KEIO ECONOMIC STUDIES 43(1), 85–112 (2006)

A PROPOSAL FOR THE POST-KYOTO FRAMEWORK

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First version received October 2005; final version accepted May 2006

Abstract: The Kyoto Protocol was, in its very presence, the driving force to turn the international community toward the earnest addressing of climate change issue, especially among developed countries, and has resulted in a definite step forward today. In view of the Protocol's limited time period to end in 2012, we are now fast approaching the time to re-negotiate over a new international framework beyond 2012. The paper is constructed in a way to present the overview of Kyoto's pros and cons, and to recommend a constructive and realistic approach in designing the international framework beyond 2012. Following the introduction in Chapter 1, Chapter 2 identifies the problems embedded in the extension of current "cap and trade" regime, from the viewpoint of environmental effectiveness and feasibility. Chapter 3 analyses the pros and cons of alternative measures, including taxation, hybrid policy (combining tax and emissions trading), intensity targets, and commitment to introduce policies and measures. In Chapter 4, a "pledge (with review) and review" option is proposed as the first step toward the designing and development of a future framework that may win the participation of US and major developing countries. The epilogue briefly discusses the importance of technological innovation and diffusion, and emphasizes the need for the optimal use of globally scarce resources.

Keywords: climate change, Kyoto Protocol, uncertainties, future framework, innovative technologies.

Acknowledgements. The authors would like to acknowledge and appreciate the significant contribution and cooperation given by Dr. Toshimasa Tomoda, Principal Researcher, and Dr. Keigo Akimoto, Senior Research Scientist, both of System Research Group at the Research Institute of Innovative Technology for the Earth.

CHAPTER 1. INTRODUCTION

Once being feared to fail, the Kyoto Protocol has finally entered into force in February 2005 by Russia's ratification, more than seven years after its signing in 1997. Upon its entry into force, the Annex B countries of the Protocol (developed countries and economies in transition, hereinafter referred to as the Developed Countries) are obligated to comply with the quantitative targets on greenhouse gas emissions reduction and limitation, set forth by the Protocol to each country for the first Commitment Period (2008–2012). The Annex I countries[1] under the Framework Convention on Climate Change, which entered into force in 1994, merely committed that " Each of these Parties shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs." (UNFCCC Article 4.2, underlined by the authors)[2]. Compared with such muted commitment, the targets set forth in the Kyoto Protocol are truly an epoch-making, and have been appreciated as such. In fact, Japan and EU member countries already implemented various domestic measures with an aim to comply with the Kyoto targets, which resulted in concrete and sound outcome, with EU even starting its regional emissions trading scheme since January 2005. Still, the Kyoto Protocol embraces various issues and problems. The Protocol's regime is valid only for the first Commitment Period, with no provision for post-2012 period. This paper will seek out these problems embedded in the Kyoto Protocol, and, based on such observation, examine the potential forms of a post-Kyoto framework the world must aim for.

Needless to say, all the climate change measures must provide global and long-term effects. In this sense, the new framework must be the one to induce the participation of US, which have decided not to ratify the Kyoto Protocol, and major developing countries[3], which have no reduction/limitation obligation at present.

According to the DNE21+ Model developed by the Research Institute of Innovative Technology for the Earth (hereinafter referred to as RITE)[4], the total emissions of countries with commitment to reduce/limit emissions contribute to only 33% of global emissions (as of the year 2000), largely due to US's withdrawal from the Kyoto Protocol. Considering the rate of economic growth and population increase among developing countries, mainly in China and India, the share of the same Developed Countries in

[1] Consisted of developed countries and economies in transition. Basically, the Annex I countries are same as the Annex B countries under the Kyoto Protocol except for few countries. For example, Turkey is an Annex I country but not an Annex B country.

[2] Akao (1993, p. 314)

[3] In this report, "participation" means committing to a certain numerical targets, rather than formally acceding to an agreement. "Non-participation" is used in a similar context.

[4] DNE21+ Model is a model to minimize energy system costs, and use 550 ppm CO_2 concentration scenario shown in the IPCC (1995, pp. 21–24) as a global stabilization scenario, which is to stabilize concentration at 550 ppm after 2150. The scenario was applied until 2050. For population, GDP, and final energy demand, the B2 scenario among IPCC SRES emissions scenarios is used. Under such restrictive conditions, regional emissions from 77 regions in the world can be calculated until the year 2050. For the Model itself, refer to Akimoto et al. (2004) or Industrial Structure Council (2004, pp. 54–57).

Table 1. Estimated energy origin CO_2 emissions in the RITE DNE21+ Model (Reference case)

Unit: Mt/C

Year	2000	2005	2010	2015	2020	2025	2030	2040	2050
World total (A)	6287.66	6946.21	7828.81	8641.34	9635.54	10756.61	11943.9	13812.02	15093.87
Annex I	3702.57	3892.18	4114.26	4453.8	4912.26	5300.15	5666.32	5952.93	5868.76
(US+Aus.)	1649.16	1867.35	2044.39	2261.55	2515.11	2690.32	2825.99	2903	2851.35
(Kyoto Parties) (B)	2053.41	2024.83	2069.87	2192.25	2397.15	2609.83	2840.33	3049.93	3017.41
Non-annex I	2585.09	3054.03	3714.55	4187.54	4723.28	5456.46	6277.58	7859.09	9225.11
Share of Kyoto parties (B/A)	33%	29%	26%	25%	25%	24%	24%	22%	20%

global emissions will decline further down to 20% by 2050 (Note: In terms of energy origin CO_2emissions, refer to Table 1).

However, as seen in the discussion at COP10 (the Tenth Conference of the Parties of the Framework Convention on Climate Change) in December 2004, both US and major developing countries have maintained extreme reluctance in committing themselves to any form of quantitative targets. An international framework without these countries is not only restrictive in terms of environmental effectiveness, but also likely to lead to the collapse of such framework in the future.

CHAPTER 2. POSSIBILITY OF EXTENDING THE "CAP AND TRADE" REGIME[5]

The Kyoto (or a cap and trade) regime could provide greater certainties in environmental effects, as it would warrant emissions reduction and limitation in absolute terms. It could also offer higher efficiencies or cost-effectiveness, as it would allow member countries to use international emissions trading to comply with the initial targets at minimum costs. The regime also allows each member country to determine domestic measures at its discretion. Because of the following reasons, however, the world will need to design a different structure for the post-Kyoto framework.

2.1. *Problems of "cap and trade" regime for the second commitment period*

The former section highlighted the major problems of "cap and trade" regime, i.e. non-participation of US and major developing countries, which will be discussed in the next section. Prior to such discussion, the paper will address the institutional difficulties of the Kyoto Protocol regime, especially those related to cap and trade scheme, as they will likely materialize if the Kyoto regime will be kept for the second commitment period and beyond[6].

[5] Here, keeping Kyoto regime does not mean that the quantities and rates of emissions reduction among developed countries (reduction and limitation targets) will remain the same in a post-Kyoto framework, but that the framework of cap and trade will be maintained.

[6] Needless to say, the discussion stated below presumes that today's scientific knowledge will be maintained in the situation stated in the previous chapter. If IPCC's ongoing works for the Fourth Assessment

First, there is a problem in setting absolute quantities as targets (capping). The Protocol values not the amount of efforts exerted to achieve the target, but the actual compliance (or non-compliance) of targets as a result of such efforts. In other words, the Kyoto regime demands member countries to deliver "results" rather than "efforts". Such approach will present problem because of inherent differences in national situation, including the difficulties or costs needed to comply with the targets. These differences will depend on external factors such as economic growth rate, rather than internal elements like the wills to implement climate change measures. Therefore, even if a country exerts much effort in climate change measures, it may still face extreme difficulty in accomplishing the target when the favorable condition of global economy leads to higher than expected economic growth rate. This means that, under the cap and trade regime, it is not possible to clearly predict the cost of target compliance. Certainly, a country can reduce the compliance cost to a certain degree by utilizing Kyoto Mechanisms (emissions trading etc.), but not entirely. As long as there is a cap on overall emissions for all participating countries, uncertainties in costs will remain.

