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# Climate Change Policies: Vertical Balance, Horizontal Balance

By Mitsutsune Yamaguchi, University of Tokyo

Global warming is assuredly occurring, and it is causing a variety of unusual changes on the earth. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change states that there is a probability stronger than 90% that the cause of the global warming is the emission of greenhouse gases from human sources. Unless action is taken, GHG emissions are sure to increase at an accelerating pace. The whole world must work together on stemming this trend so as to enable sustainable development of the global ecosystem, humankind included.

Toward this end, global GHG emissions need to be substantially reduced over the long term. But how large should these cuts be? What is the time frame? What are the criteria for answering these questions? The international community's discussion on this matter has not yet reached a state of maturity.

## The vertical balance: How far to take mitigation measures

Article 2 of the United Nations Framework Convention on Climate Change states that the convention's ultimate objective is to stabilize GHG concentrations in the atmosphere at a level that would prevent "dangerous anthropogenic interference with the climate system." It adds that this 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." In respect to the relationship with economic development, the IPCC's Fourth Assessment Report states the problem as one of balancing the risks of global warming against the risks of harming sustainable economic development through the implementation of mitigation measures, and it observes that there is no consensus on what GHG concentration can be deemed not to be dangerous. Science alone cannot define the meaning of dangerous interference with the climate system, the report maintains, as this is a matter requiring value judgments.

As can be appreciated, there is no international agreement on the extent to which policies to prevent global warming should be implemented. At their 2008 Hokkaido Toyako summit in Japan, the Group of Eight declared the "aspirational goal" of halving the world's GHG emissions by 2050 (without specifying a base year), but this is not a goal the world has agreed on. In this regard, the European Union has unilaterally proposed the target of holding the rise of temperatures to no more than 2 degrees Celsius above preindustrial levels, toward which end GHG emissions would need to peak out by 2020 and be cut at least in half by 2050.

The halving of emissions by 2050 is fine in the sense that while it is an ambitious goal championed by a group of advanced countries, it gives the world an objective toward which to strive. But it is no more than an aspiration. One would find it somewhat unreasonable if this goal were presented instead as an absolute

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target and used to apply pressure to all countries, not just the EU members, with developed countries being asked to make a 30% emissions cut from the 1990 level by 2020 and developing countries also being asked to make deep cuts from BAU, the "business as usual" levels. This halving of emissions by 2050 must not be portrayed as anything more than an aspiration.

One major reason why we should view the goal in this way involves the feasibility of achieving it. Among the greenhouse gases, the primary emission is carbon dioxide from energy sources, for which we have solid data. The volume of $CO_2$ emitted worldwide was some 23 billion tons in 2000. According to a projection by the Research Institute of Innovative Technology for the Earth (RITE), a Kyoto-based think tank, the volume will rise to 48 billion tons by 2050. If instead emissions are to be cut in half, the volume must be suppressed to 11.5 billion tons.

Under what conditions could this be achieved? Suppose, for argument's sake, that the developed countries manage to attain zero emissions by 2050. That would leave the developing world with room for emissions of 11.5 billion tons. But developing countries in 2000 had emissions of 9.2 billion tons, and the total increase allowed for them over the 50-year period would be merely 25%. Taking population growth in the developing world into account, we find that these countries would need to reduce emissions per capita from 1.8 tons to 1.4 tons. In view of the trend of increase in the emissions from such countries as China and India (with emissions rising by 67% over the five-year period from 2000 to 2005 in China's case), the developing world would hardly be likely to accept such a scheme. And as for the developed countries, not one of them has committed itself to achieving zero $CO_2$ emissions by 2050.

Next let us consider the halving goal from the technology perspective (in this case, 1990 is used as the base year). The following equation is the simplest version of the well-known Kaya identity, which was developed by Dr. Yoichi Kaya for the analysis of $CO_2$ emissions:

$$CO_2\ emissions = \frac{CO_2\ emissions}{GDP} \times GDP$$

Here, *GDP* is world gross domestic product and *$CO_2$ emissions / GDP* is the volume of $CO_2$ released per unit of GDP, which is one way of expressing the technological level. Accordingly, the equation can be restated like this:

