Energy and Environment

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Abstract

The G8 leaders agreed to set a common long-term goal of 50% reduction in the global emission of greenhouse gas by 2050 to prevent global warming. As carbon dioxide caused by human economic activities, especially by the fossil fuel consumption, is at present the major cause for the greenhouse effect. To achieve this reduction the developed countries should make efforts to convert energy from fossil fuel to other energy sources (such as renewable energy, nuclear energy) and the developing countries should pursue economic growth with environmental attention not to increase CO2 emission. Also, in providing support for developing countries, developed countries should include consideration to provide not only advanced technologies to achieve economic growth and improvement of living standards but also appropriate technologies that allow these countries to manage and control CO2 emission on their own.

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1. Introduction

Civilization and energy are closely related. Ever since mankind first learned to use fire several million years ago, use of energy has made human living richer. The energy we use now includes that energy that we need for maintaining our lives as living creatures, and that energy that we need to make our living easier or more comfortable. The first early man that lived several million years ago consumed approximately 8.6MJ (about 2,000 kcal) per day. Then, before the industrial revolution, mankind began to use watermills and windmills, and the daily consumption expanded to approximately 150MJ. After the industrial revolution, fossil fuel such as coal and oil were used and the consumption increased dramatically to reach 966MJ in the late 20^{th} century. Now the modern man uses one hundred times more energy than the early man. It is believed that a daily energy consumption of a mammal is proportional to the 0.75^{th} power of its weight. This rule tells us that an elephant, which weighs about eighty times more than men, needs thirty times greater energy to live than humans; and one hundred times greater energy equals to a volume of energy that a 23-ton monster needs for maintaining its life: we are consuming a huge amount of energy.

Since the industrial revolution, thanks to the technical experts and engineers, human life has become easier and more comfortable in all aspects of food, shelter and clothing. This was made possible to a certain extent by the manufacturing of chemical substances (chemical fiber, insulation, building materials, or pharmaceuticals) and the use of fossil fuel (greenhouse cultivation, import of foods, and transportation). However, the global environmental issues, which are the results of human activity directed towards the enrichment of living, have recently been drawing wide attention. The global environmental issues include global warming, acid rain, the destruction of ozone layer, desertification, and the destruction of the ecosystem. These are problems whose wrongdoers cannot be pinpointed as one individual or one firm, and whose victims are great in number spreading over the international borders. The countermeasures must also cross over the borders. Fig. 1 shows how the global environmental issues, the production and the use of chemical substances and the burning of the fossil fuel are related. The production of chemical substances and the use of fossil fuel both lead to global warming, and the acid rain causes desertification through deforestation: these environmental issues are mutually related.

2. Energy consumption and global warming

The Fourth Assessment Report issued by IPCC last December documented that observations lead to the conclusion that global warming is largely attributed to the increase of greenhouse gases caused by human economic activities and that global warming may

affect not only natural environment but also human health and life. Based on this report discussions on global warming and countermeasures were held at the G8 Hokkaido Toyako Summit in July 2008 and the leaders agreed to set a common long-term goal of 50% reduction in the global emission of greenhouse gas by 2050. Greenhouse gas contains carbon dioxide produced by burning fossil fuel as shown in Fig.1 and also chlorofluorocarbon produced by manufacture and use of chemical substance. As carbon dioxide is at present the major cause for the greenhouse effect and there is a continued increase, the reduction of carbon dioxide is a paramount goal.

As an example of the energy consumption in developed countries, I will explain the situation in Japan. The breakdown of the primary energy in 2006 is: oil 44.1%, coal 21.2%, natural gas 16.5%, nuclear power 11.7%, hydraulic power 3.4%, and new energy 3.1%, the sum of fossil fuel covering 81.8% of the total. Primary energy is energy resource such as oil, coal, natural gas, hydraulic power, or nuclear power. It is converted to energy (secondary energy) such as petroleum, gas or electricity that is more convenient for the consumer. The difference in primary and final energy consumption indicates the loss in energy conversion. The energy conversion loss in 2006 is as high as 33%. In Japan, about 40% of the primary energy is used for electric power generation but with only 40% efficiency and 60% loss. Although the rate of increase in Japanese GDP between 1900 and 2006 is 1.13, the transition in final energy consumption in various sectors during the same period is 1.0 for the industrial, 1.4 for the civil, and 1.2 for the transportation sectors. The data signifies that, to take effective global warming prevention measures, efforts must be made to suppress the rate of increase in civil sectors including household and commercial consumption.

