

# Environmental Impacts of Production and use of energy



*Essam E. El-Hinnawi*

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# **The Environmental Impacts of Production and Use of Energy**

**An Assessment prepared by the United Nations  
Environment Programme**

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*Published for the* UNITED NATIONS ENVIRONMENT  
PROGRAMME

*by the* TYCOOLY PRESS LTD.

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ISBN 907567 00 2

Typeset by Brunswick Press Ltd., 17 Gilford Road, Sandymount, Dublin 4.

Printed by Irish Elsevier Printers Limited, Shannon.

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ISBN 0 907567 05 3.

## Foreword

THE 1970s brought into focus two global issues that are of primary importance in determining future world development, namely "Environment" and "Energy". In the early years of the decade, the environmental movement was approaching its peak and an "energy crisis" was in the making. The emergence of the two issues at the same time was not mere coincidence. As the last decade has shown, both issues are closely related, and have marked socio-economic as well as political dimensions.

It has been realized that some fossil fuels, especially oil and natural gas, are finite in extent and should be regarded as depleting assets, and the term "energy crisis" has become a common catchword all over the world. However, it is difficult to define this "crisis". Does the problem lie in the scarcity, or the vulnerability, of supply? Or is it the rising cost of energy resources and its implicit relation to the world-wide inflation and recession? Or is the crisis defined by an "excessive" demand for energy, or by widespread habits of energy waste? Of course, it may be a combination of all or most of these things.

At local, national and in some cases regional levels, the environmental aspects of energy production and use have become the subject of wide-ranging debate. Environmental awareness and anti-pollution campaigns have affected the formulation of energy policies in many countries, and it has recently been realized that nations are not isolated in this respect; the actions of one country may affect the environment in a neighbouring one. Nowadays, energy policy decisions are dictated less by technological than by social, environmental and political factors.

The production, transportation and use of different sources of energy raise a number of important environmental issues. Among these, questions of the availability and allocation of resources are likely to play as important a role as pollution problems proper. Land and water use, emissions (including thermal discharges) and their impact on ecosystems and human health are but examples of the problems encountered. The 1970's, brought into focus some related socio-economic and geo-political problems. For example, nuclear power development

raises problems related to ultimate disposition of nuclear wastes, possibilities of diversion of nuclear material for military purpose or terrorists action and to the public acceptance of this source of energy. On the other hand, concern has been recently voiced at the implications of extensive coal utilization, especially its possible impact on climate. The atmosphere is believed to show a warming primarily due to the greenhouse effect of increasing carbon dioxide emissions. The important question is: what will the regional changes of temperature and rainfall be? Studies with climate models and of climate observations indicate that regional anomalies will probably occur, but the magnitude and impact of these anomalies cannot be reliably predicted at present. The medium and long-term effects of such possible climatic changes are of such fundamental importance that they command serious attention.

The general realization of the finite nature of fossil fuel resources has caused a re-examination of the possibility of using those energy resources which are of a non-depleting nature, and are therefore considered renewable. These energy sources are becoming increasingly important both in developed and in developing countries. In the former strategies for the exploitation of such sources constitute a part of recent policies which aim at reducing the dependence on fossil fuel. In the developing countries, particularly those short of fossil fuel resources, the renewable sources of energy show promise of meeting some of the future energy needs, especially of rural areas. Without strong rural development programmes based on decentralized energy sources, urban migration will become torrential, exacerbating the already dire urban problems brought into focus at the United Nations Conference on Human Settlements in 1976. Similarly, the United Nations Conference on Desertification convened in 1977 emphasized the importance of using locally available renewable sources of energy to reduce excessive wood cutting in arid and semi-arid areas, which is one of the most important causes of desertification. The importance of renewable sources of energy has been recently brought into focus by the decision of the General Assembly of the United Nations to convene a United Nations Conference on New and Renewable Sources of Energy in Nairobi next year.

One of the tasks assigned to the Governing Council of the United Nations Environment Programme by the General Assembly of the United Nations in its resolution 2997 (XXVII) of 15 December 1972 is to:

“keep under review the world environmental situation in order to ensure that emerging environmental problems of wide international significance receive appropriate and adequate consideration.”

