The 7th Keio and Tsinghua Student's Environmental Symposium

The 3 Pillar Approach

The Future Framework for Climate Change After Kyoto

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Introduction

Resolving Climate Change is one of the most important priorities for human beings in the 21st century. It is commonly recognized that Climate Change is indeed happening and is caused by anthropogenic emissions of the so-called Green House Gases (GHG) into the atmosphere. Inactions against this problem are likely to result in catastrophic damage to the global socio-economic system as well as the entire eco-system, and the cost will have to be largely borne by future generations. Therefore, it is the important task of the current generation as well as the future ones to reduce anthropogenic GHG emissions and stabilize GHG concentrations in the atmosphere at an appropriate level so as to minimize the damage caused by Climate Change.

Climate Change is intrinsically a global issue. Therefore, global cooperation is needed to resolve it. With this recognition, the international community has had a number of dialogues and negotiations. United Nations Framework Conventions on Climate Change (UNFCCC) and the Kyoto Protocol can be considered particularly important achievements amongst of all. UNFCCC was adopted in 1992 and it defines the ultimate goal of the international Climate Change policy as 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system' (Article 2.1). For this purpose, the Kyoto Protocol, signed in 1997, imposed quantified GHG emission limitation and reduction commitments on the so-called Annex 1 countries, which basically consists of developed countries and economics in transition (see the table below for more detail). It seems undeniable that these agreements have raised the awareness over Climate Change and has promoted scientific research as well as policy development at various levels on the issue. However, it is important to understand the current such framework as merely the first step towards resolving Climate Change.

The problems is that although Climate Change is a long-term issue, the current framework only covers the 5 year period from 2008 to 2012, thus lacking a long-term perspective. Moreover, environmental effectiveness of the current framework is in doubt, as US and developing countries do not practically participate in the Kyoto Protocol. US announced its withdrawal from the protocol in 2001 and developing countries do not have any quantified targets under the protocol. Provided that emissions from these countries far outweigh those from the others, it is not reasonable to repeat the Kyoto Protocol every 5 year from 2013 onwards. Therefore, it is necessary to create the new framework for Climate Change alternating the Kyoto Protocol with the setting a long-term objective and the description of the direction as to how the objective can be achieved. The aim of this paper is to meet this necessity by presenting the desirable future framework for Climate Change dealing with the period after Kyoto.

The chapter 1 discusses the necessity and the appropriate type of a long-term objective and concludes that aiming at the stabilization of GHG concentrations at 550 par parts million (ppm) is a reasonable one. Since this objective is very ambitious and requires substantial GHG reductions to take place, global participation and the minimization of the cost associated with reduction efforts are essential. The chapter 2 and 3 deal with these two issues one by one, respectively. The chapter 2 focuses on developing countries' participation and proposes the Multi-Stage Approach from the viewpoint of equity. Then the chapter 3 talks about the extension of international emission trading and the development of innovative technologies, both of which are considered to be important elements in bringing down the reduction cost. It is important to note here that economic efficiency of the entire framework is crucial if American participation is to be achieved. Finally, the chapter 4 summarizes the discussions made in preceding chapters and presents the overall picture of the future framework that this paper seeks to promote.

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Chapter1 Targeting 550ppm

This chapter discusses the importance of a long-term objective, why it is needed and what it should constitute. Then it argues that the stabilization GHG concentrations at 550ppm is an appropriate and reasonable target and examines its implications on the future framework.

1.1 Setting a long-term objective

1.1.1 Why it is Needed and What it Should Constitute

Climate change is a long-term issue that occurs at the global scale. A huge amount of GHG is emitted into the air, among which energy-related CO2 emission is particularly large. Then GHG accumulate in the atmosphere and stay there for more than hundred years[1]. As a consequence, temperature rises and climate change occurs. It is important to note here that the direct cause of climate change is not GHG emissions determined in the short-term, but the GHG concentrations determined in the long-term. Increase and decrease in GHG emissions for the short period of time hardly affect the level of their concentrations[2]. If GHG concentrations are to be stabilized, GHG emissions have to be continuously reduced for a long period of time. Therefore, when establishing the future framework to tackle with climate change, it is essential to set the long-term objective. GHG concentration level can be considered as an excellent candidate, as it is closely linked to the severity and the extent of Climate Change.

With respect to the Kyoto Protocol, it has near-term targets about GHG emissions for the first commitment period from 2008 to 2012. For example, EU target is -8% compared to the base year 1990, Japan is -6% and Russia is ±0% likewise. However, the protocol has no long-term objective, on which these short-term emission targets should be based. This constitutes one of the significant flaws of the protocol and therefore has to be remedied in the subsequent framework. Such a framework should have a long-term objective such as stabilize GHG concentrations at the certain level[3]. Then, near-term emissions targets like the ones specified in the Kyoto Protocol or action plan can be set based on the long-term objective. Moreover, according to the material from the Ministry of Environment Japan, the long-term objectives chosen in European

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[1] CO2 remains in the atmosphere approximately 5~200 years. IPCC(2001)

[2] According to IEA(2002), assuming that Kyoto target is achieved, there are little impact on the concentrations. It will be 382ppm, compared with the BAU concentrations 383~383.5ppm.

[3] Setting the level of temperature change is another candidate for a long-term objective. However, since it is not closely linked to GHG emissions that can only be controlled directly, it is more difficult to specify concrete measures to achieve such an objective than in the case of GHG concentrations.

countries are mainly the stabilization of concentrations (see table 1-1).

Table 1-1: Long-term objectives in European countries

Country/time	Long-term objective	Middle-term objective
Germany (2003.10)	・Restrain the rise of temperature maximum 2℃, below 0.1℃ in 10 years, compared with pre-industrialization. ・Restrain the CO_2 concentrations below 450ppm.	Reduce energy related CO_2 emissions 45~60% (compared with 1990)
United Kingdom (2003.2)	Restrain the atmospheric CO_2 concentrations below 550ppm.	Cut down the CO_2 emissions 60%.
France (2004.3)	Stabilize the CO_2 concentrations below 450ppm.	・Reduce per capita emissions up to 0.5tC (by 2050) ・Cut down the emissions up to 3GtC at the global level (by 2050)
Sweden (2002.11)	Stabilize the atmospheric GHG concentrations at 550ppm. (CO_2 concentrations below 550ppm)	Cut down per capita GHG emissions up to 4.5tC in the industrialized countries by 2050 and reduce gradually. (8.3tC now)

Source: Ministry of Environment Japan (2004)

1.1.2 Setting a Concrete Long-term Objective

The previous section made it clear that stabilizing GHG concentrations at the certain level is an appropriate and effective long-term objective for the future framework. Furthermore, this idea is consistent with the Article 2.1 of UNFCCC, which states that "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". However, the question remains as to what level is such a level. This section examines this issue.

The tricky part of Climate Change issue is uncertainty and the answer for the above question is 'we do not know yet.' Although it is widely recognized that catastrophic and irreversible environmental events might possibly occur with GHG concentrations level exceeding the certain threshold, unfortunately the current scientists are incapable of identifying where the threshold exists. Under such a condition of uncertainty, the better strategy would be to aim at the lowest possible GHG concentration level deemed to be attainable according to the current state of scientific knowledge and technologies. This can leave more options with regard to GHG concentration level for future generations to deal with uncertainty.

Then, what is the lowest possible level considered to be attainable[4]? According to IPCC Second and Third Assessment Report (SAR, TAR), GHG concentrations cannot be stabilized at 350ppm because in order to achieve it, CO2 emissions have to go negative at the certain point in the future. In the case of 450ppm, the emission global peak is predicted to be 2005~2015, and after that substantial emission reductions are needed[5]. In addition, emissions from developed countries as of 2000 have to be smaller than that of the 1990 level, and continuous emission reductions need to follow. However, CO2 emissions in developing countries have been steadily growing and have already exceeded the 1990 level considerably. In addition, developing countries, whose emissions are likely to exceed those of developed countries, have no obligation about GHG emissions under the current framework and their emissions are growing, too[6]. For these reasons, it is very difficult to achieve 450ppm unless, for instance, rapid technological progress occurs. This leads to the conclusion that the stabilization of GHG concentrations at 450ppm cannot be achieved under the conditions of current scientific knowledge and technologies. Then what about 550ppm? It is feasible to achieve this target because it initially allows the global GHG emissions to increase more for the longer period of time compared to 450ppm. However, at the next section explains, it is by no means an easy target.

1.2 Analyzing Stabilization Scenarios for 550ppm and their Implications

1.2.1 Stabilization Scenarios for 550ppm

This section introduces and analyzes the two commonly used scenarios, which present the different emission paths to stabilize GHG concentrations at 550ppm in 2150 (see Figure 1-1). One of them is called S550 profile and the other is WRE550 profile. They are introduced in IPCC SAR. The green curve shows the baseline mean scenario, in which no measure is taken to mitigate climate change (IS92a). The yellow line is present emissions. More details about S550 and WRE550 profile are explained in Box 1.

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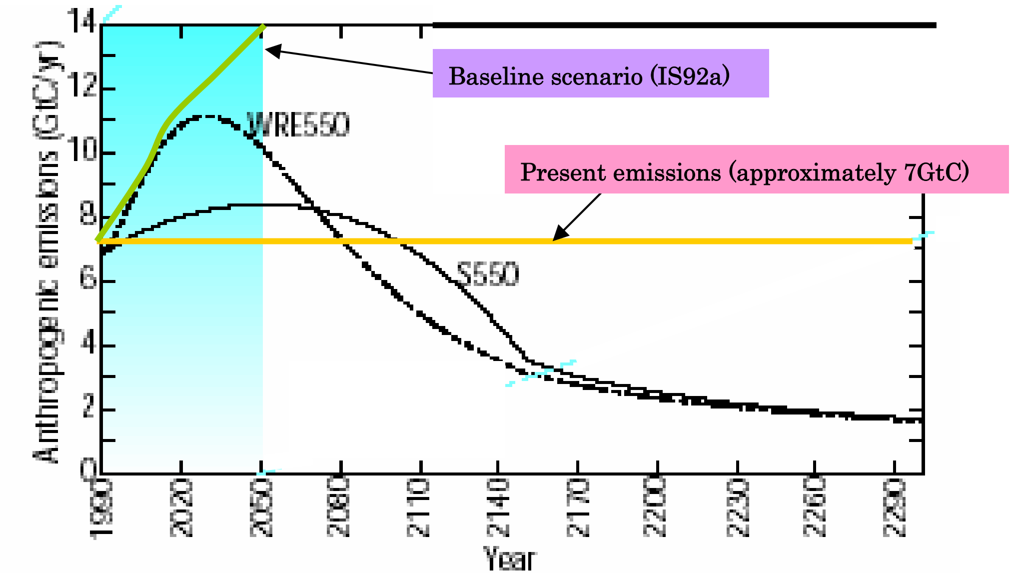
[4] In this connection, current GHG concentration level is 365ppm.
[5] IPCC(2001) WGI & Synthesis Report
[6] See figure 1-3

In each profile, emissions increase at the beginning. But there is a large difference in the extent of increase, and as a result, the following emission paths differ. S550 profile initially limits emission growth to the greater degree and thus allows the subsequent emission reductions to take place rather slowly for the longer period of time. On the other hand, WRE550 profile initially tracks IS92a and allow emissions to grow more. After the emission peak, it reduces emissions more sharply over the short period of time in order to catch up with the other scenario. As Figure 1-1 shows, these two scenarios indicate that substantial GHG emission reductions are required to achieve 550ppm. Thus, 550ppm is a feasible target, however, it is not a low-hanging fruit.