3. Renewable Energy

Renewable energy sources such as hydraulic power, solar heat, solar light, wind power, ocean power and geothermal heat will not deplete, and are environmentally clean. Its wider use is expected as an alternative energy of fossil fuel. Table 1 shows the amount of CO2 emission in the cases of fossil fuel generation and renewable energy generation, including the manufacturing of the facilities, maintenance and operation, burning and methane leakage. The figures are drawn from the result of all CO2 emission divided by the generated electrical power during the plant's operating life duration of thirty (30) years. As the CO2 emission can be considered to be directly proportional to the influence it gives to the warming, the hydraulic power generation has the smallest influence on the warming, followed by nuclear, geothermal, wind power, solar light, and steam-power generation. Electric power generation using renewable energy emits less than one tenth the CO2 compared to steam-power generation, but it has problems such as: the amount of electric power generated by wind power or solar light depends on the condition of weather; a larger plant site area per generated electrical power unit is needed; the cost is higher.

4. Energy conservation

The energy consumption in the industrial sector is not increasing because energy

conservation is being practiced widely. Energy-saving is promoted in consumer products and transportation as seen in the development of energy saving consumer electrical appliances and hybrid cars. However, further development in the conservation is necessary. While these energy conservation technologies work at the final consumer stage, progress is seen in the technology that works at the shifting from primary energy to secondary energy. Fig. 2 shows the conceptual explanatory image of cogeneration. In the steam power generation, electricity is generated by the turbine that is driven by high-temperature gas (combustion gas or steam). Here, most of the heat energy in the turbine's exhaust gas is wasted. In cogeneration, just like the hydro power generation locates a few power plants along a river in cascade style so that discharged water from one plant can be reused in the next plant, the heat energy in the exhaust gas from a turbine is used to rotate the next turbine, or in the heating or hot water supply in the local community. Thus reducing the total consumption of the primary energy.

Water pressure at the outlet of the household water supply is kept between 2 and 5 bar, so every 1 kg of water has energy of 200 to 500 J. This energy is generally wasted in the use of cooking, washing or in the toilet. To save such energy, a system is being devised where water for the toilet is supplied after it is used to open and close the doors. This is one of the examples that we engineers can find more possible energy-saving ideas in our daily life. We should make more efforts here.

5. Disparity in energy consumption

The Fifteenth Conference of Parties (COP15) was convened in December 2009 in Copenhagen. It is still fresh in our minds that it ended without any clear path to bridge the gap between the opinions of the developed and developing countries on global warming prevention measures. Fig. 3 shows the oil conversion of national and per capita CO_2 emission of countries in the world. This figure clearly demonstrates the disparity between the CO_2 emission, which is proportional to energy consumption, of the developed and developing countries. At the G8 Hokkaido Toyako Summit, it was agreed that the CO_2 emission must be reduced to 50% by 2050. The current CO_2 emission is 7.2 billion t-C and assuming the world population to reach 9.2 billion in 2050 (according to UN demographic statistics) the allowable emission per capita would be 0.4 t-C (1.47 t of CO_2 per capita). To achieve this reduction of carbon emission, as mentioned above, the developed countries should make efforts to convert energy from fossil fuel to other energy sources (such as renewable energy, nuclear energy) and the developing countries, especially China and Brazil, should pursue economic growth with environmental attention not to increase CO_2 emission. Also, in providing support for developing countries such as Bangladesh and African countries with less than 0.1% CO_2 emission, developed countries should include consideration to provide not only advanced technologies to achieve economic growth and improvement of living standards but also appropriate technologies that allow these countries to manage and control CO_2 emission on their own.

