MITIGATION OF GLOBAL WARMING AND THE ROLE OF IDENTIFICATION OF GREENHOUSE GAS SOURCES

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Abstract. Japan Science and Technology Corporation (JST) is an organization supporting R&D of frontier science and technologies under the full sponsorship of the government of Japan. Under the umbrella of JST the author is in charge of a program called "Environment friendly social systems" which includes more than 20 research projects for better environment (with as an average of 1 million US dollars per project per year). One of the projects in this program is on development of isotopomer technology and its use in identifying greenhouse gas (GHG) sources headed by Prof. N.Yoshida. JST earnestly hopes that it can contribute as much as possible to mitigation of global warming through the support of important research projects such as Yoshida's.

1. DIFFICULTIES IN GREENHOUSE GAS (GHG) REDUCTION

Needless to say that global warming is one of the most serious environmental threats mankind has experienced in its history. The framework convention of climate change (FCCC) declares that the ultimate aim of the convention is to stabilize greenhouse gas (GHG) concentration in the air. Taking into account that the concentrations of various GHG's in the air such as CO_2, CH_4 and N_2O increased significantly at least last hundred years probably due to expansion of human activities on the earth, realization of the FCCC's ultimate aim seems not to be an easy task. Particularly anthropogenic emission of CO_2 which occupies more than half of GHG radiative forcing has increased substantially mainly due to increase in fossil fuel consumption which has expanded roughly proportional to expansion of economic activities of the world.

According to IPCC [1] stabilization of CO_2 concentration in the air requires long term continuous efforts for reducing CO_2 emission, as shown in Fig.1. Although it is still uncertain what level of CO_2 concentration in the air is appropriate as the target, 550 ppmv has been very often used in many scenario analyses of global warming. Fig.1 indicates that to realize 550 ppmv target CO_2 emission be limited to the present level by the end of this century and reduced to almost 1/4 of the present level in the long run. What efforts in energy sector are needed to satisfy this requirement?

Many global modellers tried to answer this question, and a typical answer can be found in the analysis conducted in the government of Japan under the name of "New Earth 21" which aims at envisaging long term global scenarios of stabilizing climate change in the long run [2]. Fig. 2 breaks down efforts necessary to limit global CO_2 emission to 550 ppmv by the end of 21st century. The basic criterion of choosing this scenario is the cost: in other words the scenario in Fig. 2 is the least cost scenario of realizing 550 ppmv level of CO2 concentration. If without global warming the world CO_2 emission will be the top line reflecting the world preference on coal as the cheapest and the most abundant fossil fuel source. However, limiting CO_2 concentration to 550 ppmv requires introduction of a lot of measures reducing CO_2 emission.

