Electricity, health, and the environment: The DECADES project

An update of an inter-agency project providing a framework for comparatively assessing electricity options and strategies

by
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Environmental and health-related impacts of different energy systems, including those associated with the production of electricity, have become significant national and global issues. Current debates, for example, centre on the health effects of pollution, environmental damage due to acidification of forests and lakes, the safety of nuclear power plants and radioactive waste management, and the potential risks of global climate change induced by increasing atmospheric concentrations of carbon dioxide and other greenhouse gases.

All fuel chains within the electricity generation system involve some health risks and lead to some environmental impacts. This fact — together with the needs of many countries to define their energy and electricity programmes for the coming decades — stands behind a growing interest in the application of improved data, tools, and techniques for comparative assessment of different electricity generation options, particularly from environmental and human health viewpoints.

At the international level, the need to design and implement sustainable strategies in the electricity sector has been stressed throughout the 1990s at major global meetings. This was the case in 1991 at the Senior Expert Symposium on Electricity and the Environment (Helsinki), in 1992 at the United Nations Conference on Environment and Development (UNCED, Rio de Janeiro), and at the 15th Conference of the World Energy Council (Madrid). The Agenda 21, adopted by UNCED, emphasizes that environmental and development concerns should be integrated into the decision-making process. The Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), prepared in 1993 and 1994, highlights that options for alleviating the risks of global climate change should be comprehensively assessed and that adequate policies should be implemented to promote the most efficient technologies for reducing greenhouse gas emissions.

In the electricity sector, the essential goal of sustainable strategies is to provide the energy services required for supporting economic growth and improving quality of life, especially in developing countries, while minimizing the health and environmental impacts of human activities.

In mid-1992, the IAEA and a number of other organizations initiated an inter-agency joint project on databases and methodologies for comparative assessment of different energy sources for electricity generation, known as DECADES. Its objective is to enhance capabilities for incorporating health and environmental issues into comparative assessments of different electricity generation chains and strategies in the process of energy planning and decision-making.

The project is carried out jointly by the IAEA, the European Commission (EC), the Economic and Social Commission for Asia and the Pacific (ESCAP), the International Bank for Reconstruction and Development (IBRD/World Bank), the International Institute for Applied Systems Analysis (IIASA), the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (OECD/NEA), the Organization of Petroleum Exporting Countries (OPEC), the United Nations Industrial Development Organization (UNIDO), and the World Meteorological Organization (WMO). Several other international organizations, including the United Nations Environment Programme (UNEP) and the World Health Organization (WHO), are contributing to the project within their areas of expertise. The Project Secretariat, comprised of representatives of the four Vienna-

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The Cruas nuclear power plant in France. *(Credit: EDF, Henri Cazin)*

based organizations (IAEA, IIASA, OPEC, and UNIDO), co-ordinates activities within the scope and objectives defined by the project's Joint Steering Committee (JSC).

This article reviews the major elements of the DECADES project and reports on selected activities and results to date. It also looks at future developments, including the October 1995 international conference at which results will be more fully presented and reviewed.

Major elements of DECADES

The DECADES project addresses some, but not all, of the issues involved in comparative assessments of different electricity generation options and strategies. The project principally aims toward providing comprehensive information about different energy chains for electricity generation — i.e., fossil fuels, nuclear power, and renewable sources — and user friendly tools for accessing, handling, and processing key information needed for planning and decision-making purposes.

The project's first phase, from mid-1992 to mid-1995, focuses on the development of databases and analytical tools for electricity system planning and decision support studies, and their concrete application in national case studies. Upon completion of this first phase, it is expected that the participating organizations will consider the feasibility of jointly undertaking further activities in this field in order to address certain issues more comprehensively. It is also expected that the exploratory national case studies will be extended with the objective of fully testing and demonstrating the use of the DECADES tools in planning and decision-making for the electricity sector.

The major components of the project are:

- establishment of databases, in particular of a comprehensive technology inventory, providing characteristics of energy chains for electricity generation, from fuel extraction to waste management, covering technical, economic, health and environmental aspects;
- development of an information system (computer software) for user-oriented access to electronic databases, allowing retrieval, display, and handling of the data;
- development of a software package integrating technical, economic, environmental, and health aspects into electricity system analysis and expansion planning;
- compilation and review of methodologies, analytical models, and computerized tools for comparative assessment, with emphasis on those tools that may be used in the planning and decision-making process for the electricity sector;
- carrying out of some case studies addressing

specific national or regional issues, with the primary objective of illustrating the applicability of the data bases and computerized tools in the planning and decision- making process.

DECADES products

Products developed within the project's framework — i.e., computer tools, including databases and publications — are designed for use by energy analysts and planners in national institutes, in particular in developing countries and international organizations. However, they will also be relevant for use by a broader audience of individuals and groups interested in technical, economic, health, and environmental aspects of electricity generation options. In this connection, special emphasis has been given in the design of the products to ensure coherence, consistency, and transparency of the data and tools.

