Report

Energy and Global Warming
－Equitable Allocation of Efforts for Sustainable Society－

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Science Council of Japan

Committee on Energy and Global Warming

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Summary

1. Background

- Most countries share the view that global warming is a common challenge to humanity and requires immediate actions. This issue has been discussed at the G8 Summit from various perspectives.

- The G8 Summit will be convened in Japan in 2008. The commitment period under the Kyoto Protocol to the United Nations Framework Convention on Climate Change will start in the same year. Thus, the year 2008 is expected to be a symbolic year for energy and global warming issues.

- This report summarizes energy and environmental issues to be focused on global warming and presents comprehensive recommendations based on the evidence accumulated in a variety of academic fields. We hope that the recommendations will contribute to the preparation of a joint statement for the G8 summit in Japan by science academies in participating countries.

2. Current status and problems

- “Sustainability” is an essential keyword for the 21st century. In 2002, the World Summit on Sustainable Development (WSSD) adopted five main areas to be addressed on a global basis: Water, Energy, Health, Agriculture, and Biodiversity and Ecosystem Management (WEHAB). Energy is regarded to be one of the most critical themes for the achievement of sustainable society.

- Global energy consumption has nearly doubled during the past 30 years and is projected to keep increasing. This trend is significant in developing countries and effective measures are necessary to reduce energy consumption while maintaining economic growth.

- Energy issues consist of a variety of aspects such as global warming, energy security, economic growth. It is therefore essential to understand and deal with these problems in a comprehensive manner.

3. Recommendations

(1) Continuous commitment with a long term perspective

- Energy and global warming issues cannot be solved in a brief space of time. Given our existing evidence and discussions carried up to this point, there still exist various uncertainties. Under these circumstances, the industry, the government, and the academia are urged to play their respective roles continuously. Scientists are requested to acquire more academic evidence, while the private sector is required to reinforce its effort to put such knowledge into practical use. The government should take initiative in promoting strategic research and development.

- Since energy and global warming issues are so significant and urgent, national governments are urged to allocate a greater portion of their budget to cope with these issues. In addition, promotion of research and development in accordance with the long-term strategy against global warming shall be pursued, and appropriate budget allocation shall be made based on the progress of the development of countermeasures. At the same time, such the budget allocation should be implemented through international coordination on an interdisciplinary basis.

- Energy and global warming issues include a wide range of aspects such as natural science, social science, and human science. It is important to create an interdisciplinary field of science. Continuous effort is also desired to improve intellectual infrastructures, including human resource development, education, and publicity, as well as statistical and global monitoring systems.

(2) Innovation (technological and social innovation)

- To cope with energy and global warming issues, two tasks are required: continuous development of individual technologies and integration of such technologies. In this respect, the government and the private sector should collaborate in a long-term perspective to promote technological development.

- Technological development should be managed in a flexible manner to reflect regional differences and temporal changes of social needs. For instance, technologies shall be selected for each country corresponding to its characteristics and social changes. The worldwide introduction of a uniform system or technology can rather turn out to be inefficient.

- In addition to technological innovation, social innovation is inevitable for solution of energy and global warming issues. Environmental harmony must be taken into consideration in development of social infrastructures. Also, educational and publicity activities should be encouraged to review and reform countries' lifestyle, including selection of products, services and social infrastructures, through improved communication with consumers.

(3) Equitable allocation of efforts

- Energy and global warming issues involve all countries, therefore global cooperation is necessary. An international consensus should be established to build a global cost-effective framework, under which efforts shall be allocated in an equitable manner among countries and generations. At the same time, understanding of the concept of "equitability" must be clarified.

- To ensure an equitable framework, it is essential to improve basic data, including energy statistics, and establish reliable indicators for efficiency and other parameters.

- Developing countries are expected to consume more energy in accordance with their economic growth and improvement of living standards. Developed countries are encouraged to transfer their technologies to developing countries in order to help them "leapfrog" to modern energy technologies in a more efficient manner and take advantage of such technologies in ensuring both economic growth and energy efficiency.

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Foreword

Most countries share the view that global warming is a common challenge to humanity and requires immediate actions. In this respect, energy issues are particularly important not only because they are closely associated with global warming but also because of the alarming increase in energy demand. In recent years, the G8 Summit has been addressing these issues from various perspectives. A consensus was reached among countries on several points concerning issues of energy and climate change. It is notable that the joint statements issued prior to these summits by science academies in many countries, including the Science Council of Japan, have played a vital role in achieving the consensus[1][2].

