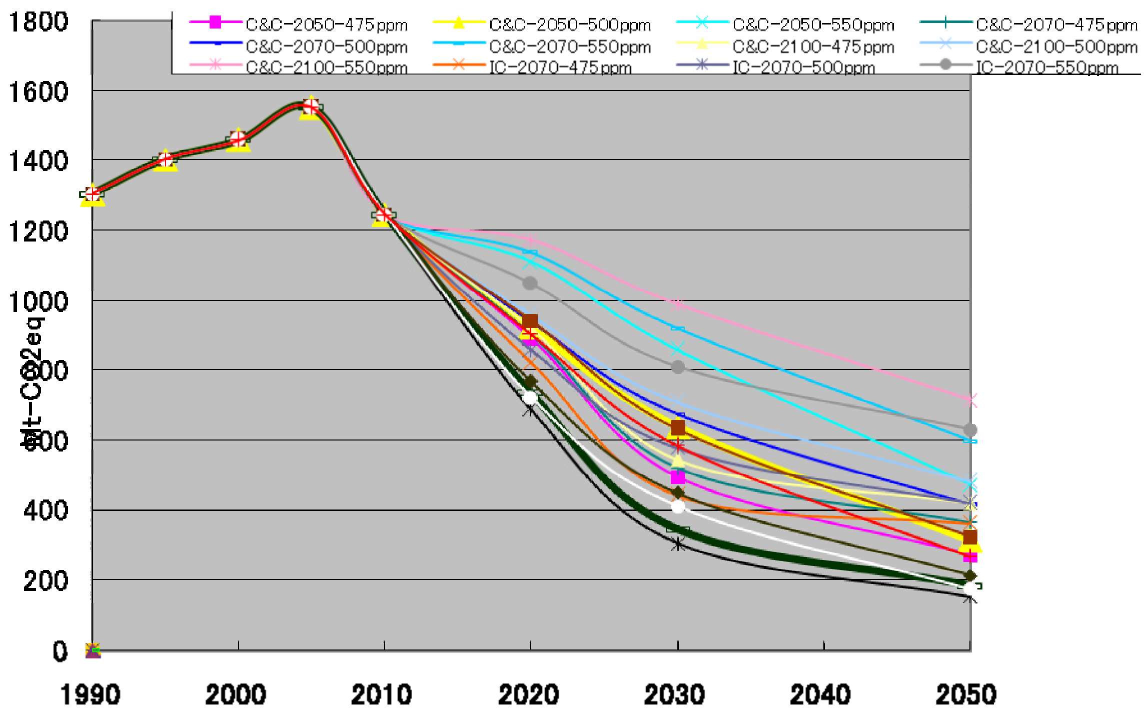
	JPN	USA	CAN	AUS	RUS	EU25	AnnexI
C&C-2050-CS2.0	0.574	0.682	0.676	0.741	0.854	0.603	0.673
C&C-2050-CS2.6	0.773	0.831	0.827	0.862	0.922	0.788	0.826
C&C-2050-CS3.0	0.872	0.904	0.902	0.922	0.956	0.880	0.902
C&C-2070-CS2.0	0.474	0.284	0.444	0.357	0.741	0.481	0.462
C&C-2070-CS2.6	0.697	0.529	0.652	0.571	0.837	0.696	0.666
C&C-2070-CS3.0	0.818	0.690	0.778	0.715	0.895	0.815	0.788
C&C-2100-CS2.0	0.374	-0.110	0.215	-0.022	0.631	0.362	0.254
C&C-2100-CS2.6	0.661	0.387	0.569	0.435	0.797	0.653	0.591
C&C-2100-CS3.0	0.803	0.632	0.744	0.660	0.879	0.798	0.758
IC-2070-CS2.0	0.432	0.329	0.519	0.290	0.521	0.513	0.426
IC-2070-CS2.6	0.697	0.642	0.743	0.621	0.745	0.740	0.694
IC-2070-CS3.0	0.829	0.798	0.855	0.786	0.856	0.853	0.827
IC-2100-CS2.0	0.710	0.431	0.607	0.357	0.463	0.630	0.507
IC-2100-CS2.6	0.845	0.696	0.790	0.657	0.714	0.803	0.737
IC-2100-CS3.0	0.913	0.828	0.882	0.806	0.838	0.889	0.852
II-CS2.0	0.758	0.458	0.628	0.381	0.466	0.656	0.530
II-CS2.6	0.873	0.717	0.806	0.676	0.721	0.820	0.754
II-CS3.0	0.930	0.844	0.893	0.822	0.846	0.901	0.864

	CHN	IND	BRA	MEX	KOR	MYS	Africa
C&C-2050-CS2.0	-0.741	-3.769	-0.549	-0.393	0.235	-0.880	-4.426
C&C-2050-CS2.6	0.071	-1.544	0.174	0.257	0.592	-0.003	-1.895
C&C-2050-CS3.0	0.476	-0.436	0.534	0.580	0.770	0.434	-0.634
C&C-2070-CS2.0	-0.711	-2.878	-0.542	-0.428	-0.101	-1.160	-3.211
C&C-2070-CS2.6	0.094	-0.871	0.179	0.230	0.338	-0.215	-0.976
C&C-2070-CS3.0	0.492	0.044	0.537	0.562	0.589	0.283	0.020
C&C-2100-CS2.0	-0.682	-1.999	-0.535	-0.463	-0.431	-1.437	-2.013
C&C-2100-CS2.6	0.104	-0.554	0.181	0.218	0.219	-0.315	-0.544
C&C-2100-CS3.0	0.496	0.172	0.538	0.557	0.540	0.242	0.196
IC-2070-CS2.0	-1.640	-2.390	-0.405	-0.425	0.333	-0.486	-1.606
IC-2070-CS2.6	-0.409	-0.809	0.250	0.240	0.644	0.207	-0.390
IC-2070-CS3.0	0.205	-0.021	0.577	0.571	0.799	0.552	0.215
IC-2100-CS2.0	-1.865	-2.568	-0.291	-0.362	0.371	-0.509	-1.837
IC-2100-CS2.6	-0.529	-0.904	0.311	0.273	0.665	0.195	-0.514
IC-2100-CS3.0	0.137	-0.075	0.611	0.590	0.811	0.546	0.146
II-CS2.0	-1.838	-2.520	-0.247	-0.324	0.390	-0.480	-1.812
II-CS2.6	-0.483	-0.839	0.349	0.308	0.681	0.227	-0.469
II-CS3.0	0.182	-0.014	0.641	0.619	0.824	0.574	0.190

Next is a fixed climate sensitivity at 2.6℃ and variations of stabilization levels at 2℃（475ppm）, 2.2℃（500ppm） and 2.5℃（550ppm）, while differentiation approaches also take 6 patterns.

Differentiation approach	Stabilization level		
	2.0℃ (475ppm)	2.2℃ (500ppm)	2.5℃ (550ppm)
C&C 2050	79	76	64
C&C 2070	72	68	54
C&C 2100	68	63	45
Intensity Convergence 2070	72	68	52
Intensity Convergence 2100	86	84	75
Equal Intensity Improvement	88	87	80

Figure. Japanese GHG emission reduction from 1990 level with climate sensitivity 2.6℃



Among 18 cases, 5 are 60-70%, 4 are 70-80%, 5 are over 80%. More than 80% of the cases require 60-80% reduction. Emissions reductions for other countries are shown below.

	JPN	USA	CAN	AUS	RUS	EU25	AnnexI
C&C-2050-475ppm	0.79	0.84	0.84	0.87	0.93	0.81	0.84
C&C-2050-500ppm	0.76	0.82	0.82	0.85	0.92	0.77	0.82
C&C-2050-550ppm	0.64	0.73	0.72	0.78	0.88	0.66	0.72
C&C-2070-475ppm	0.72	0.56	0.67	0.60	0.85	0.72	0.69
C&C-2070-500ppm	0.68	0.51	0.64	0.55	0.83	0.68	0.65
C&C-2070-550ppm	0.54	0.35	0.51	0.42	0.77	0.55	0.52
C&C-2100-475ppm	0.68	0.40	0.58	0.44	0.80	0.67	0.60
C&C-2100-500ppm	0.63	0.31	0.52	0.37	0.77	0.62	0.55
C&C-2100-550ppm	0.45	0.00	0.30	0.08	0.67	0.44	0.34
IC-2070-475ppm	0.72	0.67	0.76	0.65	0.77	0.76	0.72
IC-2070-500ppm	0.68	0.62	0.73	0.60	0.73	0.72	0.68
IC-2070-550ppm	0.52	0.43	0.59	0.39	0.59	0.59	0.51
IC-2100-475ppm	0.86	0.72	0.81	0.69	0.74	0.82	0.76
IC-2100-500ppm	0.84	0.68	0.78	0.64	0.70	0.79	0.72
IC-2100-550ppm	0.75	0.51	0.66	0.45	0.54	0.68	0.58
II-475ppm	0.88	0.74	0.82	0.70	0.74	0.83	0.77
II-500ppm	0.87	0.70	0.79	0.66	0.70	0.81	0.74
II-550ppm	0.80	0.54	0.69	0.48	0.55	0.71	0.60