$$CO_2\ emissions = Technological\ level \times GDP$$

Differentiating this equation, we obtain

$$\Delta CO_2\ emissions = \Delta Technological\ level + \Delta GDP$$

Here $\Delta$ denotes a rate of change: *$\Delta$Technological level* is the technology improvement rate and *$\Delta$GDP* is the GDP growth rate. In short, in order to reduce $CO_2$ emissions, either technology must be upgraded or economic growth must be slowed down. (Changes in lifestyles and industrial structure also affect the technology improvement rate, but for achieving a large cut in emissions, the two factors in this formula are of greatest importance. Industrial structure in this case is the structure of the world economy, not that of individual countries, so a rapid contraction in energy-intensive industries can be ruled out. Strictly speaking, the technology improvement rate is the sum of two factors: the energy efficiency improvement rate and the de-carbonization rate.)

According to the International Energy Agency, the average annual rate of technology improvement has been 1.2% since 1970, the first year for which data is available. According to a projection by RITE based on forecasts of the World Bank and the B2 (middle-of-the-road) scenarios of the IPCC, the average annual rate of economic growth until 2050 will be 2.7%. Using these figures as base rates, let us examine the relationship among the $CO_2$ reduction rate, technology improvement rate, and GDP loss rate (Tables 1 and 2).

It would be possible to cut world $CO_2$ emissions in half between 1990 and 2050 if one of two conditions were met. First, assuming that technological progress moves at the same rate as in the past, world GDP must be suppressed 76% below where it would have arrived with the business-as-usual growth rate (Table 2). Second, assuming instead that there is no GDP loss against BAU, the annual average technology improvement rate must be speeded up to 4.1%, almost 3.4 times the base rate of 1.2%. In the first case, world GDP in 2050 would amount to $29.2 trillion, some 20% below the 2005 figure of $36.3 trillion. This is a completely unrealistic supposition. (It should be noted that even in the case of no reduction in $CO_2$ emissions from the 1990 level, there would still be a GDP loss against BAU of nearly 50%.) In the second case, meanwhile, there is simply no way to make technological progress move 3.4 times faster than the past average rate by fully utilizing existing technologies. Revolutionary, breakthrough technologies would be essential, and they would have to be quickly developed and disseminated. The realism of this happening needs serious consideration, as do the costs that would be entailed.

What all this means is that further thought should be given to the GHG concentration level we aim at (the ultimate objective), taking into account the feasibility of attaining them, and the balance between the damage from rising temperatures and the cost (adverse economic impact) of suppressing temperature increases. This is what I mean here as the vertical balance.

**Table 1**
**GDP Loss and Technology Improvement for 50% Reduction in $CO_2$**

| GDP loss against BAU (%) | Technology improvement (%) |
|---|---|
| 0 | 4.07 |
| 10 | 3.86 |
| 20 | 3.62 |
| 30 | 3.36 |
| 40 | 3.05 |
| 50 | 2.68 |
| 80 | 0.85 |

**Table 2**
**$CO_2$ Reduction and GDP Loss with Unchanged Technology Improvement Rate**

| $CO_2$ reduction (%) | GDP loss against BAU (%) |
|---|---|
| 0 | 51.75 |
| 10 | 56.57 |
| 20 | 61.40 |
| 30 | 66.22 |
| 40 | 71.05 |
| 50 | 75.87 |

## The benefits of a sectoral approach

The foregoing comments notwithstanding, no argument is possible over the long-term need to make large cuts in emissions. In this connection, consideration of the Kaya identity leads to one more point: Major cuts cannot be made without technological innovations and their diffusion. Thus far, four criteria have been advocated for evaluating global warming policies: environmental effectiveness, cost effectiveness, distributional effect, and institutional feasibility (IPCC Fourth Assessment Report). I believe that one more important criterion should be added to these: the effect policies have on promoting innovation and diffusion of technologies.

From the standpoint of technology promotion, the sectoral approach deserves a second look. There are various interpretations of what the sectoral approach involves, and

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precisely defining it is difficult. The following discussion sees the approach as one in which the sectors of the major emitting countries engage in an exchange of information and use the information to spur efforts toward efficiency improvement and low-carbon technologies, with each sector acting in accord with its own circumstances. Ultimately, the players in each sector strive to overtake the world's front runner in their industry. Accordingly, this approach is not concerned with a "sectoral crediting mechanism," which is also known as a kind of sectoral approach.