One example of such technologies is the solar cooker covered with aluminum foils or metal

sheets to collect sunlight during the day and give off high temperature heat for cooking (cf. Fig.4) In African countries where social infrastructure is not well developed, the solar cooker will save several hours of daily labor of women and children to collect firewood that could be used for other chores or even for education and at the same time prevent desertification by the cutting down of trees. Similar technologies include hydraulic ram pumps that can send water several tens of meters high by converting the kinetic energy of river water falling a few meters into elastic energy. The system works by a quite simple mechanism and all it needs is some piping material and it can be constructed by the local people. Also an apparatus for distillation of water (cf. Fig. 5) has been devised using solar heat and this saves several hours spent on fetching water which can instead be used for education. Different approaches must be taken in supporting the developing countries to raise their standard of living while not stepping in our footsteps.

6. Conclusion

In order to reduce the global greenhouse gas emissions 50% by the end of 2050, it is mandatory that we reduce the fossil fuel consumption and carefully consider about alternative energy sources.

Nuclear energy is a stable energy source, but it needs to be discussed seriously how to dispose of the nuclear waste and allow time to gain public understanding. Solar energy is a promising renewable energy that can be generated by the massive amount of sunlight collected on the existing solar energy panels spread across the Gobi Desert to satisfy the need for the entire world. The potential is high, but problems of cost and maintaining a stable supply must be solved. Japan is a volcanic country and geothermal power production is very likely to be abundant, but the development has not expanded in the recent years due to problems of the National Parks regulations and the possibility of depletion of hot spring baths.

Economic growth, stable supply of energy and environment preservation are shown in Fig. 6, forming a trilemma and indicating that the issue is by no means simple. However, Goa also says that it is a gross misunderstanding to think that “there is nothing we can do any more about global warming. It is simply too late”. There are many things to be done and they must be tackled one by one.

Table 1

Comparison of CO2 emissions by each power generation system（unit：ｇ-C/kWh）

Power generating system	Establishment of facility	Operation and maintenance	Combustion	Methane leakage	Total
Coal-fired thermal power	1.09	9.78	246.33	12.69	269.89
Oil-fired thermal power	0.62	7.21	188.41	3.10	220.06
LNG thermal power	0.55	24.10	137.27	16.05	177.67
Nuclear power generation	1.00	4.46		0.24	5.70
Hydraulic power generation	4.63	0.07		0.11	4.81
Geothermal power generation	1.39	4.63		0.27	6.29
Wind-power generation	6.73	2.41		0.37	9.51
Solar energy generation (household)	11.91	3.57		0.53	16.01
Solar energy generation (ground)	26.24	6.82		1.25	34.31