	CHN	IND	BRA	MEX	KOR	MYS	Africa
C&C-2050-475ppm	0.15	-1.33	0.24	0.32	0.63	0.08	-1.65
C&C-2050-500ppm	0.01	-1.70	0.12	0.21	0.57	-0.06	-2.07
C&C-2050-550ppm	-0.48	-3.07	-0.32	-0.19	0.35	-0.60	-3.63
C&C-2070-475ppm	0.17	-0.69	0.25	0.29	0.38	-0.12	-0.77
C&C-2070-500ppm	0.04	-1.01	0.13	0.18	0.31	-0.28	-1.13
C&C-2070-550ppm	-0.46	-2.23	-0.31	-0.22	0.03	-0.87	-2.48
C&C-2100-475ppm	0.18	-0.33	0.25	0.28	0.25	-0.23	-0.28
C&C-2100-500ppm	0.05	-0.57	0.13	0.17	0.14	-0.42	-0.53
C&C-2100-550ppm	-0.43	-1.44	-0.31	-0.25	-0.27	-1.12	-1.40
IC-2070-475ppm	-0.29	-0.66	0.31	0.30	0.67	0.27	-0.27
IC-2070-500ppm	-0.50	-0.92	0.20	0.19	0.62	0.16	-0.48
IC-2070-550ppm	-1.25	-1.89	-0.20	-0.21	0.43	-0.27	-1.22
IC-2100-475ppm	-0.40	-0.74	0.37	0.33	0.69	0.26	-0.39
IC-2100-500ppm	-0.62	-1.02	0.27	0.23	0.64	0.15	-0.61
IC-2100-550ppm	-1.44	-2.04	-0.10	-0.16	0.46	-0.29	-1.42
II-475ppm	-0.38	-0.71	0.39	0.36	0.70	0.28	-0.37
II-500ppm	-0.58	-0.96	0.31	0.26	0.66	0.18	-0.57
II-550ppm	-1.39	-1.96	-0.05	-0.11	0.49	-0.25	-1.37

The purpose of the current study is to present a range of GHG reduction, and in this sense we have the result of Japan’s required share of GHG emissions reduction in 2050, which is between 40% (37%) and 90% (93%). It is inevitable for an issue with scientific uncertainty to have a range. We can also easily imagine turning the emission reduction up to 90% in 30-40 years, when aiming at a 40% reduction will be extremely difficult, or almost impossible to achieve. The other way around may be easier. From the viewpoint of risk management, it is safer to limit the risks as much as possible, and that is the role of responsible public policy. Looking at the results, while bearing in mind IPCC FAR where climate sensitivity changed from 2.6℃ to 3.0℃, it is safer to aim at 60 to 90% from the 1990 level. One may also wish to analyze further the results. For example, in the case of 2 ℃, the lowest emissions for Japan is an approach where the C&C convergence year is 2100. It is assumed in international policy scenarios that such a scenario is possible when an equity or justice idea prevails throughout the world. However, contradiction exists in that per capita emission is equal in 2100 in this case, but by 2050 there will still be a huge gap and it will take 50 years before being equalized. Whether this will still be the case is a big question. Considering the time dimension, such a case may well be out of serious consideration.

References

1) Berk, M. and den Elzen, M.G.J. (2001) "Options for differentiation of future commitments in climate policy: how to realize timely participation to meet stringent climate goals?" Climate Policy, Vol.1, No.4.

2) CEPS (2005) "Towards A Global Climate Regime: Priority Areas For A Coherent EU Strategy", CEPS Task Force Report No. 55, May 2005.

3) Den Elzen, M. and Berk, M. (2004) "Bottom up approaches for defining future climate mitigation commitments" RIVM Report 728001029/2004.

4) Gupta, J. and van Asselt, H. (2004) "Re-evaluation of the Netherlands' long-term climate targets" Report number draft E-04/07, Institute for Environmental Studies.

5) H. Groenenberg, K. Blok, J. van der Sluijs, (2002) Global Triptych- a bottom-up approach for the differentiation of commitments under the Climate Convention

6) Hohne, N., Phylipsen, D., Ullrich, S., Blok, K. (2004) Options for the second commitment period of the Kyoto Protocol, ECOFYS.

7) Meyer, A. (2000) Contraction and Convergence: the Global Solution to Climate Change, Green Books Ltd.

8) Oppenheimer, M. and A. Petsonk (2005), 'Global Warming: The Intersection of Long-term Goals and Near-Term Policy' in Michel, D. (ed.), Climate Policy for the 21st Century: Meeting the Long-term Challenge of Global Warming, Center for Transatlantic Relations, Johns Hopkins University, Washington, D.C., pp.79-112.

9) Pershing and Tudela (2003) "A long-term target: Framing the climate effort" Beyond Kyoto: Advancing the international effort against climate change, Washington, D.C.: Pew Center on Global Climate Change.

10) Retallack, Simon (2005), 'Setting a Long Term Climate Objective', Institute for Public Policy Research, UK

11) Shell International (2001) Exploring The Future: Energy Needs, Choices and Possibilities, Scenarios to 2050.

12) J. Sijm, J. Jansen, A.Torvanger, (2001), Differentiation of mitigation commitments: the multi-sector convergence approach, Climate Policy 1, 481-497

13) A. Torvanger, L. Ringius, (2000), Burden Differentiation: Criteria for evaluation and development of burden sharing rules, CICEO Working Paper

14) Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen (WBGU) (2003) Climate protection strategies for the 21st Century: Kyoto and beyond, Special Report 2003, WBGU, Berlin, Germany.

5. Global Target, Japan's Target, Local Government's Target, Corporate Target

5.1 Introduction

In this chapter, first I would like to provide a brief outline of the "global target" concerning the reduction of greenhouse gas (GHG). The global target here refers to the mid to long term target after the Kyoto Protocol. In relation to this, this paper will provide an overview on the leading examples of target setting by companies and local governments around the world concerning reduction of GHG.

Next, this paper will review the situation concerning target setting in Japan. In Japan, there exists targets imposed by the Kyoto Protocol, however, there are no mid to long term targets in terms of a post-Kyoto strategy except for the 2nd Interim Report by the Expert Committee on the Climate Change Global Strategy of the Global Environment Council under the Central Environment Council (May 12, 2005).

Following this, we have reviewed the present situation concerning target setting by local governments and companies as a premise to the examination of a mid to long term target in Japan. The subject of this review is mostly the commitment period of the Kyoto Protocol. More specifically, we examined and classified (1) the existing target and perspective on the regional global warming prevention measures plan at the level of the local government; and (2) the existing corporate target and the perspective on the Keidanren voluntary action plan on the environment.

5.2 Global Target

In this section, I would like to give an overview of the examples of the EU, the EU member states, and the US concerning the global mid to long term target of climate change measures.

5.2.1 EU's Target

The EU Summit on March 9th, 2007, adopted ambitious climate and environmental policies. Regarding climate change policies, it was decided that GHG emission would be reduced by 30% below 1990 levels by 2020, and by 60% to 80% by 2050. Moreover, until a global agreement is reached concerning a post-2012 framework, the EU promised to reduce GHG emission by 20% below 1990 levels by 2020.
(http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/ec/93135.pdf).

Regarding energy policies, the EU adopted the "EU Action Plan for Energy Efficiency" (2007-2009) and agreed upon a binding renewable energy target (to increase the percentage of renewable energy to account for the energy consumption of the EU increasing by 20% by 2020), which was specifically illustrated in the plan. Furthermore, the plan included a binding target on bio fuels (to increase the percentage of bio fuels used for transportation fuels to 10% by 2020), and an energy efficiency target (to reduce energy consumption by 20% by 2020). In addition, regarding specific prevention measures for climate change, a CO_2 emission cap for all airplanes departing from and arriving in the EU (setting the restriction back at the average existing condition from 2011), and a compulsory CO_2 emission regulation for all automobile companies (emission of 130 g per kilometer by 2012) were stipulated.

The EU has already agreed upon and announced the following mid to long term target in the reports of the EU Environment Ministries Meeting, the EU Summit and the EU

Commission. The EU had committed itself to the goal of keeping global temperature rise below 2℃ compared to that before the Industrial Revolution in 1996, even before negotiation for the Kyoto Protocol took place, and has so far maintained the goal.

- Mid to long term GHG reduction target: All developed countries are to reduce emission by 15% to 30% by 2020 below 1990 levels, (Final Report of the EU Summit March 23, 2005 and EU Final Report of the Environment Ministries Meeting March 10th, 2005). 60% to 80% reduction by 2050 (Final Report of the EU Environment Ministries Meeting).
- Long term climate stabilization target: Limit global temperature rise to less than 2℃ above the pre-Industrial Revolution temperature level. (Final Report of the EU Summit, Final Report of the EU Environment Ministries Meeting). Limit global temperature rise to less than 2℃ above the pre-Industrial Revolution temperature level.
- Aim for climate stabilization at a much lower level than GHG 550ppm (Final Report of the EU Commission Feb. 9th, 2005).

