International Meeting on Mid-Long Term Strategy on Climate Change
June 30 – July 1, Tokyo

Balanced Approach to Climate Change
A Proposal for Effective Future Framework

Mitsutsune Yamaguchi
University of Tokyo

Climate change is one of the most serious issues human beings ever encountered. All nations must cooperate to cope with the challenge we face now. This does not necessarily mean, however, that we should allocate most of our global scarce resources to the issue. We have encountered various kinds of serious issues nowadays and each country has its own priority. Moreover, economic situation can significantly affect how we cope with issues. In today's world, if we concentrate too much on a single issue, it will ultimately lead to a collapse, leaving the issue unsolved and even exacerbated. This is why a balanced approach is desirable. When we tackle with climate change, we should pay attention to two kinds of "balance". The one is a balance between other global issues and climate change, and another is a balance between climate change and sustainable economic development.

1. Millennium Development Goals

At the United Nations Millennium Summit, the Millennium Development Goals (MDGs) were adopted in September 2000. Among many issues, 8 issues were selected to tackle preponderantly. They are to: eradicate extreme poverty and hanger, achieve universal primary education, promote gender equality and empower woman, reduce child mortality, improve maternal health, combat HIV/AIDS, malaria and other diseases, ensure environmental sustainability, and develop a global partnership for development. Goals for environmental sustainability include: reserving loss of forest, halving proportion without improved drinking water in urban and rural areas, halving proportion without sanitation in urban and rural areas etc. Most of the targets are set for the period of 1990-2015. In addition to MDGs, other urgent issues have emerged recently, such as energy security, and soaring prices of oil and food that directly affect global economy and our lives adversely. How should we cope with those issues, including climate change, simultaneously using limited resources? How to allocate scarce resources to each of these issues efficiently? Once we allocate a certain portion of our resources to an issue, that portion can not be re-allocated to other issues. It is true that, as IPCC reports say, there are synergies among several issues (such as mitigation of climate change and decrease of malaria in a long run), but this is not always the case.

In May 28-30, 2008, TICAD (Tokyo International Conference on African Development) was held in Yokohama, Japan. The main issue there was undoubtedly the African Economic Development. One day before the Conference, OECD Tokyo Policy Forum "Africa 2008" was held in Tokyo where the author attended. All of the African speakers underlined the importance of MDGs without mentioning a word on climate change. It was understandable because poverty, hunger and diseases have been their main concerns as a direct threat to their economic development.

One way of efficient resource allocation is to do it based upon so-called "Cost Benefit Analysis (CBA) [1]". In 2004, a challenge of prioritization has been tried (Lomborg 2004), inviting furious criticisms (such as Sachs 2004). It is reported that the same approach will be tried again this year taking account of those criticisms. One peculiar characteristics of climate change is its long term nature. Cost incurs on current generation while future generation enjoys most part of benefit. The CBA result can have significant differences depending on the discount rate (pure time preference discount rate) used. In addition, CBA has several weaknesses; how to monetize non-market damages, how to incorporate abrupt change, and how to deal with equity issue (Azar 1998). Those are crucial points.

This does not necessarily mean that CBA has no use for resource allocation. It is noteworthy Azar (1998) also points out that "--- 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" (Schneider 1997). Rather, these models should be used to explore the implications of various choices for highly value-laden parameters"[2].

This means we should always bear in mind the concept of efficient resource allocation whenever we tackle climate change.

2. Climate Policy and Sustainable Economic Development

Article 2 of the United Nations Framework Convention on Climate Change defines the ultimate objective of the Convention is to "achieve stabilization of GHG concentration --- at a level that would prevent dangerous anthropogenic interference with the climate system". At the same time it describes that such a level should be achieved within a time-frame sufficient a) to allow ecosystem to adapt naturally to

---

[1] Schneider and Lane (2006) argue the allocation issue as a value judgment.

[2] Sachs (2004) also wrote as "The core concept --- is a good one: to engage expert opinion to evaluate policy options on major challenges facing the planet. This approach has been used before and should be adopted again. But the project's methodological failures should not be repeated".

climate change, b) to ensure that food production is not threatened, and c) to enable economic development to proceed in a sustainable manner.

This last criterion directly relates to the mutually supportiveness of economic growth and environmental protection. Climate change adversely affects sustainable development. Conversely costly mitigation measures could have adverse effects on economic development (IPCC 2007a, 2007b)[3]. We have to "balance" those two objectives. In interpreting the ultimate objective of the Convention, this point should be taken into account.

The point here is what constitutes dangerous anthropogenic interference (DAI) to climate system. Tolerable Windows Approach (TWA) and Cost Benefit Approach (CBA) are typical ones trying to show what constitute "dangerous". Millions at risk approach (Parry et al. 2001) is the typical example of TWA and have challenged to define to what extent human being can tolerate damages due to climate change. Recent approach tries to cope with uncertainties using probability density function (Mastrandrea and Schneider 2004) [4]. The paper mentioned here also shows how probabilities of DAI can be reduced by introduction of climate policy (optimal carbon tax). The crucial drawback common to TWA here is that there is no scientific base to define what constitutes DAI without relying upon value judgment.