In this respect, the United Nations Environment Programme has embarked on a number of in-depth reviews of the environmental aspects of production and use of all sources of energy. Three major studies have so far been carried out. The first one, dealing with the environmental impacts of production, transport, processing and use of fossil fuels, was reviewed by an International Panel of Experts that met in Warsaw in April, 1978. The second study, which deals with the environmental impacts of nuclear energy, was reviewed by an International Panel of Experts that met in Geneva in November, 1978, and revised at a second



meeting held in Nairobi in April 1979. The third study, dealing with the environmental aspects of renewable sources of energy, was reviewed by an International Panel of Experts that met in Bangkok in January, 1980.

The present volume consolidates these three studies into one text, summarizing the state of knowledge at the end of the 1970s. I hope that this review will be found to give a balanced assessment of the environmental impacts of energy production and use as viewed by the United Nations organ responsible for the safety of the environment at the global level. It is also my sincere hope that the scientific community will pick up the many inadequacies in our knowledge of the environmental impacts of production and use of energy, and accelerate the efforts to find adequate solutions to the problems encountered or likely to be encountered.

Many scientists participated in the three studies that constitute this volume, either by contributing background papers and/or by participating at the review panels. To all of them, I would like to express my gratitude. My appreciation goes also to the United Nations bodies and to the scientific institutions that provided information and/or helped in the review process.

A handwritten signature in black ink, appearing to read 'M.K. Tolba', with a large, sweeping underline.

Executive Director  
United Nations Environment Programme

Nairobi, *October 1980*



## Preface

At its fourth session, in 1976, the Governing Council of the United Nations Environment Programme requested the Executive Director to undertake the preparation of a comprehensive review of the environmental impacts of production and use of different sources of energy. I was then entrusted with planning and executing this Study. The plan was formulated early in 1977 and it was found most appropriate to divide the Study into three main parts: the first dealing with fossil fuels, the second with nuclear energy and third with renewable sources of energy. For each part a number of background papers was prepared by some experts and my task was to consolidate these papers, supplementing them with additional material gathered from the literature and from some United Nations Organizations and scientific Institutions, into drafts which were then reviewed by three main panels of experts. In the light of the comments of these panels and comments received from a number of reviewers, the drafts were then finalized and the reports released by UNEP in 1979 and 1980.

The three parts of the Study have been structured in such a way as to review the environmental impacts of each stage of the fuel cycle. This starts with the production of the raw material followed by its processing, transportation and use. Whenever possible the environmental impacts have been quantified on the basis of electricity production of 1000 MW (e)y to facilitate the comparison between the environmental impacts of the major sources of energy.

For the part on fossil fuels, background papers were prepared by Prof. L. Freiberg (Stockholm), Dr. B. St. John (Calgary), Dr. T. Tarnawa (Warsaw), Dr. M. Waldichuk (Vancouver) and Dr. J. Williams (Laxenburg). The following participated at the review panel that was convened in Warsaw, 17-21 April, 1978: Mr. M. Alwaer (National Oil Corporation, Tripoli), Prof. A. Beba (EGE University, Izmir), Prof. M. Berlin (University of Lund), Dr. C. Ducret (ECE, Geneva), Dr. L. Farges (IAEA, Vienna), Mr. M. Fila (IMCO, London), Dr. G. Foley (OECD, Paris), Prof. G. Goodman (Beijer Institute, Stockholm), Dr. L. Hamilton (Brookhaven National Lab., New York), Dr. W. N. Hurst