5.2.2 EU Member States' Target

Let us look at the mid to long term target of EU member states. In order to achieve the long term target of the EU, the member states have consecutively announced mid to long term plans at the national level starting from 2003. Table 5.1 shows the mid to long term target (global warming prevention plan) of EU member states.

Table 5.1：EU Middle to Long Term Target for Key Countries（Low Carbon Society Project）

Country	Reporting Agency	Report（Release Time）	Reduction Project	Long-term Stabilization Target
England	Department of Trade and Industry（DTI）	Energy White Paper (2003.2)	Reduce CO2 emissions by 60 percent from present levels by 2050	Control CO2 concentration in the air below 550ppm
Germany	Federal government Advisory Council on （WBGU）	Report （2003.10）	Reduce CO2 emissions by 45-60 percent from 1990 levels by 2050 and for developed countries by 20 percent by 2020.	Control a rise in global temperature below maximum 2℃ from preindustrial status levels(below 0.2℃ in 10 years) and CO2 concentration below 450ppm.
Germany	Parliament Advisory Committee	Report(2002.7)	Reduce CO2 emissions by 80 percent by 2050	
France	Interagency Ad Hoc Committee for Climate Change Issue （MIES）	Radanne Report (2004.5)	Reduce GHG emissions by 75 percent from 2000 levels by 2050.	Stabilize CO2 concentration in the air below 450ppm

Sweden	Environmental Protection Agency	Report(2002.10)	Reduce CO2 and other GHG emissions by 4.5t (present 8.3t) per capita by 2050 and afterward reduce them in series.	Stabilize All GHG concentration below 550ppm(for CO2 below 500ppm)
Netherland	National Research Programme (NRP)	Climate Options for the Long term (COOL Research Project, 2001.6) COOL	Reduce GHG emissions by 80 percent from 1990 levels by 2050.	

5.2.3 US Target

(Climate Change Strategy)

Just after taking office at the end of March, 2001, US President Bush announced that he would abandon the Kyoto Protocol. The reasons included that the Kyoto Protocol would have harmful effects on the US economy, and that it was unfair that the Kyoto Protocol did not specify any obligations for developing countries concerning the reduction of GHG emission.

However, although the US government abandoned the Kyoto Protocol, it remained within the framework of the Convention on Climate Change, stated its intention to propose an alternative to the Kyoto Protocol, and announced the “Climate Change Strategy” in February 2002.

The Climate Change Strategy stipulates that the US would reduce GHG emission (also referred to as GHG emission intensity or carbon intensity), per US GDP by 18% by 2012. In other words this would mean a US reduction from 193 tons of GHG per one million dollar GDP (estimation) to 151 tons by 2012. However, when we examine this target more carefully, assuming that the US economy keeps on expanding (3% annually), then US would be reducing emission by 30% below 1990 levels by 2012. To briefly note, GHG emission intensity decreased by 17.4% whereas total emission increased by 14% in the U.S in the 1990’s.

(2007 State of the Union Address)

In President Bush’s State of the Union Address delivered on January 23rd, 2007, he announced an energy policy called “Twenty in Ten” that aimed for a 20% reduction in the consumption of gasoline in the next 10 years. This would be proportional to 3/4 of the oil imported from the Middle East. The plan attempts to achieve 15% of the reduction target by using alternative fuel sources such as ethanol and bio diesel from materials like corn and plant fiber, and the remaining 5% reduction by strengthening (reducing annual CO2 emission from automobiles by 10% by 2017) CAFÉ (Corporate Average Fuel Economy). These policies correspond to climate change measures. This State of the Union Address was the first time President Bush referred to prevention measures for global warming.

The Pew Center commended President Bush for mentioning climate change in his State of the Union Address, however, the center also had the following criticisms (please refer to the following website “Response to 2007 State of the Union” http://www.pewclimate.org/press_room/speech_transcripts/ viewed 2007/02/13):

・ President Bush’s plan only targets the transportation sector (which makes up one

third of the GHG emission in the US), and does not propose specific measures for other major sources of GHG emission such as electricity, factories and buildings;
- Reduction of gasoline consumption by 20% does not mean the reduction of the present consumption but reduction of future consumption;
- The President's proposal does not mention a specific target for CAFÉ standards;
- It is necessary to propose binding measures targeted to the entire economy.
-

(State of California Mid to Long Term Target)

In California, Governor Schwarzenegger delivered a speech to commemorate World Environment Day on June 1st, 2005, and stated that California would become the leader in the fight against climate change, signed the S-3-05 Executive Order, and stipulated the following target for GHG emission reduction:

- Reduce GHG emission to 2000 level by 2010;
- Reduce GHG emission to 1990 level by 2020;
- Reduce GHG emission by 80% below the 1990 level by 2050.

In order to achieve the above target, the California Environmental Protection Agency promoted the establishment of the Climate Action Team, and the Governor submitted a report to Congress in March 2006 (Climate Action Team Report to Governor Schwarzenegger and the Legislature, March,2006）.

(Call for Action issued by US Climate Action Partnership (USCAP))

USCAP, comprised of companies including GE, DuPont, BP, and environment think tanks such as WRI and the Pew Center (10 organizations) issued the following call for action on climate change, including a GHG emission reduction target, to the President and Congress on January 22nd, 2007 (http://www.us-cap.org/ClimateReport.pdf) (refer to appendix #2 for an outline）:

- +5% to 0% reduction compared to 2007 level by 2012;
- 0% to - 10% reduction compared to 2007 level by 2017;
- -10% to -30% reduction compared to 2007 level by 2022;
- -60% to -80% reduction compared to 2007 level by 2050;
- for long term target, stabilize the CO2 equivalency of GHG intensity at 450-550ppm.

(GHG emission reduction target stated in the proposal concerning the Cap & Trade of GHG at the 110th Congress, Senate)

At the 110th Congress, US Senators proposed a bill for the Cap & Trade of GHG with the following target (refer to appendix #3 for the list of the proposal):

- Senator Bingaman (Democrat): to reduce emission per US GDP by 2.6% from 2010 to 2021 (predicting a 16% increase by 2020 compared to the 2004 level).
- Senator Feinstein (Democrat) and Senator Carper (Democrat): to reduce emission to the level of 2001 by 2015, a 1% reduction from 2016 to 2019, and an 8% reduction compared to the 2004 level by 2020.
- Senator Kelley (Democrat) and Snowe (Republican): A 1/5% reduction from 2010 to 2019. An 11% reduction compared to the 2004 level by 2020.
- McCain-Lieberman Bill (compared to the 2004 level): 0% by 2012 (compared to the 2004 level), -15% by 2020 (compared to the 2004 level, 0% compared to the 1990 level), -20% by 2030 (compared to the 1990 level) and -65% by 2030 (compared to the 2004 level).
- Senator Sundance (Independent) and Senator Boxer (Democrat): to the 1990 level by 2020, a 15% reduction compared to the 2004 level by 2020, a 27% reduction compared to the 1990

level by 2030.

Senate Greenhouse Gas Cap-And-Trade Proposals in the 110th Congress

PEW CENTER ON Global CLIMATE CHANGE

Bill	Scope of Coverage	2010-2019 Cap	2020-2029 Cap	2030-2050 Cap	Offsets	Allocation	Other Cost Controls	Early Action	Technology and Misc.
Bingaman Discussion draft As evaluated by EIA on 1/11/2007	All 6 GHGs Economy-wide, upstream	2.6%/year reduction in emissions **intensity** from 2012-2021	2.6%/year **intensity** reduction from 2012-2021. 3%/year **intensity** reduction starting 2022.	3.0%/year reduction in emissions **intensity** starting in 2022.	5% set-aside of allowances for agricultural sequestration	Increasing auction: 10% in 2012; 20% in 2021; 65% in 2044. Some sectors' allocation specified; 29-30% to states.	\$7/ton CO_2 "safety valve," increasing 5%/year (adjusted for inflation) *Safety valve projected to be triggered in 2026, causing emissions to continue to rise.*	From 2012-2021, 1% set-aside of allowances	Funds and incentives for technology R&D. Target subject to 5-year review of actions by other nations.
Feinstein-Carper S.317 Introduced on 1/17/2007	All 6 GHGs Electricity sector, downstream	2006 level in 2011. 2001 level in 2015, 1%/year reduction from 2016-2019.	1.5%/year reduction starting in 2020 (may be adjusted by Administrator)	1.5%/year reduction starting in 2020 (may be adjusted by Administrator)	Certain categories of bio seques and industrial offsets; 5% limit on forest mgmt; 25% limit on intl.	Increasing auction: 15% in 2011; 60% in 2026; 100% in 2036. Output-based allocation to generators.	If economic harm, potential for borrowing and/or increased intl offsets. Borrowing of offsets.	Credit for reductions from 2000-2010, limit 10% of cap	Funds for tech R&D, habitat protection, and adaptation. Bills expected on industry, efficiency, fuels, and vehicles.
Kerry-Snowe Introduced on 2/1/2007	All 6 GHGs Economy-wide, point of regulation not specified	2010 level in 2010	1990 level in 2020. 2.5%/year reduction from 2020-2029.	3.5%/year reduction from 2030-2050. 65% below 2000 level in 2050. *(Equivalent to 60% below 1990 level in 2050.)*	Not specified	Determined by the President	Not specified	Goal to "recognize and reward early reductions"	Funds for tech. R&D, consumer impacts, adaptation. Standards for vehicles, efficiency, renewables.
McCain-Lieberman S.280 Introduced on 1/12/2007	All 6 GHGs Economy-wide, large sources downstream, fuels upstream	2004 level in 2012	1990 level in 2020	20% below 1990 level in 2030. 60% below 1990 level in 2050.	30% limit on use of intl credits and domestic reduction or seques offsets	Administrator determines; considering consumer impact, ability to pass through costs, competitiveness, etc.	Borrowing for 5-year periods with interest	Credit for reductions before 2012	Incentives for advanced tech., adaptation, transition assistance
Sanders-Boxer S.309 Introduced on 1/15/2007	All 6 GHGs Economy-wide, point of regulation not specified	2010 level in 2010. 2%/year reduction from 2010-2020.	1990 level in 2020	27% below 1990 level in 2030. 53% below 1990 level in 2040. 80% below 1990 level in 2050.	Not specified	Cap and trade permitted but not required. Allocation criteria include transition assistance and consumer impacts.	"Technology-indexed stop price" freezes cap if prices high relative to tech options	Not specified	Standards for vehicles, power plants, efficiency, renewables