The second problem of the Kyoto regime concerns equity (or member countries' understanding) in the initial allocation of emission caps and the transparency in the criteria used for the allocation. Originally, the discussions of Kyoto Mechanisms used to focus on their efficiency after the initial allocation of caps. Here, the "efficiency" means to minimize the overall emissions reduction cost of participating countries, under the given initial allocation, without incorporating the national interest of any country. However, if a participating country cannot wholly appreciates the appropriateness and transparency of the initial allocation (i.e., the initial allocation to a country is unfairly small, making the purchase of emissions reduction from other countries inevitable), then that country will not likely participate in the post-Kyoto agreement. The initial allocation of quantitative targets under the Kyoto Protocol was the product of political negotiation and, therefore, arbitrary and non-transparent, without the thorough understanding from member countries. Ashton and Wang (2003) suggested five factors of equity in emissions reduction, which included the responsibility in emissions, equal entitlement to per capita emissions, capacity to act, basic needs, and comparative efforts in emissions reduction. Although the Kyoto Protocol provides a certain sense of equity among developing countries, Developed Countries can hardly appreciate it. For Developed Countries, the important factor is the comparative amount of efforts given, but the Protocol does not fully appreciate large gaps in abatement costs existed among Developed Countries. Inequity in initial allocation and non-transparency in allocation criteria may become significant obstacles for the continuation of cap and trade regime in the post-Kyoto era[7]. Fundamental question here is: "is there a criterion to satisfy all or almost all countries?" Whenever a country participates in an international negotiation on climate

Report provides new knowledge and insights, and finds the increased probability for the occurrence of irrevocable events with serious consequences, such as the collapse of thermohaline circulation, then keeping Kyoto may become the best option. In this sense the science can play decisive role in the climate change issue.

[7] In addition to the issue of initial allocation, the determination of the base year presents another big problem, but we will not discuss this here.

change, it brings its own national interests in mind (such as to avoid adverse effects on its economy, or on the competitiveness of own industries). Unless there is a criterion to satisfy every country, the initial allocation of emissions (or capping) must undergo modification.

Third problem is the cross-border transfer of funds. Emissions trading may mitigate the inequity of initial allocation, but it always induces the international transfer of funds. If the lenient criteria in initial allocation favor some countries, it is equal to granting unreasonably vast amount of assets to those countries[8]. On the other hand, the countries laden with higher cost of emissions reduction will have to pay significant amount of money to purchase emissions allowance from seller countries. Such inequity among countries will not be politically tolerant[9]. Moreover, the funds transferred through emissions trading will not be like those transferred under the ODA (Official Development Assistance), which usually has a specific objective. The assets transferred under emissions trading are under the exclusive ownership of a seller country, and their disposal is entirely at the discretion of that country. The situation described above may undermine the significance and feasibility of the Kyoto Mechanisms (especially the emissions trading). The Kyoto Mechanisms can play an important role in minimizing gaps in reduction costs, but, if not utilized to their full extent, they may lead to the collapse of the Protocol's very base in cost-effectiveness. Considering the facts that the cap and trade system can easily lead to the rise of hot air (which is another systematic problem of the Protocol), and that the seller country governments can freely use windfall revenues earned from emissions trading, the fund transfer issue may create huge obstacles against the continuation of a Kyoto-like regime[10].

2.2. *Continuation of "cap and trade" regime and participation of US and major developing countries*

In above sections, we identified the institutional problems of keeping a Kyoto-like regime. If there is any possibility that US and major developing countries are to participate in such a regime, then it will be worthwhile to study the possibility and to solve these problems. But, will there be?

[8] Victor (2001, p26) calculated the initial CO_2 allocation quantity at the price of $14/tonne, and came up with 2 trillion dollars in worldwide allocation. According to his calculation, Russia and Ukraine are to receive 510 billion dollars in total. If the hot air in Russia will be 30% of its total emissions, Russia will get the windfall of 120 billion dollar in assets.

[9] McKibbin and Wilcoxen (2002, p. 109) discussed about how much fund transfer to Russia US could bear for the purchase of Russian emissions allowances.

[10] In fact, both Japan and EU are extremely cautious with the purchase of hot air from Russia. Environmental reinvestment can control the transfer of hot air. Grubb et al. (2001, p. 32) describes as "Thus, in its most specific form, the proposal is that revenues obtained from selling emission allowances should be reinvested domestically in ways that would lead to further emission reductions."

The inevitable answer is that the possibility is nil. The initial emissions allocation for the second commitment period will likely be even more restrictive for Developed Countries than before[11], and US will certainly be asked to accept a prohibitive target. As a country chosen not to participate in the Protocol for the reason of stringent reduction target for the First Commitment Period (in addition to the lack of meaningful participation by developing countries), US will undoubtedly reject such a target. US's current climate change measure (to reduce GHG emissions per GDP by 18% between 2002 till 2012) indicates that the absolute volume of US's GHG emissions will inevitably increase along with its economic growth (Van Vuuren et al. (2002, p. 293) indicated 32% increase over 1990). In the prospect of large emissions increase, the world cannot afford to allow more lenient reduction target to US, and other Developed Countries cannot give a sole advantage to US. If so, the continuation of a Kyoto-like cap and trade regime will again invite US's refusal.

It is a common knowledge that, under the pretext of "common but differentiated responsibility," developing countries will not participate in a framework unless the biggest emitter, US, does. If US and developing countries do not participate, then the framework will only cover one third of global emissions, significantly limiting the environmental effects. It is inconceivable that Japan and EU will accept such situation, in view of adverse effects on their industries' international competitiveness.

As seen above, the continuation of a Kyoto-like regime will undoubtedly present many difficult problems. An entirely new framework is needed.

CHAPTER 3. REVIEW OF ALTERNATIVES TO "CAP AND TRADE"

In this chapter, we shall review four typical alternatives to Kyoto, which are commonly discussed today: harmonized carbon tax, hybrid policy (combining tax and emissions trading), intensity targets, and the commitment to introduce policies and measures (hereinafter referred to PAMs). In this chapter, we discuss these alternatives mainly from the Developed Countries' perspective. The issue of developing countries' participation will be reviewed in Chapter 4.

3.1. Outline of each alternative

First, we give an overview of four alternatives. The Kyoto Protocol's cap and trade regime aims to reduce the absolute quantities of emissions, and therefore frequently described as a "quantitative approach"—the opposite is the price approach (typical one is a carbon tax). The advantages of the price approach are; it can minimize total abatement costs through equalizing each country's marginal abatement cost and, compared with the quantitative approach, it can eliminate the uncertainty of costs. Moreover, as greenhouse gas stays in the atmosphere for a long period of time and thus additional one unit of emission has little effect to the damage induced by climate change, it could be said

[11] For example, EC (2005, p. 44) described that "The post-2012 regime should require further absolute emission reductions from each of these developed countries, defined as a percentage of a base year." From this description, it is clear that EU aims to keep the Kyoto Protocol regime at least for Developed Countries.

that the price approach such as carbon tax is more advantageous than the quantitative approach in the theoretical aspect.

After the conclusion of the Kyoto Protocol, attentions to the hybrid policy, which combines the quantitative approach with the price approach, are increasing (Mckibbin and Wilcoxen (1997, 2002), Pizer (1997, 1999), Kopp et al. (2000), Victor (2001), Aldy et al. (2001), Philibert and Pershing (2002)). Though hybrid policy adopts quantitative approach, it can avoid excessive burden of abatement cost by setting a ceiling (trigger) price on emission allowances. Once an emission allowance price reaches the ceiling price, governments can start issuing the unlimited amount of additional emission allowances at the ceiling price. Emitters do not need to bear reduction costs beyond the level of the ceiling price[12].

Intensity targets which belong to neither price approach nor quantitative approach value the abatement efforts and allow the economy to grow. Intensity targets can take various forms. The most typical ones are energy intensity and carbon intensity targets, which can take varied scopes depending on countries and industrial sectors, which will adopt them. If a nation selects efficiency improvement as a target, then the fundamental indices can be energy consumption or carbon emissions per GDP, and the targets can be set based on the efficiency improvement rate against a base year, or absolute efficiency target against production quantity (benchmark method), etc.

The introduction of PAMs is an approach, in which each country commits to the introduction of climate change policies and measures. While the Kyoto Protocol regime requires each country to be responsible for delivering "results (absolute emissions)", this option demands each country to commit to "actions (introduction of PAMs)." The forms of PAMs vary. In one case, every member country introduces a common policy, while in other case, each country adopts own policies and measures conforming to country situation. This section will discuss the latter case only. Various policies can be introduced even under the Kyoto Protocol; the stringency required to introduce the policies depends on the strictness of commitment, however. PAMs, to the contrary, aim to implement the policies and measures to the optimum capacity of each county.

3.2. *Price approach (carbon tax)*

3.2.1. *Advantages of price approach*

The price approach can provide efficiency (globally unified carbon tax enables the compliance of emissions reduction targets at minimum cost), and cost predictability,

[12] The additional emission allowances can be issued by international organizations, but it is unrealistic for each country government to purchase such allowances from international organizations, as seen in the case of international carbon tax, where it has been practically impossible to pay tax revenues to super-national organization. Therefore, this paper presumes that additional emission allowances will be issued by each national government. The example of a paper arguing for the international organization issuing additional emission allowance is Aldy et al. (2001, p. 26).

while allowing no international transfer of funds nor hot air, etc[13]. Among these advantages, efficiency is the only advantage common to quantitative approach. Although Japan has not addressed the fund transfer issue extensively, the issue will arise, if Japan is to purchase hot air from Russia.