Approaches that involve credits, such as the sectoral crediting mechanism and the "cap and trade" approach, provide incentives to pursue technological development over the short run, but companies will opt to purchase credits if this is less expensive than developing technology in-house. Another problem with these approaches is that the prices of credits can be volatile for institutional reasons, as the EU has found from its own experience with its scheme. Price volatility impedes the inclination to invest in low-carbon technologies. When efficiency standards are prescribed, by contrast, companies cannot circumvent them by acquiring credits, and because the standards are clearly spelled out, there is no wavering over judgments on investment decisions. Each company is motivated to put hard effort into technological development, and the technological level rises as a result.

The application of environmental standards to automotive exhaust in Japan offers one of the best examples. In the 1970s Japan, following the lead of the United States, established strict standards for automotive exhaust. Even as American automakers were lobbying the US government to get the standards relaxed, Japanese automakers engaged busily in technological development, came up with such advances as Honda's CVCC (compound vortex controlled combustion) engine technology, managed to attain compliance with the standards, and used their new strengths to advance into the world's markets. Probably this technological innovation would not have made so much progress if the automakers had had the option of clearing the regulatory hurdles by purchasing credits inexpensively from other entities/countries. The author often notices that people wonder why, in the absence of the incentive of selling credits by reducing its own emissions, a company will devote extra effort to reducing emissions. The response is that there is incentive. In the case of Japan's manufacturers, the foremost incentive is the wish to sustain efficiency at a world-leading level. It is because of this incentive that Japanese technology has made so much progress.

Because what is required to combat global warming is not short-term emission cuts but deep slashes over the long term, the development and diffusion of innovative technologies will play the central role. In such a situation, it goes without saying that the sectoral approach can be an effective tool, since it will promote international cooperation in each sector's efforts for efficiency improvement and de-carbonization. Naturally any country requiring support should be given the maximum assistance. In response to these needs, developing countries should be supplied with technologies, funds, and personnel.

To be sure, the sectoral approach is theoretically less efficient than approaches based on market-based mechanisms. As far as promoting technological development is concerned, however, it clearly offers a better solution. We should also note that the efficiency of an economic approach will be dependent on securing global participation, which is not a very realistic proposition. When this is taken into account, we find that in practical terms the difference of efficiency between the two approaches is not so large as textbooks might tell us.

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## The horizontal balance: Efficient allocation of limited resources

The resources of the earth are finite and often scarce, and they need to be spread around to deal with a host of pressing issues requiring international cooperation. These issues involve reconciling the three Es—environment, economy, and energy—and have been spelled out in the millennium development goals (MDGs) adopted by the United Nations Millennium Summit in 2000. There are eight goals, including eradicating extreme poverty and hunger, combating diseases, and reducing child mortality; one of them is ensuring environmental sustainability.

Relationships of both synergy and trade-offs exist among these goals. Consider the case of malaria. Climate change measures can be expected to have a synergistic effect of suppressing increases in the population suffering from malaria in the future, but there is a trade-off when today's resources are allocated to global warming mitigation instead of being devoted to treating the many children currently afflicted with this disease. Accordingly, when political leaders make decisions on what portion of scarce resources to devote to which needs, they must always ask themselves what is the most efficient way to put the resources to use.

One useful tool for the decision-making process is cost-benefit analysis. Granted, measuring benefits (the monetary value of avoided damages) can be extremely difficult in the case of global warming. Because the damage will occur over the long term, the question of what discount rate to use for computing future benefits (avoided damages) in present-day values is sure to be controversial. The problems of assigning monetary amounts to nonmarket values and assessing irreversible damages further complicate the picture.

In this light, it is clear that allocating resources among the respective pressing needs simply cannot be accomplished on the basis of cost-benefit analysis alone. On the other hand, it is also true that allocations of resources to climate change measures will mean a reduction by the same amount in the resources available for other urgent issues, and vice versa. In this context, the available resources need to be allocated among policy tasks as rationally as possible. To state this in simple terms, the allocation of resources to climate change and other top priorities must be carried out in a balanced fashion. When making decisions, this horizontal balance, as I call it, must always be kept in mind.

Mitsutsune Yamaguchi is a project professor at the University of Tokyo's Research Center for Advanced Science and Technology. He served as one of the lead authors of the IPCC Third and Fourth Assessment Reports.