Source：PEW CENTER (January 22, 2007)
http://www.pewclimate.org/docUploads/Cap%2Dand%2Dtrade%20bills%20110th%5FFeb5%2Epdf

5.2.4 Global Warming Prevention Measures Plan and Emission Reduction Target of Local Governments around the World

At least 8 cities and states around the world (London (Great Britain), California, Connecticut, Oregon (US), Victoria (Australia), Stockholm (Sweden), Munich, Berlin (Germany) have reported on a GHG emission reduction target after 2020 and specific action plans to achieve the target. The outline is shown in Table 5.4

Table 4　Plans for Promotion of Measures to Cope with Global Warming and Emission Target in the foreign local government

City[Country]、Agency	Release Year	Plan	Emission target（base year)
Greater London [England] Greater London Authority	2004	Green light to Clean Power: The Mayor's Energy Strategy	CO_2 emissions from fossil fuel 2010: -20% (1990) 2050: -60% (2000)
California State[United States of America] California Environmental Protection Agency	2006	Climate Action Team Report to Governor Schwarzenegger and the Legislature	Statewide GHG emissions 2010: the level of 2000 2020: the level of 1990 2050: -80% (1990)
Connecticut State[United	2005	Connecticut Climate Change	GHG emission reduction

States of America] Connecticut Governor's Steering Committee on Clime Change		Action Plan 2005	target 2010: the level of 1990 2020: -10% (1990) Long term: -75% (present state)
Oregon State[United States of America] Oregon Governor's Advisory Group On Global Warming	2004	Oregon's Strategy for Greenhouse Gas Reductions	2010:stopping increase of GHG emissions and starting to reduce specific amount of emissions toward the level of 1990 2020: -10% (1990) 2050: -75% (1990)
Victoria State [Australia] The Allen Consulting Group	2004	The Greenhouse Challenge for Energy	N/A
Stockholm City[Sweden] Environment and Health Administration of City of Stockholm	2002	Stockholm's action program against Greenhouse Gases	City wide GHG emissions 2030: -20% (1990) 2050: -60 ~ 80% (1990)
Munich Ciy [German City] Öko Institute e. V.	2004	Local strategies for the reduction of the emissions around 50% by the example of the city of Munich	City wide GHG emissions 2010: -20% (1987) 2030: -50% (1987)
Berlin City[Germany] Parliament of Berlin	2006	Local agenda 21 Berlin – draft coalition of parliamentary groups SPD&PDS※	City wide GHG emissions 2010: -25% (1990) 2020: -40% (1990) 2030: -50% (1990)

Source : Kaori Gomi、「A Study of Environmental Quantitative Future Vision Development in Local Government」（Master thesis at Kyoto University Graduate School of Global Environmental Studies）、Janualy, 2007、(p5、Summary of Table 2-2)

※ SPD:Sozialdemokratische Partei Deutschlands(German Social Democratic Party)、PDS:Partei des Demokratischen Sozialismus (Democratic Social Party)

5.2.5 GHG Emission Reduction Target of Foreign Companies

Companies around the world have also established their own GHG emission reduction target. Based on the information on websites such as WWF, Table 5.5 summarizes some of the major targets.

The target year varies from 2005 to 2015, which covers the 1st commitment period of the Kyoto Protocol (2005, 2006, 2010 (10 companies), 2012, 2014, 2015). Many of the companies have set their reference year to 1990 (6 companies) but they also consist of 1995, 1998, 1999, 2000, 2002, and 2004.

The target gases include GHG (10 companies) and CO2 (10 companies).

Many of the companies have set their reduction rate to 1% annually, and total emission from 1% to 75% (6 companies at 10%, 2 companies at 15%, 2 companies at 25%).

Table 5 GHG Reduction Target by foreign corporation

Corporation	Place	Sector	Target	Website
ABB（ABB Asea Brown Boveri）	Swiss	electricity, heavy electric machinery, heavy industry	Reduce GHG emissions by 1 percent each year from 1998 through 2005	Each company's website
AEP (American Electric Power)	USA	Electricity	Reduce CO2 emissions by 4 percent in 2006 below the average of 1998 to 2001 levels	

Alcoa	USA	Aluminum	Reduce GHG emissions by 25 percent from 1990 levels by 2010	
BP (British Petroleum)	England	oil, energy	Reduce GHG emissions by 10 percent from 1990 levels by 2010	
Deutsche Telekom	Germany	Telecommunications	Reduce CO2 emissions from power generation for Deutsche Telekom in Germany by 50 percent from 1995 levels by 2010.	
DuPont	USA	Chemical	Reduce GHG emissions by 15 percent from 2004 levels by 2015.	
General Electric	USA	electricity, electric equipment, material, fincance etc.	Reduce GHG emissions by 1 percent from 2004 levels by 2012	
Johnson & Johnson	USA	medical goods, medical equipment etc.	Reduce CO2 emissions from fixed source by 7 percent from 1990 levels by 2010	
Xerox	USA	copy machine etc.	Reduce GHG emissions by 10 percent from 2002 levels by 2012	
Duke Energy	USA	Electricity	Reduce and maintain GHG emissions by 5 percent from 2000 levels by 2010.	
Royal Dutch Shell	Netherland	oil, energy	Reduce GHG emissions by 5 percent from 1990 levels by 2010.	
Polaroid Corporation	USA	camera、media equipment	Reduce CO2 emissions by 25 percent from 1994 levels by 2010.	WWF website
Nike, Inc.	USA	sporting goods	Reduce CO2 emissions by 13 percent from 1998 levels by the end of 2005	WWF website
Lafarge	USA	building material	Reduce GHG emissions by 10 percent from 1990 levels by 2010.	WWF website
The Collins Companies	USA	Timber	Reduce CO2 emissions by 15 percent from 1999 levels by 2009.	WWF website
Catalyst Paper	Canada	paper manufacture	Reduce CO2 emissions by 70 percent from 1990 levels by 2010.	WWF website
Novo Nordisk	Denmark	Healthcare	Reduce CO2 emissions by 10 percent from 2004 levels by 2014.	WWF website
Tetra Pak	Sweden	food packaging	Reduce CO2 emissions by 10 percent from 2005 levels by 2010.	WWF website
IBM	USA	IT equipment	Reduce CO2 emissions by an average of 4 percent annually between 1998 and 2004.	WWF website
Xanterra Parks & Resorts	USA	Accommodation	Reduce CO2 emissions by 10 percent from 2000 levels by 2015.	WWF website
Wal-Mart	USA	retail sales	Reduce GHG emissions at existing stores, clubs and DC base by 20 percent from 2005 levels by 2012. Increase eco-efficiency by 25－30 percent from 2005 levels by 2009 in the newly-established stores. Double our fleet efficiency from 2005 levels by 2015 in the truck sector.	Wal Mart ２１ century leadership
Pfizer, Inc.	USA	medicine manufacture	Reduce CO2 emissions per ＄１M by 35 percent from 2000 levels by 2007.	2005 Corporate Citizenship Report

note : Criterion of selecting corporations : From ABB to Royal Dutch Shell, selecting the corporations which set targets to reduce total amount of GHG or CO2 from the following website (climate leaders: http://www.epa.gov/climateleaders/partners/ghggoals.html, PEW CENTER: http://www.pewclimate.org/companies_leading_the_way_belc/targets/) and confirming the data on the each corporation's website. From Polaroid Corporation to IBM, selecting the corporations which join the WWF Climate Savers seen at the site of following website（WWF: http://www.wwf.or.jp/activity/climate/clmt-svrs/world.htm） and eminent Japanese corporations, BSR member, refering to the site of WBCSD、BSR（Business for Social Responsibility) including Wal Mart and Pfizer, Inc. which released a numerial target.