CBA does not try to directly define DAI, but instead try to compare cost and benefit (avoided damages). Optimal climate policy is defined as a policy where climate policy will be pursued until marginal cost will become equalized with marginal benefit (Nordhaus 1994, Nordhaus and Boyer 2000). If successful, this is an ideal approach in that, even if climate change is to pose certain risks, it is reasonable not to introduce a climate policy unless avoided damages exceed costs. Another advantage of the approach is that it facilitates policy evaluation as everything is shown in monetary terms. There are serious difficulties in CBA, however, as discussed before.

From the above discussion, it is now clear that science can not demonstrate what level of GHG concentration is relevant as the ultimate objective of the Convention. The level then should be agreed upon among global leaders. There is no consensus on the level so far.

In June 1996 European Council has agreed as follows.

> *"Given the serious risk of such an increase and particularly the very high rate of change, the Council believes that global average temperatures should not exceed*

---

[3] Tol et al. (2006) argues "--- we see the potential for ovewly ambitious mitigation to increase vulnerability to climate change by slowing economic growth in parts of developing world" .

[4] Meinshausen (2006) showed probability of exceeding 2 degree C for different CO2 equivalent stabilization levels.

2 degrees above pre-industrial level and that therefore concentration levels lower than 550 ppm CO2 should guide limitation and reduction efforts".

Then in March 2004, the Council quietly dropped 550 ppm CO2 and stated that

"*to meet the ultimate objective of the UNFCCC to prevent dangerous anthropogenic interference with the climate system, overall global temperature increase should not exceed 2℃ above pre-industrial levels*".

This is a political decision. Based on this ultimate objective, EU argued for 50% global emissions reduction by 2050 in comparison to base year (1990). IPCC 4th Assessment Report (AR4) has been published in 2007. One of the most important change since its 3rd Assessment Report (TAR) is that of climate sensitivity. It was revised upward from 1.5 to 4.5 ℃ (best estimate of 2.5 ℃) to 2.0 to 4.5 ℃ (best estimate of 3.0 ℃). Based on this, AR4 drew up 6 categories of stabilization scenarios. The author supplemented other information (costs and damages) (Table 1).

(Table 1) Six categories of stabilization scenario

CO_2 Concentration (ppm)	CO_{2e} Concentration (ppm)	Temperature Increase (since industrialization、℃)	Peaking Year, CO_2 emission	CO_2 reduction ratio 2050/2000(%)	GDP reduction (%)	Damages	No. of scenarios
350－400	445－490	2.0－2.4	2000－2015	-85～-50	< 5.5		6
400－440	490－535	2.4－2.8	2000－2020	-60～-30			18
440－485	535－590	2.8－3.2	2010－2030	-30～＋5	1.3(-0～4)		21
485－570	590－710	3.2－4.0	2020－2060	＋10～＋60	0.5(-1～2)		118
570－660	710－855	4.0－4.9	2050－2080	＋25～＋85	—	1～5% of GDP	9
660－790	855－1130	4.9－6.1	2060－2090	＋90～＋140	—		5

Source:IPCC AR4 WG2 SPM P.20, WG3 SMP Table 5 & 6

As shown above, it seems very hard to limit temperature increase within 2 degrees. Global emissions must hit peak by 2015 at the latest while global energy-origin CO2 emissions in past five years (during 2000-2005) already increased by 22.1% (43.6% for Non Annex I countries). The table also shows 50% reduction in 2050 (in comparison to even2000, not 1990) may not be enough if we were to adhere to 2 degree target. Therefore once we agree to that target, it seems reasonable for the world to at least halve its emissions. But is it feasible?

3. Meaning of 50% reduction and importance of technology

The author would like to examine the meaning of 50% reduction by 2050 (50/50) in three different ways based on a series of studies by RITE (Research Institute of Innovative Technology for the Earth), a Japanese think tank.

According to RITE DNE21+ model, global BAU energy-origin CO2 emissions in 2050 will be around 48Gt-CO2[5]. Breakdown shows that developed countries' emissions

[5] IEA estimates BAU emissions in 2050 as 62Gt-CO2 (IEA 2008). IEA estimate include around 15 Gt-CO2

will be less than 130% of its 2000 emissions while developing countries emissions will be almost 350%. Based on the figures, it is clear that even if developed countries reduce their emissions to zero (100% reduction), developing countries need to constrain their emission increase ratio to 24% in 50 years (Table 2). In view of the fact that China's CO2 emissions increased by 67% and that of African countries increased by 20% during 2000-2005 (IEA 2007), there is no doubt how challenging 50/50 is. Furthermore, as population of developing countries continues to increase, their per capita emission must be reduced from 1.8tCO2 in 2000 to 1.4tCO2. Just for reference, China's per capita emissions in 2005 was 3.5tCO2. It is clear from these data that 50/50 target is not only non-binding but also construed as a mere index.

