A critical review of “2 degree target” and a desirable and feasible post-Kyoto international framework

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Abstract
This paper begins with the paradigm shift from top-down to bottom-up approach in Copenhagen in 2009. Then 2 degree target as the ultimate objective of response strategies under UNFCCC is reviewed from both vertical balance (purely climate change view point) and horizontal balance (view point of efficient allocation of scarce resources) and the paper finds the target is unrealistic and isn’t based on much science. The paper argues to have new Post-Kyoto international framework through pledge and review approach based on the alternative target that is scientifically sound, economically reasonable and politically feasible.
Key Words:
paradigm shift, 2 degree target, vertical balance, horizontal balance, pledge and review

1. Prologue - Paradigm shift at Copenhagen

In December 2009, prime ministers and presidents from all over the world, including the United States and China, got together in Copenhagen to negotiate face to face a new international framework after the Kyoto Protocol. Almost all the people who are interested in this issue around the world awaited the negotiation outcome. Unfortunately leaders failed to reach any legally binding international framework. Instead of adopting “top down” approach based on 2 degree target (to limit temperature increase within 2 degrees above pre-industrial level), each country voluntarily pledged (or agreed to pledge) its emission target under the Copenhagen Accord adopted at 15th session of the Conference of the Parties (COP 15). The accord describes that countries shall enhance their action to combat climate change “recognizing the scientific view that the increase in global temperature should be below 2 degree Celsius[1]”. Summing up of the targets submitted by member countries following the Accord revealed never be enough to attain 2 degree target.

Until that time, the European Union (EU) has initiated the leadership in combating climate change. The strategy of the EU was supposed to be the followings; to agree 2 degree target as the ultimate objective of global climate response strategies, to set corresponding greenhouse gas (GHG) concentration to materialize the target, then to set global emission pathways, and to set emission reduction/limitation targets in 2020 and after to each country (including the United States and all the emerging economies like China and India) in accordance with the principle of common but differentiated responsibilities and respective capabilities, and make them legally binding. As it became clear that it was premature to proceed with this strategy, EU, as the second best strategy, advocated the extension of the Kyoto Protocol under which only developed countries (excluding the United States) assume legally binding numerical targets, in vein. COP 15 was the turning point in that the paradigm shifted from top down (often called as target and timetable) to bottom up (pledge and review) approach.

According to the author's view, the reason of the set back was that the participating countries were not really convinced of 2 degree target. Before discussing the appropriateness of this target, the author would like to explain the meaning of the ultimate objective of response strategies.

2. Ultimate Objective and its interpretations

2.1 Article 2 of UNFCCC

Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992 and took effect in 1994, describes the ultimate objective of climate response strategies as follows;

> *The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.*

The prototype wordings of the Article 2 can be found in Noordwijk Declaration in 1989. If one compares the wordings with that of the article 2 of UNFCCC, one would be impressed to find the resemblance of those two wordings.

2.2 Interpretation of the Article 2

The 4th assessment report of Intergovernmental Panel on Climate Change (IPCC) interpreted the Article 2 as follows; "The choice of a stabilization level implies the balancing of the risks of climate change (risks of gradual change and of extreme events, risk of irreversible change of the climate, including risks for food security, ecosystems and sustainable development) against the risk of response measures that may threaten economic sustainability" [1]. In other words, the choice of stabilization level is a balance between too little response strategies (resulting in adverse climate impacts) and excessive response strategies (resulting in adverse economic impacts).

So far, discussions on the article 2 have inclined to focus on what constitutes *dangerous anthropogenic interference* with the climate. But as shown above, it is noteworthy to remind that

1 The phrase "above pre-industrial level" was somehow missing.

this view reflects only one side of the story. There is the other side, i.e. mutual supportiveness of sustainable economic development and climate protection.

That said, what constitutes dangerous anthropogenic interference is, no doubt, the main issue in the article. This is, according to IPCC, beyond what science (IPCC) can decide. It says that "defining what is dangerous interference with the climate system is a complex task that can only be partially supported by science, as it inherently involves normative judgments" [1].

Figure 1 below explains why. The extent of impacts to each category following the same degree increase of temperature is quite different by categories. As a result, *dangerous* increase of temperature differs according to what risk category one would think the most important.