5.3. Japan's Target

5.3.1 Target to Accomplish the Kyoto Protocol

With the Kyoto Protocol taking effect, the Japanese Government reached a cabinet decision on the "Kyoto Protocol Target Achievement Plan (KTAP)". In order to achieve Japan's reduction commitment of GHG emission by an average of -6% between 2008-2012, compared to the reference year (1990), the "Plan" has established a GHG emission reduction target per sector for 2010. The Plan proposes a +6% total emission compared to the reference year regarding CO2 emission by energy consumption, and -0.3% regarding non-energy consumption. Also, the Plan also proposes -0.2% of methane emission, -0.5% of nitrous oxide, and +0.1% of the three F-gas, HFC, PFC, and SF6. In addition, the Plan expects to secure -1.6% with projects related to the Kyoto mechanism and -3.9% with the increase in CO2 absorption by forests.

5.3.2 Mid to Long Term Target

The 2nd Interim Report by the Expert Committee on the Climate Change Global Strategy of the Global Environment Council under the Central Environment Council (May 12, 2005), stated their intention to restrict the GHG intensity to below 550ppm (for example, 475ppm) in order to limit the rise of the average temperature of the world to less than 2℃ above the pre-Industrial Revolution temperature level. For a mid to long term target, the report stated a calculation of "Global GHG emission reduction by 10% by 2020, 50% by 2050, and 75% by 2100 below the 1990 level". However, at present, this is only a tentative plan and is not the official policy of the Japanese government.

5.3.3 Target and Principle of the Regional Global Warming Prevention Measures Plan at the level of the Local Government

Based on Article 20 of the Law Concerning the Promotion of the Measures to Cope with Global Warming, the local governments in Japan have taken into consideration the basic principles concerning the global warming prevention measures of the KTAP, and have proposed and expect to implement comprehensive plans and policies (a regional promotion plan) for GHG emission reduction, in accordance with natural and social conditions.

The subject of the "Regional Promotion Plan" includes all villages, municipalities, cities and prefectures of Japan, however, the regulations that are stipulated are not binding, which means that violating the regulations would draw no punishment. Moreover, the Guideline of the Ministry of Environment states that the subjects of the plans are only "prefectures" and "ordinance-designated cities" therefore, concerning other local governments "it is desirable for other local entities to promote the analysis and evaluation of policies unique to those areas, while making reference to the principles stipulated by the Guideline". Thus, at present, almost all prefectures and ordinance-designated cities have implemented the "Regional Promotion Plan" but only a limited number of villages, municipalities, and cities that are not ordinance-designated cities have implemented the action plans.

As of December 2006, among the action plans of the local governments, if we consider these action plans as the Regional Promotion Plan, and in cases where the GHG emission of the area is known, 44 prefectures and 22 cities and special wards have implemented the plan, while 1 prefecture and 7 villages and cities are expected to implement the plan.

Villages, municipalities, and cities that have implemented the plan include 13 ordinance-designated cities, 2 wards out of the 23 wards in Tokyo, and 6 general cities.

Table 5.6 (prefectures) and Table 5.7 (villages, municipalities, cities) summarize the outline of the action plans of each local government (table 5.6 and 5.7 attached at the end of the chapter).

In the following, I would like to examine the target of the Regional Promotion Plan, including the reference year and target year, and the setting and grounds for establishing the target, targeted gases, and absorption.

(1) Reference year and target year for GHG emission

The reference year for GHG emission stipulated in the action plans is set at 1990, in line with the Kyoto Protocol. However, a few local governments have established the year 2000 or later as the reference year. For example, Ishikari City in Hokkaido has set the reference year as 2001, and the reason is because "the city was in its developmental stage in the 90's, and there was no remarkable increase in population or social capital, therefore it is inappropriate to set the reference year of emission at 1990" (Global Warming Prevention Measures Promotion Plan of Ishikari City).

Many plans have established 2010 as the target year, in line with the interim target year of the first commitment period of the Kyoto Protocol. However, some of the local governments (for example, Saitama City and Itabashi Ward of Tokyo) that recently implemented action plans have set 2012 as the target year, the final year of the first commitment period of the Kyoto Protocol. The City of Sapporo and Ishikari have set 2010 as their interim target year, and have established separate final target years. They are 2017 and 2020, respectively. Moreover, there exist some local governments that have established a long term target, such as Nagano prefecture, whose final target year is set at 2050.

(2) Setting and grounds for establishing the target

In terms of setting the target for the Regional Promotion Plan, the Guideline stipulates that the target must "either be a quantitative target that demonstrates an emission reduction or reduction rate, or a qualitative target that aims for a desirable society in the future". Furthermore, the Guideline states examples of a quantitative target which include: (a) a reduction rate of the total emission of the region; (b) a reduction rate restricted to a specific sector; (c) a reduction rate of the basic unit (emission per activity); and (d) a reduction rate for certain groups within the region. In reality, most of the targets stipulated in the plans are total targets of the entire region. However, some local governments have established a target per resident, a target for individual sectors that emit GHG, or a basic unit target per GHG emitting body. Local governments that did not establish a total emission target have their reasons. For example, in the regions where the local governments established a target per resident, many of them experienced population increase after 1990, a reference year adopted by many local governments. In such regions, the establishment of a total emission target may lead to the possibility of an increase in emission above the 1990 level; therefore, there is a risk that the impact of the target may not be strong enough in terms of enlightening the residents. Thus, prefectures such as Miyazaki have established a target per resident. In addition, this problem may be solved by shifting the reference year to after 1990 (in the case of Okinawa) or implementing a target per resident (City of Ishikari, Yokohama, Nagareyama, etc.). Local governments that have established a target for individual sectors that emit GHG, or a basic unit target per GHG emitting body have raised concerns that setting a total emission target or a target per resident may carry enlightening aspects to the residents, however, the actual policies are difficult to grasp and are inconvenient when it comes to reviewing progress (Prefecture of Chiba, Fukuoka, Oita, and Kita-Kyushu

City).

The trend concerning the target values differs between the prefectures and the villages, municipalities, and cities. At the level of villages, municipalities, and cities, many follow in the footsteps of the target of the Kyoto Protocol and have established a “6% reduction in the entire area by the target year”. Few have declared a reduction rate of over 6%, such as the 7% reduction set by Osaka and the 10% reduction set by Nagoya. On the contrary, at the prefecture level, only 1/4 of them set 6% as their target and the rest have set targets from 0% to 37% compared to the reference year.

There was no great difference in the grounds for setting the target, where many local governments based their decision on the reduction rate by taking into consideration the calculation of BAU, estimation of the future population and calculation of the reduction rate, and Japan’s reduction rate stipulated by the Kyoto Protocol. Especially those local governments that have established 6% as their target have taken into consideration the national government’s reduction target. Moreover, as mentioned earlier, some local governments have adopted a target that combines a target per entity, a target per sector and a basic unit target, because a total emission target is greatly affected by population change and by various socio-economic factors and also because many residents find it difficult to understand the concept. In order to increase people’s understanding and awareness, and to make it easier for people to follow the progress through statistical data, some local governments have implemented a target based on the consumption of energy.

(3) Targeted gases

Many local governments have set targeted GHG in line with the 6 gases stipulated in the Kyoto Protocol. However, some local governments have set CO2 as the only targeted gas because it accounts for most of the GHG emitted within the region (Iwate prefecture, Chiba prefecture). Excluding special cases such as Miyazaki prefecture, CO2 accounts for 90% or more of GHG in most regions. Moreover, most of the CO2 emission is due to energy consumption; therefore, Ube City of Yamaguchi Prefecture has also implemented a “Regional Promotion Plan” known as “Ube City Energy-Saving Vision” and has targeted only CO2. Moreover, Itabashi Ward of Tokyo has excluded HFC, PFC, and SF6 from their targeted gases because it is difficult to detect and measure their emission and they only account for a small portion of GHG.

(4) Absorption

At the prefectural level, almost half of them include absorption as a reduction measure; therefore, there exists a specific calculation method to account for absorption. In the case of villages, municipalities, and cities, if there is a forest that accounts for the absorption rate within the region, the calculation is conducted and that amount is counted as the reduction rate (Sapporo City, Kyoto City). Some local governments take the calculation into consideration but do not count it as the reduction rate.

There is a tendency for target values to be set higher in cases where absorption is calculated as the possible reduction rate and is reflected in the target value (Hokkaido Prefecture, Yamanashi Prefecture). Nagano Prefecture has a unique method of not calculating the actual maintenance of forests as the reduction rate, but counting the use of materials produced within Nagano as the reduction rate.

5.3.4 Corporate Target and Principle of the Japan Business Federation (Nippon Keidanren) Voluntary Action Plan on Environment

In this section I would like to examine the Keidanren Voluntary Action Plan, to demonstrate the GHG emission reduction target and the principle of Japanese companies.