In regards to the second advantage of the price approach, cost predictability, it is difficult for any country to accurately predict any changes in energy structure and economic growth rate (or to predict greenhouse gas emissions when no particular measures are taken, i.e. BAU emissions). Pizer (1999, pp. 4–5) conducted a simulation test based on 1,000 emission scenarios and concluded as follows:

> In the case of price approach, emissions reduction will continue until the tax and marginal cost becomes equal, even if BAU emissions undershoot the target. So the price approach may result in the overshooting of emissions reduction. On the other hand, the unit cost of emissions reduction will stay the same whether BAU emissions overshoot the target or not. In the case of quantitative approach, on the contrary, the unit cost of emissions reduction will increase to extremes in an effort to comply with the target, if BAU emissions overshoot the target. If BAU emissions undershoot the target, then the quantitative approach may provide a merit of zero reduction cost.

Above advantages of price approach are important points we must consider, especially when there is a difficulty in predicting BAUs, as in the case of Kyoto Protocol, due to the time lag between the conclusion of the agreement and the implementation of actual measures.

3.2.2. *Disadvantages of price approach*

Despite theoretical advantages described above, a carbon tax does present various problems. First of all, there are uncertainties in environmental effectiveness derived from the difficulty of predicting BAU. Aforementioned Pizer's paper indicates that: if the economic growth rate becomes higher than expected, the absolute quantity of emissions will exceed the target even with unified carbon tax (Pizer 1999, p. 4).

Second problem involves a fundamental question of the price approach, i.e. will it be possible to introduce a unified international carbon tax? In any country, taxation strongly reflects the sovereign right of that country. No country is likely to renounce its own sovereignty or to devolve taxation authority, such as that of carbon tax, to an international convention. Even a multi-nation community such as EU has failed to introduce common carbon/energy tax. The case of internationally harmonized carbon tax, in which each country must collaborate in the introduction of a unified tax rate, will be no exception.

Furthermore, public resistance to taxation may hamper the introduction of harmonized carbon tax in each country. When US tried to introduce BTU tax (energy tax) in

[13] In addition, the price approach can provide less social loss than quantitative approach, if, for some reason, the marginal cost curve is higher than expected. This feature will be discussed in relation to the hybrid policy.

1993 during the Clinton Administration, it met a strong resistance from US Congress, and ended up to adopt lower rate for fuel tax (Akao 1993, pp. 314–317). In Japan, also, strong aversion against the introduction of environmental tax has become evident.

Even if countries can agree on the introduction of a unified (or phasing-in to be unified) carbon tax, it is extremely questionable if they can agree on one unified tax rate. Moreover, if the agreed tax rate is too low, there will be no incentive to reduce emissions further. If the unified carbon tax rate is set at a level lower than the actual marginal abatement costs (which may be at higher level due to existing measures), emitters can merely pay taxes for every carbon they emit, without making any effect on emissions reduction. On the other hand, setting higher tax rate for Developed Countries will lead to an issue of leakage and the loss of international competitiveness against the developing countries. For environmental effects, higher tax rate is desirable, if the issues of leakage and international competitiveness can be solved. However, these are difficult issues to solve. Another problem is how to compare the level of a carbon tax between countries. Do we need to designate currency exchange rates or to use purchasing power parity?

Additional problem is how to encourage the participation of developing countries in a harmonized carbon tax for the future. The carbon tax rate set by the Developed Countries may be too high for developing countries. What the price approach promoters, such as Nordhaus (2002), have in mind is the introduction of universally common carbon tax. Such approach is hardly feasible, as developing countries have entirely different priorities in climate change issue.

In discussing taxation, we must consider various exemptions, subsidies, the use of tax revenue, and the scope of taxation. A subsidy (a compensatory measure) that can ease the burden of carbon tax may offset the originally planned effects of a universal carbon tax (Victor 2001, p. 86). There may be many countries that introduce tax exemption or deduction measures for energy intensive and/or export-oriented industries (OECD 2001, p. 78). Carbon tax can present many other problems, such as monitoring, but due to limited space we shall postpone the discussion of these issues to another opportunity.

3.3. *Hybrid policy*

3.3.1. *Advantages of hybrid policy*

In general, price approach is highly regarded as more advantageous policy from the aspect of economic theory. If marginal abatement costs are higher than projected, at which the slope of marginal abatement cost curve is steeper than that of marginal benefit curve[14], then both quantitative and price approaches bring economic welfare losses, but

[14] This stems from the fact that today's emissions have only a minor effect on the gross amount of greenhouse gases accumulated in the atmosphere. Under such circumstance, marginal benefits will not increase dramatically even if emissions are reduced drastically. As a result, the slope of marginal benefit curve (marginal damage curve) will become moderate. In the case of abatement costs, however, the greater the efforts to reduce emissions, the higher the costs of doing so.

the scope of losses is smaller for price approach. That is the reason why the price approach is said to be more desirable as climate change measure[15].

However, as discussed earlier, to introduce internationally universal carbon tax presents enormous problem in feasibility. The hybrid policy is developed as a policy combining the advantages of price approach into the quantitative approach (also called emissions trading with a safety valve)[16].

Let us explain the advantage of hybrid policy by using the Fig. 1. First, we assume that the initial allocation is at the optimal point Q_1, and the trigger price of additional

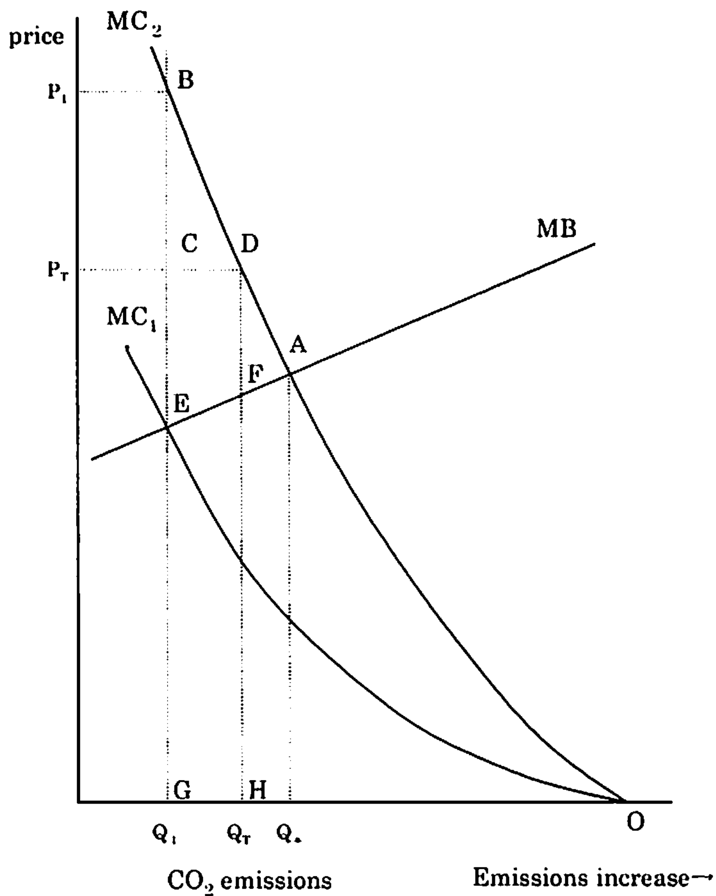

Figure 1. Comparison of quantitative approach and hybrid policy.

[15] See; Cooper (1998), Pizer (1999), Kopp et al. (2000), Aldy et al. (2001), Victor (2001), Philibert and Pershing (2002), Nordhaus (2002), McKibbin and Wilcoxen (2002), etc. Since these papers explain the theoretical advantage of price approach in details, this paper will not repeat them here.

[16] In this paper, only hybrid policy that sets the ceiling price is discussed, but the hybrid policy can take another approach setting both the cerling price and the floor price. In the case of latter approach, the floor price will become the standard subsidy grants, promoting the reduction even when the marginal reduction cost becomes less than expected. (Philibert and Pershing 2002)

emission allowances is at P_T[17]. Also we assume first the curve MC_1 for marginal abatement cost, and then change to MC_2 later. Under the quantitative approach, emissions must be reduced until the marginal abatement cost reaches P_1 in order to achieve the reduction target Q_1. The total abatement costs, therefore, will be ΔOBG. Under the hybrid policy, however, the additional emission allowances can be sold at the price P_T, so the rational action for emitters is to reduce emissions until Q_T, and to purchase additional emission allowances at the price P_T (to cover Q_T to Q_1). In other words, the cost incurred at an emitter will be the area enclosed by ODCG (among them ΔODH is the abatement cost, and the rectangle DCGH is the purchasing cost of additional emission allowances). The cost saved by the hybrid policy will be ΔDBC.