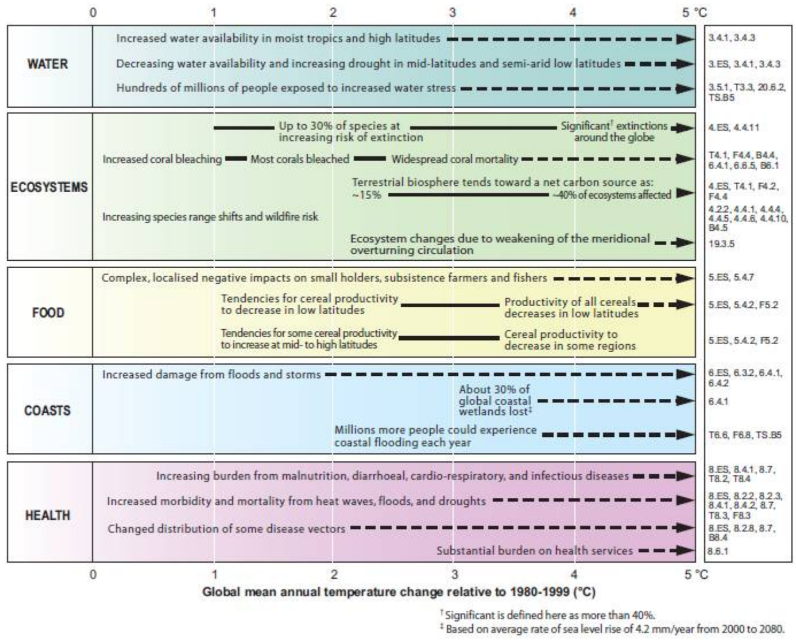

Fig. 1 Increase in global mean temperature relative to 1980-1999 (°C) and its impacts to five categories of risks. Source: Climate Change 2007: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Figure SPM.2. Cambridge University Press.

The figure shows five categories of climate impacts in proportion to the increase of temperature. X axis shows temperature increase and the extent of climate impacts. Y axis shows different categories of risks. Note that adaptation has not been taken into account.

There are several approaches trying to define dangerous anthropogenic interference with the climate, including tolerable windows approach, sustainability approach, and cost-benefit approach. In all the approaches, however, defining dangerous level includes political judgment.

Though the author has a different view, it is generally believed that holding the increase in global average temperature within 2 degrees above pre-industrial level is a globally agreed target of climate response strategies. This short article examines whether this "2 degree target" is appropriate and feasible from both vertical and horizontal view points. The former focuses only on climate change aspect and the latter focuses on efficient allocation of scarce resources among globally urgent issues including climate change.

3. 2 degree target from the view point of vertical balance – What does it mean?

3.1 Is 2 degree increase dangerous?

According to IPCC [2], if the temperature increases between 1-3°C above *1990 levels*, effects will be mixture of net benefits and net costs, depending on regions and sectors. It continues to describe, however, that "it is very likely that all regions will experience either declines in net benefits or increases in net costs for increases in temperature greater than about 2-3°C" (p. 65). It is clear in the context that the increase of temperature is relative to *1990 levels*. The temperature has already increased by 0.74°C from 1906 to 2005 [3]. When recent high rate of change is taken into account, it may be reasonable to assume that the temperature increase from pre-industrial level to that in 1990 will be around 0.6°C. If this assumption is correct, 2-3°C temperature increase above 1990 corresponds to 2.6-3.6°C above pre-industrial level. In view of the above, one cannot draw a conclusion that 2°C increase above *pre-industrial level*, that corresponds to 1.4°C increase from *1990*, is deemed to be dangerous level.

3.2 No adaptation is unrealistic

It is noteworthy to know that the above discussion does not take adaptation into account. It is quite unrealistic to imagine that people will do nothing in the face of, for example, shortage of food production due to climate change. Anybody will try to endeavor to figure out improved species that adapt to the changing climate. Even if 2°C temperature increase is deemed as dangerous, adaptation can reduce damages, making dangerous temperature increase upward. This is another reason to argue that 2 degree temperature increase from pre-industrial level cannot be deemed as dangerous.

3.3 Feasibility of 2 degree target

3.3.1 From per capita emissions view point

In order to limit temperature increase by 2.0-2.4°C above pre-industrial level, global GHG emissions in 2050 must be reduced at least 50% relative to that of 2000 [1]. This means that, though it does not precisely correspond to 2 degree target, 50% reduction target can be used to evaluate the feasibility of 2 degree target.

Feasibility of halving global emissions can be checked from a various aspects. First, this paper investigates it from feasibility of per capita CO2 emission reductions both in developed and developing countries. Note that the figure focuses only on CO2 emissions.