(Table 2) Meaning of 50/50

	2000 Actual E ($MtCO_2$)	2050 BAU		50% reduction in 2050 Case 1 (Zero E. for Annex I)			50% reduction in 2050 Case 2 (20% E. for Annex I)		
		Emission ($MtCO_2$)	Ratio (%)	Emission ($MtCO_2$)	Ratio to 2000 (%)	Ratio to BAU (%)	Emission ($MtCO_2$)	Ratio to 2000 (%)	Ratio to BAU (%)
	A	B	B/A	C	C/A	C/B	D	D/A	D/B
Annex I	13507	17391	128.8	0	－	－	2701	20.0	15.5
Non A. I	9151	30928	348.9	11329	123.8	36.6	8628	94.3	27.9
Total	22658	48319	213.3	11329	50.0	23.4	11329	50.0	23.4

Let us examine 50/50 target from another aspect. What kind of technologies are necessary and to what extent in order to achieve the target. According to RITE DNE21+Model, 37GtCO2 reduction is required to implement the target and around two third of the reduction volume should come from power generation. Moreover, emissions from power generation sector should be negative by 2050. For this purpose, all the coal fired power plants worldwide must be equipped with CCS (carbon capture and storage) facilities, nuclear power should be four-folded (from 2,600 to 10,800 TWh/yr), wind power around 100 times (from 30 to 2,630 TWh/yr), and solar power more than 20,000 times (from 0.2 to 4,450 TWh/yr). Even if these are enormous challenges, these are not enough. Only when biomass fired power plants with CCS have been additionally introduced, emissions from power generation will become negative. Whether this is feasible and at what cost should be seriously reconsidered.

Third aspect is to examine the speed of technology improvement that is

emissions that would enable the reducion with minus cost, whereas RITE model assumes those minus cost emissions will be reduced in BAU case. Take this into account, difference of those two models are very small.

necessary to achieve the target. The following is the simplest form of Kaya Identity.

$$CO2\ emissions = CO2\ emissions/GDP \times GDP \quad (1)$$

By differentiating the above, equation (2) is obtained.

$$\Delta CO2/CO2 = \Delta(CO2/GDP) \div (CO2/GDP) + \Delta GDP/GDP \quad (2)$$

Here we call $\Delta(CO2/GDP) \div (CO2/GDP)$ as technology improvement ratio (more strictly speaking, this include energy efficiency improvement ratio, fuel switching ratio and structural change).

From the above, it is quite clear that there are two ways to reduce CO2 emissions, one is to improve technology and another is to reduce GDP growth ratio. In the past 35 years since 1970, average annual global technology improvement ratio was 1.227% (IEA 2007). According to RITE estimate[6], annual GDP growth ratio is assumed as 2.76%. Two tables below are calculated based on these figures.

(Table 3a)

To achieve 50% reduction, Relationship of technology improvement ratio and GDP loss against BAU	
GDP loss (%) against BAU	Technology improvement ratio (%)
0	3.856
10	3.681
20	3.485
30	3.262
40	3.005
50	2.701
80	1.174

(Table 3b)

50% reduction with technology improvement ratio remain unchanged	
CO2 reduction (%)	GDP loss (%) against BAU
0	58.710
10	62.839
20	66.968
30	71.097
40	75.226
50	79.355

Table 3a shows that in order to achieve 50% reduction in 2050 from the level of 1990 without sacrificing GDP growth ratio, annual technology improvement ratio should be 3.856%, more than three times as high as past average. Similarly, table 3b shows that in order to achieve the same target, GDP loss against BAU should be as

[6] RITE estimate is based on per capita growth rate by World Bank (during 2005-2030) and IPCC SRES B2 marker scenario (during 2030-2050). As a result, world GDP in 2050 is estimated to be 121.5 trillion US dollars (in comparison, GDP in 1990 and 2005 were 24.0 and 36.3 trillion US dollars respectively). In case of GDP reduction of 80% from BAU in 2050, GDP in 2050 will be 24.3 trillion US dollars which is almost same as that in 1990 and 33% absolute reduction from that in 2005.

much as 80% while technology improvement ratio is to remain the same as past average. From these two tables and the observation that no policy makers would not dare to introduce any policy that would seriously affect GDP growth, the only path is to develop innovative technologies as well as diffusion of existing technologies to developing countries. In this sense "technology is the key" and whether certain policies contribute to promote technology innovation/diffusion should be one of the most important criteria of policy evaluation.

4. Post Kyoto International Framework

This paper now focuses on mid-term target; Post Kyoto International Framework. Many leaders of G8 summit now argue for 50/50 (non-binding) long-term target as the evidence of their political will. As shown above, however, this target is so hard to achieve. Moreover, it is too costly. Again, according to the analysis based on the RITE DNE21+Model, marginal abatement cost will be \$334/tCO2 (\$200-500/tCO2 in case of IEA 2008) which corresponds to the carbon tax of \$475 per person per year. This will not be feasible. The mid-term target should be the one to be assuredly implemented and should be incorporated in an international framework that should not be led to collapse. For this purpose the framework should be realistic. This means that it is necessary to decouple long-term target from mid-term one.