【Figure 1-1: Stabilization Scenarios】



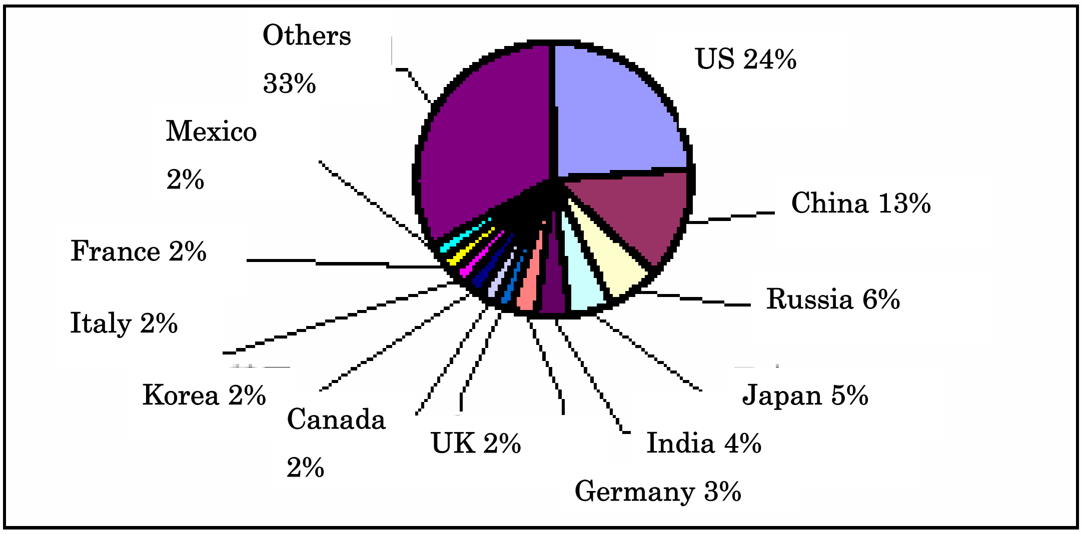
Source: IPCC SAR technical paper 3

1.2.2 Implications from the scenario

The fact that 550ppm requires substantial emission reductions seems to have two implications for the future framework. First, global participation into the framework is essential. However, the current framework, namely the Kyoto Protocol, fails to attain it because it lacks US participation and developing countries' participations. As a result, it covers only one third of the total emissions. Therefore, when establishing the future framework, considerations should be made as to how to encourage more countries to participate into it. Chapter 2 discusses this issue with particular reference to developing countries' participation.

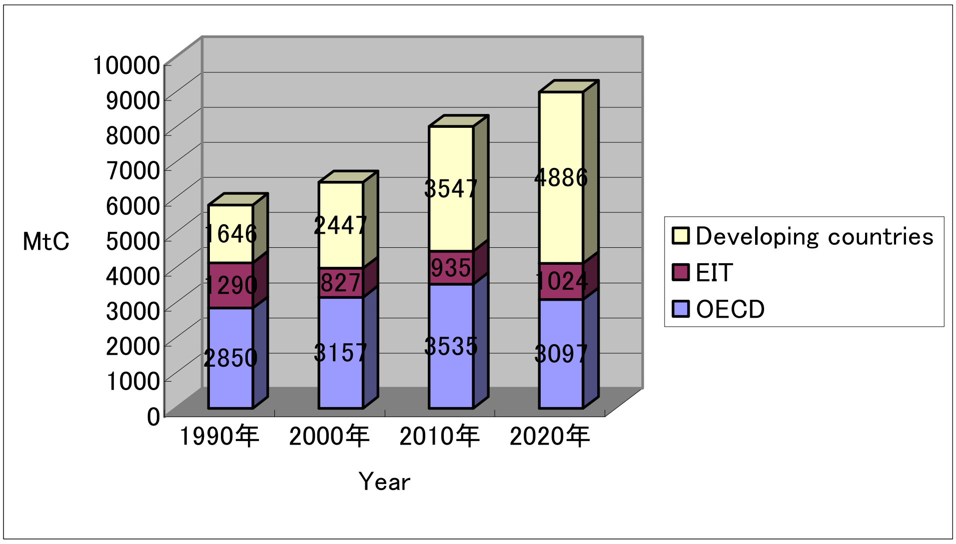
Second element is the minimization of reduction cost. No countries are willing to participate in the regime that has negative impacts on their economies, US in particular. It is stated in UNFCCC article 3.3 that "policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest cost". Moreover, the cost minimization is important in terms of the efficient allocation resources. Chapter 3 examines how to improve economic efficiency of the future framework.

【Figure 1-2: Ratio of energy related CO2 emissions】



Source: METI Japan

【Figure 1-3: The prospect of CO2 emissions】



Source: METI(2003)

Box 1. S550 profile and WRE550 profile[7]

Though S550 and WRE550 profile assume stabilizing GHG concentrations at 550ppm in 2150, there is a large difference between the emission paths of two profiles. S profile is constructed under these constraints: (1) prescribed initial (1990) concentration and rate of change of concentration; (2) a range of prescribed stabilization levels and attainment dates; and (3) the requirement that implied emissions should not change too abruptly. WRE profile is added an additional constraint to these three, the view of cost-effectiveness. It considers the balance of the economy and the environment. This is what makes the two scenarios differ. In WRE profile, emissions trajectory initially tracks IS92a. This is because substantial reductions in the near future are less expensive than immediate reductions[8]. However, it does not imply that “do nothing” or “wait and see” policy is better. WRE profile is one of the emission path scenarios and it requires measures and investments in earlier stage to reduce GHG emission in the subsequent periods.

[7] Wigley, Richels, Edmonds (1996)
[8] There are three reasons below;
①Positive marginal productivity of capital
②Capital stock (stock for energy production and use is typically long-lived)
③Technical progress

Chapter2 Achieving Developing Countries' Participation

2.1 From the Viewpoint of Equity

Chapter 1 set the appropriate but rather ambitious long-term objective for the future framework, which is to stabilize GHG concentrations at 550ppm. It requires substantial GHG emission reductions to be made globally. Therefore, developing countries' participations are essential. However, in order to achieve it, the issue of equity needs to be resolved. This sections deals with this issue by explaining the basic principles of equity firstly, and then by examining the future framework that meets such principles.

2.1.1 What Is Equity?

Equity is a situation in which all people is treated equally and no one has an unfair advantage. However, it needs to be noted that such situation is in reality too ideal to be realized. For example, the Kyoto target, namely, the fixed emission cap which urges countries to reduce their emissions by absolute terms compared to 1990 is not be able to treat equally developed and developing countries, both of which are in different industrialized stages, and have different priorities on global warming. In general, from an economic viewpoint, developing countries are expected to achieve a rapid economic growth in the future, while from an environmental aspect, they are putting a relatively higher priority on pollution such as water pollution and air pollution than on global warming. For these reasons, developing countries have not yet born any emission reduction target[9]. Besides, U.S., the No.1 economy in the world withdrew from Kyoto Protocol Mar. 2001, being anxious about serious harm to its economy[10].

Although it is difficult, a multi-lateral environmental treaty should avoid a situation where national interests of only a handful of countries are met. However, at an international negotiation where national interests conflict with one another, they might possibly come to a conclusion similar to Kyoto Protocol, and it is much more likely without any scientific data or concept. This is why the concept of equity should be incorporated into the future framework.

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[9] UNFCCC(1995) I. Decisions adopted by the conference of parties(Berlin mandate) Article 2.b "Not introduce any new commitments for parties not included in Annex1" As written here, developing countries (non-Annex1 countries) have taken no commitments.

[10] Declaration of President Bush (13/3/2001) "I oppose the Kyoto Protocol because it exempts 80 percent of the world, including major population centers such as China and India, from compliance, and would cause serious harm to the U.S. economy."

2.1.2 Five Basic Principles of Equity

There are many elements of equity at climate change. John Ashton and Xueman Wang (2001) said equity has 5 dimensions; responsibility, equal entitlement, capability, basic need and comparable effort. Next I will explain these elements one by one

1. Responsibility

   It is clear that global warming is cased by increasing GHG concentration. At present, developed countries that industrialized primarily should assure larger responsibility and act first, because they have more historical GHG emissions. However, developing countries will industrialize in the future. So they would have responsibility. This element is compatible “common but differentiated responsibility” specified in the Article 3.1 of UNFCCC.

2. Equal Entitlement

   This element is about natural resources. Atmosphere can be considered as sort of limited resource that we can use to emit GHG into. It should be equally distributed among individual livings on this planet regardless of developing country or developed country. In other words, every living is the stakeholder.

3. Capability

   Capability is the ability to deal with global warming financially and technically. Economic resources and technology is essential to act in tackling with climate change. Developed country has more economic resources, more technologies and more possibility to access new technologies. On the other hand developed country has less economic resources and technologies.

4. Basic Need

   Basic Need means poverty, public health, water problem, education and so on. The countries that lack basic need should be exempted from taking actions to mitigate climate change. These countries that are so-called least developed countries (LDCs) should act to domestic problems at first. The new agreement permits LDCs to grow their economy firstly.

5. Comparable Effort

   Effort is a cost to act for climate change. Nation will compare the others in terms of cost per a unit of GHG reductions. If the other country bears lower cost, the nation would reject an agreement. This dimension relate to other dimensions particular capability. Under the international agreement, it is necessary that each country pay the same cost per a unit of GHG reductions.

2.1.3 A Proposal That Meets Equity

There are some proposals that meet equity. In this section, l will give examples of proposals.

For Responsibility, Brazilian proposal is a good example. This approach would be to distribute emissions according to the relative historical emissions of different countries (only about developed countries) for the extent of problem[11]. Developing countries, however, exempted from obligations. Therefore it does not satisfy Equal Entitlement. Moreover this approach sometimes impose extreme reduction upon earlier industrialized country[12]

For Equal Entitlement, Contraction and Convergence (C&C) that is based on per capita emissions is a good idea. If everyone has an equal right to account for emissions, the next stage of the climate regime should bring per capita emissions closer together. So countries with higher per capita emissions should reduce them; but those with low ones should have headroom within which to increase them. This approach is not taken Responsibility into consideration because of simultaneous participation.

For Comparable Effort, emission trading will be good idea (Cf. chapter.3). The country that has higher marginal abatement cost can buy the permit from the country that has lower one by emission trading. So each country can achieve target by lower cost. Emission trading makes each country's marginal abatement cost equal. Therefore Comparable Effort will be satisfied.

We suggest differentiation of timing and commitment based on Responsibility, Capability and Basic Need. And for Equal Entitlement, we propose convergence of per capita emissions across countries. We assume that dimensions of equity should express per capita GDP and emissions. For example, Responsibility for global warming will express per capita emissions. Capability and Basic Need will be per capita GDP. The countries that have larger per capita GDP should be developed countries. So these countries must have economic resources and technologies. On the other hand, the country that has less one should be developing country. Moreover if this figure is very little, that country would lack Basic Need. In addition, using emission trading would satisfy Comparable Effort. Consequently, every element of equity can be satisfied. Next section introduces "Multi-stage Approach" which meets every element of equity explained above.

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[11] UNFCCC (1997)

[12] E.g. UK should reduce 65% of 1990 level by 2020.

Box 2. Contraction and Convergence

The "Contraction and Convergence" proposal, developed by Aubrey Meyer (2000), assigns every human being an equal entitlement to emission of GHG. Every country should move towards the same per capita emissions. Total emission should contract over time, and per capita emissions should converge on single figure. After 2013, all nation should take part in the framework simultaneously and per capita emission should converge at target year, say 2030 or 2050. Finally, this approach set a target to stabilization of GHG concentration at 450 ppm or 550 ppm after 2100.

It is valuable that the proposal stands on a long-term viewpoint and converge per capita emission on single figure. Per capita emission convergences across countries permit developing countries particular LDC to increase their emissions for now. It means satisfying Basic Need.

