Realization of Carbonless Society

By Kaya Yoichi

When the first United Nations Conference on the Human Environment was held in 1972, discussions were dominated by the issue of deforestation in developing countries. Since then, various issues such as acid rain, destruction of the ozone layer and dwindling biodiversity were taken up in connection with the human environment. For the past 10 years, however, global interest has been focused on global warming. In fact, temperatures throughout the world have been rising since 1980 and various effects of global warming, including the receding of glaciers in Europe and Asia, have been reported by mass media. Symbolizing such a situation was a declaration issued by major industrial countries in June at their G-8 summit meeting in Heilingendam, Germany. The document said they agreed to "consider seriously" a target of halving global greenhouse gas emissions by 2050.

In this article, I would like to discuss from an overall viewpoint what action Japan should take to address global warming.

1. "Cool Earth 50" & Its Realistic Development

It is now widely known that progress of global warming will have serious consequences. "An Inconvenient Truth," authored by former US Vice President Al Gore as a book and produced as a documentary film, has played an important role in driving home the seriousness of global warming. The US government had been passive in dealing with global warming on grounds of the uncertainty of scientific knowledge. Lately, however, Washington admitted on various occasions such as the G-8 summit to the necessity of addressing global warming. China, too, has begun to take measures, mainly energy saving, to restrict emissions of greenhouse gases. In this regard, it can be said that moves to curb global warming have been gaining momentum throughout the world.

Yet, the current Kyoto Protocol is only the first milestone in combating global warming although it sets a goal of reducing global warming by the five target years of 2008-2012. The problem is how to take long-term measures. "Cool Earth 50," Japanese Prime Minister Abe Shinzo's initiative to address global warming announced in May, proposed setting a long-term target of cutting global greenhouse gas emissions in half from the current level by 2050. The European Union, meanwhile, has set a target of limiting to less than 2 C the rise in the average temperature of the Earth surface from the days before the Industrial Revolution. As a means of achieving the target, the EU has proposed halving global emissions from the 1990 level by 2050. In this regard, "Cool Earth 50" is identical with the EU initiative, though the former does not set a base year.

The "Cool Earth 50" scheme sounds pleasant, but the problem is that its feasibility is doubtful because the term "global" refers to both industrial and developing countries. We must consider the level of emission reductions that developing countries – aside from economic powers – are to be asked to pursue.

To make the story simple, I limit my argument to carbon dioxide (CO_2), which constitutes the core of greenhouse gases. If the 2004 level of global CO_2 emissions was taken as 100, those by industrial countries accounted for 55 and those by developing countries 45. Yet, while emissions by industrial countries are increasing slowly, those by developing countries are soaring at a phenomenal rate in step with their fast economic development, increasing nearly twice in 14 years since 1990. According to projections by the Institute of Energy Economics, Japan, emissions from Asian developing countries, which form the linchpin of the developing world, will swell to double the current level by 2030. They are expected to further increase – three to four times – by 2050 if left as they are.