At the same time, the hybrid policy can retain the advantages of price approach in reducing economic welfare losses. If the marginal abatement cost curve is MC_2 under the hybrid policy, the actual reduction will continue up to Q_T, bringing the social loss of ΔADF, which is definitely smaller than the social loss of ΔABE under the quantitative approach.

The significance of the hybrid policy is to limit economic welfare losses to less than those of the quantitative approach, while maintaining the advantage of price approach.

3.3.2. Theoretical difficulties and institutional problems in hybrid policy

As discussed in the above 3.3.1, the hybrid policy can provide the advantage of less economic welfare losses and offer cost reduction effect when the marginal abatement cost becomes higher than expected. However, this theoretical conclusion can apply only in the case when the initial allocation of emission allowance is set at the optimal point (where the marginal abatement cost curve and marginal benefit curve intersect). If the initial allocation of emission allowances tolerates emissions above the optimal point (i.e. the state of insufficient reduction), then it can undermine the advantages of the hybrid policy. Let us examine this point closely. For example:

If an international framework for climate change like the Kyoto Protocol will be actually adopted, it is unlikely that such a framework will set overall emissions reduction targets at the optimal point. This is partly because it is practically impossible to make the initial allocation at the optimal point, due to uncertainties in the positioning of marginal abatement cost curve and marginal benefit curve (especially the latter, as monetary value of environmental damages are hard to determine). Moreover, if significant emissions reduction is needed to reach the optimal point, it is likely that the initial allocation is set in a way acceptable and feasible to participating countries, leading to less emission reduction required to reach the optimal point. The hybrid policy proposed by McKibbin and Wilcoxen (2002) uses CO_2emissions level of year 1990 as the initial

[17] The trigger price of the hybrid policy works as a warranty in case of more-than-expected increase in marginal reduction cost, so it is to be set in between P_1 and P_2 of the Fig. 1. If set at the price higher than P_2, then there will be no opportunity to purchase additional emission allowance. If the price is set lower than P_1, on the other hand, then additional emission allowance can be purchased even when the marginal abatement cost curve is MC_1 as expected. Therefore, the price of additional emission allowance should be set in between $P_1$and P_2.

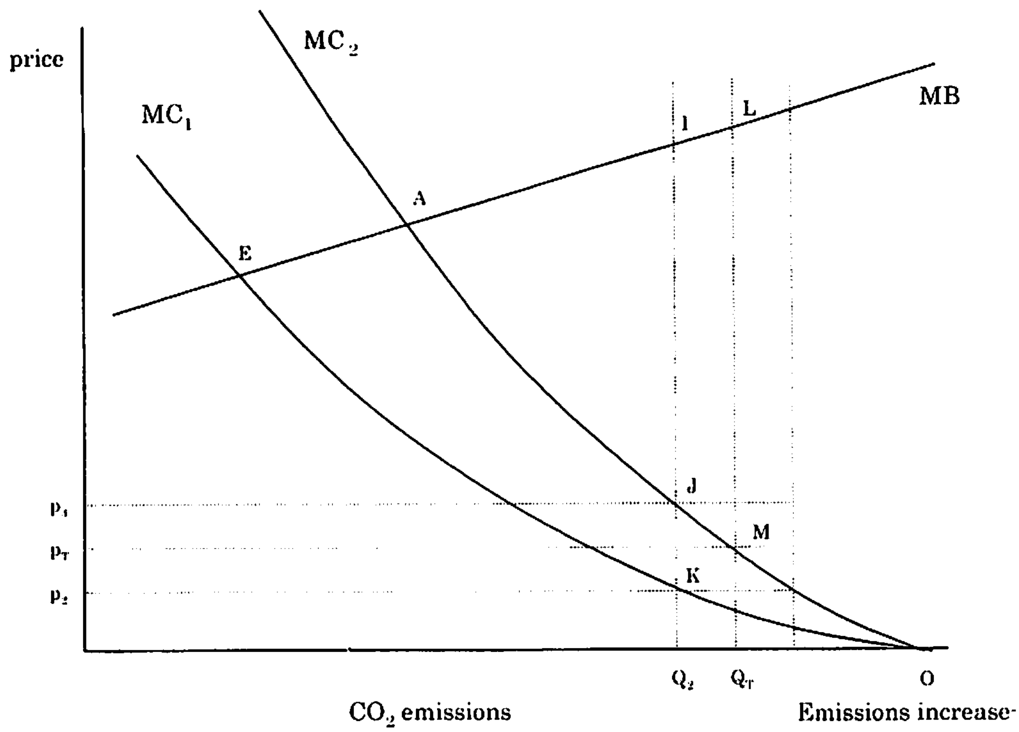

Figure 2. Analysis of quantitative approach and hybrid policy at the initial allocation above the optimal point.

allocation, as the one more lenient than that of the Kyoto Protocol. Fig. 2 assumes the initial allocation of Q_2 with the Trigger Price of P_T.

Under purely quantitative approach and hybrid policy, the emissions reduction will continue until Q_2, when the marginal abatement cost curve is MC_1, so the economic welfare losses for these approaches will be ΔIEK. If the marginal abatement cost curve is MC_2 instead, then the economic welfare losses in the case of purely quantitative approach will be ΔIAJ and those for hybrid policy will be ΔLAM, which is greater than ΔIAJ. Although the results are opposite of those described in Fig. 1, only difference is initial allocation, which is not set at the optimal point. Considering the greater feasibility of such initial allocation as shown in Fig. 2, hybrid policy cannot be clearly described as more favorable approach than quantitative approach.[18]

In addition to the theoretical issue, there are many other problems involved in the implementation of the hybrid policy[19]. First problem concerns the possible restraints over national sovereignty. Assuming that each nation (not an international organization)

[18] If the initial allocation is to make reduction greater than the optimal point, the result will be opposite, making hybrid policy more favorable. However, such a case is not likely to occur.

[19] The hybrid policy is applicable as an international policy as well as the domestic policy. (Mckibbin and Wilcoxen (2002) discuss this as a domestic policy). However, this paper examines the hybrid policy only in the context of an international policy, as the paper is to argue the post-Kyoto framework.

is to issue additional emission allowances, the implementation of international hybrid policy necessitates every member country to introduce emissions trading as its domestic system, which may limit the sovereign right of a nation as it is binding to a nation's domestic policy-making. In view of the above, it is extremely difficult to reach consensus on international hybrid policy among all the relevant countries.

Considering the increased opportunities to introduce emissions trading among Developed Countries[20], the world may be able to agree on the introduction of a global emissions trading scheme. The problem, however, is what kind of a scheme to introduce. Let us assume that the allowances are allocated to each country most appropriately (i.e. in a way to equalize marginal abatement cost among countries), and that each country allocates a part of its allowances to down-stream, such as the manufacturing and power generation sectors as in the case of European Union Greenhouse Gas Emission Trading Scheme (hereinafter, EU ETS). If, as likely be, one country allocates lenient allowances to down-stream, while another country distributes allowances more stringently to the same, that will create differences in marginal abatement costs between the down-stream sectors of both countries. In that case, the same trigger price may be rather high for one country sectors and comparatively low for corresponding sectors in another country, bringing the equity issue. In order to avoid this problem, an emissions trading scheme must be designed to target up-stream. If a nation introduces such up-stream emissions trading scheme and builds a framework to allow the issuance of (an infinite number of) additional emission allowances when the allowance price exceeds the trigger price, then the hybrid policy works effectively. However, if each country is mandated to develop such an emission trading scheme (which is not the case in EU), then it will place considerable restraints on its sovereign right.