Simultaneous participation regardless of developing country or developed country does not satisfy Capability and historical Responsibility. Should not those living in cold countries (with high heating needs) or large countries with dispersed populations (high transport needs) be allowed higher per capita emissions? Geographical difference leads difference of energy consumptions. The large resource transfers from currently high per capita countries to low ones implied by the scheme may be equitable; but it is probably unrealistic to expect such commitments at this stage. By such transfers, this proposal would not be accepted all over the world.

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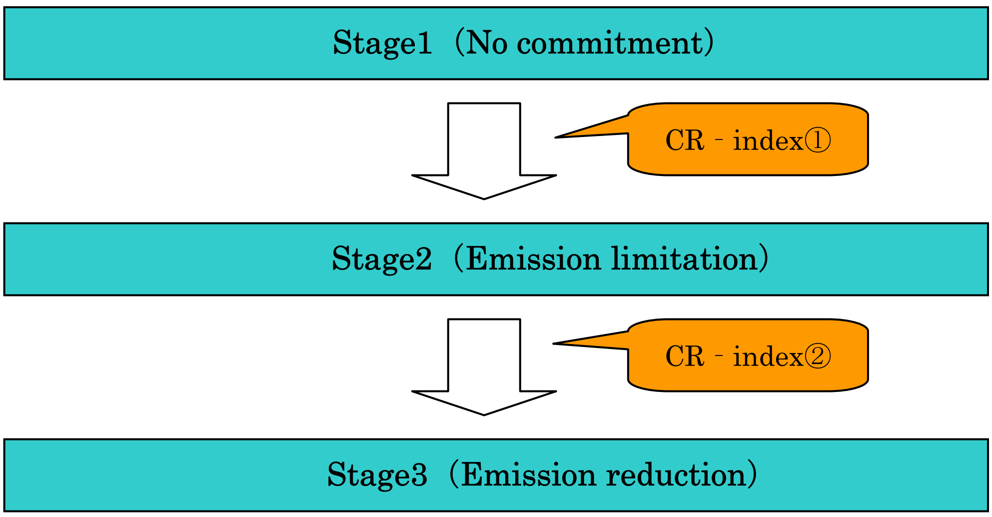
2.2 Explanation of Multi-stage Approach

The previous chapters argued that developing countries' participations are essential in order to stabilize GHG concentrations at 550ppm. Moreover, the future framework should meet the viewpoint of equity so as to promote developing countries' participations. In concrete, it is necessary to incorporate the convergence of per capita emissions (equal entitlement) and the differentiation of participation timing and the degrees of commitments (responsibility, capability and basic need) into the future framework. The Multi-Stage Approach, originally designed by Den Elzen who is the researcher in the Dutch governmental research institute called RICM, contains and therefore is likely to satisfy the viewpoint of equity. This section explains this approach and analyzes the result of Elzen's simulation, which aims to understand how it works for the period after Kyoto

2.2.1 Outline of Multi-stage Approach

The ultimate objective of the Multi-Stage Approach is to stabilize GHG concentrations at 550ppm in 2150. This approach consists of three stages with different types and degrees of commitments, into which each country is categorized. The degrees of commitments increase as countries move to the next stage. The stage 1 contains no quantitative commitments, the stage 2 with limitation targets and the stage 3 with reduction targets. It is reasonable to argue that at the very beginning of the post-Kyoto period, least developed countries belong to the stage 1, other developing countries to the stage 2, and developed countries to the stage 3 according to their respective responsibilities, capabilities and fulfillment of basic needs. Thus, the Multi-Stage Approach differentiates participation timing and the degrees of commitments among countries, and thus successfully satisfies equity. The following two subsections explain the commitment in each target in more detail and how to move from one stage to another, respectively.

【Figure2-1: Outline of Multi-stage approach】



2.2.2 Explaining the Type of Commitment in Each Stage

Those countries that belong to the stage 1 do not have quantified commitments and allowed to emit as much GHG as they would like to. They are equivalent to developing countries under the Kyoto Protocol. Those countries in the stage 2 have to limit their emission growth relative to business-as-usual cases; however, they are allowed to increase their emissions in the absolute term. Intensity targets, which are emission divided by GDP, are reasonable as the concrete type of commitments in the stage 2. Since such a target allows emissions to increase to some extent with the economy growing, it is highly acceptable for developing countries that have to achieve more economic growth. Finally, those countries in the stage 3 have to commit themselves to absolute emission reduction targets. Theses targets are derived from the long-term objective of the entire framework, namely the stabilization of GHG concentrations at 550ppm. This is quite a contrast to the Kyoto Protocol for which emission targets were largely determined by political negotiations.

In order to attain the emission reduction amount for each country, the total reduction amount for all the countries belonging to the stage 3, let's say TRA, is calculated in such a way that it is consistent with the long-term objective. Then, the share of the country n within the total reduction amount, S (n), can be calculated as the ration of its absolute emission multiplied by its per capita emission to such a value of all the countries in the stage 3 put together (See Equation 1 and 2 in Figure 2-3)[13]. Finally, the reduction amount for the country n is equal to TRA multiplied by S (n). The implication of this calculation method is that countries with either larger absolute emissions or higher per capita emissions or even the both have to reduce more GHG emissions. This will ultimately lead to the convergence of per capita emissions as show in Figure 2-4.

【Figure 2-2: calculation of emission reduction amount for each country】

Emission reduction for the country n	=	Total emission reduction for the entire stage 3	×	Share of country n S (n)

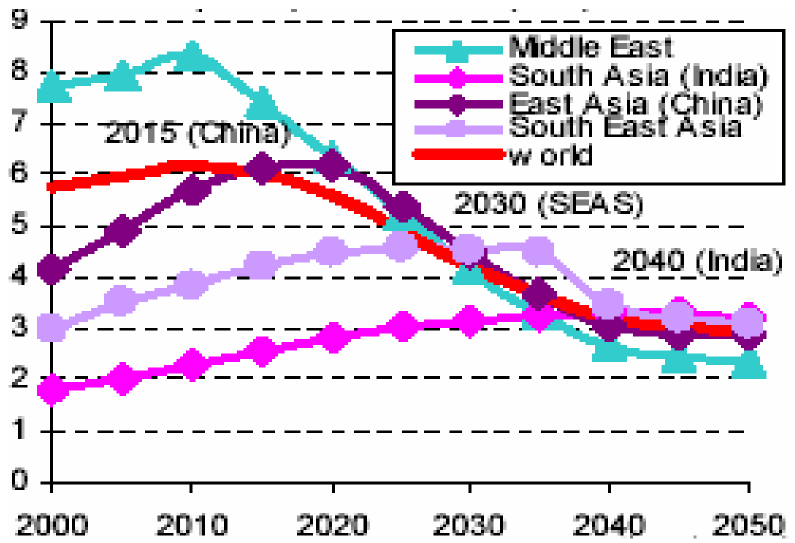
Equation 1: $Sn = Xn / X_1 + X_2 + X_3 + \cdots + Xn$

Equation 2: Xn = absolute emission (n) × per capita emissions (n)

n : country

[13] Every country compared multiplying total emissions to per capita emissions in other countries. Then, share of each country is determined, and calculated emission reduction. For example, there are only two countries (A and B) in stage3. And the figure which multiplied total emissions to per capita emissions in A country is 100, that figure in B country is 200, total emission reduction in the world in a commitment period is 600. So, amount of emission reduction in A is 200; 600*(100/100+200). In the same way, that figure in B is 400.

【Figure2-3: Trajectories of per capita emissions of different regions (unit: tCO2/year)】



Source: den Elzen(2004)

2.2.3 Transfer of Countries between Each Stage

Under the Multi-Stage Approach, each country moves to the next stage[14] when its CR-index reaches the certain thresholds as shown in Figure 2-2. 'CR' stands for 'Capability' and 'Responsibility', both of which are stated in the Article 3.1 of UNFCCC, 'Common but differentiated responsibilities and respective capabilities'. Capability is reflected in GDP per capita (unit: 1000$) while responsibility is reflected in pre capita emission (unit: CO2-eq). CR-index is simply the sum of these two indicators[15] and it plays an important role in differentiating participation timing and hence the degrees of commitments. The table 2-1 shows CR-index of different regions[16] and countries..

14 Shift to a stage 3 from a stage 2 and a stage 2 from a stage 1. A stage does not fall in principle.

15 "～, in this particular variant, a one - to - one weight produces fairly satisfactory results." den Elzen (2004)

16 In the model of den Elzen, data is only created in regions, but in fact, it is not an every place region, but in each country in participating.

Table 2-1: CR-index in each country or region in 1995[17]

Country, region	Per capita GDP (1000＄)	Per capita emissions (tCO2−eq)	CR−index
USA	28	26	54
Canada	24	21	45
Oceania	17	19	36
Japan	24	11	35
OECD Europe	20	11	31
Former USSR	5	12	18
Eastern Europe	7	9	15
Middle East	5	7	12
South America	7	5	12
Central America	5	5	10
Southern Africa	2	4	7
East Asia (China)	3	4	7
Northern Africa	3	3	6
South East Asia	3	3	6
South Asia (India)	2	2	4
Western Africa	1	1	2
Eastern Africa	1	1	2

Source: den Elzen (2004)

2.2.4 Analyzing simulation made by Elzen

Elzen put 5 for the first threshold of CR-index between the stage 1 and 2. This means that countries in the stage 1 have to move the stage 2 when their CR-indexes reach 5. Likewise, the second threshold between the stage 2 and 3 is 12[18]. The figure 2-1 indicates the projections of CR-indexes four different regions and their corresponding participation timing into the later stages[19]. Based on such projections,

[17] Below the a small number of point is calculating in strict, and CR-index has carried only the integer portion intelligibly for a table.

[18] "A lower CR - value would imply the early participation of the low - and middle - income non - Annex I regions, especially for East Asia and Southern Africa, which may not be realistic. CR - values as high as 15 lead to negative emission allowances for the Annex I regions. Therefore, a CR - threshold value of 12 was chosen." den Elzen(2004)

[19] Annex1 countries belong to the stage 3 at the beginning of post Kyoto period like Kyoto Protocol. Moreover, by this model, the United States which seceded from the Kyoto Protocol will be in stage3 in 2013.

participation timing of each region or country into the stage 2 or 3 can be calculated. Table 2-2 and 2-3 show the results of such calculations. It is important to note that different thresholds can lead to different participation timing.