Keidanren announced its “Keidanren Environment Appeal” in July 1996, and proposed “to establish a voluntary action plan for each industry that states specific targets and policies and to conduct a regular review on the progress” for global warming prevention measures. Following this, the “Keidanren Voluntary Action Plan on the Environment” (at the time the Keidanren Voluntary Action Plan) was announced in June, 1997. In the beginning, 137 groups from 36 different industries participated, and this has expanded to 58 industries at present. In the following, I would like to summarize the investigation results regarding the present situation of target setting and grounds for the target of the Keidanren Voluntary Action Plan on the Environment.

The target value of the voluntary action plan is “to restrict the emission of CO2 from the industrial sector and energy conversion sector to below the 1990 level by 2010” (1997). It is perceived that the reason why the target was set at below the 1990 level was because the target values of 2010, decided individually by each industrial group, were all at the 1990 level; however, there is no direct relation between the targets set by individual industries and the target set by the voluntary action plan. The outlook on the 2010 emission differs according to economic indicator; therefore, even if each industry achieved its target, there is a possibility that the overall target may not be achieved.

The individual targets vary with industries. Table 5.8 shows the overall overview.

Table 5.8

		58 Keidanren Voluntary Action Plan Member Sector	(Keidanren industrial and energy-conversion sectors ±0% target 35 of 58 in the left cell)	32 Sector formulating Voluntary Action Plan, nonmember of Keidanren	Total 90 Sector
Total Amount Target	Total CO2 Emissions	14 Sector	(11)	3	17
	Energy Consumption	4	(3)	2	6
Basic Unit Target	CO2 Emissions Basic Unit	10	(7)	4	14
	Energy Consumption Basic Unit	22	(9)	9	31
Multiple Target Setting		6	(5)	2	8
No Numerical Target		2	(0)	12	14

The targets are differentiated between industries that have an absolute target value and those that have a basic unit target, and consist of two types of unit, CO2 emission and energy consumption. In general, most industries have basic unit targets. The grounds for establishing targets include cases where industries choose a total or a basic unit in order to reflect appropriately individual efforts, where industries choose the total amount upon taking into consideration the fundamental aim of global warming prevention, and where industries choose the basic unit as an indicator that can be managed by the company.

When looking at the 35 industries subject to Keidanren's overall target (plus/minus % in the industry and energy conversion sectors), there are approximately the same number of industries that establish a total target and a basic unit target. The grounds for establishing the target are based on the fact the Keidanren's target is set at the total target.

The target values greatly differ among the industries. Some industries base their calculation on the energy-conserving effect and the predictions of member companies of the industrial group, whereas some establish their targets based on the Protocol or voluntary action plans, or in accordance with other groups. Regarding the former, the calculation method differs from industry to industry and the differences are not clear, however, some industries set a high target in accordance with advanced measures while some just base it on the accumulation of simple predictions.

Due to the differences in the perception concerning target setting, some have more difficulty in achieving the targets than others.

The following issues can be pointed out when considering the present situation of target setting proposed in the Keidanren Voluntary Action Plan:

- There is no relation between the targets set by individual industries and the Keidanren's overall target of "making efforts to restrict the CO2 emission of the industrial sector and the energy conversion sector to below the 1990 level by 2010". In other words, even if each industry achieves its target, it does not mean that the overall target has been achieved.
- There is no regular or fixed pattern in terms of the types of targets of individual industries, the difficulty of achieving the targets and the grounds for the targets. The targets are a mixture of ambitious targets, achievable targets, targets that follow in line with those of other groups, targets that follow in line with the Protocol, and targets that have no grounds. Moreover, there exist industries that change their targets to strengthen their direction and some that conduct changes that leave the possibility of easing the targets.
- At present, the number of industries subject to the Keidanren's target (35) is small, and there is a gap between these industries and industries that are not subject to the Keidanren's target. We are able to confirm 90 industries that have implemented some kind of a plan; however, compared to industries subject to the Keidanren's target, industries not subject to the Keidanren's target do not have a specific target value and are behind in information disclosure.
- There is divergence between the target of the industrial sector proposed by the Target Achievement Plan of the Kyoto Protocol and the target by Keidanren. In the Target Achievement Plan, the target of the industrial sector is set at -8.6%, however, the Keidanren's target is set at ±0% by 2010. Just to briefly note, in Keidanren's 2005 follow-up (enforced in 2004), the calculation for 2010 was set as -2.6% compared to the 1990 level.

Conclusion

- The EU has already established a mid to long term target at the EU summit. The EU has committed itself to the goals of limiting global temperature rise to less than 2℃ above the pre-Industrial Revolution temperature level, implementing specific policies to achieve this target, and leading the international society on prevention measures for global climate change.

At the moment, no agreement has been reached by the Japanese government concerning a mid to long term target. There have only been reports submitted by councils and committees or by research institutions.

The US government has abandoned the Kyoto Protocol; however, individual states have been pursuing target setting that takes into consideration the Kyoto Protocol or post-Kyoto strategy. The Senate in the Congress has proposed bills to establish a mid to long term target (a restriction on total emission, Cap & Trade) that transcends party factions.

There are several local governments around the world that have stipulated a mid to long term target. In Japan, most of the local governments that have stipulated a target in accordance with the Kyoto Protocol are prefectures and ordinance-designated cities, and although there are exceptions, some have even stipulated a long term target. The grounds for target setting differ with various groups.

There are many businesses around the world that have established a voluntary GHG emission reduction target. However, most of them correspond to the first commitment period of the Kyoto Protocol. In Japan, the Keidanren Voluntary Action Plan on the Environment was implemented before the adoption of the Kyoto Protocol and has been maintained until this day. In terms of the Keidanren Voluntary Action Plan, the grounds for target setting vary from industry to industry.

Table 5.6

Prefecture	Program Serveyed	Drafing and Revising Program Year	Base Year	Target Year	Reduction Target	Target Gas	Wheter carbon sink is included in target or not	Concept of Target etc.
Hokkaido	Hokkaido Global Warming Countermeasure Plan	2000	1990	2010	△9.2%	6	○	Hokkaido determined from emission reduction estimation
Aomori	Aomori Global Warming Countermeasure Plan	2001	1990	2010	△6.2%	6	○	Aomori determined from emission reduction estimation
Iwate	Iwate Global Warming Countermeasure Area Promotion Plan	2005	1990	2010	△8.0%	CO2 only	○	Iwate determined from emission reduction estimation

Miyagi	"Low Carbon Society" Federal Miyagi Promotion Plan	2004	1990	2010	△2.4% per capita	6	○	Miyagi set per capita in consideration of population increase. It determined from emission reduction estimation by Outline for Promotion Effects to Prevent Global Warming and Miyagi approach.
Akita	Measures to Cope with Global Warming Beautiful Akita Plan	1998	1990	2010	±0%	CO2 only	×	Akita determined in consideration of national view at the time
Yamagata	Yamagata Global Warming Countermeasure Area Promotion Plan	2005	1990	2010	△7.0%	6	○	Yamagata determined from emission reduction estimation
Fukushima	Fukushima Global Warming Countermeasure Promotion Plan	2005	1990	2010	△8.0%	6	○	Fukushima determined from emission reduction estimation
Ibaraki	Ibaraki Global Warming Countermeasure Offense and Defense Plan	2005	1990	2010	△4.6%	6	○	Ibaraki determined from national target, Fukushima status and emission reduction estimation
Tochigi	Tochigi Global Warming Countermeasure Area Promotion Plan	2005	1990	2010	△0.5%	6	×	Tochigi referred to -0.5 percent target which can be achieved only by national GHG emissions limitation
Gunma	The Second Gunma Global Warming Countermeasure Promotion Plan	2006	N/A	2010	△6.0% (compared to 2010 levels with the BaU Option)	CO2 only	○	Gunma determined from emission reduction estimation
Saitama	Saitama Global Warming Countermeasure	2004	1990	2010	△6.0%	6	×	Saitama conformed to Japan's Kyoto Protocol target