Secondly, there is a difficulty in agreeing to a single appropriate ceiling price, as described in the above section (3.2. Price approach). With the vast differences in marginal abatement costs existing among countries today, a ceiling price must be set with a very narrow range to make it effective. If a ceiling price is too high, then it will not function effectively, making the hybrid policy indifferent from the ordinary cap and trade policy. Pizer (1999, p. 9) recommends the adoption of much lower ceiling price, so there will be no need of international emissions trading scheme. If a ceiling price is too low, however, the hybrid policy will not provide any substantial reduction (making the initial allocation meaningless). Moreover, the lower the ceiling price, the more the criticism that the policy will discourage the development of technologies, if it will cost higher than the ceiling price. (Müller et al. 2001, p. 31)

Here is an example to show the difficulty of agreeing on unified ceiling price. In December 2004, the National Commission on Energy Policy (NCEP) announced a new proposal for US climate policy. This suggestion is based on the mandatory intensity targets and hybrid policy with the ceiling price of 7\$/tCO_2. However, this price is

[20] EU started the emissions trading since January 2005, and Japan will introduce subsidized voluntary emissions trading in 2006. In US, also, NCEP (2004) recommended the emissions trading, although with intensity targets.

much lower than the penalty price introduced in EU ETS (this penalty price could be deemed as one of the indicators of ceiling price[21]). EU ETS's penalty price for the non-compliance of targets is Euro 40/CO_2tonne for the First Phase (2005–2007), and Euro 100 for the Second Phase (2008–2012). Considering such significant price gaps among Developed Countries, it seems almost impossible to agree on a universal ceiling price for the world. To set a different ceiling price for each country is possible, but then such a scheme requires some mechanism to restrict the trading by the countries of lower ceiling prices. Moreover, the international (ceiling) prices tend to move from the higher to lower, leading to the mass issuance of emission allowances by lower priced nations.

3.4. Intensity targets

3.4.1. Advantages of intensity targets

The advantage of intensity targets is that economic situation will not affect the possibility of target compliance. Even if economic growth rate becomes better than expected, only thing a country with efficiency target has to do is to simply attain that target. Thus even a fast-growing economy can find an incentive to adopt efficiency target, making it a desirable approach for developing countries with a higher prospect of economic growth in coming years. This is the reason why many have argued for introducing intensity targets to encourage developing countries' participation[22].

Another advantage of intensity target is its feature of not producing hot air. To attain intensity targets, there must be actual improvement of energy intensity or CO_2 intensity, regardless of economic state. As these targets can remove uncertainties derived from the state of economy, some argue that intensity targets can be set at the level more restrictive than quantitative targets (Kim and Baumert 2002, and Van Vuuren et al. 2002). Moreover, intensity targets can be set in a way to respond more flexibly to economic fluctuation. Other methods of setting intensity targets can be to set efficiency improvement rate more restrictive (more lenient) than GDP increase rate (decrease rate) or to aim for a range of efficiency rates, which is called Dual Intensity Targets (Kim and Baumert 2002). The denominators of these targets need not be GDP. Other denominators such as population or trade quantities can be used if appropriate. One example is the target proposed by Argentine in 1997, which deliberately suppress GDP's influences over the target, in consideration of less energy dependent agriculture sector (Bouille and Girardin 2002).

Besides the feature to act as a safety valve against economic fluctuation as described above, intensity targets can provide a profound advantage of directly reflecting the reduction efforts. Compared with the absolute quantity targets of cap and trade, which attainment will largely depend on economic situation irrelevant to reduction efforts, the

[21] The obligation to abate excess emissions will be carried over in the following calendar year even the operators pay the penalties. Therefore, strictly speaking, it is not appropriate to say that the penalty of EU ETS has the same function as the ceiling price in hybrid policy; it could be assumed as one indicator of acceptable ceiling price for EU, however.

[22] For example, Philibert and Pershing (2002), Michaelowa et al. (2004), Kim and Baumert (2002), and den Elzen et al. (2004)

compliance of intensity targets will directly reflect the efforts given to efficiency improvement.

3.4.2. Disadvantages of intensity targets

First of all, there are uncertainties in environmental effects. Intensity targets allow emissions increase with economic growth, so the attainment of intensity targets does not necessarily guarantee the actual reduction of emissions. To realize the actual reduction of greenhouse gas emissions, efficiency improvement targets should be set in a way to exceed the economic growth rate. This will not always be the case.

The second problem of intensity targets is the selection and setting of targets and indexes. As mentioned above, intensity targets can provide the flexibility to reflect country situation. If the setting of intensity targets is left to the discretion of each country, however, it will be necessary to introduce a system to assess the appropriateness of these national targets, making international negotiation over intensity targets more complex. If an efficiency improvement target is to set universally, there will be no need to have detailed and delicate negotiation to assess and approve national targets. However, it will be extremely difficult to find and negotiate for a universal target that can reflect the situation of different countries[23].

Fig. 3 shows energy consumption per GDP of major Developed and developing countries. As shown in this figure, there exist vast differences in energy consumption rate

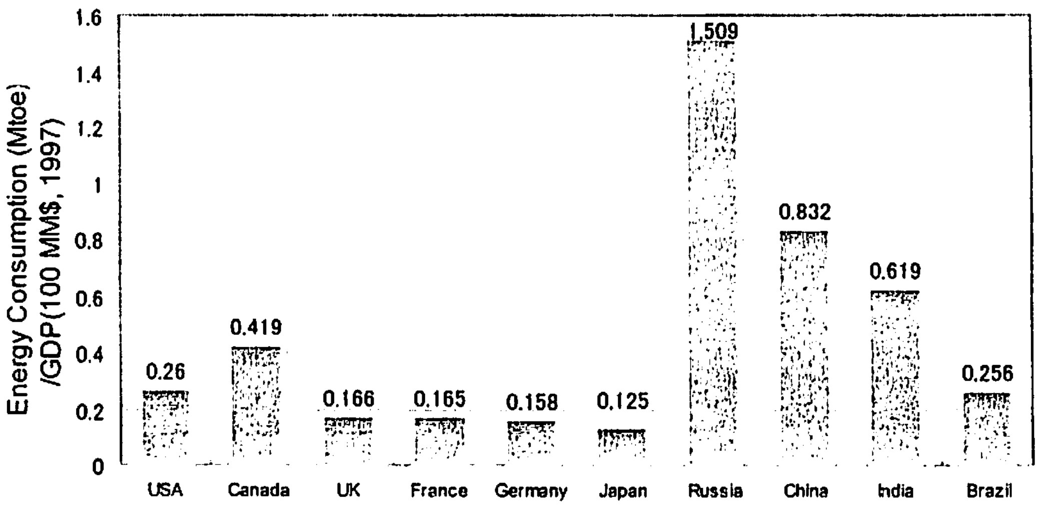

Figure 3. Energy consumption per FDP (as of 2001)

*1 Energy consumption is shown in oil equivalent. The unit is million tons oil equivalent (Mtoe).

*2 The unit for the GDP is 100s of million dollars (as of 1997).

(Reference) EIA (2004, p. 166, 176).

[23] For example, Mïer et al. (2001) pointed out that the unified targets might result in different difficulties in attaining targets for China and Brazil. They also pointed out that the former can use hydro to cover a part of their energy demand increase, but the latter must increase fossil fuel dependency for future growth. Another issue is how to evaluate the historical efforts.

even among Developed Countries. So, the feasibility to set a unified target for energy consumption improvement among countries is extremely low, especially in view of equity. Moreover, if the rate of BAU energy consumption per GDP is not predictable, then it is extremely difficult to set any target in the form of energy consumption improvement rate. To set energy consumption rate of one country as a benchmark is meaningless, too, as every country has a different industrial structure. As seen here, setting intensity targets agreeable to every country will inevitably present significant difficulties in implementation, even among Developed Countries.

The same can be said for the setting of intensity target indexes. The question is whether to apply a unified index related to GDP, or to use the combination of indexes related to GDP and other factors, depending on each country's situation[24]. The latter will likely invite complicated international negotiation, thus being difficult to reach agreement.

3.5. Commitment to introduce policies and measures (PAMs)

3.5.1. Advantages of the commitment to introduce PAMs

The most important advantage of PAMs is their feasibility. Also notable is its feature to allow each country to adopt own domestic policies that can conform to country situation. Under the PAMs, for example, Country A can adopt a carbon tax, Country B emissions trading, and Country C the direct regulations for products and/or emission standards. The PAMs option can start, at an earlier stage, allowing maximum flexibility to each country, and gradually develop to incorporate more and more policies and measures common to each other. Such common policies and measures can be the abolition of fossil fuel subsidies (environmentally-harmful subsidies) or the adoption of unified standard for vehicle fuel efficiency, etc. These measures can actually deliver considerable environmental effects, as long as they ensure the participation of major GHG emitter countries. Therefore, whether implemented voluntarily or mandatory, this option can provide results, without resorting to the compulsory introduction of common policies and measures. Victor (2001, pp. 95–96) indicated that the PAMs would be a useful tool in international cooperation "as a general framework for *starting* the process of international cooperation in climate change."

To harmonize national policies of member countries, either gradually or immediately, it will be helpful to solve the problems of international competitiveness and leakage. WTO is a good example of a system for globally harmonized national policies. WTO's considerable success in coordinating member country policies may be a powerful support factor to PAMs. Another type of PAMs worthy of attention is the one promoted mainly by US these days, which aims to promote voluntary international cooperation in technological development. For instance, China and India are participating in the Carbon Sequestration Leadership Forum (CSLF) and the International Partnership for Hydrogen Economy (IPHE), both started in 2003. As many models indicate that to

[24] Especially in the case of developing countries at the less advanced stage of industrialization, the correlation between GDP and energy consumption is lower. Therefore, these countries will need to have indexes that can reflect the actual situation of non-CO_2 emitting sectors, such as agriculture.

stabilize CO_2 concentration within 100 years has become increasingly difficult unless innovative technologies can be developed and diffused (Edmonds 2004, p. 394). Under such situation, PAMs, such as international technology cooperation mentioned above, are the one that may provide sufficient results.

