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ACTION ARISING FROM THE SECOND SESSION

Scientific and technological aspects of sustainable energy systems

Note by the UNCTAD secretariat

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PREFACE

At its second session (15-24 May 1995), the Commission on Science and Technology for Development requested the secretariat to prepare an issues note on the identification of scientific and technological aspects of sustainable energy systems. This note is to be reviewed by the Commission at its third session in 1997 in conjunction with its future work programme.

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INTRODUCTION

1. Energy has always been an important item on the United Nations agenda. As early as 1949, it already addressed the problem of "conservation and utilization of resources" and has since played an active role in identifying sources which could provide sufficient, affordable and inexhaustible energy. [1] The first international conference to address the issue, the United Nations Conference on New Sources of Energy (Rome, 1961) explored alternative energy sources such as solar, geothermal and windpower. Marked by two worldwide energy crises and the ensuing concern over the supply security of conventional energy resources, the 1970s saw intensified discussions on new and renewable sources of energy. These discussions culminated in the United Nations Conference on New and Renewable Sources of Energy (Nairobi, 10-21 August 1981) which adopted the Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy. [2] The application of environmentally sound technologies is also one of the key issues within the accords agreed upon at the United Nations Conference on Environment and Development (UNCED). [3]

2. Reflecting the need for treating energy resources in an integrated manner, the United Nations General Assembly, in its resolution 46/235 (1992) on restructuring and revitalization of the United Nations in the economic, social and related fields, established the Committee on New and Renewable Sources of Energy and on Energy for Development (UNCNRSEED), a body of government-nominated experts. This Committee assumed the mandates of both the Committee on the Development and Use of New and Renewable Sources of Energy and the Committee on Natural Resources pertaining to energy. Its primary objective is to provide policy options and recommendations to the Economic and Social Council on energy matters, including the consideration of their relation to environment and development.

3. It was in this context that the Commission, at its second session (15-24 May 1995), decided to consider energy systems as a possible area for its

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[1] For an exhaustive review of energy-related activities of the United Nations system, see: United Nations (1997), Report of the Secretary-General on an *Inventory of ongoing energy-related programmes and activities of entities within the United Nations system, on coordination of such activities and on arrangements needed to foster the linkage between energy and sustainable development within the system,* United Nations , New York (E/CN.17/1997/7).

[2] The Committee on the Development and Utilization of New and Renewable Sources of Energy (UNCDURSE) was established as an institutional arrangement to follow up on the Nairobi Conference and to monitor the implementation of its Programme of Action.

[3] See, for example: United Nations, Department of Economic and Social Development (1992), *Compendium of excerpts on science and technology related issues and recommendations, extracted from the documents adopted at the United Nations Conference on Environment and Development.* New York (unpublished working document).

future work. To this end, it requested the secretariat to submit to the Commission, at its third session, an issues note on the identification of scientific and technological aspects of sustainable energy systems. According to some members, the emphasis ought to be placed on revolutionary options such as the total energy systems approach. Recognizing the competence of UNCNRSEED in this area, the Commission also requested that the secretariat prepare the note in consultation with UNCNRSEED. The discussion during the second session also suggested that this issue could be a potential area for cooperation between the Commission on Science and Technology for Development and the Commission for Sustainable Development. The intention would be to work jointly on specific aspects of energy development and application that have not been sufficiently dealt with in other bodies of the United Nations system. [4] For the purpose of carrying out the required consultations and also to benefit from inputs by experts in the area of energy, the secretariat organized an informal meeting of experts, including a member of the secretariat of UNCNRSEED. The report of the meeting containing a summary of the discussion and recommendations for future work is given here. The secretariat circulated the report of the meeting among the members of the Commission and the suggestions received concerning both the issues taken up by the experts as well as their proposals for alternative themes for future work in the area of energy are summarized in conference room paper E/CN.16/1997/CRP.1

[4] See: United Nations, Commission on Science and Technology for Development, *Report on the Second Session (15-24 May 1995) (* Economic and Social Council, Official Records, 1995, Supplement No. 11, E/1995/31, E/CN.16/1995/14), p.5 and p. 29.