Table 2-2: Participation timing into the stage 2

Regions	Central America	South America	Northern Africa	Western Africa	Eastern Africa
Year	2013	2013	2013	2055	2065
Regions	Southern Africa	Middle East	South Asia	East Asia	SE Asia
Year	2013	2013	2015	2013	2013

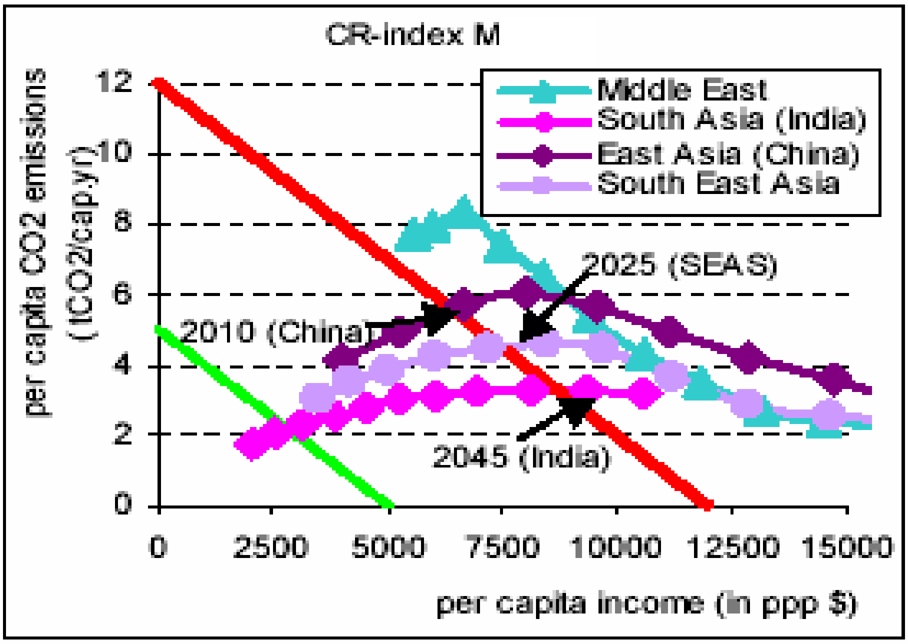
source：den Elzen(2004)

Table 2-3: Participation timing into the stage 3

Regions	Central America	South America	Northern Africa	Western Africa	Eastern Africa
Year	2015	2013	2050	2100	2100
Regions	Southern Africa	Middle East	South Asia	East Asia	SE Asia
Year	2060	2013	2050	2015	2030

source : den Elzen(2004)

【Figure 2-4: Transition of CR-index in each regions】



Source: den Elzen (2004)

Chapter3 Minimizing Abatement Costs

3.1 Extending an Emission Trading Scale[20]

3.1.1 Economic Theory of Emission Trading

According to OECD (1994), emission trading is categorized as one of economic instruments such as tax, fine, subsidy and deposit-refund. Emission trading is an instrument that enables pollutants to meet their reduction targets with minimum abatement cost. Under such a scheme, emission caps are distributed to pollutants such as firms, factories by policy makers (often Governments), and are allowed to trade the gap between the caps and their actual emissions. The core of this mechanism is an equalization of abatement costs of each pollutant. Supposing that there are two countries whose marginal abatement costs are different, a country with low marginal abatement cost reduces by itself and sells the emission gap as permits to another country with relatively high marginal abatement cost. In this way, both of them can get profits from this trading[21]. The Important point is that there is a potential for improving a social economic efficiency as long as there are countries with different marginal abatement costs.

The merit of emission trading is that total emission reduction is certain because policy makers decide the amount of initial allocation, while price of emission permits can fluctuate due to being traded at markets. Total emission reduction is certain in the Kyoto Protocol because it is proclaiming that total emission reductions of Annex1 countries in 2010 compared to 1990 be 5.2 %. On the other hand, cost is uncertain because of the difficulty of projecting a permit price and total cost of domestic reduction[22].

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[20] Relating to Multi-stage approach, we assume that emission trading takes place in stage3. If countries in stage 2 are allowed to take part in the emission-trading scheme, the volume of permits sold at the market will increase rapidly and it could cause a sharp drop of permits' price and market destruction eventually.

[21] Let us assume the marginal abatement cost of country A as MAC1, country B as MAC2, and permit price as P. If MAC1>MAC2 is the case, country A buy permits from country B at the price P (MAC1>P>MAC2). In other words, country B sells emissions it reduced by itself to country A. On the contrary, if MAC1<MAC2 is the case, then country A becomes a seller and country B becomes a buyer. Anyway, trading is continued to the point where the marginal abatement cost of each nation is equalized with one another.

[22] In recent years, many scholars and researchers have been establishing a theory to tackle with cost uncertainty of emission trading. This theory is called "Hybrid" because this mechanism is practically the same as the combination of emission trading with tax.

3.1.2 Emission Trading in Kyoto Protocol

At COP4 (Buenosailes) in Nov. 1998, a discussion on Emission trading started. After intensive discussions at COP5 (Bonn) and COP6 (Hague), finally at COP7 (Marrakech) in Oct. 2001, a consensus on the specific rules of Kyoto Mechanisms was formed (Marrakech Accord). Marrakech Accord allows countries to trade permits gotten from JI (Joint Implementation) and CDM (Clean Development Mechanism). JI, CDM and emission trading are called "Flexible (Kyoto) Mechanism" and literally it is a mechanism that gives countries flexibility to reduce GHGs in a cost-effective manner.

Emission trading is specified in the Article 17 of Kyoto Protocol[23]. It is important to distinguish the international emission trading of Kyoto Protocol from a domestic one. The parties in emission trading are AnnexB countries, namely, OECD countries, economies in transition including Central and Eastern European countries, Russia, Ukraine and the Baltic. However, the Kyoto Protocol covers only 32% of total emission of the world in 2010 (see Figure 3-1). And what is more, if U.S. and Australia remain outside of Kyoto Protocol, in 2020 the figure is going down to be 29% of the total emission of Annex2 countries[24].

The Japanese Government is claiming from an environmental standpoint that in the near future it is essential for U.S. and developing countries such as China and India, large emitters to start limiting and reducing GHGs emissions (METI 2003). It is an opinion from environmental aspect. The next paragraph interprets this issue from an economic viewpoint that increasing the number of participants in stage 3 is necessary to extend the trading scale.

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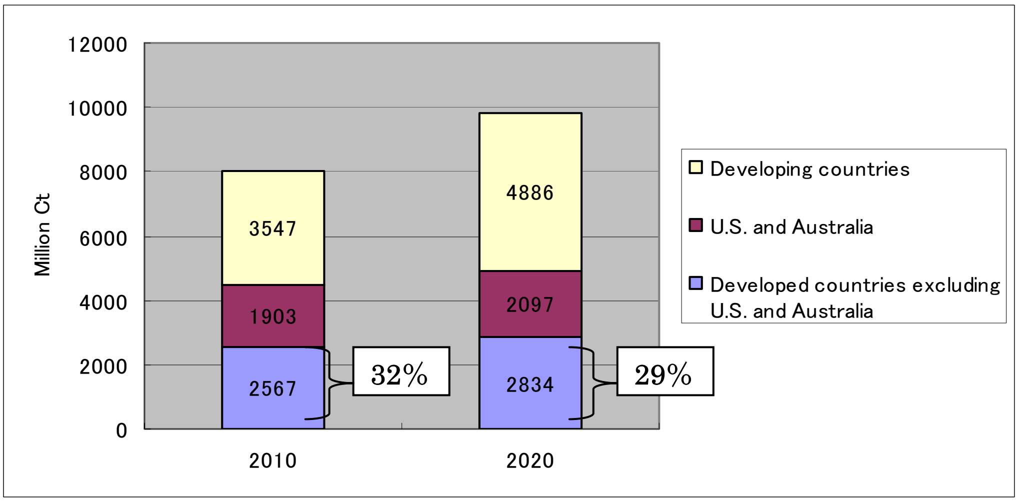
[23] Article 17 "The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3.Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article."

[24] The amount of emissions itself of developed countries excluding U.S. and Australia is increasing over time, but the proportion of that is decreasing.

【Figure 3-1: Future Projection of CO2 Emission Volume in the World】



Source: Ministry of Economy, Trade and Industry (2003)

3.1.3 Cost Reduction by Extending Emission Trading Scale

The subsection 3.1.1 mentioned that when equalizing marginal abatement cost across counties occurs, an emission reduction with minimum social cost is achieved. In other words, as long as there are countries with different marginal abatement costs, there can be a potential for improving a social economic efficiency. On the basis of this theory, we are going to examine the situations of emission trading after the first commitment period.

The case where marginal abatement costs of each country are equalized with one another during the first commitment period can achieve "a minimum social cost among developed countries" but not "a minimum social cost among all countries". Then the question arises as to which is better in terms of cost effectiveness. Since emission trading under Kyoto Protocol cannot achieve an equalization of marginal abatement costs of developing countries, the latter is better in that marginal abatement costs of both developed and developing countries are equalized with one another. It is important to remember that regardless of marginal abatement cost of each country, whether high or low, extending trading scale leads to social cost reductions because of an improvement of trading market efficiency.

It needs to be noted that marginal abatement cost is projected to decrease when developing countries begin to join in emission trading after the second commitment period (2013～)(See Table 3-1). Figure 3-2 tells that countries such as Japan, EU and U.S. have achieved higher energy efficiency than countries such as China and India. Generally speaking, marginal abatement costs of developed countries are higher because of their higher energy efficiency, and the opposite in developing countries (METI 2003). This is why developing countries' participations into emission trading can reduce the equalized marginal abatement cost.

【Table 3-1: Marginal Cost of CO_2 Abatement with and without Trading[25]】

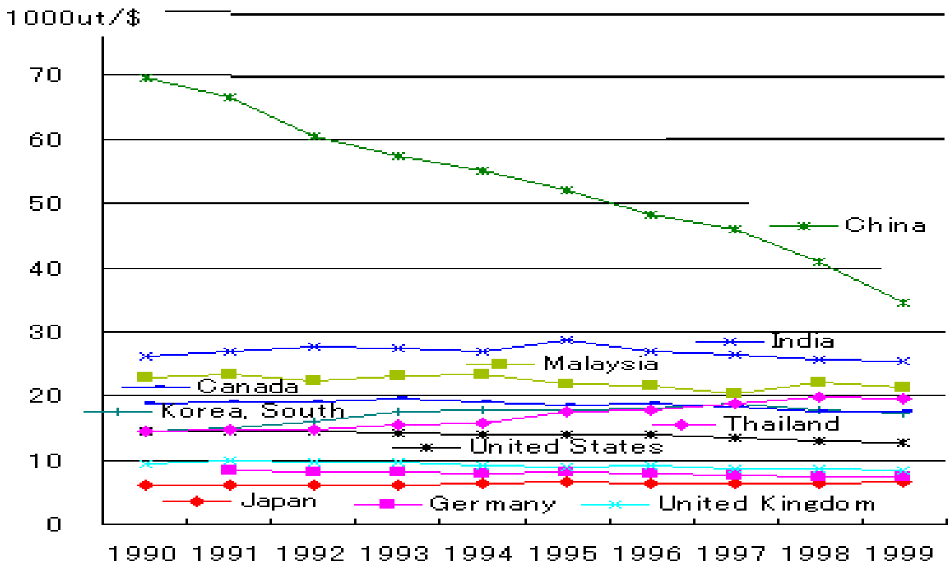
($ of the year 2000 /tCO_2)

Model	No trading U.S.	No trading Europe	No trading Japan	Annex B Trading	Global Trading
SGM	48	—	—	22	8
MERGE	81	—	—	34	24
G-Cubed	19	49	74	11	4
POLES	24	38-41	71	33	10
GTEM	111	228	222	36	—
WorldScan	11	23	26	6	—
GREEN	44	58	23	20	7
AIM	49	63	75	19	13
Average	48	77	82	24	8

Source : IEA（2001）"International Emission Trading: from concept to reality"

[25] Differences between models can be explained by: (a) variations in business-as-usual projections of CO_2 emissions, which determine the magnitude of the effort; (b) different assumptions on the availability and cost of less carbon-intensive technology; (c) the extent to which end-use energy and corresponding prices and taxes are treated in detail, as they affect the level of the additional tax to reduce emissions.

【Figure 3-2: A Change of Energy Consumption per unit of GDP】



Source : http://www.nihonkaigaku.org/ham/eacoex/index.html

There is an example showing that extending the scale of trade lowers a total cost. This is the cost analysis of EUETS (EU Emission Trading Scheme) that is going to start in Jan. 2005[26].

In the case where each country domestically carries out emission trading within nation, total annual cost amounts to 9 billion euro, whereas it costs only 6.9 billion euro under EU wide trading where all institutions and facilities are allowed to trade across borders (Figure 3-3). Figure 3-4 shows a projection that the more industries participate in EUETS, the more cost reduction is achieved.

26 EUETS is not inter-governmental trading but trading among firms. Emission caps are allocated to each facility and institution. The number of facilities participating in this scheme is about 12,000.