3.5.2. Disadvantages of the commitment to introduce PAMs

The disadvantages of PAMs include, first of all, uncertainties in environmental effects. As long as PAMs is an option committing to action, uncertainties remain. PAMs focuses on the efforts made to accomplish GHG emissions reduction, rather than the actual outcome of emissions reduction. Moreover, it is difficult to achieve even phase-by-phase harmonization of policies that can provide significant environmental effects. The voluntary harmonization of carbon tax among countries is unlikely, and the same can be said of emissions trading. This enormous difficulty in policy harmonization will further decrease the environmental effectiveness of PAMs.

The second problem is efficiency. When each country adopts its own policies that are considered appropriate (or feasible), it is impossible to equalize the marginal abatement costs among them. It is not like the cases of quantitative approach or price approach, under which marginal abatement cost becomes equal, theoretically at least. In practice, however, the quantitative approach will not likely bring equalized marginal abatement costs among participating countries, due to the presence of hot air. Similarly, to set a universally harmonized tax rate in the price approach is not realistic. Yet, PAMs cannot truly be described as the most efficient option. Efficiency is one of their weak points.

The third problem is the difficulties of monitoring and enforcement. Victor (2001, p. 94) pointed out the difficulties in monitoring and verifying whether various policies introduced in each country would actually bring the originally planned results. This point could be applicable to a universal carbon tax, also. Victor maintained, however, that PAMs would present greater difficulty. Victor also described the difficulty of enforcement in PAMs, exemplifying the GATT's dispute settlement. Still, these problems are common to all other options except the quantitative approach adopted by the Kyoto Protocol.

The review of post-Kyoto alternatives discussed above did not reveal any clear winner in every aspect, as each showed its own advantages and disadvantages, as summarized in Table. 2. In assessing these alternatives, the international community must determine which factor to focus on and which policy to implement in building a post-Kyoto framework. This paper will recommend a feasible post-Kyoto scheme from such viewpoint.

CHAPTER 4. A PROPOSAL FOR THE POST-KYOTO FRAMEWORK

In this chapter, we shall first discuss the uncertainties that underlie the climate change. Then, based on these uncertainties, we study the future framework for Developed Countries including US, and examine the issue of developing countries' participation.

Table. 2 Advantages and disadvantages of alternatives to the post-Kyoto Protocol framework

	Outline	Advantages	Disadvantages
Quantitative approaches (cap and trade)	Maintaining the Kyoto Protocol system. A country must comply with the absolute quantity of emissions fixed for each country, while being allowed to use emissions trading to reduce costs. A typical scheme to value results over efforts.	· Ensure environmental effectiveness · Attain a given target at the minimum cost (cost-effectiveness) · Domestic policies to the discretion of each country	· Difficult to ensure the equity and transparency in initial allocation · Impossible to predict abatement costs · Fund transferred from an allowance buyer to a seller · Hot air inevitable
Price approach (Internationally unified/Coordinated/ harmonized carbon tax)	To achieve targets based on the price signals rather than quantitative targets. Typical one is a carbon tax. Reduce emissions through market mechanisms by setting a universal carbon tax (or coordinated/harmonized carbon tax)	· Initial target attainable at the minimum cost (cost-effectiveness) · Costs are predictable · No cross-border fund transfer · Avoid excessive cost burden · No hot air	· Uncertainties in environmental effectiveness · Difficult to agree on a single unified carbon tax · Each nation has a barrier for introducing a tax · Difficult to agree on an appropriate tax rate · Differences in the national priorities of climate change measures
Hybrid policy	Each country has an obligation to achieve quantitative reduction target, but, once the abatement cost equals the ceiling price, each country can issue unlimited emission allowances at the ceiling price.	· Reduce cost burden by the issuance of additional emission permits · Maintain the advantages of price approach	· Presumed the introduction of emissions trading in each member country as its national policy · Conflict with the sovereign right of each nation. · Difficult to set a universal ceiling price · Theoretical drawbacks if initial allocation is set at the volume larger than the optimal volume.
Intensity Targets	A method to set efficiency improvement targets for greenhouse gas emissions or energy use per GDP or production. Several alternatives such as benchmark method, efficiency improved over BAU, and others.	· A framework to value efforts · Allow potentials for economic growth · No hot air · To enable to invite developing countries' participation	· Uncertainties in environmental effectiveness · Lack of efficiency · Difficult to agree on targets or setting of indexes
Policies and measures	Each country promises to introduce own policies and measures for climate change mitigation. Possible to harmonize policies through international negotiation. A method to value actions	· Higher feasibility · Each country can adopt policies conforming to the national situation · Precedents such as GATT	· Uncertainties in environmental effectiveness · Lack of efficiency · Cannot be a main stream in climate change measures · Needs an international monitoring system

4.1. Climate change and its uncertainties

The most difficult factor in addressing climate change is how to deal with uncertainties. As it is not the main theme of this paper, the issue will not be discussed in details here. However, the authors would like to stress the fact that the uncertainties do exist throughout the chain of climate change causalities[25], i.e.

Economic activities, etc. → Greenhouse gas emissions → Rise in atmospheric concentrations → Temperature rise → Damages in consequence

The Article 2 of the Framework Convention on Climate Change states that "the ultimate objective . . . is to achieve . . . stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference (hereinafter referred to as DAI) with the climate system." However, world scientists could never provide sufficient scientific knowledge and information so policy makers could decide what would constitute DAI. There is no doubt that humans must avoid "DAI". Yet, there is no consensus even on what kind of targets we must take. In other words, no one is sure whether we must aim for the stabilization of atmospheric concentration at a certain level (as in the case of the Framework Convention on Climate Change), or for the control of temperature rise within a certain range (as in the case of EU).

With no definition of stabilization targets and/or levels in sight, the international community has tacitly envisioned a tentative goal of stabilizing CO_2 concentration at 550 ppm (almost twice the pre-industrial level)[26]. Such a target is not exactly founded on the concept of "avoiding DAI." Rather, it highlights the seriousness of situation we face today, in which the unlikelihood of developing countries' participation in emissions reduction, at least for the moment, makes the stabilization at the level less than 550 ppm politically impractical. Even if the world can agree on the stabilization target of 550 ppm, there will be several options available to reach the path for attaining the target, or to determine the timing to start reduction. Moreover, these options will vary depending on the selection of a target year for stabilization. With many uncertainties involved, however, it may be difficult to persuade member countries to agree on an international post-Kyoto framework that may significantly hinder their economic growth. Such a framework will likely attract less number of countries willing to participate in it. Especially, those countries with mounted cost burden in achieving the first Commitment Period targets may be adverse to join the framework.

[25] For example, when the atmospheric concentration of CO_2 doubles, temperature is said to rise by the range between 1.5° to 4.5° (climate sensitivity, IPCC (2001a, p. 61)). References to uncertainties can be found throughout the IPCC Third Assessment Report.

[26] Some of recent literatures suggest much lower concentration levels such as 450 or even 400. For example, Meinshausen M. (2006) argues, based on the assumption that 2°C temperature increase will cause DAI, that "550 ppm CO_2 equivalent stabilization scenario is clearly not in line with a climate target of limiting global mean temperature rise to 2°C above pre-industrial levels". It is important to note that the arguments on the level of stabilization of CO_2 or temperature do not affect the discussion of this paper.

The ultimate risk of climate change is a non-linear and abrupt change in the Earth's climate system, and the most typical event will be the complete shut-down of thermohaline circulation. Once such an event takes place, it will be irrevocable and likely to cause the maximum temperature decline of 10 degrees C in Europe[27].

Should there be such an event actually happening or projected to take place in near future, all the countries in the world will shed their reluctance and rush to adopt more stringent climate change measures. Such an event will bring a slope of marginal damage curve steeper, thereby providing the rationales, in terms of cost-benefit analysis, to prioritize climate change measures over economic activities. Now, what level of scientific knowledge do we have in this respect?

According to the review conducted by the IPCC (Inter-governmental Panel on Climate Change), no model calculation has ever predicted the occurrence of such non-linear event within the next 100 years, even in the case of greenhouse gas concentration doubled from the pre-industrial level[28]. After year 2100, on the other hand, the possible occurrence of such non-linear event has been indicated in some models under a certain condition. Still, it is a very distant possibility, and will not heavily influence today's decision making. In other words, the current level of scientific knowledge is not sufficient to provide a definite support for the immediacy of drastic measures.