(Department of the Environment, Canberra), Dr. L. Feng (Research Institute of Petroleum, Peking), Dr. A. Martono (Electric Power Research Centre, Jakarta), Dr. Z. Nowak (Research Centre of Coal Processing, Warsaw), Dr. Y. Ogisu (National Research Institute for Pollution and Resources, Kawaguchi-Saitama, Japan), Dr. W. S. Osburn (Department of Energy, Washington), Dr. A. Podniesinski (Research Institute on Environmental Development, Warsaw), Dr. A. Pradinaud (Ministère de la Qualité de la Vie, Paris), Dr. L. Reed (Department of the Environment, London), Dr. P. Ruyabhorn (National Energy Administration, Bangkok), Dr. B. St. John (Petro-Canada, Calgary), Dr. A. Sauer (Ruhrkhole AG, Essen), Dr. K. W. Sedlacek (IPIECA, London), Dr. T. Tarnawa-Tomaszkiewicz (Ministry of Environmental Protection, Warsaw), Dr. A. Titkov (IAEA, Vienna), Dr. B. Turyn (General Bureau Energy Studies, Warsaw), Dr. G. S. van der Vlies (Shell International Research, The Hague), Dr. M. Waldichuk (Pacific Environment Institute, Vancouver), Dr. Wang Po-yung (Research Institute of Petroleum, Peking) and Dr. G. Woznjuk (Department of the Environment, Ministry of Coal, Moscow).

For the part on nuclear energy background papers were prepared by Dr. J. M. Costello (Australia), Dr. A. J. Gonzalez (Buenos Aires), Dr. A. K. Biswas (Laxenburg), Dr. J. R. Beattie (Culcheth), Dr. H. Howells (Risley), Dr. F. Kenneth Hare (Toronto), and Dr. Y. Sousselier (Paris). The following participated at the review panel that was convened in Geneva, 20-24 November, 1978: Dr. P. Albrecht (World Council of Churches, Geneva), Dr. Y. Ahmed (IAEA, Vienna), Dr. M. N. Aybers (Technical University of Istanbul), Dr. J. R. Beattie (UK Atomic Energy Authority, Culcheth, Warrington), Dr. D. Benninson (UNSCEAR, Vienna), Dr. A. Bishop (ECE, Geneva), Dr. A. K. Biswas (IIASA, Laxenburg), Dr. K. H. Buob (Institut Fédéral des Recherches en matière de réacteurs, Würenlingen, Switzerland), Dr. M. Carriera Vasquez (Junta de Energia Nuclear, Madrid), Dr. J. H. Chesshire (University of Sussex), Dr. J. Costello (Australian Atomic Energy Commission, Sutherland, Australia), Dr. C. Ducret (ECE, Geneva), Dr. L. Farges (IAEA, Vienna), Dr. A. K. Ganguly (Bhabha Atomic Research Centre, Bombay), Dr. J. de Givry (ILO, Geneva), Dr. A. Gonzalez (Comision Nacional de Energia Atomica, Buenos Aires), Dr. G. Gorrie (Department of Environment, Canberra City, Australia), Dr. L. Hamilton (Brookhaven National Lab., New York), Dr. H. Howells (British Nuclear Fuels Ltd., Risley, Warrington, UK), Dr. R. Ichikawa (National Institute of Radiological Science, Chiba-Shi, Japan), Dr. L. Ilyin (Institute of Biophysics, Moscow), Dr. H. P. Jammet (Institut Curie, Paris), Dr. Z. Jaworowski (Central Lab. for Radiological Protection, Warsaw), Dr. E. Komarov (WHO, Geneva), Dr. W. L. Lenneman (IAEA, Vienna), Dr. B. Lindell (National Institute of Radiation Protection, Stockholm), Dr. G. Ozolins (WHO, Geneva), Dr. Y. Sousselier (Commissariat à l'Energie Atomique, Fontenay-aux-Roses, France), Dr. P. Strohl (OECD, Paris), Dr. L. Teh-Ping (Institute of Energy, Peking), Dr. B. Wachholz (US Department of Energy, Washington, D.C.), Dr. B. Wallenberg (OECD, Paris) and Dr. J. L. Weeks (White Shell Nuclear Research Establishment, Pinawa, Manitoba, Canada). From these experts the following

attended a second panel convened in Nairobi in the period 2-6 April, 1979: Dr. Y. Ahmed, Dr. J. R. Beattie, Dr. K. H. Buob, Dr. M. Carriera Vasquez, Dr. J. Costello, Dr. L. Hamilton, Dr. H. Howells, Dr. H. P. Jammet, Dr. Z. Jaworovski and Dr. J. L. Weeks. In addition Dr. H. T. Daw and Dr. C. H. Millar, both of IAEA, Vienna attended the meeting.