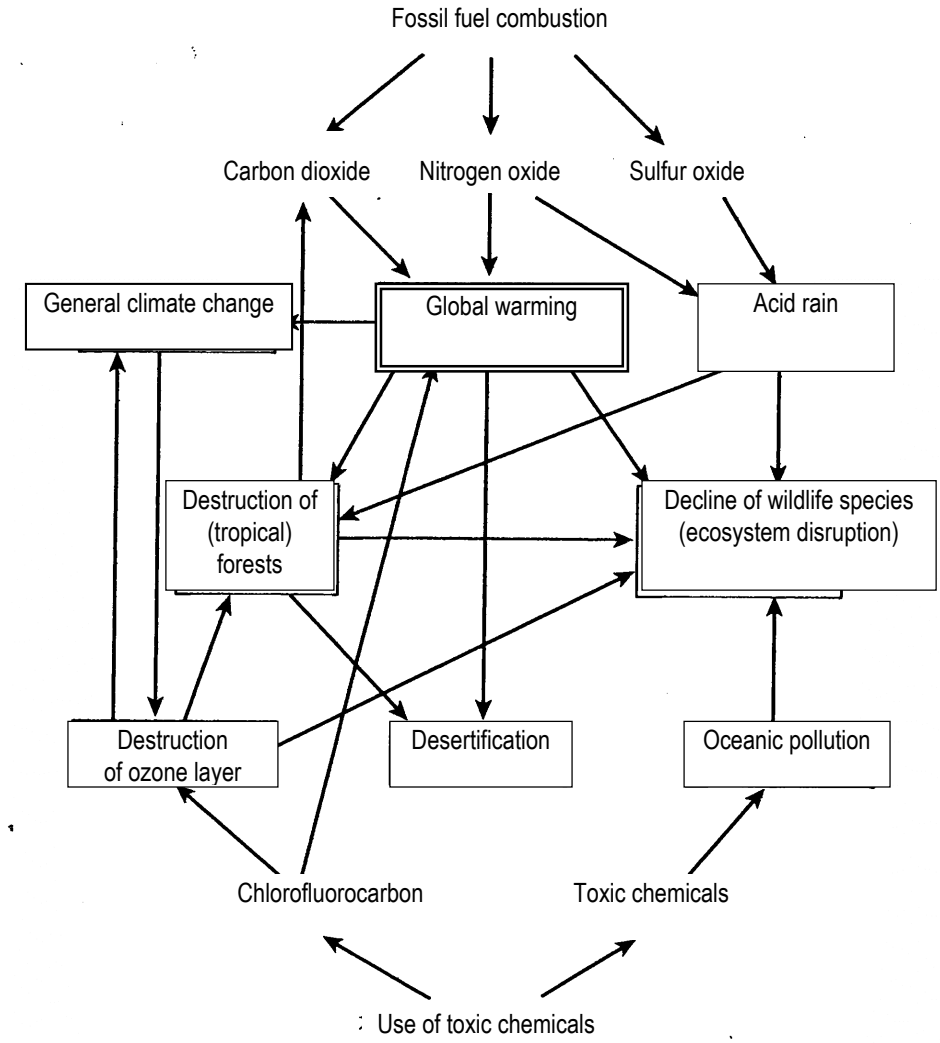


Fig. 1 Interrelation of global environmental issues

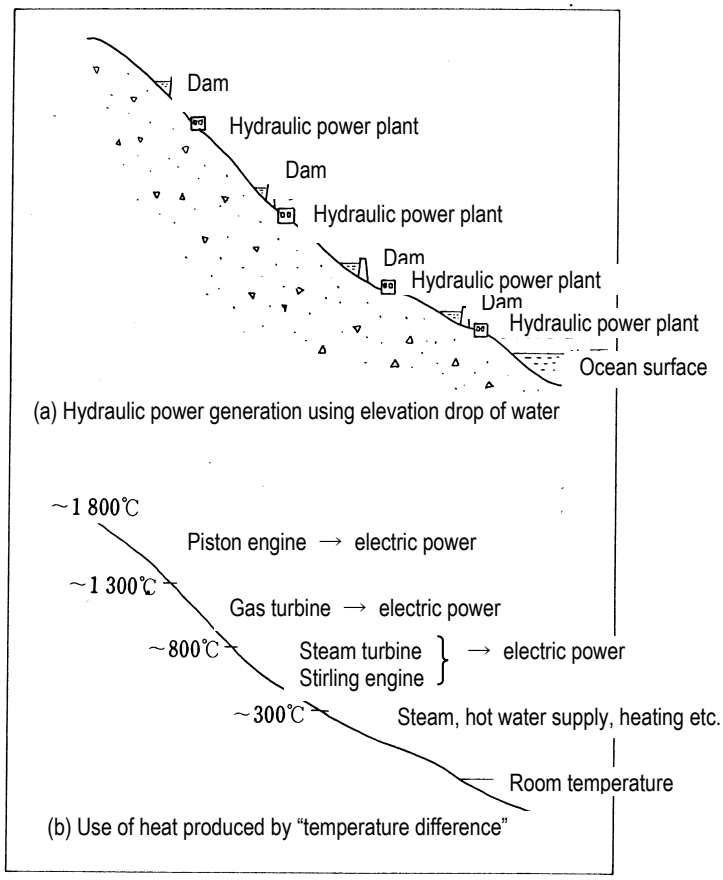


Fig. 2 Concept of co-generation (elevation drop and temperature difference)