Bearing this in mind, there should be principles for which most countries agree to follow. They are; All major emitters must participate (to ensure environmental effectiveness), Pay attention to each countries' circumstances (to promote the participation of as many countries as possible), Mutual supportiveness of climate change counter measures and economic growth, and Add "technology promotion" as policy criteria.

4. 1 Can a Kyoto-like framework survive?

Here, this paper examines first whether a Kyoto-like cap and trade framework is feasible or not. This seems to be the best solution both from environmental and cost effectiveness aspects provided that all major emitters join the scheme. At this moment it would be too optimistic to expect emerging economies such as China and India would accept to cap their total emissions. In such case, there is no doubt the scheme will not be environmentally effective. In addition, it would be unlikely for the United States to join the scheme without emerging economies' participation. Through the observation of US domestic policy, it is rather easy to draw the same conclusion as above. Though several bills that include cap and trade have been proposed to either the US Senate or the

House of Representatives, none of them assumes a national cap. If such is the case, Japan will not have any incentive to join the scheme as it is not environmentally effective.

It is not quite sure whether a Kyoto-like framework would be the best even if all major emitters join. This means that all major emitters agree to (global) cap on absolute emissions volume. As no one can make an accurate forecast for future global economic activities, setting global cap does not necessarily lead to global reduction unless accompanied by technology improvement ratio much higher than economic growth, as explained before. Setting cap always leads to reduction is an illusion the advocate of drastic reduction may fall into.

It will be of some help to explain using the example of Japan's restoration after the World War II. In September 1951, the Peace Treaty between Japan and Allied forces were concluded and Japan restored its sovereignty, but Soviet and Chinese Governments did not join the treaty because of the Cold War. Before ratified by the Japanese parliaments, however, the treaty was subjected to fierce battle between those who would argue for the treaty with all parties concerned including communist bloc and those who would argue for immediate independence under the treaty without communist bloc. At a glance, it was desirable to conclude the peace treaty with all countries concerned. Considering the fact that the Cold War just started, it was clear that the argument might have ended up with continued occupation. Ultimately, the treaty was ratified without the participation of the Communist countries at that time, and Japan restored independence. In the same way, an international framework with stringent cap joined by all major emitters seems to be an ideal one. On the other hand, the efforts to engage all major emitters to the scheme may lead to a collapse of negotiation. Even if those countries accede to the scheme, such treaty may result in many participating countries' non-compliances and prove to be environmentally ineffective if the cap is so challenging.

Another reason why a Kyoto-like framework has least feasibility is that it is too hard to agree upon fair and equitable initial allocation. There exists no such formula nor the least definition of fairness and equity. Prevailing feeling among Japanese society is that Japan suffers the most in the Kyoto scheme. Its marginal abatement cost is the highest (IPCC 2001) and at this moment both Japanese Government and private corporations are forced to purchase outside credits for as much as 220-250 Mt-CO2. In addition it is a general feeling that the Government may have to purchase additional credits using taxpayers' money. Without reasonable criteria of initial allocation for which most countries agree with, and considering the fact that it is inevitable to create "hot air", it is very hard to expect a Kyoto-like framework will be accepted even among developed countries.

Even if this kind of scheme has been accepted by major countries, another problem arises, i.e. enforcement. Canada has already announced of its intention to giving up implementation of the Kyoto target. Theoretically speaking, it could comply with the target by purchasing outside credits from, say, Russia. In Canada's implementation plan, however, it is clearly stated that the Government's Climate Fund will not purchase any hot air[7]. Who can enforce Canada to comply with the target? Legally binding penalty under the Kyoto Protocol has ever been agreed yet, and even though it has been agreed, is it possible to force Canada to pay penalty? It could do so in expense for Canada's departure from the scheme. This kind of issue will become serious if leading countries fall into non compliance situation. Needless to say, EU's Stability and Growth Pact has not been enforced to Germany and France when both countries failed to keep their deficits within the limit allowed under the Pact for several years.

From the discussion above, it is quite unlikely that a Kyoto-like international framework continues after 2012. The author would like to add one more point; one international framework does not fit all because of diversities in various countries' economic, social and cultural situations. Under the situation, alternative framework should be pursued.

4.2 Basic Assumption

Before discussing alternative framework, the author would like to make sure on what basic assumption the following alternatives are proposed. In designing climate policy, one of the most worrying issues is the probability of catastrophic loss. Whether abrupt change is likely or not in a certain period of time crucially affects future framework discussion. Typical examples of catastrophe are the collapse of Meridional Overturning Circulation (MOC) of the Atlantic Ocean and of Greenland and West Antarctic Ice Sheets. As long as IPCC 4th assessment report is concerned, it will not be likely that those abrupt changes will occur during this century. The followings are some excerpts from the IPCC report.