As for the part on renewable sources of energy, background papers were prepared by Dr. H. J. Allison (Oklahoma), Brace Research Institute (Canada), Dr. A. J. Ellis (New Zealand), Dr. H. Korniewicz and Dr. A. Podniesinski (Warsaw), Dr. M. Saleh (Cairo), Dr. J. W. Tatom (Smyrna, Georgia, USA) and Dr. E. N. Terrado (Manila). The following participated at the review panel convened in Bangkok in the period 7-11 January, 1980: Dr. J. Ahmed (IAEA, Vienna), Dr. J. Allison (National Science Foundation, Washington, D.C.), Dr. A. Arismunandar (Ministry of Mines and Energy, Jakarta), Dr. S. Arungu-Olende (UN, New York), Dr. A. K. Biswas (Biswas and Associates, Oxford), Dr. T. Cheickne (National Solar Energy Lab., Bamako, Mali), Dr. S. I. Dolgov (GKNT, Moscow), Dr. A. Ellis (DSIR, Wellington, New Zealand), Dr. Y. S. El. Mahgary (ESCAP, Bangkok), Dr. L. Hamilton (Brookhaven National Lab. New York), Dr. S. Hurry (University of Mauritius), Dr. P. Kambhu (ESCAP, Bangkok), Dr. J. Martinod (World Bank, Washington, D.C.), Dr. J. McDivitt (UNESCO, Paris), Dr. R. N. Morse (Victorian Solar Energy Research Committee, Melbourne), Dr. K. Openshaw (University of Dar es Salaam, Tanzania), Dr. J. Phéline (Commissariat à l'Energie Atomique, Paris), Dr. P. Ruyabhorn (National Energy Administration, Bangkok), Dr. W. Shearer (UNU, Tokyo), Dr. B. Sørensen (Niels Bohr Institute, Copenhagen), Mr. H. R. Srinivasan (Khadi and Village Industries, Bombay), Mr. H. S. Subasinghe (Ceylon Electricity Board, Colombo), Dr. J. Tatom (Smyrna, Georgia, USA), Mr. L. Wiltshire (UN, New York) and Dr. G. Woldegiorgis (National Energy Commission, Addis Ababa).

The Study benefited enormously from the contributions and comments of the previously mentioned experts. Dr. Mostafa Kamal Tolba, despite his many commitments, as the Executive Director of UNEP, followed closely the progress of the Study and provided most valuable advice and support. A great deal of credit goes also to Mr. R. B. Stedman, the former Deputy Executive Director; Mr. P. S. Thacher, Deputy Executive Director and Mr. S. Evteev, Assistant Executive Director who provided all possible assistance and encouragement.

Finally, several colleagues at UNEP provided useful comments and/or information that was of great help in drafting the parts of the Study. Mrs. D. Orrill, Mrs. Y. Da Costa, Miss E. Itaka and Mrs. A. Fernandez were responsible for typing the different manuscripts and greatly helped in the preparations for the panel meetings; their efforts are gratefully acknowledged.

*Essam El-Hinnawi*  
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Nairobi, October 1980

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Dr. Essam El-Hinnawi is Research Professor of Environmental Geochemistry at the National Research Centre, Cairo. He was awarded the State Prize for Science in 1967 for his achievements in geochemistry. He worked for a number of years as visiting research professor in Italy, and the Federal Republic of Germany. Besides his work at the National Research Centre in Cairo, he served as Secretary General of the Environmental Research Council, co-ordinating environmental research programmes in Egypt. He acted also on several advisory committees for policy planning at the Academy of Scientific Research and Technology. Since 1976, Dr. El-Hinnawi has been on leave of absence from the NRC, working with the United Nations Environment Programme as Chief of the State of Environment Unit and as Chairman of the Energy Task Force. Dr. El-Hinnawi has published more than 120 papers in mineralogy, environmental geochemistry, and natural resources. He supervised more than 25 M.Sc. and Ph.D theses in these fields, and is the author of three books and editor of a recent one on Nuclear Energy and the Environment.

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