4.2. Significance of the United States' participation

Nevertheless, the atmospheric concentration of CO_2 will not be stabilized if the current CO_2 emissions level remains as is. The most frequently referred scenario of WRE 550 Profile indicates that the world must greatly reduce current level of emissions within 100 years, in order to stabilize the atmospheric concentration at 550 ppm by 2150 (IPCC 2001a pp. 99–100). Although 550 ppm is not necessarily an agreed figure as a target, the world is now gradually sharing the recognition of the needs to reduce greenhouse gas emissions considerably from current level in 100 years. However, substantial reduction would not be realized without the involvement of the world's largest emitter, US.

US's participation has a direct influence on the environmental effectiveness. For instance, when comparing two scenarios—one is to focus on environmental effectiveness by maintaining the Kyoto Protocol scheme without US's participation (in this case, major developing countries will not commit to specific obligations), and to face the second commitment period by further strengthening the Kyoto scheme in wait of participation by US (and developing countries) in the future; the other is to design a scheme acceptable to US (and developing countries) with the sacrifice of short term environmental effectiveness—it is doubtful to conclude that the former can truly provide better

[27] IPCC (2001a, p. 83).

[28] "In experiments where the atmospheric greenhouse gas concentration is stabilized at twice its present day value, the North Atlantic Thermohaline Circulation is projected to recover from initial weakening within one to several centuries".—"However it is too early to say with confidence whether an irreversible collapse in the THC is likely or not or at what threshold it might occur and what the climate implications could be. None of the current projections with coupled models exhibits a complete shut-down of the THC by 2100" (IPCC 2001b, p. 73).

Table 3. Energy Origin CO_2 Emissions (Forecast)

(Unit: MtC/yr)

Years	1990	2010	2020			2050		
		BAU	BAU	Party nations only (%= compared with BAU)		BAU	Party nations only (%=compared with BAU)	
World total	5,613.51	7,828.81	9,635.54	8,894.29	(−7.7%)	15,093.87	13,009.63	(−13.8%)
Developed countries	3,727.39	4,114.26	4,912.26	4,171.01		5,868.76	3,784.52	
(Kyoto Protocol Parties)	(2,332.92)	(2,069.87)	(2,397.15)	(1,655.90)	(−30%)	(3,017.41)	(933.17)	(−60%)*
(US and Australia)	(1,394.47)	(2,044.39)	(2,515.11)	(2,515.11)		(2,851.35)	(2,851.35)	
Developing countries	1,886.12	3,714.55	4,723.28	4,723.28		9,225.11	9,225.11	

Authors' calculation based on RITE, DNE21+ data.

*Compared with emissions in 1990.

environmental effects. As the authors have already pointed out in this paper, the environmental effects will decrease, as the share of emissions from Kyoto commitment countries will decline in the future (see discussion in Chapter 1 and Table 1).

In addition, US's involvement has an indirect influence to environment, since developing countries will not launch substantial emissions reduction without US's engagement. Based on the authors' calculation using the RITE DNE21+ model, the environmental effectiveness does not differ between the case when every country in the world implements 7.7% reduction from BAU scenario by 2020, and the case when countries currently committed to the quantitative targets under the Kyoto Protocol (i.e. Developed Countries excluding US and Australia) comply with the obligation to make 30% emissions reduction from BAU (Table 3). Considering the large potentials of energy efficiency improvement in developing countries, the former case presents significantly higher feasibility, thus greater environmental effectiveness. Moreover, as shown in Table 3, the environmental effectiveness does not differ between the case, in which Developed Countries makes 60% emissions reduction from the year 1990 by 2050 (as described in the Energy Policy White Paper of UK, published in February 2003), and the case, where the world simply reduces emissions by 13.8% from the BAU scenario.

As long as the future framework is founded on the current scientific knowledge and insights, it will be more environmentally effective to induce the participation of US (and developing countries) by offering more lenient conditions, and to aim for long term emissions reduction based on the advancement in scientific knowledge, although it may appear regression for a short term.

Hybrid policy and intensity targets are somewhat feasible from the point of view of US's participation. Since both regimes avoid extreme burden of abatement costs, one of the major concerns of US—adverse effects on American economy—can be moderated. Nevertheless, if US participate actually in either regime, it would be derailed, due to the difficulties of agreeing to the single appropriate ceiling price and the uniform intensity targets respectively. If so, then the only option remained is the PAMs, where member countries commit to implement certain policies and measures. Here, the authors would like to recommend the introduction of a framework that combines the pledge and review (PAMs) and sector-specific benchmark efficiency, to raise environmental effectiveness.

4.3. Pledge (with review) and review

4.3.1. Pledge (with review) and review mechanism for Developed Countries

Generally, pledge and review option is where each country pledges to implement climate change measures, and receives a review by other countries or international organizations after a certain time period. As seen here, it is a type of PAMs, but with the feature of mandatory review. Those countries not complying with the pledge must explain the reason, and re-develop the measures for the future.

Here, the authors would like to suggest a somewhat different framework; "pledge (with review) and review" (hereinafter referred to as PWRR). Let us explain the details of this option. First of all, the contents of the "pledge" are determined at the discretion of each country, but each country must declare the effects of the "pledge" in numerals. All the policies and measure as well as their declared effects must undergo thorough examination by experts. Based on the result of experts' examination, the policies and measures are classified into several classes depending on their severity and strictness in implementation.

Total environmental effects summed up from the contents of member countries' pledges are to be examined by an international organization (such as a committee consisted of member country governments), or an organization consisted of experts from member countries, with the result being notified to member country governments[29]. Based on the result of these examinations, member countries are to re-examine their own policies and measures, and to re-submit the result to the Secretariat.

After repeating these processes until member countries agree on the contents, then the contents of their pledges are to be disclosed with the experts' comments on the difficulty of implementing each pledge. After extensive discussion and negotiation prior to the finalization of pledge contents (pledge with review), a framework can be built to provide a certain level of environmental effectiveness. The time period of pledges must be the same for all member countries, for example, five or ten years. In the case of ten years-pledge, the revision may be made in every five years, if necessary.

During and after the time period of the pledge, each member country will receive the review conducted by the experts of other countries (same as the OECD's environmental policies review). Those countries that are unlikely to, or will not be able to, comply with the Pledge will not receive penalties, but shall identify the cause of non-compliance

[29] How to disclose environmental effectiveness may need some consideration. To be specific, environmental effectiveness cannot be considered in comparison to the path toward the achievement of target under the UN Framework Convention on Climate Change Article 2 "a level that would prevent dangerous anthropogenic interference with the climate system," as there is no agreed level. Therefore, disclosure may include the assessment on the potentials of global greenhouse gas emissions reduction if every party implements its pledge, compared with the case of no pledge (and, if possible, how these pledges affect the global emissions reduction 100 years from now).

through the discussion with reviewers, and have obligation to propose alternate policies and measures for the next period, which can provide greater effect than the one pledged for the existing period.

Under such framework, each country can select its domestic policies from various options, including carbon tax, emissions trading, hybrid policy, intensity targets, and voluntary agreements, or the combination of those, thereby ensuring sufficient flexibility in its policies. Moreover, member countries may be able to build a cooperative system between countries with similar policies (bilateral or regional approaches possible). At the same time, it is possible to include pledges to introduce policies which can contribute to technological innovation. If the world's leading technology states such as US join the regime through this way, advancement in technological development may be enhanced.

In addition to these options, the authors would like to recommend the efficiency index system for the Developed Countries, using the benchmark method in specific sectors such as power generation sector, energy-intensive industries, and in specific commodities such as automobiles. For this, it will be necessary to identify standards and boundaries of statistical indexes, and to develop data to allow sectoral comparison. In the case of automobiles, for example, cross-border comparison based on the same standard is available, as seen in EU's voluntary agreement. Therefore, this option seems to be fully feasible. One recent noteworthy development is that, following G8 Gleneagles Summit, the International Energy Agency (IEA) is to conduct a review on energy efficiencies in various sectors. This will make a benchmark method easier to introduce (Gleneagles Plan of Action, Climate Change, Clean Energy and Sustainable Development, 2005).

From the very beginning, the pledge and review option was the one Japan proposed during the negotiation of the Framework Convention on Climate Change, and received strong support of European countries led by UK (Akao 1993, p. 108–). Although the PWRR method presented here may not be the "ultimate" solution, it has a higher feasibility as the "first step" toward winning the participation of US. The authors believe that the PWRR option described here is worth promoting as a practical policy for long term climate change measures applicable throughout the 21st century, when combined with sectorial benchmark energy efficiency standards.

