International senior expert symposium on electricity and the environment: Highlights and conclusions from Helsinki

Summary of key issues and findings

by L.L. Bennett

The Senior Expert Symposium on Electricity and the Environment was held from 13 to 17 May 1991, in Helsinki, Finland. It was organized jointly by the IAEA and 10 other international organizations — the Commission of the European Communities (CEC), Council for Mutual Economic Assistance (CMEA), International Energy Agency (IEA), International Institute for Applied Systems Analysis (IIASA), Nuclear Energy Agency of the OECD (OECD/NEA), Economic Commission for Europe (ECE), United Nations Environment Programme (UNEP), World Bank (IBRD), World Health Organization (WHO), and World Meteorological Organization (WMO) — and was hosted by the Ministry of Trade and Industry of the Government of Finland. More than 300 experts from 40 countries and 20 different organizations took part.

The symposium's main objective was to provide a comprehensive assessment of the environmental, health, and economic factors involved in supplying electricity services, and to suggest a framework within which these issues should be taken into account in making future plans and decisions on electricity production and use. In so doing, the symposium produced concrete results that could be an input to the preparations for the 1992 United Nations Conference on Environment and Development (UNCED), in light of the important role electricity production and use play in both environmental and developmental issues.

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As a basis for discussions, four international expert groups, composed of more than 50 experts from 21 countries and 7 different organizations, prepared key issues papers in four areas that were selected as the central themes at the symposium:

- *Energy and electricity supply and demand: implications for the global environment.* This paper assessed scenarios of future energy requirements, the share of electricity in the end use energy mix in the context of social, environmental, and technological development, and the role of electricity in minimizing impacts on the environment.
- *Energy sources and technologies for electricity generation.* This paper assessed the characteristics of different energy sources and technologies for electricity generation, namely fossil fuels, nuclear energy, and renewable energy sources, from the perspectives of resource base, technological capability (including ways of protecting the environment), and economic viability.
- *Comparative environmental and health effects of different energy sources for electricity generation.* This paper assessed and compared the overall environmental and health effects of different energy systems for electricity generation, under normal operating and accident conditions, and covered the entire cycle of energy production, conversion, and end use.
- *Incorporation of environmental and health impacts into policy, planning, and decision making for the electricity sector.* This paper examined issues and options for managing the impact of the electricity sector on environment and health, and the framework for incorporating environmental and health impacts into the

decision making process for electricity policies and strategies.

Energy and electricity supply and demand: implications for the global environment

The symposium concluded that the global demand for electricity services will continue to increase, subject only to constraints on economic growth. Electricity services are essential to the quality of life to which most of the world's people aspire. The global demand for these services will continue to increase during the next decades, as both population and income increase. This is especially true in developing countries, where electricity is only beginning to penetrate potential markets.

Furthermore, it was concluded that economic welfare and growth are not incompatible with a healthy environment. In developing countries, in particular, increases in electricity services are regarded as a tool for supporting industrialization, increasing productivity throughout the economy, and improving living standards.

Efficiency improvement throughout the electricity sector, from generation to end use, was seen as having a substantial potential to reduce impacts and should be pursued vigorously. However, it was concluded that efficiency improvements will not obviate the need for investments in electricity supply facilities. In spite of all practical and economic measures to improve the efficiency of electricity production and use, there will be a need to build additional electric power capacity, and existing power plants will have to be replaced as they reach the end of their useful lifetimes. Therefore, it is necessary to consider what the power generation options are that will be available in the considered time horizon, that is, up to 2020.

The electricity sector has made and can make further significant contributions towards a reduction in future environmental impacts. Efficiency improvements, demand side management, and the use of non-fossil fuel supply side alternatives are options that are available to contribute towards a substantial reduction in emissions. Moreover, increased use of electricity may lead to a reduction in emissions from the total energy system by permitting substitution of electricity from cleaner generation sources for fossil fuels burned directly at the point of end use, and also by improving the efficiency of industrial processes.

One striking conclusion reached by the symposium was that the most ambitious feasible global target for carbon emissions from total energy sources in the year 2010 would involve emissions that are above the 1990 levels. This stands in stark contrast to stringent global targets being discussed in many international fora, calling for substantial reductions from present levels of CO_2 emissions. For example, the Toronto Conference (1988) called for a 20% reduction by 2005, relative to 1988 emission levels. The symposium concluded that such targets cannot be met by the electricity sector without socially and economically unacceptable curtailments in electricity services in many countries.