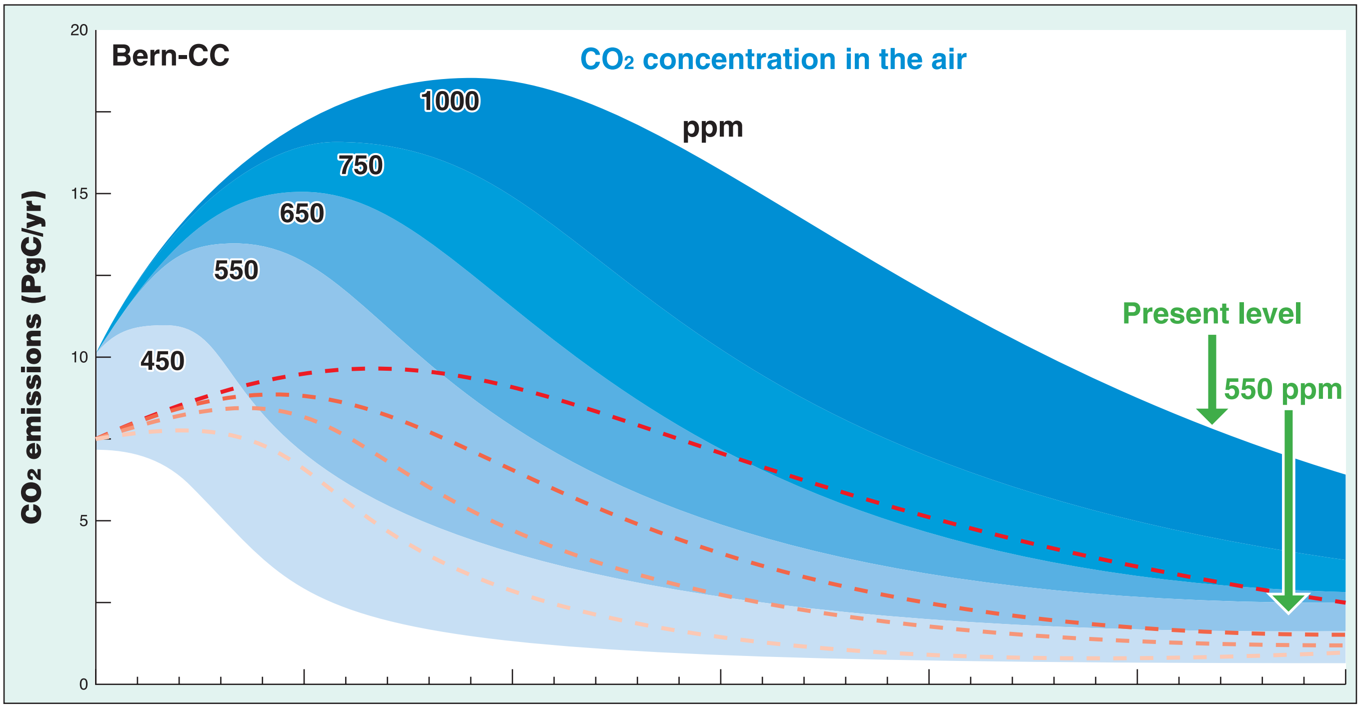
Under "Cool Earth 50," the global total of emissions must be halved by 2050 – from the current level of 100 to 50. If emissions by developing countries, set at 45 under the 2004 standard of 100 as mentioned earlier, are to increase 1.1 times, they will reach almost 50. If they increase three times as projected, they will reach 135, well surpassing 50. Since the difference between 50 and the level of emissions from developing countries is the amount industrial countries are allowed to emit, the target of halving emissions would not be achieved unless developing countries limited their emissions to not more than1.1 times the current amount. And this scenario is based on the assumption that industrial countries could reduce their emissions to zero.

Thus, "Cool Earth 50" can be regarded as a proposal for requesting developing countries to drastically cut CO_2 emissions. But by all accounts, the proposal appears hard to realize. Furthermore, it is unthinkable for industrial countries, for their part, to realize a world of no CO_2 emissions in 40 years' time.

I understand the spirit of "Cool Earth 50" that calls for global efforts to reduce emissions of greenhouse gases. Given such circumstances, I think the emission reduction target should be revised in favor of a more realistic one. My proposal is as follows:

(1) Industrial countries should set a target of halving emissions by 2050.
(2) Developing countries are requested to minimize emissions through energy saving and other means, but are not required to set a specific numerical target for emission reductions.
(3) No time limit will be set on a global target, but, as a long-term target, CO_2 emissions should be reduced until CO_2 emissions and absorptions are balanced.

Chart 1 CO_2 emission for stabilizing its concentration in the air



Source : *IPCC TAR technical summary*

The third point would need further explanation for clarification. As mentioned in Article 2 of the UN Framework Convention on Climate Change, mankind's ultimate goal of addressing global warming is to stabilize the concentration of greenhouse gases in the air at a harmless level. Regardless of the harmless level, it is necessary to reduce greenhouse gas emissions to the level where they are balanced with absorptions. The most important point is above all how to deal with CO_2. At present, almost half of CO_2 emissions are believed to be absorbed on land and in the ocean. But the balance is not achieved even if emissions are cut by half because absorptions decrease when emissions – an environmental load factor – decrease. The balance can supposedly be achieved only when emissions are cut by 70%-90% from the present level.