【The Relationship between the Scale and the Total Annual Cost of EUETS】

Figure 3-3: Nationwide vs. EU wide

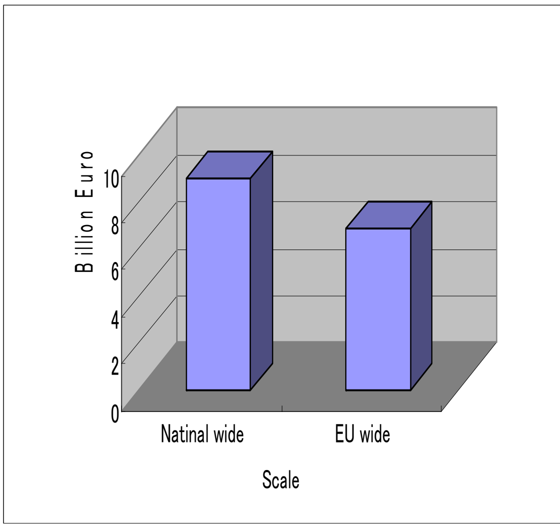
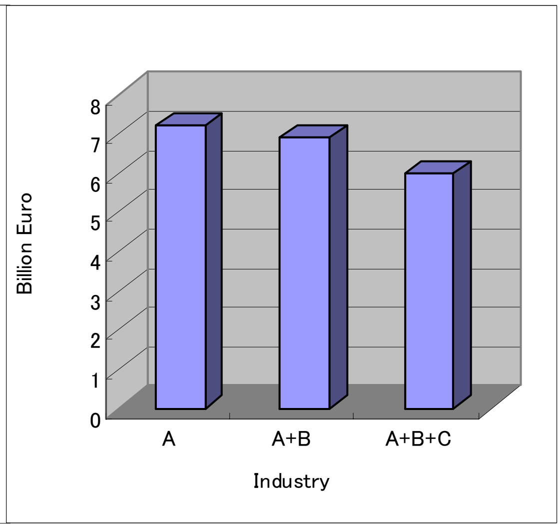


Figure 3-4: Coverage of Industries



A: Energy supply（Power）B: Energy Intensive sector（Steel、Cement）
C: Others（Agriculture、Transport、Manufacturer、etc.）
Source: OECD, Kobayashi, Yamamoto (2002)

The main point of this section is that in the near future of the post-Kyoto period, U.S., Australia and developing countries are required to participate in emission trading in order to secure cost reduction. However, extending the scale of emission trading is not enough to meet cost reduction to achieve a stabilization of atmospheric GHG concentrations at less than 550ppm. Furthermore, a great amount of international transfer of wealth seems to be unacceptable for Governments. Politically speaking, to achieve a target only by emission trading is quite controversial. To take these points into consideration, it is necessary that innovative technologies on improving energy efficiency and on fuel switching will become available and result in the drop of marginal abatement cost. Looking at the long-term horizon, innovative technology is essential to achieve the goal 550ppm.

3.2 The Development of Innovative Technology

It is crecognizeed that CO2 is a single dominant contributor of all GHG to Climate Change after industrial revolution.[27] In addition, energy related CO2 occupies largest share of CO2 emissions. Therefore, it is essential to de-carbonize energy system in order to reduce GHG emission. However, it is said that fossil fuels will continue to dominate the global energy mix in the near future, meeting most of the increase in overall energy use (IEA 2004a). This mean that a different type of technology is also needed to catch and store CO2 that is generated from the combustion of fossil fuels. Thus the diffusion of innovative technologies is inevitable to reduce substantial GHG emission and minimize the cost from long-term perspective.

As far as the process of disseminating innovative technologies is concered, it is important to consider both “inertia in energy system” and “learning by doing”. [28]The development of innovative technology to change energy system radically takes very long time. Therefore, it is needed that the government takes the initiative for development, demonstration and diffusion of such technologies and gives the market the continuous incentives for a long-term technological development by the economical instrument from an early stage.[29]

3.2.1 The Definition of Innovative Technology

$$\text{CO2emissions} = \underbrace{\frac{\text{CO2}}{\text{energy consumption}}}_{①} \times \underbrace{\frac{\text{energy consumption}}{\text{GDP}}}_{②} \times \frac{\text{GDP}}{\text{population}} \times \text{population}$$

There are two kinds of de-carbonizing technologies: a technology aiming at reduction of the degree of carbon intensity (energy conversion) and a technology aiming at improvement in energy efficiency (energy saving)[30]. We define innovative technology as “technologies which promote to de-carbonize energy system and which is not

[27] The breakdown of the contribution of different GHGs to climate change from the Industrial Revolution to 1998 shows that CO2 60.1%, methane 19.8%, N2O 6.2%, CFC and HCFC 13.5% and others 0.4%.

[28] We explain “inertia in energy system” and “learning by doing” in 3.2.2 attentions of innovative technology development

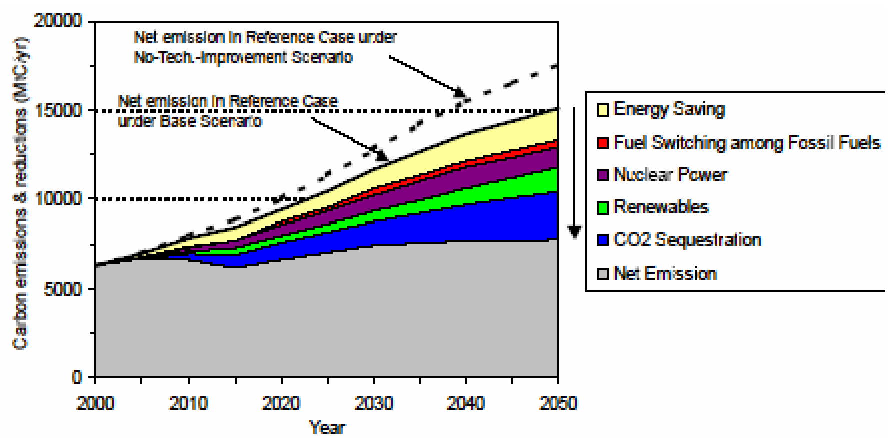
[29] The following chapter describes our view over protraction of a commitment period.

[30] This equation is called “Kaya equation” and shows the structure of CO2 emission by 4 factors.

commercialized in near term but disseminated in the long term" and thus focus on the first type. That is because the other one is not effective enough to mitigate climate because there is a risk of "rebound effect"[31].

The examples of the innovative technologies as defined above include large scale of existing renewable energy technologies such as wind, solar and nuclear, production of hydrogen fuel from renewables and carbon sequestration.[32] Moreover, satellite solar power and nuclear conversion are also included.[33] Innovative technologies exist parallel with each other in order to reduce GHG emission in energy sector[34].

【Figure 3-5】



Ministry of Economy, Trade and Industry (2004)

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31 When technical changes reduce the costs of an activity, leading to increases in that particular activity. For instance, more-efficient cars might be able to travel longer distances at lower cost – but the lower cost may induce drivers to use their cars more frequently and for longer trips, offsetting some of the efficiency gains. The increase in real income derived from increases in efficiency can also be used for other activities – some of which may themselves lead to increases in emissions. This is "rebound effect". However, we should continue to improve energy efficiency by existing technologies.

32 As mentioned above, the use of fossil fuels will be continued for decades to come. Therefore, we think that catching and storing CO2 generated from energy-intensive industries is important over such a period in addition to de-carbonizing by renewable energy.

33 Satellite solar system is the system which collects solar energy with the solar cell panel on its orbit and sends to a terrestrial antenna with transmitting equipment. Then, the sent energy is transformed into the electric power which can be used. In addition, nuclear fusion power generation is generated at a nuclear fusion reaction.

34 This figure is projected by Research Institute of Innovative Technology for the Earth (RITE). The figure shows how to stabilize 550ppm through CO2 abatement technologies. From this figure what we want to tell is that single de-carbonizing technology is not enough to achieve 550ppm and technology mix is important.

3.2.2 Attentions of Innovative Technology Development

3.2.2.1 Inertia and Capital Stock Turnover

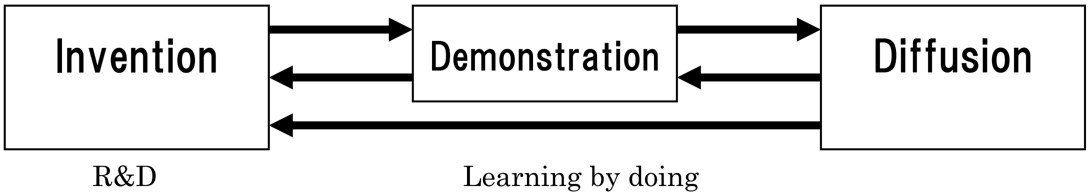
The one of the important features in the energy system is inertia. Each capital stock has different lifetime, and the lifetime of energy system is relatively long. For example, power plants and pipelines are normally used for thirty years. The choice of fossil fuels as primary energy orients technology development to rather carbon-intensive direction. IEA forecast that fossil fuels will continue to dominate the global energy mix, meeting most of the increase in overall energy use from now to 2030 (IEA 2004a). This is called the lock-in effect that industries and infrastructures tend to depend upon fossil fuel because of selection in the energy supply side.

Delays in de-carbonizing the energy sector can be significantly costly. For instance, if a firepower plan has been used for 30 years and alternative renewable energy becomes available after investment has been fully collected, smooth transfer to de-carbonizing technologies can be made. On the other hand, if renewable energy becomes available when a plant is only 5 years old and hence needs to be used more to recover investment, transfer to de-carbonizing technologies is very costly. This implies that it is very expensive to change the types of energy suddenly at one point when the importance of Climate Change is recognized or when alternative technologies become available. The better strategy would be to deploy de-carbonizing technologies gradually from the early stage.

3.2.2.2 The Role of the Marketplace – Learning by Doing－

Innovative technologies develop and diffuse in parallel with GHG abatement efforts. The development of technology is not a linear process. In fact the process is complicated, as shown below. There are feedbacks from the market place. The deployment of a new technology in the marketplace promotes its dissemination process by bringing down the cost (Figure 3-2). The expectation that a technology diffuse automatically into the marketplace in the future makes private sector invest more in R&D. This promotes the further development of innovative technologies. The policy that constrains CO2 emission gives incentives to shift energy related R&D investment from carbon-intensive technologies to lower carbon-intensive ones.

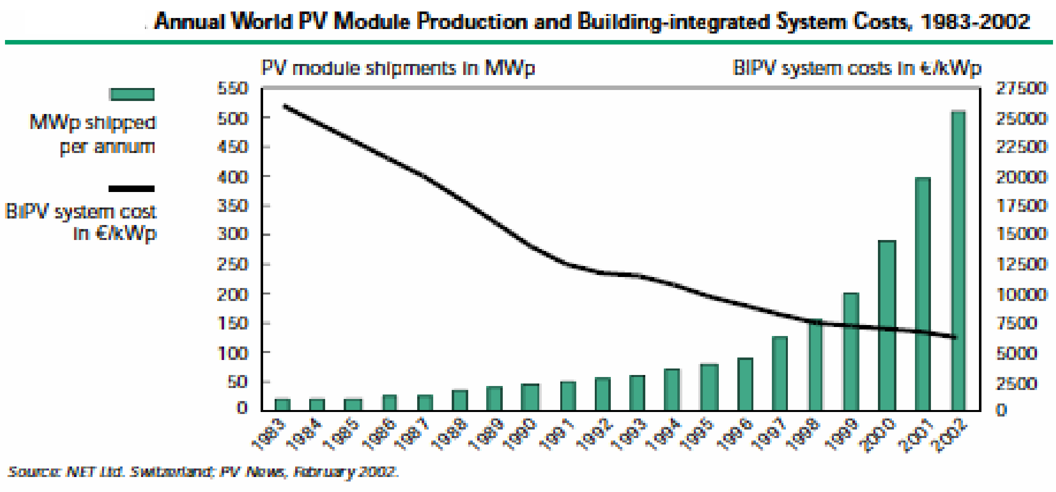
【Figure 3-6: The process of technology development】



Source : Ministry of Environmental (2004) adapted by authors

The following two case studies highlight the importance of developing innovative technologies in the market from the early stage so as to reduce its cost and promote its diffusion process. First example is solar photovoltaic. Costs for PV systems vary widely and depend on system size, location, customer type, grid connection and technical specifications. Because the cost is much higher than that of other fuels, PV is unlikely to be a significant contributor to the overall energy balance in the short term[35]. However, Figure 3-3 indicates that if it is possible to increase more volume produced, the cost will decline and PV system will diffuse.