- It is *very unlikely that* the MOC will undergo a large abrupt transition during the 21st century. (IPCC (2007) SPM p. 16)
- The Greenland and Antarctic Ice Sheets contain much more ice and could make large contributions over many centuries. The processes of accelerated ice flow

[7] Only "green" credits — i.e., credits that represent real and verified emission reductions — will be recognized; there will be no purchases of so-called "hot air." (Government of Canada 2005, p. 23)

are not yet completely understood but could result in overall net sea level rise from ice sheets in the future. (IPCC (2007) TS p.51)

- If a global average warming of 1.9℃ to 4.6℃ relative to pre-industrial temperatures were maintained for millennia, the Greenland Ice Sheet would largely be eliminated except for remnant glaciers in the mountains. (IPCC (2007) TS p.80)
- Current global model studies project that the Antarctic Ice Sheet will remain too cold for widespread surface melting and will gain in mass due to increased snowfall. (IPCC (2007) TS p.80)

From the above, we will be able to design our policy on the assumption that there may not be any threshold in coming 100 years for which global emissions should never overshoot. This gives us some flexibility.

5. Alternative Frameworks

5.1 Structure of the treaty

Under the situation that global warming is inevitable at certain pace (0.2 degree per decade for two decades, IPCC (2007)), mitigation treaty is not enough. One of the shortcomings of the Kyoto Protocol is that it does not incorporate any adaptation efforts or technology innovation/diffusion. It counts only mitigation efforts. In an alternative treaty, these efforts as well as the removal of environmentally harmful subsidies should be counted.

In addition, a separate treaty of technology may be effective. So far only several independent international co-operations in this respect are ongoing. Examples are CSLF (Carbon Sequestration Leadership Forum), IPHE (International Partnership for Hydrogen Economy) etc. So far most successful attempt will be those of APP (Asia Pacific Partnership on Clean Development and Climate). It has formed 8 public private sector task forces covering power generation, steel, renewables etc. The author understands that the establishment of automobile task force is under discussion today.

As stated previously, technology is the key. Based on the above experience in technology co-operation field, therefore a new treaty to promote RDDD&D (research, development, demonstration, deployment and diffusion) should also be considered.

5.2 Alternative framework (Commitment and Act)

Having said that, what kind of alternative (mitigation) treaty will be environmentally effective and feasible? As suggested previously, for any treaty to be environmentally effective, all major emitters must participate in it. Most of major emitters have already committed in various forms to tackle climate change, though not just for climate change purpose. Table 4 shows those commitments.

(Table 4) Current Commitments of Major Emitters

Japan	(30% improvement of energy efficiency by 2030, base year 2005)
EU27	20% reduction in 2020 (base year 1990) 60% reduction in 2050
USA	20% reduction of gasoline consumption by 2017, 30% improvement of energy efficiency by 2015 (base year 2003)
APEC	25% improvement of energy efficiency by 2030 (base year 2005)
China	Same as above
India	--------
Other Major Emitters	--------

APEC: ASEAN 7 (Brunei, Indonesia, Malaysia, Philippine, Singapore, Thailand, Vietnam), Japan, Korea, China, Taiwan, Mexico, Papua New Guinea, Australia, New Zealand, USA, Canada, Peru, Chile and Russia (20 countries).
Japan has not made any formal commitment so far. The above description in bracket is the one the Government declared to achieve in its New National Energy Strategy released in May 2006.
Other Major Emitters: Korea, Indonesia, Australia, Brazil, Mexico, South Africa

Based on the above existing commitments, three case studies have been conducted (Table 5, 6, and 7).

In case 1, both India and other major emitters are assumed to make the same commitment with China. Also for the United States, linearly toward 50% reduction in 2050 is additionally assumed.

(Table 5) Case 1

	Assumed Commitments
Japan	30% improvement of energy efficiency by 2030 (base year 2005)
EU27	20% reduction in 2020 (base year 1990) then linear 60% reduction in 2050
USA	20% reduction of gasoline consumption by 2017, 30% improvement of energy efficiency by 2015 then linearly toward 50% reduction in 2050
APEC	25% improvement of energy efficiency by 2030 (base year 2005)
China	Same as above
India	Same as above
Other Major Emitters	Same as above

In case 2, sole difference is that marginal abatement cost of Japan was assumed to be the same as that of EU (i.e. $43/tCO2 in 2020). All other assumptions remained unchanged.

(Table 6) Case 2

	Assumed Commitments
Japan	Marginal Abatement Cost (MAC) is equal to EU's commitment
EU27	20% reduction in 2020 (base year 1990) then linearly 60% in 2050
USA	20% reduction of gasoline consumption by 2017, 30% improvement of energy efficiency by 2015 then linearly toward 50% reduction in 2050
APEC	25% improvement of energy efficiency by 2030 (base year 2005)
China	Same as above
India	Same as above
Other Major Emitters	Same as above

In case 3, assumed commitments are strengthened. Though Japan's Case 2 commitment remains unchanged, it is additionally assumed that Japan would also follow APEC's strengthened commitment. This makes Japan's commitment much costly to implement. USA is assumed to commit the same reduction ratio as proposed in the Lieberman/Warner Bill. APEC countries have been assumed that their commitment has been tightened. China, India and other major emitters' commitments have been assumed to be tightened respectively.