	Area Promotion Plan							
Chiba	Chiba Global Warming Counterm easure Plan	2006	1990	2010	Basic unit target for each entity	CO2 only	×	A target of total amount of emissions in Chiba is difficult to promote each actor's effort. Hence, basic unit reduction target is set for each actor. The target is made easier for citizens and businesses to understand.
Tokyo	Tokyo Metropolit an Environm ental Master Plan	2001	1990	2010	△6.0%	6	×	Tokyo determined in consideration of national view
Kanagaw a	New Agenda 21 Kanagawa	2003	1990	2010	±0%	CO2 only	×	Kanagawa can contribute to achieve ＋0.6 percent reduction target of energy oriented CO2 and -0.3 percent noneneryg oriented CO2 according to Japan's Plan to Meet the Kyoto Target, even though Kanagawa set ±0 percent reduction target only for CO2.
Niigata	Niigata Global Warming Counterm easure Area Promotion Plan	1994	1990	2000	±0%	CO2 only	×	Niigata determined in consideration of national view at the time. Kanagawa has another plan to reduce CO2 as much as possible in 2010.
Toyama	Toyama Global Warming Counterm easure Promotion Plan	2003	1990	2010	△6.0%	6	○	Toyama determined in consideration of national view. According to emission reduction estimation, it is possible to reduce by 7.9 percent.
Ishikawa	Ishikawa Enfironme ntal Master Plan	2004	2001	2010	△7.8%	CO2 only	×	Ishikawa set the target applied allocation rate of emissions reduction target at each sector to 2001 emissions target in Ishikawa.
Fukui	Fukui Global Warming Counterm easure Area Promotion Plan	2005	1990	2010	△3.0%	6	×	Fukui set a feasible reduction target in consideration of emissions reduction by countermeasures of Japan's Plan to Meet the Kyoto Target, Fukui's original efforts

								and situation.
Yamanashi	Yamanashi Global Warming Countermeasure Promotion Plan	2003	1990	2010	△15.8%	6	○	Yamanashi set 2.1 percent reduction target due to calculation that it took 3.9 percent national carbon sink from 6 percent national reduction target. Furthermore, it added 13.7 percent Yamanashi's carbon sink to 2.1 and finally lead 15.8 percent reduction.
Nagano	Nagano Global Warming Countermeasure Prefectural Citizens' Plan	2003	1990	2010	△6.0%	6	×	Nagano conformed to national target in 2010. reduce 30 percent from 1990 levels by 2030 as midterm target and 50 percent by 2050 as final target.
Gifu	Gifu Global Warming Countermeasure Promotion Plan	2002	1990	2010	△6.0%	6	×	Gifu calculated the amount of reduction and sets a feasible target assuming it can gradually enhance effectiveness referring to data of activity status and reduction effectiveness based on Gifu citizens and businesses survey and businesses hearing.
Shizuoka	Stop Global Warming Shizuoka Action Plan	2006	1990	2010	△12.0%	6	○	Shizuoka took account of it's capacity to reduce 12.3 percent from emission reduction estimation.
Aichi	Aichi Global Warming Countermeasure Strategy	2005	1990	2010	△6.0%	6	○	Aichi took account of it's capacity to reduce 6 percent from emission reduction estimation in consideration of 0.9 percent carbon sink and it's capacity to reduce 5.1percent.
Mie	Mie Global Warming Countermeasure Area Promotion Plan	1999	1990	2010	△6.0%	6	○	Mie took account of national target.

Shiga	Shiga Global Warming Counterm easure Promotion Plan	2002	1990	2010	±0% (per capita△ 15.0%)	6	○	Shiga applied base year level to total amount target and 15 percent reduction to par capita target because of population increase. The target was also based on emission reduction estimation.
Kyoto	Kyoto Global Warming Counterm easure Promotion Plan (Tentative)	2006	1990	2010	△10 .0 %	6	×	Kyoto conformed to "Kyoto global warming countermeasure". It aimes to achieve low carbon society due to much amount of GHG emissions reduction.
Osaka	Osaka Global Warming Counterm easure Area Promotion Plan	2005	1990	2010	△9.0%	6	○	Osaka determined it's target from emission reduction estimation
Hyogo	New Hyogo Global Warming Counterm easure Promotion Plan	2006	1990	2010	△6.0%	6	○	Hyoto took account of national target.
Nara	Nara Area Energy Conservati on Vision	2003	2000	2010	△5.0% (energy usage)	-	○	Hokkaido didn't set a target inclucing a vision for GHG but energy saving .
Wakayam a	Wakayam a Global Warming Counterm easure Area Promotion Plan	2006	1990	2010	△10.6 %	6	○	Wakayama determined it's target from emission reduction estimation. The target not including carbon sink is 3.9 percent reduction.
Tottori	Tottori Environm ent-Orient ed Prefecture Action Plan	2004	2000	2010	Electrici ty and oil usage △16.0 %	-	○	Tottori didn't set a numerical target for GHG reduction, only stating GHG "reduction".
Shimane	Shimane Global Warming Counterm easure Promotion Plan	2005	1990	2010	△2.0%	CO2 only	○	A target for carbon sink was set apart from a target for amount of reduction. Shimane concluded that a prior plan aimed to reduce 6 percent was difficult to be achieved and should

								reestimated it again.
Okayama	Okayama Global Warming Countermeasure Action Plan	2001	1990	2010	△6.5%	6	○	Okayama determined it's target from emission reduction estimation. To achieve 6 percent reduction target of Kyoto Protocol, it estimated citizen's actual effect to the maximum.
Hiroshima	Hiroshima Global Warming Area Plan	2003	1990	2010	△2.0%	6	○	Hiroshima determined it's target from emission reduction estimation
Yamaguchi	Yamaguchi Global Warming Countermeasure Area Promotion Plan	2006	1990	2010	△2.0%	6	○	Yamaguchi determined it's target from emission reduction estimation
Tokushima	Promotion Plan for Global Warming Countermeasure in Tokushima (Tentative)	in preparation	1990	2010	△10%	6	○	Tokushima determined it's target from emission reduction estimation
Kagawa	Kagawa Global Warming Countermeasure Promotion Plan	2006	2003	2010	△6.0%	6	○	In consideration of future acitivity in Kagawa, Kagawa esitmated feasible nemerical target to reduce 6 gases in cooperation with citizens, businesses and governmental officials. The target doesn't just slide a national target.
Ehime	Ehime Global Warming Countermeasure Guideline	2001	1990	2010	△6.0%	6	○	Ehime took acount of feasible amount of reduction based on a national target and questionnaire.
Kochi	Kochi Global Warming Countermeasure Area Promotion Plan	2003	1990	2010	△2.9%	6	○	Kochi reflect in it's target a spirit to reduce GHG emissions as much as possible in consideration of feasibility.

Fukuoka	Fukuoka Global Warming Counterm easure Promotion Plan	2006	2002	2010	Basic unit target for each entity	6	○	While Fukuoka's targeted gases are 6, the only CO2 is related to it's numerical target. Regarding CO2 which is the largest source of GHG in Fukuoka, Fukuoka selected the most influential sector for future CO2 emissions increase and set a reduction target for each actor. Furthermore, Fukuoka set a straightforward target for citizen's activity to reduce 10 percent electricity consumption due to strong relation between the electricity usage and CO2. It expected that the target lead 6 percent reduction in Fukuoka.
Saga	Saga Global Warming Counterm easure Area Plan	2003	1990	2010	□7.0%	6	○	Saga determined it's target from emission reduction estimation
Nagasaki	Nagasaki Environm ental Master Plan	2004	1990	2009	□6.0%	CO2 only	○	Nagasaki took account of emission reduction estimation and national target.
Kumamot o	Kumamot o Global Warming Counterm easure Action Plan	2001	1990	2010	□6.0%	6	○	Kumamoto took account of 6 percent reduction target of Kyoto Protocolt.
Oita	Oita Global Warming Counterm easure Area Promotion Plan	2005	2002	2010	Sectoral target	CO2 only	○	Oita leave an acitivity of industrial process sector to an industrial world's voluntary action plan. Oita set a target for social and carrier sector.
Miyazaki	Miyazaki Global Warming Counterm easure Area Promotion Plan	1997	1990	2010	□37.0%	6	○	The reason for Miyazaki's higly motivated numerical target is that it can reduce a wide range of nitrogen oxide. Regarding CO2, Miyazaki set a target to reduce 7 percent emissions. Furthermore it took

								account of emission reduction estimation and national target.
Kagoshima	Kagoshima Global Warming Countermeasure Promotion Plan	2004	2002	2010	□1.1%	6	○	Kagoshima hasn't been a large source of GHG emissions because of small scale of industry and nuclear energy and so forth in Kagoshima. It set a target to reduce 1.1 percent emissions. If the target is achieved, emissions par capita in Kagoshima will be less than national avarage.
Okinawa	Okinawa Global Warming Countermeasure Area Promotion Plan	2003	2000	2010	□8.0%	6	○	It is actually impossible to achive 6 percent emissions reduction from 1990 levels. The reason for Okinawa set a base year in 2000 is that emissions par capita in Okinawa caught up with a national average in that year. Okinawa determined 8 percnet emissions reduction target in consideration of emission reduction estimation.

Table 5.7

Prefecture	Program serveyed	Drafing and revising program year	Base year	Target year	Reduction target	Target Gas	Wheter carbon sink is included in target or not	Concept of Target etc.
■Hokkaido								
□□Sapporo City	Sapporo City Global Warming Counter measure	2001	1990	2010(midterm)	□6%	6(Target will be achieved only by CO2 reduction)	○	Sapporo city took account of a numerical target of Kyoto Protocol.