【Figure 3-7】



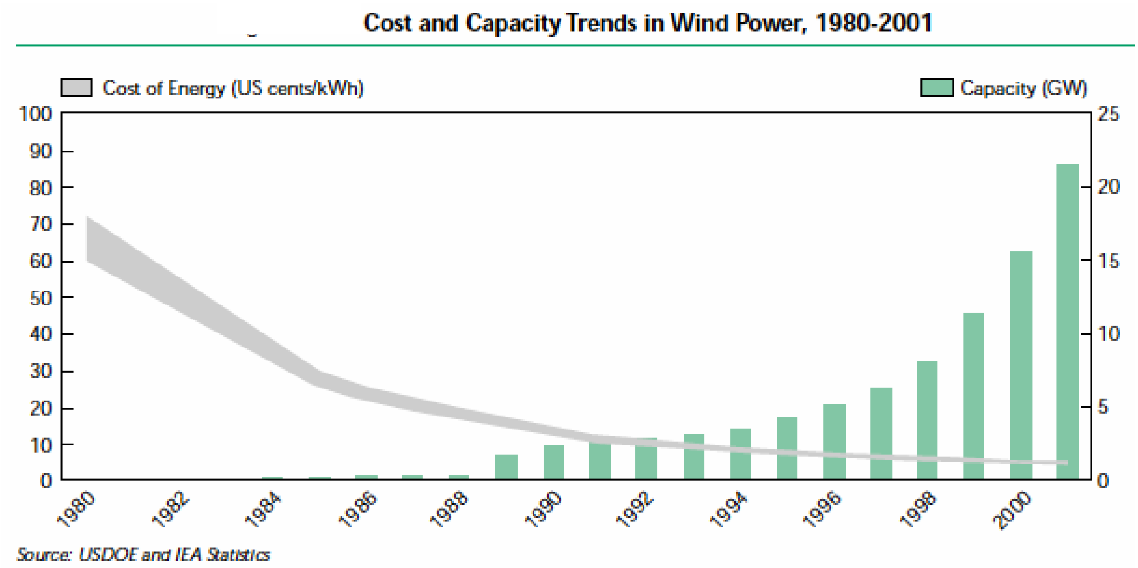
Source: IEA (2004b)[36]

[35] The weighted average price of modules in 2002 in the reporting countries with the largest markets was US$ 3.5 per Watt.

[36] IEA member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. The European Commission also takes part in the work of the IEA.

Second one is wind power. The commercial development of grid-connected wind generators started after the oil price crises in the 1970s. The government-led R&D in, the development of the wind market, and private investment in R&D has improved the technology and reduced the cost. Therefore installed capacity has increased since 1990s. Figure 3-4 shows the growth of wind capacity in IEA countries and the progression of cost reductions of delivered energy. From about US$ 0.70/kWh in 1980, wind power costs have declined steadily. The costs have dropped to about US$ 0.035 –0.04/kWh.

【Figure 3-8】



Source: IEA (2004b)

3.2.2.3 The Role of the Government－Importance of Policy－

Governments play an important role in developing innovative technologies. Appropriate policies that governments take in each stage promote the development of innovative technologies. In invention stage, government R&D is important. Even if the innovative technology is favorable, the technology that requires huge amount of costs does not diffuse automatically. That is because private sectors are reluctant to invest in R&D project because they might not be able to gain profits out of them. In short, government should subsidize R&D investment in innovative technology in order to make the technology technologically available.

In demonstration stage, there are two policies such as regulations and economic instruments. First, an example of regulations is Renewable Portfolio Standard (RPS). This standard is proposed in U.S. as a policy measure in order to disseminate renewable energy. RPS is a law to enforce electrical power suppliers to use more than a certain percentage of electricity generated by renewable energy, in proportion to annual net sales of energy. Thus it is necessary to create niche market for innovative technology to get feedbacks such as cost reduction and technological progress from marketplace. Second, economic instruments are implemented in same stage. For example, carbon tax and emission trading are known. These instruments gives incentive to employ de-carbonizing technologies in order to reduce energy related CO2. In conclusion, economic instruments and regulations are also important to reduce CO2 emission in addition to governmental subsidy for innovative technology.

3.2.2.4 The Need for International Technological Collaboration

It is necessary to diffuse de-carbonizing technologies all over the world to achieve substantial GHG emission reductions because climate change is a global problem. Moreover, invention of innovative technologies such as carbon sequestration and establishment of hydrogen economy requires an enormous cost and involved a lot of risks. Therefore, international co-operation is needed in developing such technologies and it has already started. For example, technological co-operation about carbon sequestration is agreed in June 2003 (Carbon Sequestration Leadership Forum). In addition, framework for establishing hydrogen economy is agreed by Australia, Brazil, Canada, China, European Commission, France, Germany, India, Iceland, Italy, Japan, Republic of Korea, Norway, Russian Federation, United Kingdom, and United State in November 2003 (International Partnership for Hydrogen Economy). This framework promotes to build hydrogen economy through the implementation of R&D and demonstration about hydrogen technology and using common rule.

Thus international co-operation started recently and each government should continue to cooperate with other countries for decades to come. Moreover Kyoto mechanisms like CDM and JI would be effective measures in diffusing of innovative technology. International technological collaboration should exist parallel to UNFCCC and Kyoto Protocol although it is not described in two treaties.

Chapter4 3 Pillar Approach

This chapter reviews the discussions in previous chapters and put the important elements together so as to illustrate the outline of the desirable future framework for Climate Change that is 3 Pillar Approach. Then it goes on to evaluate the approach from the perspectives of environmental effectiveness, economic efficiency, equity and feasibility, all of which are thought to be important criterions when evaluating any environmental policy.

4.1 The Setting of a Long-term Objective

Since Climate Change is a long-term issue affecting a number of generations, a long-term objective needs to be set in any framework dealing with Climate Change. However, the Kyoto Protocol fails to satisfy this point. This left the international community the need to make sure that the succeeding framework contains a long-term objective and shows how this can be reached. When setting such an objective, it is necessary to pay attention to the following two concerns. The one is that given the insufficient scientific knowledge on Climate Change to date, there is a great deal of uncertainty as to at what level GHG concentrations should be stabilized. The other one is that catastrophic and irreversible environmental events might possibly occur with GHG concentrations level exceeding the certain but unknown threshold. Considering these uncertainties, it makes sense to aim at stabilizing GHG concentrations at the lowest possible level that is consistent with the current state of scientific knowledge and technologies. This is because of the need to leave more potions regarding to GHG concentrations for future generations so that they will be well equipped to deal with uncertainties surrounding Climate Change. The chapter 1 concluded that 550ppm is an appropriate target and the following chapters have analyzed how to achieve it.

4.2 Important Elements in the Future Framework to Achieve 550ppm

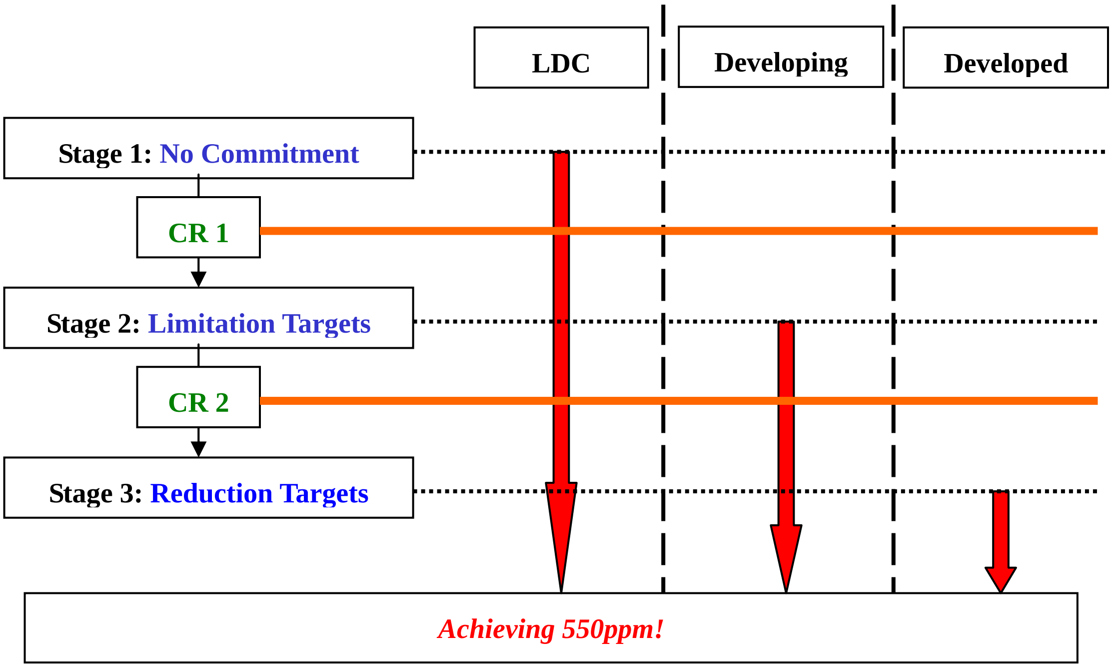
550ppm is a rather ambitious goal because it requires substantial GHG emission reductions to be made. In order to achieve it, Global participation into the future framework is very essential in the first place. Since GHG emissions from developing countries are likely to exceed those from the developed ones in the near future, their participations are particularly crucial. Secondly, the future framework should employ the certain mechanisms by which the cost of reducing GHG emissions can be minimized.

If it does, then the negative impacts on the economy can be minimized and the sufficient amount of resources can be secured for other pressing issues such as food and water shortages, health care, the fight against HIV, and so on. The concern over the economy is particularly important because if it is removed, then US is more likely to join the framework that otherwise. The following subsections will look into these issues in more detail.

4.2.1 Achieving Developing Countries' Participation

If developing countries' participations are to be achieved, the issue of equity needs to be resolved. As Chapter 2 explains, the analysis on 5 dimensions of equity leads to the conclusion that per capita GHG emissions need to be converged and the participation timing and the degrees of commitments need to be differentiated among countries according to their historical emissions and economic capabilities. The Multi-Stage Approach, introduced in Chapter 2, satisfies these points and therefore can be considered to be desirable from the viewpoint of equity. As the figure 4-1 shows, it consists of three separate stages with different types and degrees of commitments. Basically, the later stage has a stricter commitment. At the beginning, least developed countries (LDC) are in the stage 1, other developing countries in the stage 2 and developed countries in the stage 3, thus differentiating the participation timing and the degrees of commitments across countries. Those countries that initially belong to the earlier stages will have to move to the next one when their respective CR-index, which is the sum of per capita emission and per capita GDP, reaches the certain threshold between each stage. The stage 3 is designed in such a way that countries with higher per capita emission have relatively large reduction amounts. This will ultimately lead to the conversion of per capita emissions across countries over time as well as to the stabilization of GHG concentrations at 550ppm in 2150.