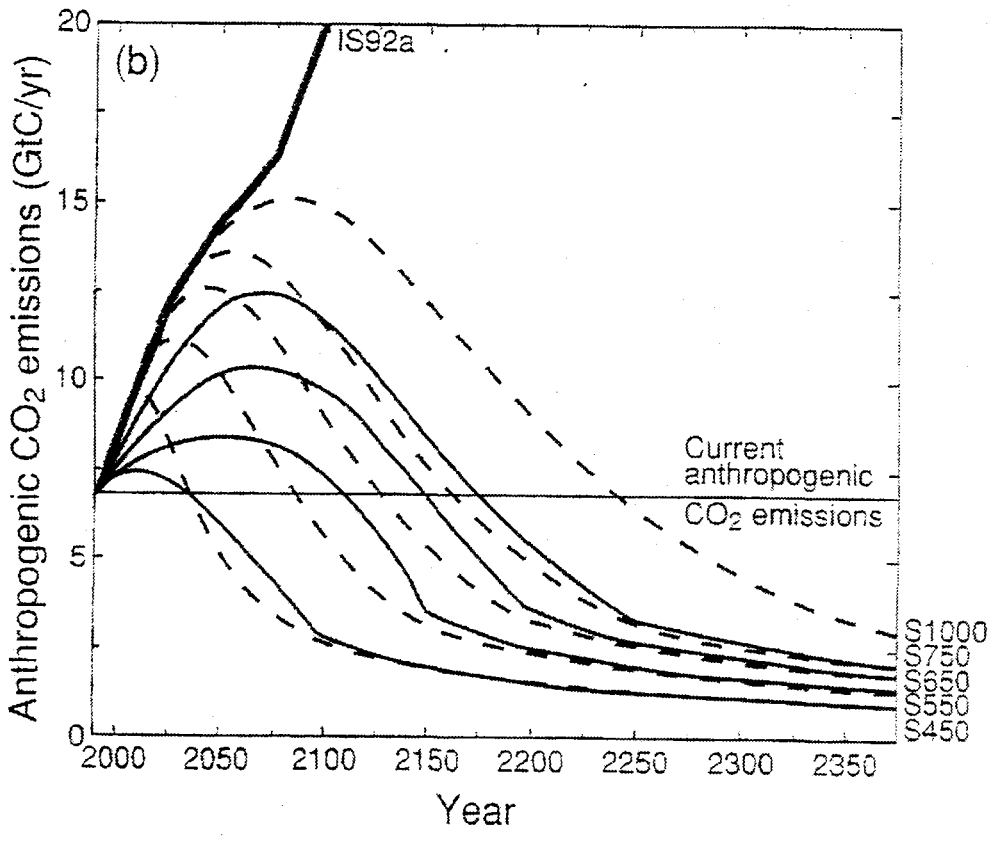

FIG. 1. CO_2 emissions leading to stabilization at concentrations in the air.

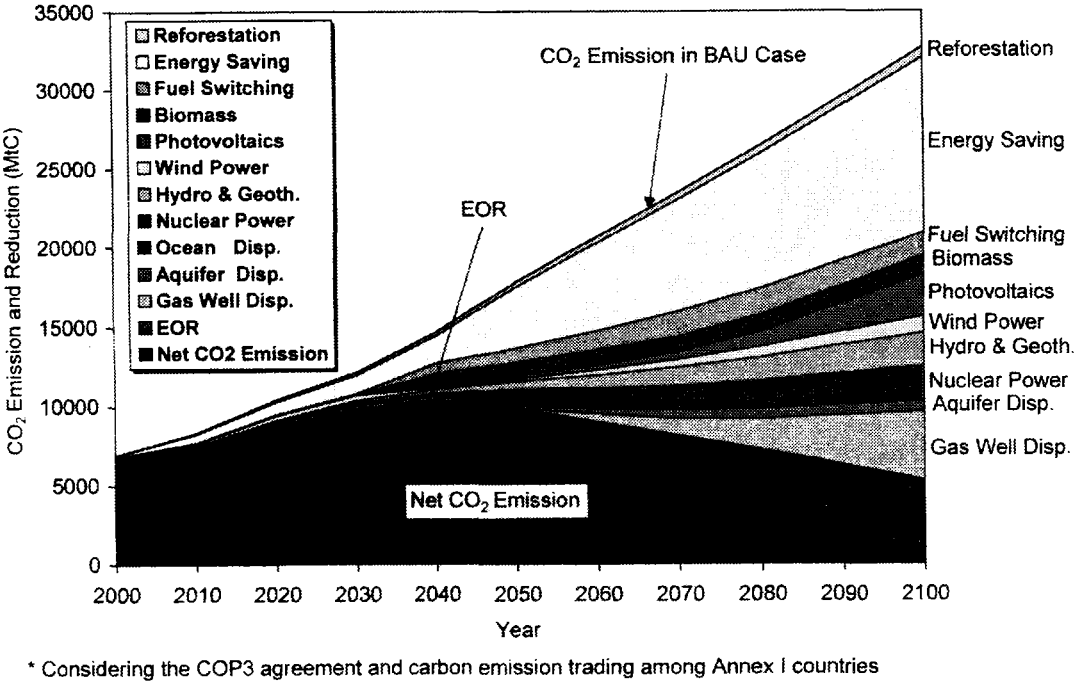

FIG. 2. CO_2 emission reduction effects of technological options under a 550 ppmv limit.