Since the DECADES products are developed and maintained by international organizations, they will be distributed upon request to non-profit international organizations and national institutes. Workshops and seminars will be organized to provide opportunities for exchange of information and experience between users and with the developers of the databases and computer tools.

The products are intended to be of particular relevance for planning and implementing electricity system expansion strategies in developing countries. These countries, which are experiencing the highest rates of growth in electricity demand and rapidly increasing environmental problems, need reliable information and easy-to-use tools to design and implement economically competitive and environmentally sound strategies for electricity supply. The generic data provided by the DECADES project, as well as the computer structure for collecting, storing, and processing specific national data, will be useful in the process of establishing a country-specific framework for electricity planning. The methodologies that will be reviewed and demonstrated could also serve as a basis for comprehensive and coherent approaches that could be adapted to each specific national context.

For international organizations, the products can be useful tools in that they reflect a broad consensus on reference data and methodological approaches which could be used for analysis and studies in different countries and regions. The tools could be applied within the framework of their technical assistance programmes to developing countries.

The transparency and user friendliness of the DECADES products are key aspects of their design. These features should facilitate their use by energy/electricity system analysts and senior executives, as well as by a broader public less familiar with technical issues. In this connection, the dissemination of the databases and reports is intended to lead to a better understanding of the implications of electricity generation choices and policies.

The products developed up to April 1995 and already distributed to a number of selected users include:

- a database management system (DBMS), distributed in electronic format for use on personal computers (PCs) together with a user's manual. The package includes: a Reference Technology Data Base (RTDB) containing information on different energy chains for electricity generation, including their technical and economic parameters, emissions, and other residuals at each level of the chains; a computer structure for establishing a user/country specific database; and a graphical user interface for accessing, displaying, and handling the information contained in the databases.
- a software package (DECPAC Phase I) for electricity system planning, which is provided as executable code with a user's manual. The package runs on PCs and includes the supporting databases developed within the project, i.e. the RTDB and Country Specific Data Bases (CSDBs) whenever they have been established by national scientific teams.
- a document on computer tools for comparative assessment of electricity generation options and strategies. It provides information on selected PC-based computer tools currently available or expected to be available in the near future;
- interim reports on case studies being carried out to assess and compare alternative strategies in the electricity sector, taking into account their technical, economic, health, and environmental aspects. The studies illustrate the use, in the planning and decision-making process, of the databases and computer tools developed and reviewed within the DECADES project.

DECADES databases

The databases within the DECADES project cover not only currently available technologies but also advanced technologies expected to be commercially deployed within the next two or three decades. They are designed for use on personal computers with an accompanying database management system.

Technology databases. The technology inventory databases contain information on all levels of different energy chains, i.e., fossil fuels, nuclear power, and renewable energy sources, for electricity generation. Data on fuel characteristics and abatement technologies are included. Transmission and end-use of electricity are not covered in the first phase of the project, but the database structure and management system are flexible enough to allow for incorporating these levels at a later stage.

Country Specific Data Bases (CSDBs). CSDBs are being developed by national institutes mainly under research or scientific contracts with the IAEA. Data on electricity generation technologies in a given country or region are collected by national teams and stored in a computer structure identical to that of RTDB. Technical support and guidance are provided by the IAEA on the use of the DBMS for establishing country-specific databases. Furthermore, the information contained in RTDB can be used for complementing and checking the consistency of the data available in the country.

Vendor database. As part of the DECADES technology inventory, comprehensive information on state-of-the-art electricity generation chain facilities offered by manufacturers would be highly valuable for users. Recognizing this need, the JSC recommended to establish an Extended Vendor Specific Data Base providing quantitative and qualitative information on commercial equipment and facilities currently available from vendors. Its establishment will be considered during the second phase of the DECADES project.

Toxicology database. Data on toxicology profiles for pollutants released at different levels of energy chains for electricity generation are needed for assessing health impacts resulting from the emissions. Although the first phase of the project will not address comprehensively the issues of health impact assessment, the JSC recommended to collect and structure the data that will be required for this purpose at an early stage of the project. The prototype Toxicology Data Base (TOXDB) is based largely upon an existing one established by UNEP and WHO. It covers most chemical products emitted at all levels of the energy chains for electricity generation. Information on the toxicity of radiochemicals has been collected to complement this existing data and to cover dose-effect relationships for all significant pollutants. TOXDB will also contain textual information related to toxicology profiles, as well as standards and regulations in different countries on emission limits.

Health and environmental database. A database on Health and Environmental Impacts of Energy Systems for Electricity Generation (HEIES) also will be developed. It will be used for storing results from selected studies and measurements related to health and environmental impacts from different electricity generation chain facilities and systems.