The G8 Summit will be convened in Japan in 2008. In the same year, the 1st commitment period (2008-2012) will start under the Kyoto Protocol to the United Nations Framework Convention on Climate Change, which went into force in February 2005. Discussion on post-Kyoto Protocol should be intensified. In addition, a joint declaration was adopted at the 2006 G8 Summit in St. Petersburg on further deliberation under the Plan of Action for Climate Change, Clean Energy and Sustainable Development, whose results will be reported at the 2008 Summit in Japan. Energy and environmental issues are certain to be placed as one of the main agenda of the 2008 summit.

Under these circumstances, to make comprehensive recommendations based on the knowledge of various academic fields and to contribute to the joint statement of science academies for the G8 summit in 2008, the Science Council of Japan has summarized energy and environmental challenges for the coming 30 or more years, including global warming issues, which have been made clear by experts in a variety of research fields.

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[1] “Joint Science Academies’ Statement: Global Response to Climate Change,” June 8, 2005, Science Council of Japan homepage.
http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-19-s1027.pdf (English)

[2] “Joint Science Academies’ Statement: Energy Sustainability and Security,” June 14, 2006, Science Council of Japan homepage.
http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-20-s1.pdf (English)

1. Scientific background to energy and global warming issues

“ Sustainability” is an essential keyword for the 21st century. In 2002, the Johannesburg World Summit on Sustainable Development (WSSD) adopted five main areas to be addressed on a global basis: Water, Energy, Health, Agriculture, and Biodiversity and Ecosystem Management (WEHAB). Energy and global warming are critical themes to be tackled in order to achieve a sustainable society.

During the last 30 years, global energy consumption has nearly doubled and is expected to continue increasing. International Energy Agency (IEA) predicts that, in the base scenario, the world’s primary energy consumption in 2030 will be 1.5 times more compared to that in 2005. By region, non-OECD countries, mostly developing countries, will show the largest increase. On a per-capita basis, people in developing countries now consume much less than those in developed countries. As a sharp rise in energy consumption is anticipated in line with economic growth of developing countries, the establishment of effective measures is indispensable in order to achieve both economic growth and reduced energy consumption.

Fossil fuel is being consumed at a tremendous speed and is today’s main cause for global warming. At the G8 Summit in July 2005 at Gleneagles Hotel, Perthshire, Scotland, the leaders reached a consensus– that climate change is happening now, human activity is contributing to it, and it could affect every part of the globe. In the meantime, the scientific understanding of climate change is developing consistently and the Intergovernmental Panel on Climate Change (IPCC) released its fourth assessment report (February 2007, Working Group I). The report concluded global temperatures are rising and that global warming is brought about by the man-caused increase in greenhouse gases in the atmosphere. According to the same report, global surface temperatures have risen about $0.74^{O}C$ during the last 100 years, and over the coming 20 years they will increase about $0.2^{O}C$ each decade. Global warming may adversely affect water resources, ecosystems, costal areas, industrial activities, human health, and other factors. If the temperatures soar by over $3^{O}C$, scientists point out, irreversible huge impacts may be brought about because the general circulation of the ocean might cease and the Arctic and Antarctic ice sheets might crumble. However, climate change predictions are subject to uncertainties due to assumptions in future scenarios and lack of clear understanding of the climate system. The 4th IPCC assessment report provides rough temperature rises for the 2000-2100 period, varying between $1.1^{O}C$ and $6.4^{O}C$ (individual scenarios include more accurate figures due to improved prediction models and new academic evidences). Researchers are divided in their views of the stabilization target level of concentration of greenhouse gas in the atmosphere. Deeper scientific understanding is crucial to reduce these uncertainties.

Global energy demand is exploding, especially in Asia. There are growing concerns over the long-term potential depletion of energy sources, such as the “peak oil” threat claimed by some experts. At the same time, there are globally growing political tensions. Under these circumstances, many countries are beginning to realize the significance of energy security as a national-level challenge. At the G8 Summit in St. Petersburg, the leaders proclaimed: “Therefore, ensuring sufficient, reliable and environmentally responsible supplies of energy at prices reflecting market fundamentals is a challenge for our communities and for mankind as a whole.”

Energy issues consist of various aspects, including global warming, energy security, and economic growth. Thus, the solution of energy and global warming problems requires multiple strategies and actions. It is important therefore to understand these issues from a comprehensive perspective and combat global warming, while endeavoring to maintain economic growth and enhance convenience and comfort for the lives of people.