【Figure 4-1: Multi-Stage Approach】



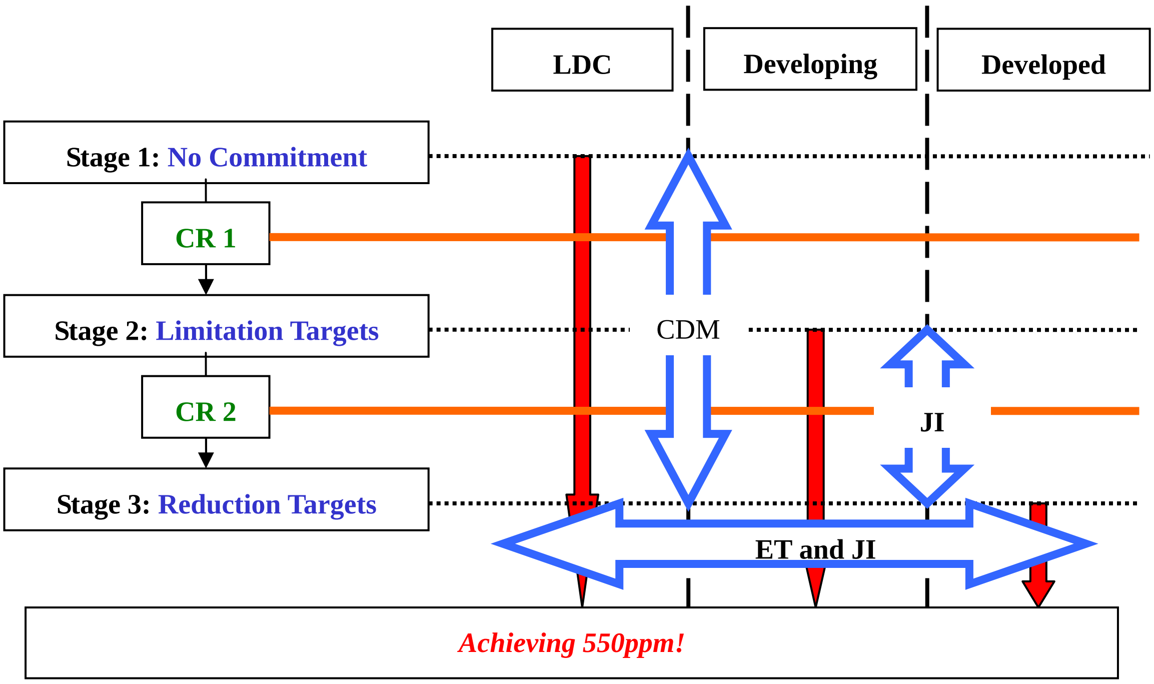
4.2.2 Minimizing the Total Cost Associated with GHG Emission Reductions

The minimization of the total reduction cost requires the equalization of marginal abatement cost in the short-term. This can be done by economic instruments such as a carbon tax and emission trading. In the long-term, technological progress can shift the marginal abatement cost curve downwards and make it less steep.

As far as economic instruments are concerned, the Kyoto Mechanisms, which are specified in the Kyoto Protocol, can be continuously used in the subsequent framework. When combined with the Multi-Stage Approach, as the figure 4-2 shows, Emission Trading (ET) and Joint Implementation (JI) can be done within the stage 3, JI between stage 2 and 3, and Clean Development Mechanism (CDM) between stage 1 and 3. JI within stage 2 and CDM between stage 2 and 1 are technically possible, however, they are omitted from the discussion due to the lack of feasibility. With particular reference to ET, its efficiency is likely to improve over time because the number of participants is expected to increase as more countries reach the stage 3, thereby producing the scale merit. However, the sudden increase of participants is likely to lower the carbon price sharply for the very short period of time. This would lead to a huge disruption in the carbon market and undermine the environmental effectiveness of the entire framework. Therefore, in relation to ET, the Multi-Stage Approach should be constructed carefully so as to allow the number of entries into the stage 3 only to increase gradually.

As for technological progress, the development, the demonstration and the diffusion of innovative de-carbonizing technologies in the energy-supply sector are essential. For this purpose, the following actions and policies are deemed to be particularly effective: international technological cooperation, the lengthening of the commitment period in the stage 3 that results in more robust and comprehensive evaluation of emission reductions by technological progress, and the deployment of new technologies from the early stage aiming to minimize inertia and maximize the effect of learning-by-doing, appropriate policies to promote innovative technologies at the national level and so forth.

【Figure4-2: Multi-Stage Approach and the Kyoto Mechanisms】



4.3 3 Pillar Approach

It can be said from the earlier discussions made so far that the 3 Pillar Approach, which consists of the Multi-Stage Approach, the continuous use of the Kyoto Mechanisms and the development, the demonstration and the diffusion of innovative technologies, is an excellent candidate for the future framework for Climate Change after Kyoto. This section examines how each pillar functions, how they relate to each other and how the entire framework can achieve its long-term objective, which is to stabilize GHG concentrations at 550ppm. Then the next section clarifies and addresses important issues with regard to the 3 Pillar Approach itself and Climate Change policy in general.

The first pillar : Multi-Stage Approach

The Multi-Stage Approach is designed to meet equity. It satisfies 4 out of 5 basic principles of equity, which are responsibility, equal entitlement, capability, and basic need. By adopting this approach, it has become possible for each country to assume a differentiated commitment with differentiated timing according to its historical emissions and economic capability. This can lead to the conclusion that the 3 Pillar Approach is more acceptable for developing countries, and hence it is more likely to invite their participations, compared to the Kyoto Protocol that uniformly imposes an absolute emission cap on each country.

The second pillar : Kyoto Mechanisms

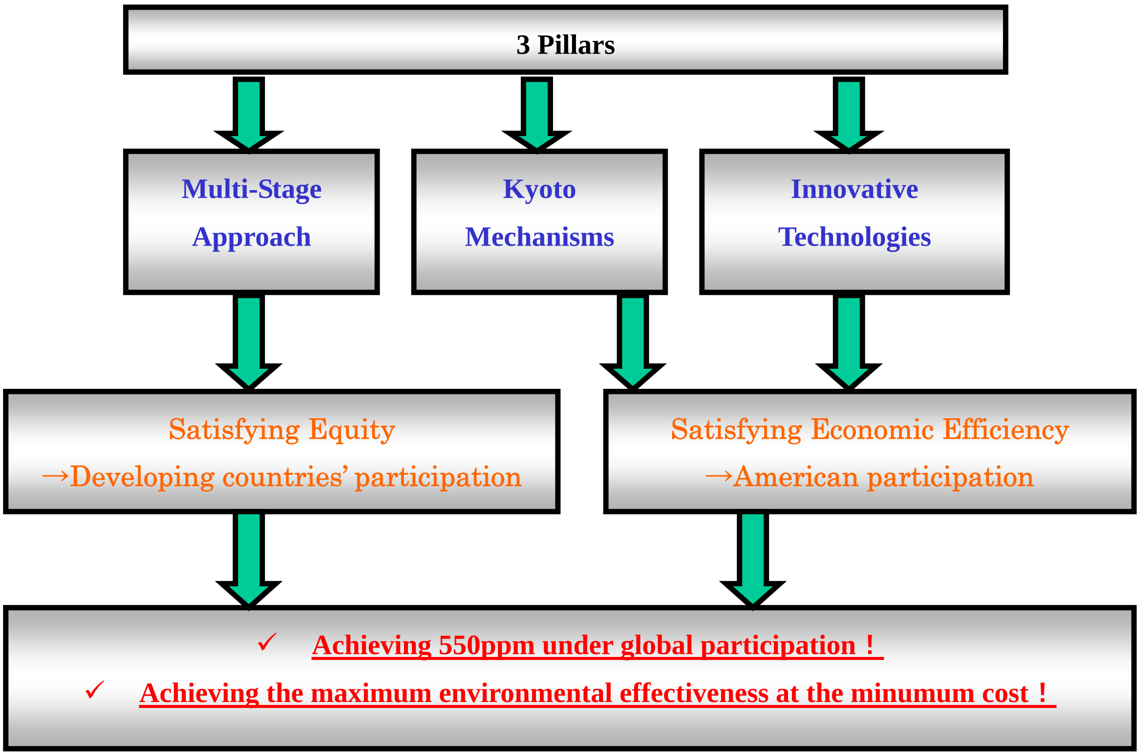
The continuing use of the Kyoto Mechanisms can lead to the equalization of marginal abatement cost, and as a result, can minimize the total GHG reduction cost in the short-term. Moreover, when combined with the Multi-Stage Approach, the efficiency of Emission Trading is likely to enhance as more countries participate in the stage 3 whereby trading takes place. These mechanisms can partially resolve the American concern over the future framework that it might have a negative impact on the economy, and therefore can pave the way for American participation into the framework. Finally, the Kyoto Mechanisms satisfy the remaining dimension of equity, namely comparable effort. This means that the combination of the first and the second pillars meet all the important dimensions of equity discussed in Chapter 2.

The third pillar : Innovative Technologies

The development, the demonstration and the diffusion of innovative technologies can significantly lower the total GHG reduction cost. This is a very important element that needs to be incorporated into any comprehensive Climate Change policy; however, the Kyoto Protocol seems to neglect this point. Furthermore, the promotion of innovative technologies and the active evaluation of GHG reductions made by them are more or less compatible with the American insistence saying that the better strategy to deal with Climate Change would be to wait until such technologies emerge and then reduce GHG emissions drastically and more cost-effectively. It is reasonable to argue that the 3 Pillar Approach, with the combination of the second and the third pillars, is more acceptable for US than the Kyoto Protocol, and therefore is very likely to succeed in persuading it to join the framework. The minimization of the total reduction cost is good not only for Americans but also for the others because it can lead to the efficient allocation of resources at the global scale and within each nation. Finally, the combination with the Kyoto Mechanisms such as JI and CDM can promote technological transfer from developed nations, whereby new technologies are likely to developed first, to developing ones.

As the above shows, the first pillar promotes developing countries' participations by fully integrating the issue of equity into the framework whilst the second and the third ones encourages American participation by resolving its concern over the economic efficacy of the framework. In addition, each pillar has the so-called synergy effects, affecting each other positively and thereby improving the performance of the entire framework. Thus, it is reasonable to conclude that the 3 Pillar Approach as a whole is an effective approach to achieve universal participation into the future framework and stabilize GHG concentrations at 550ppm. If it does work that way, it is likely to prevent catastrophic and irreversible environmental events and therefore achieve the maximum environmental effectiveness at the minimum cost (See the figure 4-3).

【Figure 4-3: 3 Pillar Approach】



4. 4 More issues to be addressed

Issue ① : Flexibility Concerning the Long-term Objective in the 3 Pillar Approach

One of the most important goals of the international future framework for Climate Change is to minimize the risks of catastrophic and irreversible environmental events, which might occur with the GHG concentration level exceeding the certain limit. Therefore, it is reasonable to aim at the stabilization of GHG concentrations at 550ppm , which is considered to be the lowest possible level to be achieved for the moment. However, whether or not this level continues to be an appropriate one remains to be seen due to a great deal of uncertainties with regard to Climate Change. As more scientific knowledge is accumulated and more technological progress occurs, the desirable level of GHG concentrations, and the range of feasible levels, might change in the future. Therefore, it is essential to ensure that 3 Pillar Approach can be flexible about its long-term objective whenever adjustments are needed.

For instance, if it is understood that 450ppm, not 550ppm, is the appropriate level at the certain point in the future, then the total reduction amount in the stage 3 and the speed at which technological progress occurs will have to be increased so as to achieve the stricter long-term objective. On the contrary, if it is realized that 650ppm is low enough to avoid catastrophic and irreversible environmental events and the extent of the consequent climate change is acceptable economically as well as environmentally, then the total reduction amount in the stage 3 can be decreased and more resources can be used for adaptation and other important environmental issues so that environmental effectiveness can be maximized as a whole.