(Table 7) Case 3

	Assumed Commitments
Japan	MAC is same as EU's pledge, also subject to APEC's pledge
EU27	20% reduction in 2020 (base year 1990) then linearly 60% in 2050
USA	Same commitment as proposed in the Lieberman/Warner Bill (15% reduction in 2020 and 33% reduction in 2030, base year 2005)
APEC	30% improvement of energy efficiency by 2020 (base year 2005), 40% by 2030 (same as above)
China	20% improvement of energy efficiency by 2010 (base year 2005) 40% by 2020 (same as above), 60% by 2030 (same as above)
India	30% improvement of energy efficiency by 2020 (base year 2005) 50% by 2030 (same as above)

Other Major Emitters	Same as APEC Countries

Though these assumptions are rather arbitrary, this will allows us to figure out how much reduction will be possible if these commitments are fulfilled. In Case 1, total global reduction[8] is calculated at 4.0 Gt-CO2 for 2020 and 6.0 Gt-CO2 for 2030 respectively. Similarly in Case 2, the figures change to 4.2 to 6.4 Gt-CO2, and in Case 3, 5.6 to 8.9 Gt-CO2 respectively.

5.3 Alternative Approach (Sectoral Benchmark Approach)

Another alternative measure is so-called sectoral approach. The definition of the term "sectoral approach" has not been well established (Baron et al. 2007). In this paper it is defined as sectoral top-runner benchmark approach, meaning major players in each sector are required to catch up top-runner player's efficiency.

In order to estimate potential reduction volume, major emitting sectors (power generation, steel, cement, aluminum, paper & pulp, transport and electric appliances) are selected. Then it is assumed (to some extent arbitrary but still thought to be feasible) that by 2020 efficiency of those sectors in various parts of the world will be improved as shown in Table 8. In this table, Japanese sectors' efficiencies (or intensities) in 2005 have been set as 1. As shown in the table, Japanese top-runner efficiency/intensity level will be further improved by 2020 (for example by 5% in power generation and manufacturing sectors) and other regions' efficiency is also assumed to be improved[9].

(Table 8) Assumptions of intensities in 2020 by regions and by sectors

	Japan	Other Annex I	Other APP	Other Major Emitters
Power Generation	0.95	1.00	1.20	1.20
Steel, Cement, Aluminum	0.95	1.00	1.20	1.20
Paper & Pulp	0.95	1.00	1.20	1.20
Transport	0.6	0.65	0.85	0.85
Electric	1.00	1.05	1.25	1.25

8 Please note that the figures do not incorporate emissions from countries not listed in the tables, but, it is negligible as their emission volumes are so small

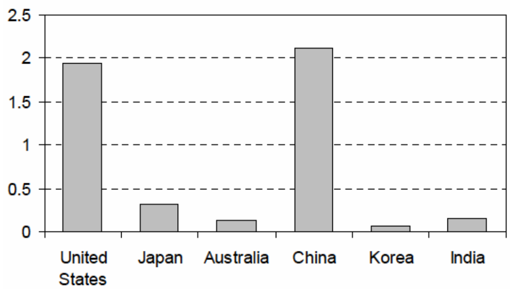
9 Refer to Akimoto et al. (2008) for detailed analysis of each sector's intensity.

Appliances				

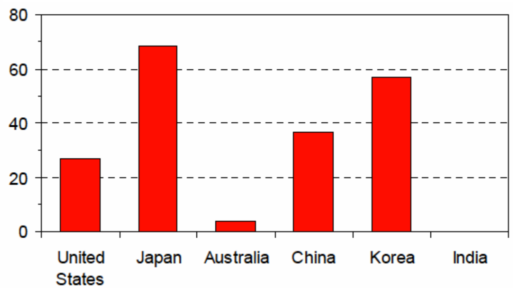
For power generation, intensity means CO_2 intensity and for other sectors it means energy intensity. For each sector, Japanese intensity level in 2050 is shown as 1. In 2005, other APP and other major emitters' intensity in power generation and other manufacturing sectors was around 1.3. Other APP includes China, India and Korea.

Figure 1 shows the reduction potentials in 2020 of 6 countries that are members of APP[10]. Figure 2 shows the average cost of reduction for those countries. Both figures are calculated by DNE21+Model. It is noteworthy that reduction potential of those 6 countries will be as much as 4.7Gt-CO2. Furthermore, if covered countries are expanded to Russia, EU and other major emitters, reduction potential will be increased to 6.3Gt-CO2. The figure will be further increased up to 8.8Gt-CO2 in 2030[11].

(Figure 1) Reduction Potential of APP 6 countries in 2020 (Gt-CO2)



(Figure 2) Average Cost of APP 6 countries in 2020 ($/tCO2)



5.4 Comparison and evaluation of environmental effectiveness

So far this paper focused on estimating reduction potentials of alternative frameworks. The outcome is shown in Table 9 below. From the table it is clear that, though huge reduction from BAU can be expected in alternative approaches, absolute emissions volume in 2020 and 2030 will be much higher than figures in year 2000. Does this mean those approaches are environmentally ineffective? To answer the question, it is necessary to compare those figures with the case when a "Kyoto-like" framework has been pursued.

[10] Canada is not included as it is quite new to join to APP (October 15, 2007).