DECADES Computer Products and Documents

Documents completed, in preparation, and planned under the DECADES project include:

- The DECADES Project – Outline and General Overview
- Computerized Tools for Comparative Assessment of Electricity Generation: Options and Strategies
- DECADES Databases: Overview and General Description (in preparation)
- Reference Technology Data Base (RTDB) Vol. 1: Overview and General Description (working paper)
- Reference Technology Data Base (RTDB) Vol. 2: User's Manual (in preparation)
- Reference Technology Data Base (RTDB) Vol. 3: Description of Computer Structure and Data Management System (working paper intended for data management specialists)
- DECADES Software Package (DECPAC) Vol. 1: Overview and General Description of Software Design and Functions
- DECADES Software Package (DECPAC) Vol. 2: User's Manual
- Case Studies on Comparative Assessment of Electricity Generation Options: Vol. 1: Executive Summary (working paper)
- Case Studies on Comparative Assessment of Electricity Generation Options: Vol. 2: Detailed Reports on Country Studies (working paper)
- Reference Book on Incorporating Economic, Social, Health and Environmental Concerns into Policy Making for the Power Sector (in preparation)
- Electricity, Health and the Environment: Comparative Assessment in Support of Decision Making, Proceedings of a Symposium to be held in October 1995 (subsequent publication by the IAEA)

Electronic databases and software include:

- Reference Technology Data Base and Data Base Management System (released)
- DECADES Software Package (DECPAC) Phase 1 (released)
- Toxicology Data Base (under development)
- Health and Environmental Impacts of Energy Systems for Electricity Generation Data Base (under development)

Analytical tools

Although a number of methodologies, models, and tools exist or are under development for comparative assessment of energy/electricity supply options and strategies, no single methodology, model, or tool incorporates all the elements needed for a comprehensive approach. Potential users thus need information on the different approaches, and their capabilities and limitations. Under the DECADES project, a review

was carried out of methodologies and models for comparative assessment of analytical tools for use on personal computers that are available at little or no cost. A detailed project document that catalogues available tools has been prepared. Additionally, a group of international experts from the IAEA and World Bank is preparing a reference book focusing on the incorporation of economic, social, health, and environmental aspects into policy-making for the power sector.

Within the DECADES project, software was develped to provide an integrated tool for comparative assessment of electricity options and strategies in the process of system expansion planning. The software package (DECPAC Phase 1) implemented in the project's first phase is intended to be a screening tool for preliminary assessment and selection of options that might be investigated further. It includes analysis modules — covering electricity systems, primary energy supply, and the environment — that have been drawn from methodological approaches and computer codes developed by the IAEA in co-operation with the Argonne National Laboratory in the United States. These include the Wien Automatic System Planning model (WASP) and the Energy and Power Evaluation Program package (ENEP).

Case studies

Within the DECADES framework, the scope and objective of the case studies were defined by national scientific teams. They are focusing on concrete issues that have to be addressed by analysts and planners in support of the decision-making process.

The IAEA has established two Co-ordinated Research Programmes (CRPs), which provide an organizational and support framework for national institutes from Member States wishing to undertake case studies in their respective countries. Other studies are supported by the IAEA through other mechanisms, while some are being carried out by other organizations participating in the DECADES project, e.g., ESCAP, IBRD, and UNIDO. These studies also will contribute to the overall set of DECADES case studies.

The two CRPs were initiated over the past 2 years. The first one, started in December 1993, focuses on case studies to assess and compare the potential role of nuclear power and other options in reducing emissions and residuals from electricity generation. Research contracts and agreements have been signed with 19 Member States. The second CRP, launched in April 1994, is directed at comparative health and environmental risks of nuclear and other energy systems. Eleven scientific teams are participating in this research. Reports from each case study will be prepared by national teams and published in the DECADES Project Document Series.

Milestones and future directions

In October 1995, the IAEA and its DECADES partners will convene the International Symposium on Electricity, Health and the Environment: Comparative Assessment in Support of Decision Making. The meeting marks a major milestone of the DECADES project. Technical and panel sessions on various topics will draw upon results of the DECADES project, as well as other international and national studies. Computer tools available to decision makers for carrying out comparative assessment studies also will be demonstrated. The symposium thus offers to provide a valuable base of comprehensive information on issues related to assessing electricity options.

The results obtained within the DECADES project so far are encouraging. Many experts, in particular from developing countries, have expressed interest in the project. More than 15 national institutes are already using the RTDB computer structure. Moreover, many of the same countries have requested training on the use of DECPAC.

In 1995, work plans are placing emphasis on maintenance, enhancement, and dissemination of DECADES products and tools. The work includes a systematic expert review of data contained in RTDB and the preparation of more extensive numerical, textual, and pictorial information. More workshops also are being organized to assist national teams in establishing country-specific databases. Also under way is the final design and implementation of the databases covering toxicological and health and environmental information, and the further improvement of the DECADES software for electricity system planning, DECPAC.

Most tasks within DECADES draw upon ongoing programmes of the project's participating organizations. In this connection, the IAEA in years ahead is planning to continue its emphasis on DECADES-related activities through its programme on comparative assessment of nuclear power and other options. Important ingredients of the programme are national and regional technical co-operation projects designed to assist countries in applying computer tools and models for analyzing their electricity needs and for effectively assessing the risks and benefits of specific technologies. ❐