Chart 1 shows concentration-stabilizing scenarios described in the third report of the Intergovernmental Panel on Climate Change (IPCC) *(‡ Ref.1)*. Each scenario projects substantial reductions in CO_2 emissions in the long run, though ultimate CO_2 concentrations are more or less different.

If CO_2 emissions are to be reduced globally in such a drastic way, we will have to rely on non-fossil fuels for almost all of our energy needs. In other words, the third point means a request for no carbon use in energy supply. But this is a long-term goal requiring a period of time as long as 100 years, let alone 40 years. In order to achieve the goal, humans must start pushing now for long-term technological development toward energy supply without the use of carbon.

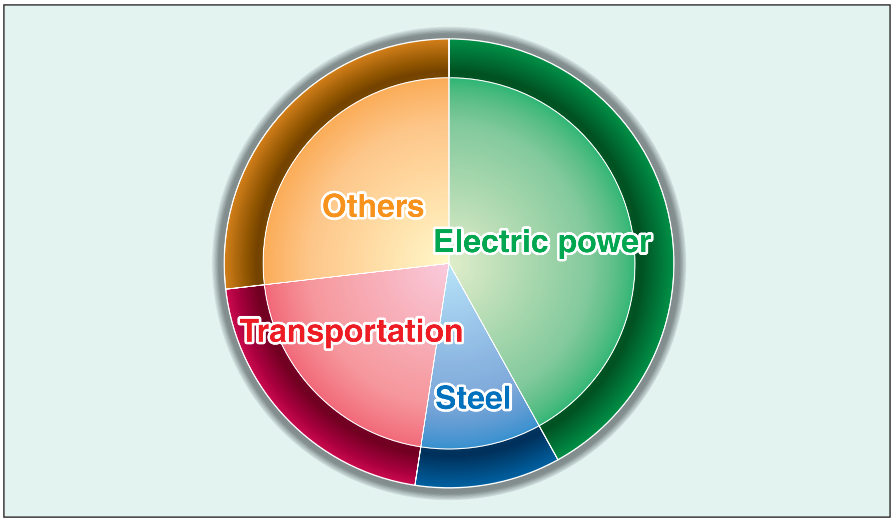
The first and second points of my proposal represent realistic modifications of the goal set by "Cool Earth 50," but the third point goes further, setting a global non-binding target and urging global cooperation in the long-term development of innovative technologies in various forms. I explain below what kinds of technological development are necessary.

2. Technological R&D for Carbonless Energy & Path Japan Should Follow

The third point is not a request easily met because the world today relies on fossil fuels for 80% of primary energy needs. To reduce CO_2 – inevitably emitted from burned fossil fuels – by 70%-90%, the following measures must be taken: (a) strictly limiting energy demand; and (b) drastically reducing fossil fuels as a percentage of energy supply. But the world population is still on the rise and economic development continues, mainly in developing countries. Given these realities, measure (a) alone will not be enough to address the problem and thus realization of measure (b) holds the key. This means nothing but carbonless energy supply.