Less stringent global impact reduction targets could be met by the electric power sector without curtailing electricity services significantly, but only with forceful policy intervention. Such targets can be met through a combination of widespread efficiency improvements, increased use of nuclear energy and other non-fossil energy sources, and switching from coal to lower impact fossil fuels.

Symposium discussions showed that there is a wide diversity of viewpoints, both between regions and within regions, and that there is also great divergence between actions that experts judge to be needed and actions that policy makers and the general public consider to be acceptable. This is strikingly illustrated in developing countries, where the first priority is economic and social development.

Energy sources and technologies for electricity generation

The symposium considered that a technology response is needed to cope with the increasing evidence of the risk of global warming and climate change. The key elements of an interim response strategy will include expanded use of nuclear power based on the deployment of improved and advanced nuclear power plants, upgrading the efficiency of existing fossil plants, expanding the use of natural gas as a substitute for coal, expanding the use of hydropower resources where available, promoting other renewable energy sources where economically viable, and accelerating investment in cost-effective measures for demand management and end use efficiency improvement.

Nuclear power was seen as being the most likely non-fossil energy source which can be deployed on a much larger scale and with costs competitive with fossil fuels for base load generation. Nuclear energy has the potential for expanding its already significant contribution towards a reduction in carbon emissions. Tech-

nologies and resources are available to support greatly expanded use of nuclear energy in higher and middle income countries, but public concerns about health, safety risks, and waste disposal have currently blocked nuclear energy as an option in many countries. Technology advances are being made to improve the already good performance of existing reactor technologies, to develop advanced reactors with passive safety features, and to provide the means for better management of wastes. These advances would help to improve public acceptance of increased deployment of nuclear power. Social attitudes towards nuclear energy will also be influenced by social and environmental concerns about other energy sources.

Hydroelectric energy continues to be attractive on a large and small scale, in particular in developing countries because of the large economic resource base still unharnessed. However, the financial constraints faced by many countries, and also environmental impacts such as land use requirements, risk of accidents, and possible local climate changes, may limit its development.

Renewable energy sources other than hydropower are unlikely to meet a large share of the global electricity demand. While the renewable sources are an essential part of any impact reduction strategy, and they may be important locally, their overall contribution towards global electricity generation is likely to remain small. Most of these sources still require considerable development effort before they are ready for large-scale deployment as economic options for base load generation.

A wide range of technology options needs to be maintained and developed in order to cope with uncertainties that may affect future energy markets and to meet the variety of local and regional resource endowments. Therefore, all technology options should be kept open, and none of them should be dismissed. Enhanced international co-operation in research and development (R&D) and technology transfer is needed to facilitate implementation of the most efficient electricity generation systems.

Comparative environmental and health effects of different energy sources for electricity generation

All fuel cycles within the electricity generating system involve some health risks and environmental impacts. The symposium concluded, however, that all the major fuel cycles in the electricity generation systems, when fitted to state-of-the-art technology, are able to deliver electricity at relatively low risks to health and the environment. An exception is CO_2 emissions from fossil fuels. Therefore, the problem of CO_2 emission control is at the top of the current environmental impacts agenda. The implications of global climate change have strong social, political, and economic linkages that also require adequate consideration in the overall decision making process. The potential global impacts of CO_2 emissions from fossil fuel use are apparent, as are the potential regional impacts through acid rain. For such issues, energy mixes with a high component of fossil fuels are at the high end of the environmental risk spectrum.

Data presented to the symposium showed that, under routine operating conditions, nuclear power and renewable energy systems are in the lower range of health risk and that energy systems based on coal and oil are in the higher spectrum of health risk. However, variations in technologies, the state of equipment, and safety and environmental controls can lead to variations in the levels of risk from different systems.

Most energy systems have a potential for severe accidents at various stages of their fuel cycles. The Chernobyl accident, the worst to have taken place in the nuclear fuel cycle, resulted in 31 immediate deaths, and the risk of delayed fatalities has yet to be established. There was also contamination of large areas of land and evacuation of a large number of people; the social consequences of the accident are particularly significant. Major accidents also have occurred in the coal, oil, and gas fuel cycles.