Issue ② : The Necessity of Adaptation Measures

Although Climate Change is the issue of uncertainty as the above discussions show, it is uncertain that stabilizing GHG concentrations at the current level is close to impossible at least for the next couple of hundred years. This is largely due to the fact that GHG concentrations and their impacts such as temperature changes and sea level rise are very slow to respond to changes in GHG emissions. Even if remarkable technological progress lowers GHG emissions rapidly as well as drastically at the global scale, it is highly likely that GHG concentrations will continue to increase for a long time and so will their impacts for even longer. Therefore, it is important to realize that GHG concentrations continue to increase and consequently, Climate Change continues to occur. Provided that the 3 Pillar Approach only aims at mitigating Climate Change, additional policy needs to be implemented so as to promote adaptation both at the international and the national levels.

Issue ③ : The Feasibility of the 3 Pillar Approach

The 3 Pillar Approach intrinsically meets the viewpoints of equity and economic efficiency. This can lead to global participation into the framework, thereby improving its environmental effectiveness. Moreover, if the flexibility with regard to the long-term objective and the necessity of adaptation are taken into account, the environmental effectiveness of the entire framework can be further enhanced. Thus, the 3 Pillar Approach satisfies 3 out 4 criterions considered to be very important when evaluating any environmental policy. However, as far as the remaining feasibility is concerned, there is a room for arguments.

The feasibility concerns are considered to be twofold. Firstly, the 3 Pillar Approach aims at the convergence of per capita emissions, it might be the case that developed countries, particularly US, will have to bear disproportionate burdens. For this reason, it might be difficult for negotiators to reach the consensus because developed countries might be strongly opposed to the idea. However, it is important to note that under the 3 Pillar Approach, the convergence of per capita emissions is not the absolute policy goal but the general direction of concrete measures to be taken. Moreover, it is not certain whether or not the complete convergence of per capita emissions is desirable due to differing industrial structures among nations. In any case, burdens of developed countries in practice are likely to be smaller than those specified in the simulations of the models in which per capita emissions of different countries converge simultaneously in the certain year, say 2050. Moreover, the 3 Pillar Approach contains the Kyoto Mechanisms and the promotion of innovative technologies, which can minimize the financial burdens on developed countries. For these reasons, there is also a possibility that consensus can be made.

The other concern is the 3 Pillar Approach can not be implemented unless capacity building is made in the international organization supervising the future framework, possibly UNFCCC, and also in developing countries. Since the 3 Pillar Approach involves such elements as the differentiations of commitments, the necessity of reviewing CR-index on a regular basis, and a possible adoption of intensity target for the stage 2, it is more complicated and therefore harder to put into practice compared to the Kyoto Protocol. This will necessitate the more robust recruitment and training of competitive employees as well as the broadening and deepening of the operations in the relevant international organizations. Moreover, comprehensive capacity building needs to be carried out in the relevant authorities of developing countries, as many of them will have practical commitments under the 3 Pillar Approach.

Issue ④ : Looking at the 3 Pillar Approach from a broader perspective

The 3 Pillar Approach is an international official policy for mitigating Climate Change. It is an important and effective policy for resolving Climate Change; however, more actions need to be taken. The necessity of adaptation highlights this issue. In addition to that, supplemental frameworks or agreements to the official one might be very helpful. For example, voluntary intensity targets can be set in the certain private sectors across different countries and technological transfers can be made to achieve the targets. Furthermore, appropriate mitigation and adaptation measures need to be implemented at the national, regional and even community levels. Thus, in order to tackle with Climate Change, various kinds of policies need to be implemented by various actors and various levels. The 3 Pillar Approach should be considered as the core of such a whole policy package and it is important to realize that it cannot completely resolve Climate Change on its own. Nonetheless, it is also true that the international official policy is particularly essential amongst all because it determines the general direction of the entire policy package and therefore influences any other policy with regard to Climate Change. As the earlier discussions have proved thus far, the 3 Pillar Approach shows the right direction, and therefore will be able to lead the entire policy package to resolve Climate Change efficiently as well as effectively.

APPENDIX

APPENDIX 1

ANNEX I Countries	(OECD+EIT)
Australia	Latvia
Austria	Lithuania
Belarus	Luxembourg
Belgium	Netherlands
Bulgaria	New Zealand
Canada	Norway
Czechoslovakia	Poland
Denmark	Portugal
European Economic Community	Romania
Estonia	Russian Federation
Finland	Spain
France	Sweden
Germany	Switzerland
Greece	Turkey
Hungary	Ukraine
Iceland	United Kingdom of Great Britain and Northern Ireland
Ireland	United States of America
Italy	
Japan	
ANNEX II Countries	
Australia	Japan
Austria	Luxembourg
Belgium	Netherlands
Canada	New Zealand
Denmark	Norway
European Economic Community	Portugal
Finland	Spain
France	Sweden
Germany	Switzerland
Greece	Turkey
Iceland	United Kingdom of Great Britain and Northern Ireland
Ireland	United States of America
Italy	

APPENDIX 2 Timing of Chinese Entrance into Stage3

Figure 1 shows the change of CR-index over time until 2050. CR-index is shown by the sum of per capita GDP (unit: 1000$) and per capita GHGs emission (unit: CO2-eq). We used two types of GDP data, i.e. exchange rate and purchasing power parity (OECD 2004). Since the threshold number with which a country enters into stage 3 is 12, the year when China is going to move into stage 3 is 2030 in the case of exchange rate, and 2015 in the case of purchasing power parity (See grayish area on Table 1).

It can be expected that China prefers GDP shown by exchange rate because China can delay the timing of its entrance into stage 3. It could be possible for China to delay their entrance by changing the threshold number 12, which den Elzen (2004) used in his latest paper. What is to be remembered is that under an actual negotiation, it is quite unrealistic for China to follow this figure exactly.

【Figure 1:Projection of Chinese CR-index toward the Year 2050】

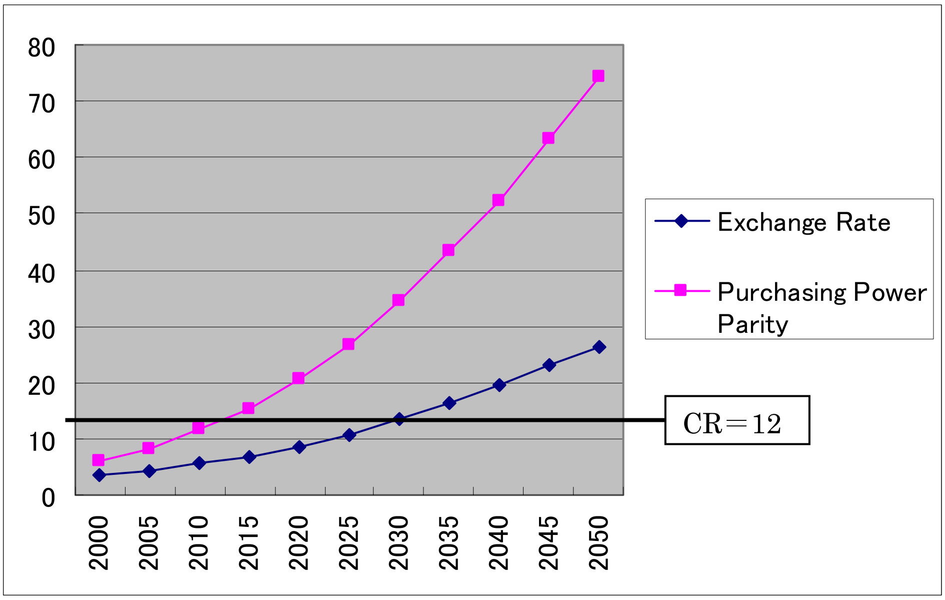


Table 1:Data of Chinese CR-index

Year	Exchange Rate	Purchasing Power Parity
2000	3.4	6.2
2005	4.1	8.2
2010	5.6	11.6
2015	6.9	15.4

2020	8.6	20.5
2025	10.7	26.6
2030	13.5	34.4
2035	16.5	43.4
2040	19.5	52.3
2045	23.0	63.3
2050	26.4	74.3

Source: RITE Mr. Tomoda's Data

APPENDIX 3　Matrix of available technologies from 2003 to 2050

There are three scenarios in this matrix. First one is "Clean but not sparkling". This scenario is characterized by a strong concern for the global environment by both the public and policy makers but relatively slow rate of technological change. Second one is "Dynamic but careless". This scenario is characterized by very dynamic technological change, low priority for climate change mitigation and a generalized belief that sustained growth and rapid progress in technologies will take care of all problems without need for much policy intervention. Third one is "Bright skies". This scenario is characterized by both rapid technological change and strong concern for the global environment by the public and policy makers. In addition the rate of economic growth of "Dynamic but careless" is the highest of the three. the rate of "Bright skies" is higher than that of "Clean but not sparkling". Energy price of "Clean but not sparkling" is the highest of the three. The price of "Bright skies" is higher than that of "Dynamic but careless" (IEA 2004b).

Time horizon and sector	Clean but not sparkling	Dynamic but careless	Bright skies
2003-2025			
energy supply	Energy efficiency improvement (EEI) technologies	Oil and gas explanation, extraction and transport technologies	Rapid energy efficiency improvement (EEI) in supply technologies

	Gas tubine plants replace coal fired plants in OECD	Oil shale and tar sands treatment technologies	Low carbon fuels (gas and renewables) in power generation
	Cleaner coal fired plants in DCs	New powergeneration fuelled by coal and gas: centralised options	Combined cycle gas turbines, first in OECD and later DCs
	Gas-fuelled generation in various forms	Some decentralised power in OECD	Gas transport technology
	Gas transport technology	Pollutant abatement technologies (Sox, Nox, PM)	Gas liquefaction and regasification technologies
	Combined cycle gas turbines, first in OECD and later DCs	Large hydro projects in DCs	Cleaner coal fired plants in coal-rich DCs
	Pollutant abatement technologies (Sox, Nox, PM)	Wind power, where competetive	Pollutant abatement technologies (Sox, Nox, PM)
	CHP micro-generation	Nuclear programmes restart in 2015-2020 in DCs and some OECD countries	CHP micro-generation
	Stationary fuel cells	Gas transport technology gas liquefaction and regasification technologies	Stationary fuel cells
	Few new nuclear plants; lifeextension and safety in OECD	Coal liquefaction and regasification technologies	Few new nuclear plants; lifeextension and safety in OECD; new reactor concepts explored
	Power generation from renewable sources; Solar PV, Wind, Biomass, Hydro (mostly in DCs)	EEI technoloies for energy transformation important towards end of period	Power generation from renewable sources; Solar PV, Wind, Biomass, Hydro (in DCs)

	continued R&D on fusion		continued R&D on fusion

Time horizon and sector	Clean but not sparkling	Dynamic but careless	Bright skies
2003-2025			
energy supply	Continued EEI as in the previous period Improvement in renewable energy technologies Continued focus on gas Resumption of nuclear programmes especially in DCs Carbon capture and storage Continued R&D on fusion	Large resumption of nuclear programmes Hydrogen production technologies (from gas, coal nuclear or biological agents) Fuel cell power plants Carbon capture and storage Technologies for hydrogen transport and long term storage technologies Wind power Solar thermal develops Fusion gets closer to commercial stage	Large resumption of nuclear programmes Significant share of new renewables in power generation (Wind, PV, high temparature solar thermal, some biomass) Hydrogen production technologies (from gas, coal nuclear or biological agents) R&D on power storage technologies Fuel cell power plants Carbon capture and storage ready for large-scale use Technologies for hydrogen transport and long term storage technologies Fusion gets closer to commercial stage

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