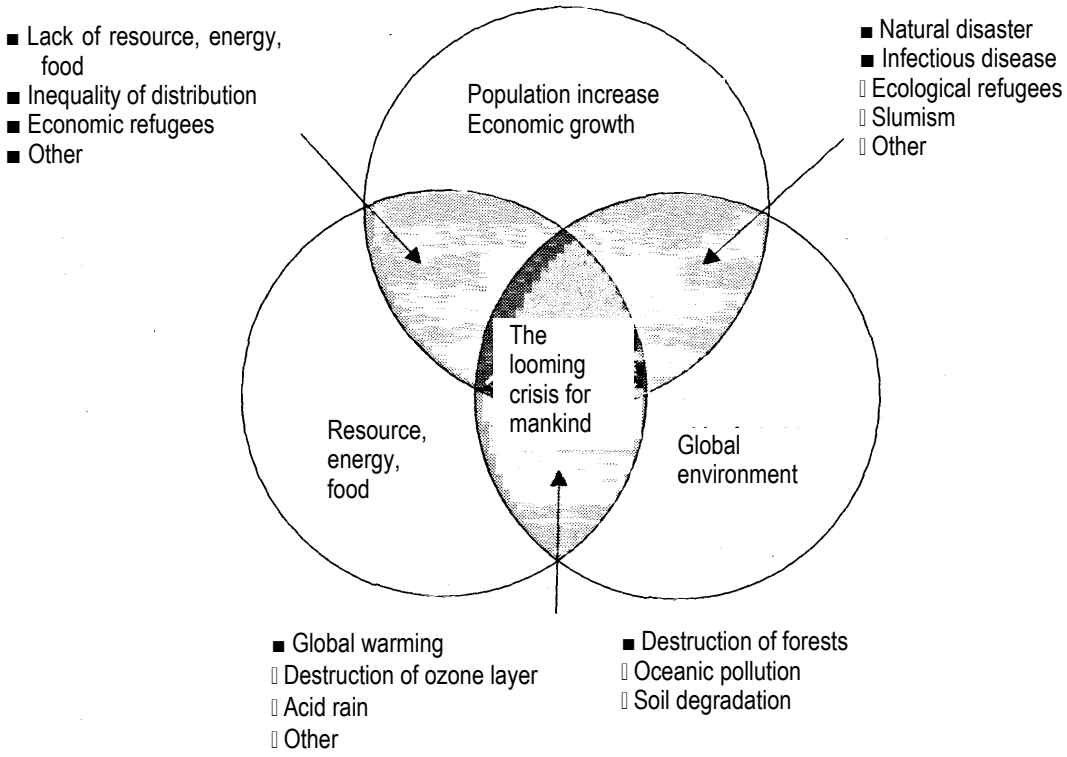
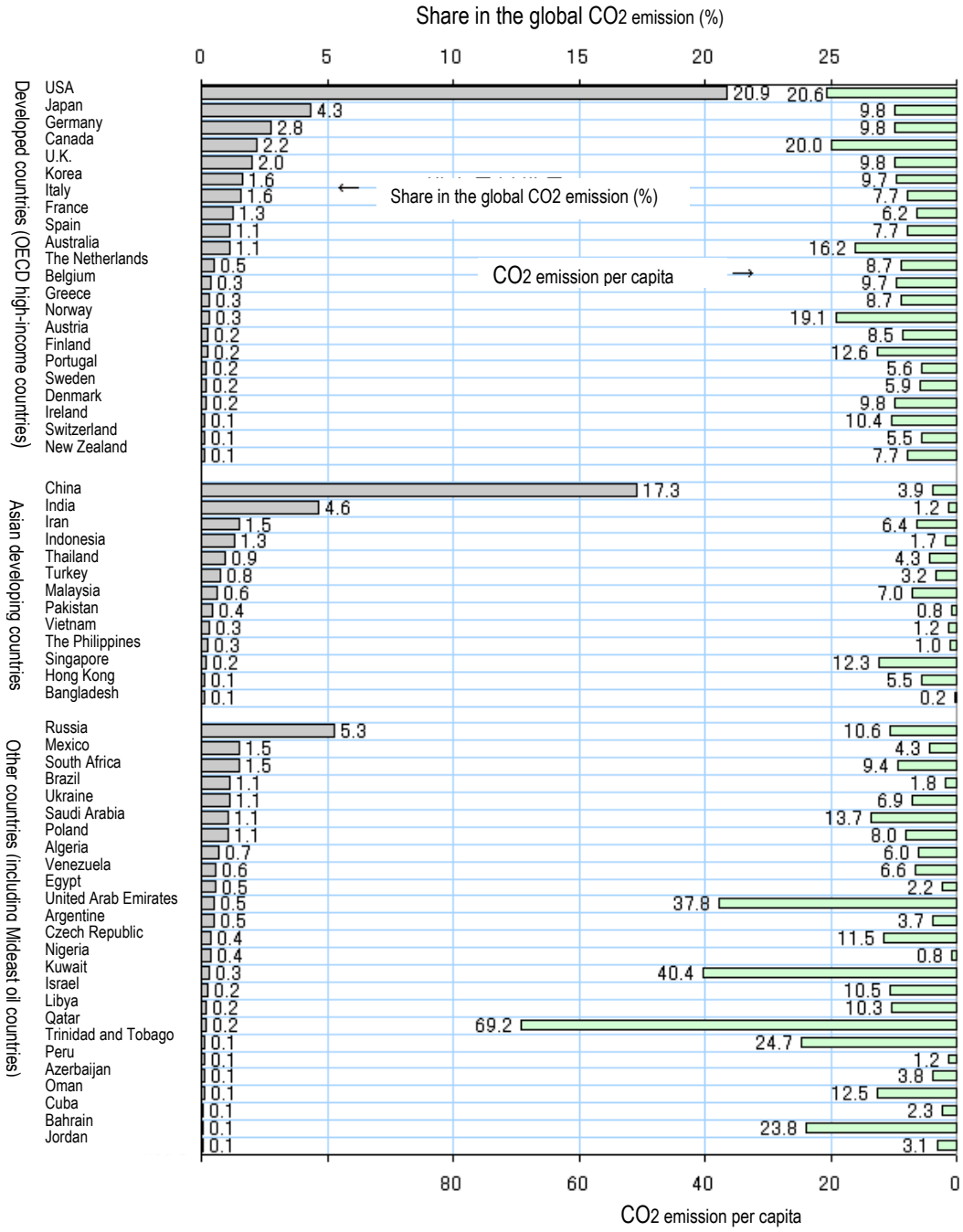