Not only substitution of coal by natural gas and other less carbon dependent fossil fuels than coal, but also various new measures such as introduction of renewable energy as photovoltaics, wind power and biomass and of CO_2 removal and disposal should be expanded. Nevertheless these measures are still in their infancy and vast, extraordinary efforts are called for to satisfy the above requirements well in time.

When we look at short term future envisaged by the Kyoto protocol, the situation may be more serious despite that it aims only at reducing GHG's to a certain degree as the first step toward the realization of the ultimate target of stabilizing GHG concentrations in air. Let us take the case of Japan as an example. The government of Japan agreed in Kyoto to reduce GHG emission by 6 % by around 2010 when compared to the level in 1990. According to the government plans GHG emission should be stabilized by efforts of energy conservation and fuel switching, and furthermore be reduced by 6 % by other efforts such as utilization of emission trading. However we also foresee a number of difficulties in putting these measures into effects. To realize this let us look at recent macroscopic figures of economy and energy in Japan . We see that about 95% of radiative forcing of GHG's from Japan comes from CO_2. So focussing our attention only on CO_2, the author introduces a simple analytical tool, i.e. disaggregation of CO_2 emission in the folowing factors [3].

$$CO_2 = (CO_2/ \text{Energy})(\text{Energy} / \text{GDP}) \text{GDP} \qquad (1)$$

where CO_2/Energy (or C/E) is the carbon intensity of primary energy, Energy/GDP (or E/G) is the energy intensity and GDP is the gross domestic product.

Table I Rates of Change of 3 factors(%/year)

	Carbon intensity C/E	Energy Intensity E/G	Gross Domestic Product GDP	CO2 eimission
1980-89	- 0.7	- 1.8	+ 3.5	+ 0.7
1990-99	- 0.6	+ 0.4	+ 1.1	+ 0.9
2000-2010 (scenario)	- 0.6	- 2.2	+ 2.0	- 0.8
20^{th} century, world average	- 0.3	- 0.9	+ 3.0	+ 1.8

Equation (1) means that the average rate of change of CO_2 emission is simply a sum of those of three factors, i.e. C/E, E/G and GDP. Table I exhibits recent trends of these figures together with those for the government plan for next 10 years. It is seen that we are required to reverse the trends of energy conservation of last ten years and also to keep the level of fuel switching despite of worsening public acceptance of nuclear power.

2. IMPORTANCE OF IDENTIFYING GHG SOURCES AND THE ROLE OF JST

In the previous section the author has stressed how difficult it is to reduce GHG's. Nevertheless, possible serious outcomes of global warming such as sea level rise compels us to doing all kinds of efforts for mitigating global warming. We should also notice the

importance of scientific efforts to reduce uncertainties about GHG emission and sink sources and also their quantities.

In case of CO_2 its anthropogenic emission sources are mainly in energy and industry sectors and the total amount of its emission can be evaluated from economic and industrial statistics of fossil fuel consumption. However we have only limited knowledge about CO_2 absorption by geosphere and ocean: the word "missing sink" symbolizes this situation.

More uncertain are emissions and absorptions of other GHG's such as CH_4 and N_2O. Unlike CO_2 any data of anthropogenic emissions of these gases are not available in ordinary statistics.CH_4 emission sources include natural gas fields, gas pipelines, rice fields, landfills and cows and N_2O comes from agriculture, industry and energy consumption. There are estimates of these emissions but with much lower accuracy than that those of CO_2. At non CO_2 GHG session of GHGT-5 held in Cairns, Australia in August 2000 a question raised from the floor to the authors of the session about the accuracy of their estimates of emissions, and the reply indicated the accuracy of estimates of CH_4 and N_2O to be around 50-100 %.

Taking into account that not only CO_2 but also CH_4 and N_2O are "official" GHG's registered in Kyoto protocol we are required to make efforts for identifying emissions of these gases with as high accuracy as possible. The first step to do this is to identify where these gases come from and then how much they are. The author is convinced that the technology of isotopes and isotopomers helps very much this process and appreciates in this sense the efforts by NOAA CMDL GHG group to expand global networks of measuring GHG's.

REFERENCES

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