REPORT OF INFORMAL MEETING ON SCIENTIFIC AND TECHNOLOGICAL ASPECTS OF SUSTAINABLE ENERGY SYSTEMS

4. The Informal Meeting on Scientific and Technological Aspects of Sustainable Energy Systems took place in Geneva on 24 and 25 October 1996. It comprised two Commission members [5], a member from the secretariat of UNCNRSEED and two independent experts, one from the private sector and one from academia (the agenda and list of participants are given in the annex to the report.) There was a frank and constructive exchange of views on all the aspects of the energy question. The report focuses on those issues on which there was a general understanding as to their importance or relevance for consideration by the Commission. The substantive proposals for future work by the Commission on Science and Technology for Development are intended to stimulate the discussion at the third session.

A. Recognition of the problem

5. There was general agreement that energy trends in developed countries suggest a relatively weaker relationship between GDP and energy consumption. This, however, remains relatively stronger in developing countries where energy demand for satisfying basic needs and production requirements is rising. It was considered that the relationship between electricity and development might even be stronger.

6. With the threat of imminent depletion of fossil fuel having been largely discounted during the past few years, environmental considerations have become of increasing importance in the search for alternate energy sources. Carbon dioxide build-up at the global level and the dwindling forest cover at the local and regional levels are of particular concern.

7. Whereas the development and utilization of clean energy sources and technologies are imperative for all countries, access to sufficient energy is a precondition to economic development and global integration for most developing countries. The international community, therefore, is facing the twofold challenge of having to satisfy the rising needs for affordable energy systems among developing countries and, at the same time, to reduce its excessive dependence on fossil fuels. It was generally agreed that there is a broad range of technological options which, either singly or collectively, have the potential to deal in large measure with this challenge. Foremost among these options are the considerable potential for energy efficiency improvements in the conversion, transport and storage of energy as well as in its final use [6], and the broad range of new and emerging

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[5] During its second meeting, the Bureau of the Commission requested one member of the Commission, Mr. Niels Busch, to work with the secretariat in preparing the issues note.

[6] While the potential for efficiency improvements in developing countries, often at low investment cost, is considerable, the group's feeling was that energy consumption in industrialized countries could be further optimized through programmes designed to reduce wasteful consumption: first, because it is in industrialized

technologies for delivering energy, including solar, wind, ocean-thermal, ocean-tidal, geothermal, biomass and hydrogen, that is scientifically proven, technologically viable, socially acceptable and environmentally less damaging [7].

8. Given the different stages of development of these technologies and the state of the world economy which is characterized by low energy prices and limited financial resources, the challenge is to translate this potential into reality. The main issues discussed can be clustered around the following general concerns.

B. Making alternative energy sources competitive

9. There was general agreement in the Informal Meeting that the competitiveness of emerging technologies is not determined by scientific and technological factors alone. Competitiveness, being a relative concept, depends on the cost/price of the technologies/sources that are being substituted. As long as market prices of energy sources do not reflect total costs, particularly those related to environmental impacts, most new technologies, even those that are already commercially available, will remain uncompetitive. Removing subsidies applied to conventional energy technologies [8] and internalizing the cost of environmental impacts would be one way of greatly enhancing the competitiveness of commercially available alternative technologies. However, this would have -- from a developmental point of view -- the problematic, albeit temporary, effect of raising energy prices. Positive action in favour of diffusion of alternative energy technologies would be another way.

10. For technologies not yet fully commercially available, technological factors would be more or less important. Those technologies which have already moved out of the scientific laboratories and past the technological workshop might still need to be adapted to actual working and climatic conditions. Mechanical and structural adjustments might be needed, for

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countries that most R&D takes place and new processes and products are developed; and secondly, in view of the high energy consumption of the industrialized countries, small improvements in energy efficiency have a large impact on global consumption.

[7] For a description of the various options see Johansson T. B., Williams R.H., Ishitani H. and J. A. Edmonds (1996) "Options for reducing Co_2 emissions from the energy supply sector" in *Energy Policy,* Vol. 24 pp. 985-1003; and IPCC(1996) *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-technical Analyses: Contribution of Workin* g *Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change* , New York.