Fig. 6 Trilemma

CO_2 emissions of various countries (2004)



(Data) World Bank, WDI Online 2008.4.17

Fig. 3 CO_2 emissions

Fig. 4 Solar cooker

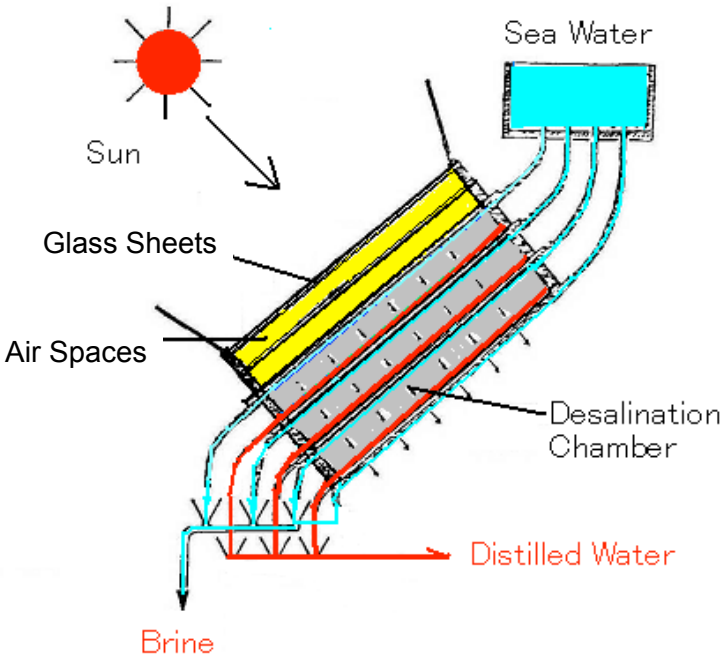


Fig. 5 Solar still (desalination apparatus using solar heat)