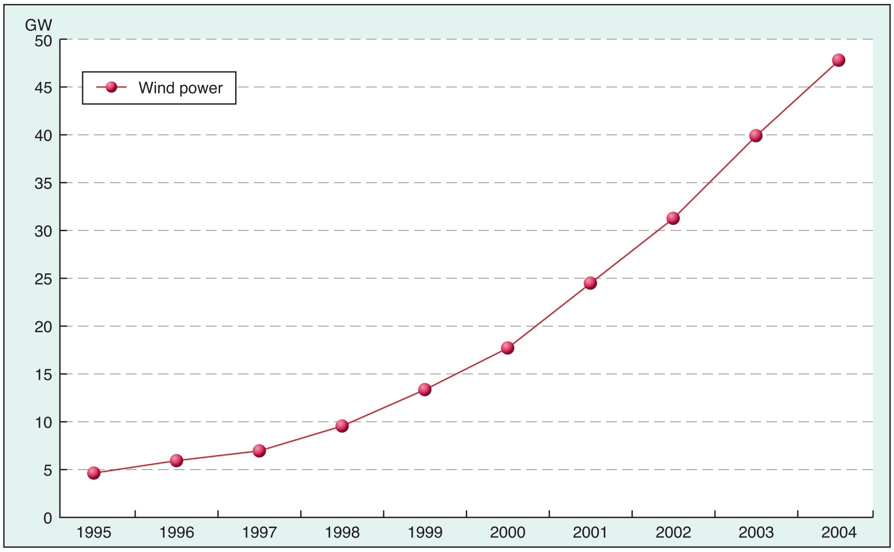
Chart 2 shows the composition of CO_2 emissions in the energy sector of Japan as a reference for specifically considering the measure. As seen from the chart, carbon emissions from the three

Chart 2 CO_2 emissions in Japan (2005)



Source : *Compiled by author from various data*

Chart 3 Total capacity of wind power (world)



Source : *Compiled by author from various data*

sectors of electric power generation, transportation (particularly automobiles) and steel production account for three quarters of total CO_2 emissions in Japan. Fossil fuels consumed in other sectors are mostly oil, 60% for industrial use and 40% for household use. Most of fossil fuels used in households are for thermal energy (air conditioning and heating for hot water) and temperatures involved are less than 100 C. Supply of such thermal energy can mostly be substituted by electricity by use of heat pumps. This means it is possible to reduce CO_2 emissions by more than 80% if the use of carbon is abandoned in electric power generation and in automobile and steel production.

Hereafter I briefly discuss how to stop the use of carbon in each of the power generation, automobile and steel industries and the CO_2 Capture and Storage (CCS) technology commonly used in sectors striving to reduce CO_2 while continuing to use fossil fuels.

1) Carbonless electric power generation

Non-fossil fuels include nuclear energy and renewable energy. Fixed costs are high while variable costs are small in nuclear power generation. From economic viewpoints, therefore, nuclear energy should desirably be used to meet base demand, covering about 50% of total electricity demand at the maximum. But there is still room for expanding the use of nuclear power because nuclear energy accounts for about 16% of total electricity demand in the world now.

Since the 1986 Chernobyl accident, the pace of building new nuclear power stations has remarkably slowed down. Lately, however, the United States and European countries are moving to build new nuclear plants. China is following suit, having unveiled a grandiose project of building nuclear plants capable of generating about 30 GW by 2030. Given limitations to the supply of uranium, it will be necessary to globally spread the recycling of nuclear fuel, though improvement in public acceptance is a precondition. As the issue is related to nuclear nonproliferation policies of countries concerned, further discussions are necessary on the scope of countries to be included in the recycling scheme.

In the renewable energy sector, little potential is left for further development of hydroelectric power in industrial countries, while wind and solar power generation is in the spotlight. As shown in *Chart 3*, wind power has been rising sharply worldwide and already generates 20 GW in Germany, accounting for several percentages of total electric power generation in the country. Germany seeks to meet 30% of its electricity needs with wind power in 2025 while Denmark is more ambitious, intending to cover 50% of its electricity needs with wind power in 2030, according to national plans of these countries.

The problem with wind power generation is that its output varies greatly according to time as weather conditions change. Given that supply and demand must always be the same in electric power systems, wind power requires other power stations capable of changing output according to needs or electric storage facilities such as pumped-up hydropower stations so that output can be stabilized. Since costs of installing such equipment are quite high *(‡ Ref. 2)*, electric power companies in Japan severely restrict the output of wind power generation linked to their respective systems to hold down costs. Under the circumstances, it is considerably difficult to count on wind power for great contribution to electric power as mentioned earlier. Some other measures need to be considered.