4.3.2. Participation of developing countries and mid to long term perspectives

If Developed Countries can agree on the PWRR, how do they extend this option to developing countries? As the energy origin CO_2 emissions from developing countries are expected to exceed those of OECD countries in about next 10 years, and China is likely to become the world's largest emitter exceeding US within 30 years (cf. RITE, DNE21+ model), developing countries will no longer be allowed not to participate in an international framework. Under the concept of "common but differentiated responsibility", the important factors in winning the participation of developing countries is the timing of their participation (to PWRR approach) and the contents of their pledges.

As to the timing of developing countries' participation in an international framework, the most preferable timing, from Developed Countries' view, is just after the year 2013.

For PWRR option, such timing is feasible. It may be necessary, however, to allow less restrictive pledges for developing countries than those for Developed Countries, and to exempt them from the initial review. This option is generally called a "non-binding target" approach. In implementing this option, some argues for allowing developing countries to participate in emissions trading, provided that they are to achieve the targets (Philibert and Pershing 2002, p. 128). The details of the possibility of emission trading will not be discussed here as this paper does not concern quantitative approach as a desirable future framework.

But the authors believe that, under non-binding target option, the developing countries voluntarily pledging for the implementation of a certain policies and measures must be given some incentives. These incentives can be in the forms of financial and/or technological assistance exclusively aimed for climate change measures.

The contents of the "pledge" are to be determined by each developing country at its own discretion, but it is possible to incorporate greenhouse gas reduction system into the pledge, in the form of joint projects between Developed and developing countries, such as those promoted under the Kyoto Protocol (CDM). In addition, there are other options that may provide significant environmental effects when implemented, such as the abolition of environmentally harmful subsidies.

Subsidies are usually offered for a specific purpose, such as employment security and the poverty alleviation, but the provision of subsidies may hamper the efficient use of resources, hence leading to loss of economic welfare. For example, if the subsidies are used intentionally to lower prices of certain products, it may result in the excess consumption of applicable commodities. Energy subsidies, particularly, tend to provide double negative dividends of increased adverse effects on environment and on the optimal use of energy resources. According to IEA (1999, p. 64), if eight countries including China, Russia, India, Indonesia, Iran, South Africa, Venezuela, and Kazakhstan are to abolish such subsidies, there will be 16% reduction in their overall CO_2emissions (13% reduction in the case of China). IEA considers that such emissions reduction will equal to 4.6% reduction in global emissions. Among these eight countries, Russia is not a developing country, and the data used for the calculation are from the year 1997. The situation may have changed today. Still, it can give us a clearer picture on the effects of abolishing environmentally harmful subsidies in energy field. As an incentive for developing countries to introduce such policies of subsidy abolition, Developed Countries may need to offer technological and financial assistances as well as the dispatching of experts for energy efficiency improvement.

Nevertheless, while many developing countries still fail to fulfill their obligation for the submission of emissions inventory to the secretariat of the Framework Convention on Climate Change, untimely and impulsive enforcement of their participation in an international framework will merely provoke their resistance. The best way will be to earn their consent in a phase-by-phase participation, based on a certain criteria. Even US, which demands the participation of major developing countries before its joining of a framework, may agree to a scenario that will allow the gradual participation of developing countries based on a given standard.

Den Elzen et al. (2004) proposes an option to allow the phase by phase participation of developing countries in taking obligations, under a method called a Multi-Stage Approach (hereinafter referred to as MSA). This approach requires developing countries to take new obligations phase by phase, while asking Developed Countries to bear the burden of reduction obligations in a way to make per capita emissions of Developed Countries converge with that of developing countries by 2050, thereby aiming to reach the path for emissions stabilization at 550 ppm or 650 ppm (CO_2 equivalent). Under MSA, each phase will be determined by economic scale criteria (per capita GDP), per capita emissions, etc. The developing countries that meet the criteria advance to the next phase, ultimately committing to the emissions reduction/limitation obligations in absolute terms. The basic concept of MSA is equity.

The above option, when aimed for emissions stabilization at 550 ppm, will require most of developing countries except some African countries to have intensity targets by 2013, and East Asian countries including China to have obligations to reduce per capita emissions during 2015 to 2025. Developed Countries, on the other hand, must reduce their emissions by 67 to 80% before 2050. By this, per capita emissions of Developed and developing countries will reach almost equivalent level in 2050, making the stabilization at 550 ppm achievable. To stabilize at 650 ppm, however, will be somewhat easier to achieve, but still require developing countries, which have a priority in their economic growth, to agree to mid to long term caps, and Developed Countries, which find the drastic emissions reduction unacceptable for their economies, to accept massive reduction in their emissions. The outcome of the study reveals the difficulty of aiming for stabilization at the concentration levels of 550 ppm (or even 650 ppm).

As long as the ultimate goal is to reduce global emissions, the longer the developing countries wait to take on obligations, the severer the reduction targets of Developed Countries will be, and vice versa. This is where we find the essence of North-South problem in climate change. To solve this, the best option will be to provide incentives (funds, technologies, human resource, and capacity building in developing countries) for emissions reduction and limitation in developing countries, and to promote fundamental technological innovation, deployment and diffusion toward the carbon free society (including carbon sequestration technologies).

At this point, the authors would like to introduce the result of studies consigned to RITE on the needs of developing country participation. The study used the aforementioned DNA21+ Model, and IPCC's global stabilization scenario to stabilize CO_2concentration at 550 ppm (IPCC 1996, pp. 21–24) Assumptions are that Developed Countries must undertake more restrictive reduction to encourage developing countries' participation; that Developed Countries other than US and Australia must comply with the Kyoto Protocol targets; that US must attain the current intensity target (18% improvement from 2002 to 2012); and that Developed Countries must implement 60% reduction from 1990 by 2050.

The difference between the path for 550 ppm stabilization and the actual emissions of Developed Countries will be the amount of emissions developing countries can emit.

From this, we can find the amount of emissions reduction developing countries must implement in order to have the global emissions fall within the required range.

In conclusion, the study predicts that developing countries must start emissions reduction when their per capita GDP reaches 50% of the level of Developed Countries as of year 2000. The result will be the same even if per capita emissions are used in place of per capita GDP. As long as developing countries claim not to take on any reduction obligations until their per capita GDP and/or per capita emissions becomes equal to those of Developed Countries, there will be no possibility to stabilize emissions at 550 ppm.

Whether such drastic emissions reduction is politically acceptable to Developed Countries or not presents a huge problem. Another problem is how to persuade developing countries to start emissions reduction and limitation once their per capita GDP or per capita emissions reach only 50% of Developed Countries. The enormous difficulty of the latter is apparent. Considering the difficulties humans face now, the only solution will be the development and diffusion of innovative technologies toward a carbon free society supported by appropriate policies.

EPILOGUE

We have explored four alternatives to Kyoto-style regime, and proposed pledge (with review) and review as a desirable post-Kyoto framework. However even under any regimes, there is no doubt that the stabilization of atmospheric concentration of greenhouse gas "at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC Article 2) could not be realized without any technological development and diffusion. The world is now focusing on the efficacy of the policies to induce technology development and diffusion (Edmonds (2004), Gritsevsky and Nakicenovic (2002), Grubb (2004), Nordhaus (2002), and Sanden and Azar (2005)). As this paper refers mainly to the future framework, the subject of technology development will be left for discussion at another occasion.

Another factor that should not be overlooked is the priority of climate change issue in global policy issues. The Millennium Development Goals set in the year 2000 recognized eight challenges as the World's most imminent problems[30], and one of them is "Ensuring Environmental Sustainability" which includes climate change. The world's scarce resources must be allocated optimally among these challenges. There exists an attempt to prioritize global imminent issues based on the cost-benefit approach; nonetheless, this is exposed to some critics which question the applicability of the cost-benefit analysis to climate change issue. Main arguments here include the difficulty of measuring damages to non-market values, difficulty of assessing damages by abrupt changes, difficulty of agreeing on a discount rate etc. Though we share such views, we

[30] Eight challenges are; Eradicate extreme poverty and hunger, Achieve universal primary education, Promote gender equality and empower women, Reduce child mortality, Improve maternal health, Combat HIV/AIDS, malaria and other diseases, Ensure environmental sustainability, and Develop a global partnership for development.

cannot support the idea that completely ignores the perception of cost-benefit[31]. This point must be explored continuously as a future issue.

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[31] After pointing out four drawbacks of simply applying cost-benefit approach to climate change issue, Azar (1998) writes as "But this does not mean that cost-benefit optimization models cannot and should not play any role in climate change policies, The problem only arises if we use optimization models as "truth machines".—Rather, these models should be used to explore the implications of various choices for highly value-laden parameters." The authors of this paper agree with him.

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