Rough estimates suggest that the human health risk from severe accidents from nuclear, oil, and natural gas systems are of the same order of magnitude and two orders of magnitude smaller than that from the hydroelectric option. On the basis of a normalized per unit of electricity produced, the hydroelectric option appears to have caused more immediate fatalities during the period 1969-86 than other energy sources. Any direct comparisons of severe accidents in the electricity generation sector must, however, be interpreted with great caution, as no internationally co-ordinated database on severe accidents exists, except for the nuclear fuel cycle. Delayed health effects and long-term environmental damage from major accidental emissions are particularly difficult to determine.

Therefore, the establishment of a comprehensive, internationally co-ordinated database on the health and environmental impacts of different energy sources is a priority issue. This should include the establishment of appropriate mechanisms for the collection and dissemination of such data. There is also a need for further R&D of quantifiable environmental indicators

and on related methodologies for the comparative health and environmental risk assessment of different energy sources and technologies for the generation of electricity.

There is further a need to ensure formalized co-ordinating and liaison mechanisms among the various international organizations with an interest or role in the health, environment, and energy sectors to deal creatively with the range of research, policy, and other issues. A number of international initiatives are warranted, in particular on the interpretation and integration of comparative environmental and health impacts into the decision making process to ensure that all electricity generating options are considered in their proper perspective. The methodological initiatives that should be focused upon include: agreement on definition of the boundaries of the fuel cycles to be compared; how to take into account future technological developments in estimating and comparing risks; estimation of delayed and indirect health effects; and the development of appropriate environmental indicators and comparative methods.

Policy, planning, and decision making for the electricity sector

The integration of health and environmental impacts into energy planning for electricity generation will have significant implications that go beyond traditional current practices. First, considerations of the health and environmental impacts from the entire fuel cycle elevate the decision making to at least the level of the overall energy sector. Second, the global environmental dimension of electricity generation by different energy sources implies that it is necessary to look beyond the energy sector, since other sectors have similar greenhouse gas effects. Third, the time scale of many health impacts (e.g., long-term or delayed effects) and of environmental impacts (e.g., irreversible damage to ecosystems) means that a perspective much longer than the traditional capacity planning horizon of 7 to 10 years for power utilities is necessary. These factors highlight the complexity and multi-level nature of future electricity planning.

Policies in the electricity sector should be based on considerations of the full cost to society of different options, including the costs associated with health and environmental impacts, which need to be internalized. Comprehensive energy and electricity planning has to take into account the costs of health and environmental damages, which are an important component of the full social cost of energy supply. Some participants in the symposium questioned whether the developing countries can afford to concern themselves with environmental cost internalization when they have so many other problems. However, it cannot be overlooked that the environmental costs of local pollution are borne by the local population anyway if they are not internalized by the power companies, so society as a whole pays. Health and environmental costs also affect the productive economy directly, in addition to indirect effects. The full costs need to be carefully evaluated and internalized, based on the best available scientific data, consistent assumptions, and reliable methodologies. In many respects this will tend to make electricity generating decisions more realistic and result in more efficient practices.

Integrated least-cost planning approaches should be used as the basis for policy formulation and decision making, with consideration of energy conservation and efficiency improvement options as well as new supply options.

The symposium recommended that national governments should follow the precautionary principle when setting health and environmental protection standards, rules, and regulations to be met by electricity producers and users, as well as by other sectors of the economy.

International organizations should target their programmes, including policy criteria, dissemination of public information, and technical assistance, in support of sustainable development. They should undertake policy and technical studies and research appropriate to their expertise and role; these should be aimed at the design and implementation of feasible sustainable paths of electricity development, including international agreements on the standards to be met in relation to protecting health and the environment.

Commercial and development banks should establish and adopt formal guidelines governing their appraisal of electricity projects in accordance with their overall impact as assessed under a broadly agreed framework. When appraising projects for financing, they should take into account the complete range of alternatives, including rational use of electricity and all the available supply options.

The symposium further underscored the importance of public involvement. Each citizen of the world should be concerned with the need for sustainable development and contribute, to the extent possible, to its achievement.