	Area Promotion Plan			2017(final term)	□10%	CO2 only	undescribed	Sappro city set a bese year in 2001 because it was remarkable busy time for maintaining it's population and social capital because it was in the process of development in 1990.
Ishikari City	Ishikari City Global Warming Countermeasure Area Promotion Plan	2004	2001	2010(midterm)	□6% (per capita)			
				2020(final term)	□10% (per capita)			
Fukagawa City	□It has been released as public information of Priority Measure implemented by 2009 fisical year					6	×	Fukagawa city took account of emissions reduction estimation and Kyoto Protocol target.
■Iwate								
□□Sendai City	Sendai City Global Warming Countermeasure Promotion Plan	2002	1990	2010	□7% (per capita)			
■Ibaraki								
Tokai Village	Tokai Village Global Warming Countermeasure Offense and Defense Plan (Tentative)	in preparation		2011	suspense			
■Tochigi								

□Utsunomiya City	Utsunomiya City Global Warming Countermeasure Area Promotion Plan (Tentative)	in preparation				6	×	
■Gunma								
Isesaki City	Isesaki City zGlobal Warming Countermeasure Area Promotion Plan	2005	2004	2010	□5%	6	×	Isesaki city determined it's target from emission reduction estimation.
■Saitama								
□□Saitama City	Saitama City Global Warming Countermeasure Area Promotion Plan	2005	1990	2012	No less than □6% (per capita)	6	○	Saitama city determined it's target from emission reduction estimation and took account of a numerical target of Kyoto Protocol.
■Chiba								
□□Chiba City	Chiba City Global Warming Countermeasure Plan	2003	1990	2010	□6% compared to 2006 levels	6	×	Chiba city determined it's target from emission reduction estimation. It estimated 0.9 percent reduction from 1990 levels.
Funabashi City	Funabashi City Global Warming Countermeasure Plan (Tentative)	in preparation	suspense					
Nagareyama City	Nagareyama City Environmental Action Plan (4th Edition)	2005	2003	2009	No less than □6% (per capita)	6	×	Nagareyama city referred to a numerical target of Kyoto Protocol. It set a par capita target because its population would increase due to opening of Tsukuba Express and so forth.

■Tokyo								
Taito Ward	Taito Ward Global Warming Countermeasure Area Promotion Plan	2005	1990	2009	□6%	6	×	Taito ward estimated 2.2 percent reduction from base year levels (because of large amount of reduction by industrial sector). It set a target to reduce 6 percent to cope with increase in emissions from home and office.
Itabashi Ward	Itabashi Ward Global Warming Countermeasure Area Promotion Plan		1990	2012	□6%	CO2, CH4, N20	○	Itabashi ward conformed to a target of its environmental master plan.
■Kanagawa								
□□Yokohama City	Yokohama City Global Warming Countermeasure Area Promotion Plan	2001	1990	2010	No less than □6% (per capita)	6	×	Yokohama city took account of a Kyoto Protocol target. It set a par capita target because its population would increase remarkably.
□Kawasaki City	Kawasaki City Global Warming Countermeasure Area Promotion Plan	2004	1990	2010	□6%	6	undescribed	Kawasaki city set 6 percent reduction target in consideration of Japan's Kyoto Protocol target. It set the target for each actor and gas.
Yokosuka City	□Details have not yet been decided.	2007 (expected)						
Fujisawa City	Fujisawa City Environmental Master Plan (Chapter 4)	2005	1990	2010	□6%	6	undescribed	Fujisawa city determined it's target from emission reduction estimation. It took account of a Kyoto Protocol target.
■Aichi								

□□Nagoya City	Nagoya Global Warming Countermeasure Action Plan (Amendment)	2001	1990	2010	□10%	6	×	Nagoya city determined it's target from emission reduction estimation and maintained a target of prior plan.
■Kyoto									
□□Kyoto City	Kyoto City Global Warming Countermeasure Plan	2006	1990	2010	□10%	6	○	Kyoto city revised the first revised target. It maintained 10 percent reduction target and added numerical target for each policy.
■Osaka									
□□Osaka City	Osaka City Global Warming Countermeasure Area Promotion Plan	2002	1990	2010	□7%	6	×	Osaka city determined it's target from emission reduction estimation.
■Hyogo									
□□Kobe City	Kobe City Global Warming Countermeasure Promotion Plan	2000	1990	2010	□6%	6	×	Kobe city took account of Kyoto Protocol.
Amagasaki City	□in preparation								
■Hiroshima									
□□Hiroshima City	Hiroshima City Global Warming Countermeasure Area Promotion Plan	2003	1990	2010	□6%	6	included when calculation method will be established	Hiroshima city determined it's target from emission reduction estimation. It tooka account of a numerical target of Kyoto Protocol.
■Yamaguchi									
Shimonoseki City	Shimonoseki City Global Warming Counter	1997	unspecified						

	measure Plan							
Ube City	Ube City Area Energy Conservaiton Vision		1990	2010	Below base year	CO2 only	undescribed	
■Fukuoka								
□□Fukuoka City	The Second Fukuoka City Global Warming Countermeasure Promotion Plan	2000	1990	2010	□6～7%	6	undescribed	
□Kitakyushu City	Kitakyushu City Global Warming Countermeasure Area Promotion Plan (Tentative)	in preparation	2002	2010	Sectoral basic unit target	6	○	Kitakyushu city determined it's target based on Kyoto Protocol Target Achievement Plan and reduction rate of Fukuoka.
■Nagasaki								
Saseho City	Saseho City Global Warming Countermeasure Area Promotion Plan	2006	1990	2010	□6%	6	○	Saseho city determined it's target from emission reduction estimation.
■Kagoshima								
□Kagoshima City	Kagoshima City Global Warming Countermeasure Area Promotion Plan (Tentative)	in preparation						

note: □prefectural capital, □government-designated city

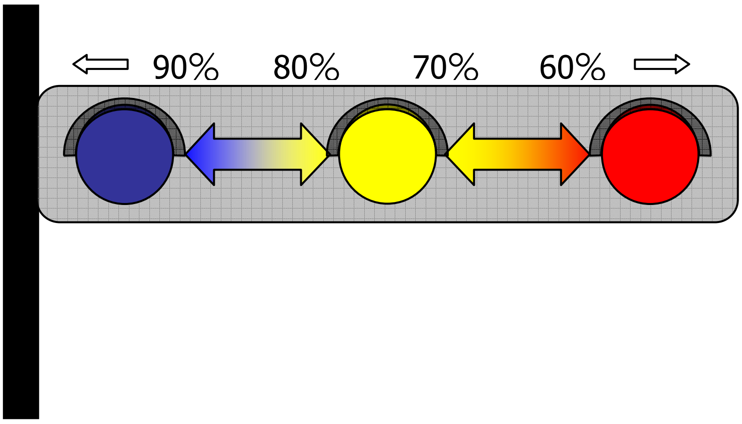
Interim Conclusion

Our exercises in this paper have shown that it would be necessary for Japan to reduce its GHG emissions by between around 65% and more than 80% in 2050 from 1990 level, should we set a long-term goal of climate protection at 2℃ global mean surface temperature increase from pre-industrial level, which corresponds to the stabilization level of 475ppm by a calculation made by the AIM Impact[policy]. This figure is based on various assumptions and calculations. But, even if we consider the scientific uncertainty, it is highly likely that it would be necessary to reduce the emission by 60% or more in order to manage the risks of climate change. The range of these numeric values may change when applying methods such as emission differentiation, and may also be affected by the level of emission stabilization and calculation assumptions to draw it. Also, these target figures may change depending on the level at which people consider the acceptable level of the risks associated with climate change, let alone scientific uncertainty between the level of climate change and its impact. Moreover, when we consider the same emission level, whether a country such as Japan sets its target at 70% or 80% would directly affect and alter the emission of other countries (including those of developing countries), as the total global emission allowed is limited. They are zero-sum game when you put it globally.

Differentiation is necessary whatever scenario we take on international political change, but the way to differentiate may differ from scenario to scenario. For example, if "prioritize economic development" scenario is taken, then sector target model might fit into the scenario better than the currently calculated intensity improvement model. Further work is needed in exploring better differentiation model for each scenario. In addition, we need to explore the extent to which international institutions can deal with in making global differentiation work. Also important is to observe carefully the shift in paradigm. This affects the direction of the international society, according to our analysis. Changes may undergo without showing clear phenomenal indication at empirical level of international politics of our generation. As constructivists argue, "seeds" of paradigm changes might grow up at normative and perceptional level.

For a country based target, our tentative conclusion, which may serve as a starting point of the domestic target-setting debate, is that 60% to 80% reduction of GHGs by 2050 from 1990, or even more reduction where the situation allows, is needed in order to limit the impact of climate change at manageable level. Low carbon scenario should be made taking these figures into account. As the scenario develops, it may then provide bottom-up, scenario-based targets, which would then give inputs to the target study in return. Such interaction between target study and scenario study would further develop the frontier to move towards de-carbonized society.

The current signal indicates 60-80% reduction in 2050 as a starting point, but the signal may be changed depending on the signal from science and the signal from the society. It is ultimately the choice and value judgment of people that decides the amount of reduction and the target that the society aims at in order to manage the risk.



<u>2050 GHG reduction target indicative signal to avoid dangerous climate change</u>