Global CO2 emissions was 22.7 billion tons in 2000 (13.8 billion tons from Annex I countries and 8.9 billion tons from Non-Annex I countries). Per capita emissions was 3.7 tCO2 (11.0 tCO2 for Annex I and 1.8 tCO2 for Non-Annex I countries). Halving emissions in 2050 require that global CO_2 emissions be reduced to 11.35 billion tons. According to the UN World Population Prospects 2008, population in 2050 is estimated as 9.2 billion (1.4 billion for Annex I and 7.8 billion for Non-Annex I). Based on those data, if Annex I countries reduce their per capita emissions by 80% to 2.2 tCO_2 in 2050, Non-Annex I countries' per capita emissions in 2050 must be 1.1 tCO_2 to reach global total emissions to 11.35 billion tons. In the extreme case, should Annex I countries' emission will become zero, Non-Annex I countries must reduce their per capita emissions to 1.5 tCO_2 to halve global emissions. Under the situation, even if developed countries are successful to reduce per capita emissions by 80%, whether developing countries will be able to reduce their per capita emissions by 40% (from 1.8 tCO_2 in 2000 to 1.1 tCO_2 in 2050) is yet to be seen, especially in view of the fact that developing countries' per capita emissions has already increased to 2.3 tCO_2 (in this case reduction ratio is more than 50%). To sum up, in view of rapid economic growth in emerging economies and per capita emissions in China has almost reached 4 tCO_2 in 2005, feasibility of halving global emissions by 2050 (necessary to achieve 2 degree target) seems to be infeasible.

3.3.2 Technological view point

Without very high technology improvement ratio, 2 degree target will be un-achievable. The author explains the reason by relying on the famous Kaya Identity. The simplest form of the Identity is as follows.

$$CO2 = CO2/GDP \times GDP \qquad (1)$$

$$\frac{\partial}{\partial t}[CO2] = \frac{\partial}{\partial t}[CO2/GDP] + \frac{\partial}{\partial t}[GDP] \qquad (2)$$

Equation (2) above shows that in order to reduce CO_2 emissions, society must either reduce CO_2 intensity ratio or GDP growth ratio, or both. In this context, the author deems the reduction ratio of CO_2 intensity as technology improvement ratio, though the change of consumers' behavior is included here.

Calculation based on CO_2 Emissions from Fuel Combustion by the International Energy Agency (IEA) shows annual average technology improvement ratio during past 30 years from 1971 has been 1.2%. Average annual BAU GDP growth ratio from 2000 to 2050 is estimated as 2.76%/yr. (RITE estimate[2]).

Note that IEA emission data are confined to CO_2, not GHG due to lack of reliable data.

Table 1 shows tradeoff between GDP loss relative to BAU and needed technology improvement ratio to reduce global emissions by 50% (base year 2000).

From the table it is clear that, to reduce 50% emissions without compromising GDP, average annual technology improvement ratio must be around 3.9% every year for 50 years from year 2000.

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[2] The figure is based on the World Bank data and the IPCC SRES B2 Marker Scenario. RITE (Research Institute of Innovative Technology for the Earth) is one of Japan's leading research institutes on climate change and technologies.

The fact that we have never experienced such a high technology improvement ratio (the highest was 2.9% in 1981) even in a year in the past 30 years tells us that, firstly, 50% reduction target is very challenging, and secondly, large GDP losses may be inevitable to achieve the target without unprecedented technology improvement ratio. It is noteworthy that even with annual 2.7% technology improvement ratio, GDP loss relative to BAU will be as large as 50%.

To achieve 50% reduction in 2050 (base year 2000)	
GDP loss (%) against BAU	Technology improvement ratio (%)
0	3.9
10	3.7
20	3.5
30	3.3
40	3.0
50	2.7
80	1.2

Table 1 Tradeoff between GDP loss and technology improvement

3.4 Uncertainty and 2 degree target

Current scientific knowledge tells us that climate sensitivity is estimated as 2°C-4.5°C. This means that there are wide ranges of concentration levels to achieve 2 degree target.