2. Three recommendations for equitable effort to build a sustainable society

(1) Continuous commitment from a long-term perspective

Energy and global warming issues require solutions from diverse fields and long-term technological development, and there can be no simple and instant solution to the problems. Given our evidence accumulated and discussions carried out to date, there still remain uncertainties. In this aspect, the industry, the academia, and the government are required to play their respective roles through a continuous coordination. Scientists should put forth their best endeavors to accumulate relevant academic evidence. The private sector should reinforce their R&D and commercialization efforts. On the other hand, the government should support the efforts of the private sector, as well as taking initiative in ensuring continuous basic and technological studies with respect to problems involving high risks.

One of the important roles of the government is budgeting for R&D and the implementation of countermeasures to energy and global warming issues. The energy budgets in OECD countries have remained almost unchanged during the last decade. Considering the significance and urgency of the problems, a greater portion of the national budgets should be allocated for energy and global warming issues. In addition, appropriate budget allocations should be made based on a mid- and long-term strategy against global warming and progress of the development of countermeasures. Such budget allocations should be implemented under international cooperation in an integrated and interdisciplinary manner.

Energy and global warming issues concern a large number of fields such as natural science, social science, and human science. It is urgent therefore that a special interdisciplinary academic field and system should be established and human resource development and education should be enforced. The new academic field such as “science of energy” should integrate academic fields of natural science, social science, and human science to concentrate on energy and global warming issues. Although the Science Council of Japan have already presented a recommendation on this issue, international coordination is not sufficient for the development of dedicated study and human resource development on energy and global warming. In this respect, it is necessary to promote research and human resource development under collaboration between international academia and industries. It is suggested, for instance, that in the Asian region, a forum should be set up to carry out discussion on the whole range of energy and global warming issues, including individual themes such as biomass and nuclear power, with the

participation of scientists, policymakers, and other experts.

Further, in order to carry out appropriate analysis of the present status of problems from a long-term perspective and establish technologies and policies necessary to combat these challenges, it is indispensable to improve basic intellectual infrastructure, such as an internationally orchestrated accurate statistical database and a monitoring system. For example, energy consumption figures are provided by OECD members in “Energy Balance of OECD Countries” compiled by IEA. On the other hand, few data of developing countries are collected on a periodic basis. In this regard, industry -academia-government coordination is necessary to build an international framework for an energy and global warming data system. Under this system, standardized statistical basics shall be established, including definitions, conversion formulas, and scopes. IPCC has been engaged actively in collection and evaluation of data and evidences regarding phenomena, impacts, and countermeasures associated with global warming. This framework should be reinforced and the monitoring system should be strengthened through international cooperation for better understanding of global warming phenomena and their impacts.

(2) Innovation (technological and social innovation)

In order to find solutions to energy and global warming problems, technological innovation is essential in continuous development and integration of individual technologies, as well as in construction of a framework for utilizing such technologies. To realize such innovation, the industry, the government, and the academia should collaborate to strengthen continuous basic research and technological development. Through development and integration of individual technologies, a new paradigm for a sustainable society should be created.

Technological development should be managed in a flexible manner in its introductory phase so that it reflects regional differences and temporal changes in social needs. For instance, development and introduction of a new energy technology or energy system should be based on regional characteristics (e.g. natural conditions such as climate, socioeconomic conditions such as industrial structure, and energy supply-demand conditions) and regional needs (e.g. needs of developing countries for technological transfer), in addition to changes in consumer needs and the economic development stages of developing countries. It should be noted that global introduction of uniform technologies or systems can rather cause inefficiency.

Meanwhile, solution of energy and global warming issues calls for not only

technological innovation but also for social innovation. In construction of social infrastructure, environmental harmonization should be taken into consideration. In addition, communication with consumers should be improved by promoting education and publicity activities concerning energy issues with a view to reforming people's lifestyle elements, including selection of products, services, and infrastructure.

(3) Equitable allocation of efforts

Energy and global warming involve all countries, and therefore collaboration across the international community is crucial to the solution of the problems. In such collaboration, an international consensus should be established about a framework under which efforts are allocated in an equitable manner among countries and among generations, while maximizing cost-benefit performance.