[11] On the assumption that in 2030 Japanese intensities of each sector will be about 0.8 for power sector, 0.9 for industries, 0.5 for transport and 0.95 for electric appliances. For other APP and other major emitters, intensity is assumed as around 1.0 for power generation, 1.1 for industries 0.7 for transportation and 1.2 for electric appliances.

(Table 9) Comparison of reduction potential of Commitment & Act and Sectoral Benchmark Approach

Unit GtCO2

	Global Emissions	Global Emissions		BAU Emissions		Increase Ratio in Comparison to 2000		Reduction Ratio in Comparison to BAU	
	(A)	(B)	(C)	(D)	(E)	B/A-1	C/A-1	1-B/D	1-C/E
	2000	2020	2030	2020	2030	2020	2030	2020	2030
C&A 1	22.7	33.6	36.7	37.6	42.7	48.0%	61.7%	10.6%	14.1%
C&A 2	22.7	33.4	36.3	37.6	42.7	47.1%	59.9%	11.2%	15.0%
C&A 3	22.7	32.0	33.8	37.6	42.7	41.0%	48.9%	15.8%	20.8%
SA	22.7	31.3	33.9	37.6	42.7	37.9%	49.3%	16.8%	20.6%

C&A 1(2,3): Commit & Act Case 1(2,3), SA: Sectoral Benchmark Approach

The figures in a column "Global Emissions" are the ones corresponding to various approaches. For example in case of commitment and act (Case 1), global emissions will be 33.6Gt-CO2 in 2020 and 36.7GT-CO2 in 2030.

What will be the global picture if several countries strongly insist on to stick to a "Kyoto-like" framework after 2012? As discussed before, there will be little feasibility for emerging economies to join and negotiations will ultimately collapse. If that may be the case, EU will unilaterally pursue for 20% reduction target, and Japan, at best, will have target same as Commitment and Act Case 3 (30% intensity improvement in 2020 in comparison to 2005, and 40% in 2030). In the United States, though Lieberman/Warner Bill failed to become a law this year, it will be reasonable to assume that the same kind of law will be enacted in near future. Therefore we have assumed that the United States will reduce its emissions in accordance with the Bill. And, without agreement, the rest of the world is assumed to follow BAU emissions, except for China and APEC countries that follow their commitments as shown in Commitment and Act Case 1. Table 10 below shows the comparison of reduction potential of three cases.

(Table 10) Reduction Potential, Comparison of 3 cases

	Increase Ratio from 2000		Reduction Ratio for BAU	
	2020	2030	2020	2030
C&A Case3	41.0%	48.9%	15.8%	20.8%
SA	37.9%	49.3%	16.8%	20.6%
Kyoto-Like	45.3%	56.6%	12.5%	16.9%

6. Discussions

A Kyoto-like framework is expected to be environmentally effective as it sets cap on global emissions. Sticking so strongly to this framework, however, may lead to the risk of a breaking off of negotiations. If this being the case, global emissions reduction potential will be even smaller than alternative frameworks such as Commitment and Act or Sectoral Benchmark Approach (Table 10).

Of course, environmental effectiveness of alternative frameworks depends upon their assumptions. Especially for Commitment and Act Case 3, there is no guarantee that developing countries will assume such stringent commitments. Also it is unrealistic to think that all major emitters immediately agree to Sectoral Approach covering wide range of industries as well as transport and household appliance sectors. What matters here, however, is that except for a case where all major emitters agree to adopt cap and trade scheme, a Kyoto-like framework is not necessarily effective environmentally when compared to other approaches.

One argument against alternative approaches is that these are not cost effective. Theoretically this argument is correct. Marginal abatement cost will never be equalized throughout countries/sectors in alternative frameworks. However, what is the significance of equalizing marginal abatement cost among developed countries under Kyoto-like framework, especially when the United States will not join? Cost effectiveness among EU, Japan etc. will not be decisively advantageous to alternative frameworks.

When it comes to competitiveness, sectoral approach is more appropriate. Corporations in a same sector can compete without distortion. That is the reason why the European Commission is studying a possibility to apply this approach for sectors exposed to international competition in its Phase Ⅲ proposal and also several energy intensive sectors are lobbying for. By the same token, this approach is most suitable for establishing each country's emission cap (if necessity arises to do so), because it enables countries to set fair, equitable and reasonable cap to some extent.

What about institutional feasibility? Commitment and Act is more feasible since there are many countries/regions already declared their own targets (though not legally binding), and it can reflect diverse situations of both developed and developing countries. As a result, this approach has a good chance for all major emitters to join.

Final criterion of policy choice is whether a climate policy promotes technology innovation and diffusion. No wonder that sectoral approach just fits for this purpose as it urges corporations to catch up the top-runner technologies in their fields. From this point, sectoral approach seems to be quite attractive.

7. Concluding remarks

This paper first argued for a balanced approach between climate change and other global issues such as Millennium Development Goals. This paper also drew attention to mutual supportiveness of climate measures (mitigation and adaptation) and sustainable economic growth. In determining the ultimate objective of climate policy, this point should never been disregarded. Then this paper made it clear that the target of 50% global emissions reduction by 2050 is very hard to achieve without drastic technology improvement (both for energy efficiency improvement and fuel switching to low or no carbon energy). Any policy not accompanied by technology improvement would bear the risk of ending up with reduction of GDP growth ratio, for which no policy makers would dare to put force.