Meinshausen [4] compared 11 research outcomes of the probability density function of climate sensitivity and tried to find the probability to hit 2 degree target. According to the paper, the probabilities to exceed 2 degree target is between 26-78% (mean 28%) if concentration level is stabilized at 450ppmCO2e that is generally considered to be necessary to achieve 2 degree target[3]. Even if concentration level is stabilized at 350ppmCO2e, the probability is between 0-31% (mean 7%). Because of the uncertainty of climate sensitivity, it is impossible to set the concentration level to be able to surely attain 2 degree target. Provided that people share the idea that 2 degree increase above pre-industrial level constitutes dangerous, then, even 350ppmCO2e stabilization is not enough. Every expert knows this target is so costly and therefore quite unrealistic.

The author regrets, due to space constraint, not to able to provide further review of 2 degree target such as from the view point of catastrophe and cost benefit analysis.

4. 2 degree target from the view point of horizontal balance – efficient allocation of scarce resources

So far discussions on ultimate objective have focused solely on the aspect of climate change (vertical balance). The conclusion was that there was no solid ground for 2 degree target. This section focuses on horizontal balance, i.e. efficient allocation of scarce resources. Policy makers have to deal with various globally urgent issues at the same time without having sufficient

[3] Note that at the time of Meinshausen's research, climate sensitivity is believed to be between 1.5~4.5 °C.

resources. Even if 2 degree target is relevant from the vertical point of view, policy makers still have to think about efficient use of their resources among global urgent issues, including energy and food security, healthcare and poverty etc. How to prioritize them? In addition, policy makers have to pay full attention to global competitiveness of their own industries.

Millennium Development Goals (MDGs) had been worked out based on the United Nations Millennium Declaration in September 2000. Eight goals including eradication of extreme poverty and hunger, reduction of child mortality, combatting HIV/AIDS, malaria and other diseases, and eighteen targets have been set. Seventh goal is ensuring environmental sustainability and climate change is included there. MDGs are, no doubt, the urgent issues human beings should cope with globally.

The issue is that the global resources are finite. How to allocate limited resources to the globally urgent issues? There were such attempts in the past; The Copenhagen Consensus Projects in 2004 and 2008 based on cost-benefit analysis (CBA). In both cases climate policies were given low priorities in allocating scarce global resources among globally urgent issues. When the outcome of 2004 project was released, most of the environmental NGOs, many climate community experts and environmental negotiators fiercely criticized the result. Jeffrey Sachs of Columbia University joined the camp [5]. His argument consisted of wrong question, wrong participants, and wrong conclusions. While Sachs criticized the outcome, he admitted that the core concept of the Copenhagen Consensus is a good one but need to be improved in several points. The purpose of the introduction or the outcomes of the Copenhagen Consensus here does not mean that the author shares the same view on priorities. Rather, as Sachs pointed out, the author believes that this kind of concept is quite important as the world need to allocate the scarce resources efficiently and effectively to various globally urgent issues including climate change. Especially, under recent world economic situation, much more attention should be given to prioritization issues, because once we allocate certain amount of resources to some particular issue, that portion of the resources cannot be used to other issues. And in doing so, CBA still remains as one of the important tools.

Same thing applies for domestic policies. Everybody agrees that for developing countries sustainable economic development was and still is the first priority. Developed countries are no exceptions. The United States, European Union, Japan are all in the midst of the economic mess.

The author has never seen any academic and political discussion whether 2 degree target will be relevant or not from the view point of efficient allocation of global resources (horizontal balance).

5. Concluding remarks

Through discussions above, it became clear that 2 degree target is unfounded both from vertical and horizontal balance. It "bears no relationship to emission controls that most governments will actually adopt. And it isn't based on much science either" [6]. This is the reason why policy makers were not really convinced with 2 degree target, and paradigm has shifted from top down to bottom up approach.

What world leaders and negotiators should do is to revisit 2 degree target and agree alternative target that is scientifically sound, economically reasonable and politically feasible. Thereafter, new Post-Kyoto international framework should be restructured, based on the Copenhagen Accord, i.e. pledge and review. Each contracting members are legally binding for its effort (to take policies and measures) and not for numerical target. Not only mitigation, but also adaptation, technology innovation/transfer, and financing activities should be integrated under the new framework. We must not forget the risk of catastrophe, however. Due to uncertainty, especially of climate sensitivity, and inertia of climate system, we have to manage the risks, including low probability but high impact catastrophic risks.

Geo-engineering is a tool for risk management. Now that society cannot spend so much amount of money for invisible threats, we have to be prepared for the worst case. Of course, we should be very cautious in actually implementing this tool. That may invite other unknown risks. On the other hand promoting R&D and to be prepared for the worst case may be the second best way we can do for future generations.

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