In the Post Kyoto Protocol discussions, scientists, policymakers, and other interested parties shall discuss optimization policies from a global perspective and form an international consensus, including the concept of "equitability," instead of claiming its own interests. Japan's recommendation to calculate energy consumption per unit GDP and Brazil's idea of taking account of historical emissions figures of individual countries, both of which have been deliberated on the establishment of emissions reduction targets under the Kyoto Protocol, are a few examples. Other recommendations have been presented for the Post Kyoto scheme, including introduction of energy efficiency criteria or setting a carbon intensity target, in addition to implementation of a reduction target for each country. It is necessary to review these recommendations on an equitable framework and pursue an internationally acceptable system. Such review should address the improvement of an energy-related statistical database and energy efficiency indicators for both developed and developing countries.

In developing countries, energy consumption is expected to grow in line with economic growth and improvement of quality of life. Developed countries are encouraged to transfer their technologies to developing countries in order to help them "leapfrog" to modern energy technologies in a more efficient manner and take advantage of such technologies in ensuring both economic growth and energy efficiency.

3. Current status and prioritization of individual themes

This section discusses challenges for the international community to concentrate on in order to achieve efficient supply and utilization of energy amid globally expanding energy demand.

On the supply side of energy, an internationally coordinated framework is indispensable to ensure worldwide supply of various energy sources while dealing with global warming issues. With respect to utilization of energy, energy-efficiency efforts should be reinforced to contribute further to mitigation of global warming and improvement of energy security.

(1) Energy supply

(a) Primary energy supply

(i) Fossil fuel

Use of fossil fuel should be reduced to mitigate global warming. Over a medium term, however, fossil fuel is still a valuable primary energy source. Further, fossil fuels can be utilized on a longer-term basis if CO_2 capture and storage technologies are developed and put into practical use in the future.

Now that mutual relation and dependence are being strengthened among national economies worldwide, price fluctuation and supply instability of energy can result if each country excessively pursues its own interest in competition for fossil fuel resources. To maintain the global stability of energy demand and supply, international coordination should be encouraged in development of resources, cultivation of transportation routes, and construction of storage systems.

(ii) Nuclear power

Nuclear power is important to strengthen energy security and mitigate global warming. At the same time, however, nuclear power arouses concerns about safety assurance and nuclear proliferation, in addition to “back-end” measures such as treatment and disposal of radioactive waste and closure and scrapping of nuclear power plants. Each country should form a popular consensus about its nuclear development policy. Developing countries considering introducing nuclear technology are required to ensure safety and, by obtaining relevant technology from developed countries, establish an appropriate nuclear non-proliferation policy.

(iii) Renewable energy

More aggressive introduction of renewable energy sources, such as photovoltaic, wind, and biomass, is encouraged in order to counter global warming, ensure energy security, and improve energy accessibility. The international community should set up a collaborative research system for settling technical issues such as energy supply fluctuation and cost reduction. It should establish a policy for the accelerated introduction of renewable energy sources to meet the needs of each country, form a social consensus about such policy, and enhance technology transfer to developing countries. While bioenergy sources have an advantage that they are "carbon neutral[1]", they are potentially subject to unrestrained development and competition with food supplies. To ease these disadvantages, a framework should be created for ensuring sustainable use of these resources.

(b) Energy conversion

(i) Hydrogen energy technology

Research efforts are being made in developed countries to develop elemental hydrogen energy technologies, including fuel cells. Hydrogen-based energy system could eliminate substantial portions of environmental effort. To realize such a system, there are many barriers to overcome such as transformation of existing energy infrastructures and achievement of a wide range of technical developments like technology for reducing carbon dioxide emission generated in the hydrogen production process from fossil fuel. Countries are required to consider introducing a hydrogen utilization system that meets their respective needs and join international cooperation to study and develop necessary infrastructures.

(ii) Clean coal technology

Clean coal technologies such as coal liquefaction, zero-emission power generation, and low-quality coal refinery, will not only contribute to the global stability of energy supply but also reduce carbon dioxide emission and efficiently utilize otherwise unusable low-quality coal resources. International collaboration is required to accelerate technological development and commercialization.

(C) Energy transportation

(i) Energy transportation infrastructure

In many developing countries, commercial energy is still inaccessible to a major

[1] Biomass emits carbon dioxide when burned, but plants absorb CO_2 from the air by photosynthesis during their growth, and thus there is no net increase in carbon emissions. The term *carbon neutral* refers to the property of having no effect on changes in carbon dioxide emissions.

portion of population. To promote efficient use of energy, it is important to improve and reinforce energy transportation infrastructure under a well organized program.