In this regard, it will be important in future to develop renewable energy sources capable of generating electricity on a large-scale, stable basis even in remote places. I cite the following two schemes: (a) the Space Solar Power System (SSPS) and (b) transportation to consumer regions of large-scale renewable energy sources produced and liquefied in developing countries. The SSPS is a system under which sunlight is collected in space 36,000 km above the Earth, converted into microwave or laser form and sent to the ground. An example of the latter is a system in Patagonia to generate electricity with wind power, convert it into hydrogen and transport it to consumer areas. Both systems are not economically and technically viable at present. Even so, their development should be promoted in the long run because they have the advantage of generating a great amount of electricity on a large-scale and stable basis.

2) Carbonless fuels for automobiles

Most automobiles currently rely on oil or natural gas for their energy. Non-fossil fuels used by automobiles are ethanol derived from biomass or electric power. Biomass is already used as car fuel in industrial countries, mixed in gasoline. In Brazil, automobiles using only ethanol fuel are already in practical use. Yet production of ethanol is limited because the material of ethanol is biomass currently used mainly as foodstuff such as corn or sugarcane. Lately, the technology of converting cellulose into ethanol is being developed and if this technology takes off, non-food biomass such as plant stalks will be used for this purpose, and thus the use of ethanol could be greatly expanded.

What about electricity? Battery-driven automobiles still take a backseat to oil-fueled automobiles since they are costly, their running distance covered in one battery charge is limited and take a long time in battery recharging. But hybrid cars, already widely used, will be able to have their use of oil drastically reduced if a plug-in recharging function is added for easy recharging at gas stations. In future, fuel-cell cars using hydrogen energy will be also feasible. At present, however, there is no established way of making hydrogen from non-fossil fuels. There are just a few attempts being made in this connection, including one to explore the possibility of using nuclear energy for making hydrogen (decomposing water through thermochemical reaction using heat generated by a high-temperature gas furnace). We must remember, meanwhile, that an extensive hydrogen transportation system is required to supply hydrogen to a large number of automobiles and that it takes time and cost to establish such a system.

As discussed above, there are various possibilities in the future selection of fuel types for automobiles. It is difficult at present to determine which option is most desirable. We must determine the direction of automobile fuel development for the future by examining the various options.

3) Carbonless steel industry

The blast furnace, which forms the base of the steel industry today, entails the use of coking coal, and thus either of the following measures must be taken if the steel industry is to stop using carbon: (1) linking the blast furnace to the CCS mechanism or (2) changing the entire steelmaking process to an iron oxide reduction process using an element other than carbon. As the latter method, reduction by hydrogen made in the process of nuclear power generation is being studied, though it is far from practical use. Accordingly, it will be necessary to study the former method in specific terms while furthering detailed studies on a non-carbon reduction process.

4) CCS

CCS is the technology to collect CO_2 from gases emitted from thermal power stations and steel mills, and inject it underground for sealed storage (in a disused oil / natural gas field or in an aquifer). Collection and storage of CO_2 emitted in the production of natural gas is already under way in the Sleipner field in the North Sea. Various industrial sectors plan to further promote the development of CCS at thermal power stations. The problem with CCS is that its cost is quite high (several thousand yen per ton of CO_2) and it needs storage sites in the vicinity of plants from which CO_2 is emitted. At any rate, global attention is focused on CCS as an option capable of drastically reducing CO_2 emissions while using fossil fuels. Thus further development of the technology is closely watched. For further details, readers are requested to refer to the attached data*(‡ Ref. 3)*.

Conclusion

I have stated above how the world should address global warming in future and what will be the key technologies in this regard. No carbon use, or decarbonization, will be the basic long-term measure to address global warming. It is strongly hoped that related technologies will be further developed. JS

References:

1. IPCC: Climate Change 2001, The Scientific Basis, p.223, Cambridge Univ. Press (2001)
2. Kaya,Y.: Energy and Resources, No.166 (to be published) (in Japanese)
3. IPCC: Carbon Dioxide Capture and Storage, Cambridge Univ. Press (2005)

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