Then this paper compared environmental effectiveness of a Kyoto-like cap and trade policy and alternative approaches for post-Kyoto framework and found that to stick too strongly to a Kyoto-like cap and trade scheme may be less environmentally friendly. At the last part of the paper, it discussed about other important policy criteria, such as cost effectiveness, equity and competitiveness, institutional feasibility and promotion of technological innovation/diffusion.

This paper argues for the mixture of "Commitment and Act" and "Sectoral Benchmark Approach" for next framework. What is absolutely necessary for Post-Kyoto framework is to have all major emitters' participation. For that purpose Commitment and Act is the most feasible. It will be optimistic to project that they will commit rather stringent targets as shown in Case 3 in Table 7. Therefore continued effort toward more stringent targets is necessary. In order to supplement the weakness of Commitment and Act approach, Sectoral Benchmark Approach should be introduced to sectors and/or countries to the extent possible. Then, as data becomes available, covered sectors/countries should be extended further. For this purpose, setting up some kind of international scheme to promote technology transfer and financial assistance from developed countries to developing countries should be encouraged and promoted.

The above proposal may not be enough to achieve 50/50 target. As discussed here, however, the target was proved to be almost unattainable. Equally important is that, at least for coming 100 years, there will not be any threshold for which global emissions should never overshoot, as it is unlikely for catastrophe to occur during this period of time, according to the IPCC report. Moreover, to pursue so stringent a target may lead to collapse of international framework. Considering these factors and also the estimates that potential reduction (environmental effectiveness) of alternative approaches would be bigger than failed Kyoto-like approach, the above proposal would worth further consideration.

References

Akimoto et al. (2008), "Sectoral approach as a Post Kyoto Framework, analysis and evaluation", the report of the Ministry of Economy, Trade and Industry titled as 'Research of climate policies and evaluation', Akimoto, K. and Yamaguchi, M. March 2008 (in Japanese), Chapter 2.1

Azar, C. (1998), "Are optimal CO2 emissions really optimal? Four critical issues for economists in the greenhouse", *Environmental and resource economics*, 11 (3-4), April/1998

Baron, R. et al. (2007), "Sectoral Approaches to Greenhouse Gas Mitigation, Exploring Issues for Heavy Industry", Baron, R., Reinaud, J., Genasci, M. and Philibert, C., IEA Information Paper

Government of Canada (2005), "Moving forward on climate change, a plan for honouring our Kyoto commitment"

IEA (2008), "*Energy Technology Perspectives 2008, in support of the G8 Plan of Action*, *Scenarios & Strategies to 2050*"

IEA (2007), "*CO2 Emissions from fuel combustion 1971-2005*"

IPCC (2001), "*Climate Change 2001, Synthesis Report*", Cambridge University Press

IPCC (2007), "*Climate Change 2007, The Physical Science Basis" Working Group I Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*"

Mastrandrea, M.D. and Schneider, S.H. (2004) , "Probabilistic Integrated Assessment of 'Dangerous' Climate Change," *Science*, Vol. 304, pp. 571—575.

Meinshausen, M. (2006) , "What Does 2°C Target Mean for Greenhouse Gas Concentrations? A Brief Analysis Based on Multi-Gas Emission Pathways and Several Climate Sensitivity Estimates," in Schellnhuber H.J. (ed), '*Avoiding Dangerous Climate Change*', Cambridge University Press, Chapter 28

Nordhaus, W. D. and Boyer, J. (2000) , *Warming the World: Economic Models of Global Warming*, MIT Press.

Nordhaus, W. D., (1994) , "*Managing the Global Commons: The Economics of Climate Change*" Cambridge, MA: MIT Press.

Nordhaus, W. (2007), "The Challenge of Global Warming: Economic Models and Environmental Policy", July 24, http://nordhaus.econ.yale.edu/dice_mss_072407_all.pdf

Parry, M.et al. (2001) , "Millions at risk: Defining critical climate change threats and targets," Parry, M., Amell, N., McMichael, T., Nicholls, R., Martens, P., Kovats, S., Livermore, M., Rosenzweig, C., Iglesias, A., and Fischer, G. *Global Environmental Change*, Vol. 11, pp. 181—183,

Sachs (2004), "Seeking a global solution, The Copenhagen Consensus neglects the need to tackle climate change" *Nature* Vol. 430 12 August 2004, 725-726

Schneider, S.H. and Lane, J. (2006), "An overview of 'Dangerous' Climate Change", in Schellnhuber H.J. (ed), '*Avoiding Dangerous Climate Change*', Cambridge University Press, Chapter 2

Tol, R.S.J. and Yohe, G.W. (2006), "Of Dangerous Climate Change and Dangerous Emission Reduction", in Schellnhuber H.J. (ed), '*Avoiding Dangerous Climate Change*', Cambridge University Press, Chapter 30