The global construction of oil and gas pipelines and power grids will play a vital role in stabilizing energy supply. In construction of such infrastructure, an international rule, such as the Energy Charter Treaty, and a surveillance system should be implemented effectively so that benefits of transportation infrastructure are allocated to all concerned countries in an equitable and peaceful manner.

(ii) Innovative energy transportation technology

In addition to conventional transportation technologies, intensive research and development is under way for innovative energy transportation and storage technologies, such as energy demand management systems and power transmission systems based on superconductive technology. These technologies, which utilize information, communications, and electronics technologies, will contribute to efficient use of energy. In consideration of actual situation of each country, the international community should enhance R&D of elemental technologies, and at the same time, consider a future vision of total energy systems, including energy supply and conversion framework. Introduction of innovative technology from developed countries would provide great benefit for developing countries, which desperately need efficient energy transportation infrastructure.

(2) Energy utilization

(a) Energy-saving policies

Developed countries are taking initiative in forming a framework for saving energy. An international standard should be established for energy systems that require global collaboration. Countries are advised to be more aggressive in following examples of other successful countries and exchange policies on such systems. Systems for which international collaboration is effective should be internationally standardized. Each country should also set up a policy for providing consumers with a variety of options concerning energy sources and energy-consuming products.

Developing countries, on the other hand, need to solve basic problems, including insufficient systems, poor capability, and low consumer awareness. Developed countries are encouraged to assist developing countries in policymaking and human resource development. It is important to recognize that energy saving will not only preventing acceleration of global warming but also bringing about economic benefits for each country.

(b) Energy efficiency of products

To enhance energy efficiency of products, national governments are required to establish a policy to develop markets for energy-saving products. Such policy should address proper evaluation of technologies, review of existing efficiency standards, and development of international efficiency standard products sold worldwide.

Although many existing policies have effectively been successful, the government and the private sector should cooperate in reinforcing research and development of next-generation energy efficient technology.

(c) Energy efficiency of industrial process

Different industrial technologies are employed by different countries, and there still remain cost-effective energy efficient measures to be applied globally. Just as IEA is compiling energy-efficiency indicators, concerned sectors are urged to build a coordinated data collection and analysis system and establish a framework for encouraging energy-efficiency measures based on evaluation results. In this effort, it should be noted that energy-efficiency effect should be evaluated considering whole lifecycles of products.

(d) Development of social infrastructure

Social infrastructures, including transportation facilities and buildings, have a long service life and thus, if developed in a systematic manner, have a great potential for both developed and developing countries to achieve energy savings. Optimal comprehensive social infrastructure should be planned and developed subject to evaluation of not only amenities available to people but also energy efficiency and environmental impacts.

(e) Enhancement of public awareness

Consumers' lifestyle, including choice of products, services, and social infrastructures, substantially affects energy demand. In consideration of the fact that their present lifestyle has been formed in the cultural, political, and economic backgrounds, governments should accurately envisage consumer needs and indicate an environmentally friendly lifestyle appropriate to the people. At the same time, energy education and publicity activities need to be strengthened through communication with consumers to help their decision in selecting such a lifestyle.

Conclusion

For sustainable development of the international society, three recommendations have been presented concerning policy formulation for energy and global warming issues–continuous effort from a long-term perspective, innovation (technological and social innovation), and equitable allocation of efforts.

There can be no single and absolute solution to energy and global warming issues. Instead, different strategies are required for different countries. Unfortunately, however, information and academic evidences currently available are not sufficient to deal with these challenges. We believe that the individual strategies to achieve equitable allocation of efforts and rights proposed in this report are applicable or are highly likely to be applicable under the current state of technology and society. In the near future, these proposals should be reevaluated according to development of technologies and other circumstances.

The international community is strongly urged to establish an international and multidisciplinary system for solving energy and global warming issues in a comprehensive manner immediately. In this recommendation we emphasize importance and necessity of a number of actions to be taken–establishment of a multidisciplinary framework for promotion of academic research, construction of an infrastructure for policymaking and scientific research, and establishment of an international system for discussion on energy problems. To put these proposed strategies into practice, joint international activities, such as an Asian forum, should be strengthened.

We hope that our recommendations will be taken into consideration in the preparation by the group of science academies of a joint statement for the 2008 G8 Summit in Japan and make a contribution to an international consensus.