[8] Annual subsidies on conventional energy sources/technologies are estimated to total more than US$ 300 billion. These subsidies involve tax exemptions, financial support, price support etc. in the production and use of conventional energy. A. Shah, (1994), "Energy pricing and taxation options for combatting the greenhouse effect" in *Climate Change: Policy Instruments and Their Implications,* Proceedings of the Tsukuba Workshop on IPCC Working Group II, 17-20 January; OECD (Organization for Economic Cooperation and Development) (1992), *The Economic Cost of Reducing Co_2 Emissions,* OECD Economic Studies Special Report No. 19 OECD, Paris. For examples of types of subsidies provided by some OECD countries, see IEA(International Energy Agency) (1993), *Taxing Energy: Why and How,* OECD, Paris.)

which further investments may be required. For example, modern electricity-producing windmills, which have been in use for some time now, continue to experience problems, including structural ones. There is also the problem of by-products, such as sulphuric acid from photovoltaics, for which proper disposal could be costly. Like all new technologies, novel energy technologies have to undergo a period of adaptation before they can become technologically viable and readily adaptable. It is only after these initial problems are resolved that such technologies can be mass-produced and thus become commercially competitive with conventional sources. The slow progress in the R&D and commercialization of technologies may also be attributed partly to the low pricing of conventional sources. The role of the private sector at the pre-competitive stage of development is critical and private firms, which are under strong pressure for rapid return on investments, are unlikely to invest in these technologies if they perceive that benefits are distant.

11. Regarding technologies that are still at the stage of scientific research and for the development of which government plays a greater role, it was pointed out that investment in R&D has been declining in the 1990s. [9]

12. The experts felt that, in view of the fact that the costing and pricing of energy sources/technologies is a dynamic process, decisions on optimal systems ought to be based on maximization of net present value. [10] Costs of present and alternate energy systems need to be compared. A new energy source would replace an old one only if the new alternative is economically viable. Energy alternatives could become attractive as their costs decline as a result of economies of scale and as the *real* costs of traditional energy technologies are reflected in their price as, for example, through carbon taxes.

C. How to increase the share of alternative sources of energy in the energy systems

[9] Aggregate government R&D expenditure of IEA countries has declined, in real terms, by 21 per cent between 1985 and 1995. The decline has been observed in the individual expenditures of most countries. See OECD/IEA (1996), *Energy Policies of IEA Countries: 1996 Review* , OECD/IEA, Paris. One could argue that, in view of the liberalization of most economies, the decline in public expenditures has been compensated by increased investment by the private sector. It was felt that this, however, has not been the case.

[10] Money now is worth more than money in the future, because it can be invested to produce a greater sum of money in the future. For example, US$105 in a year's time has a present value of US$100, if the interest rate is 5 per cent. Thus, the net present value of an investment is the difference between the capital cost of the investment and the present value of the future cash flows to which the investment will give rise.

13. The experts felt that increasing the application of renewable sources of energy would better help to diversify energy systems than is possible with current patterns of energy production and consumption. [11]

14. As a general principle, however, it was agreed that there was no single solution to the energy dilemma. Thus, conventional energy sources will be continue to be used even in the medium and the long term. The application of sustainable energy systems is not just a matter of ptimary concerning developing countries; it is a task of global responsibility. Considering that the use of energy is one of the main factors contributing to global environmental degradation, the adoption and application of environmentally sound energy technologies require concerted action on the part of the entire global community. Strategies on how to pursue available options were the major thrust of the discussion during the meeting and are summarized below.

(i) *The need for removing institutional, policy and financial constraints*

15. This includes the building of capabilities to use sustainable energy technologies on a global basis. It requires enhancing scientific and technological capacity in diverse fields such as, *inter alia,* energy use, adaptation, maintenance, organization, information dissemination, management. Acquiring adequate equipment to measure the effective use of energy along with quality control systems will be needed, particularly in developing countries. Furthermore, the level of technological capacities of recipient countries is a determining factor in decision-making, since it affects not only the level and type of technology but also its cost in terms of installation and maintenance.

16. General awareness of adverse environmental consequences needs to be enhanced. There is also a need for training energy specialists to take a systems approach to meeting energy requirements.

(ii) *Overcoming bottlenecks*

17. The process described above will not be automatic. It requires the allocation of financial resources, the development of technical and scientific skills to improve the efficiency of existing systems and correction of infrastructural problems. These have to be assessed on a national level. Economies in transition often cope with a rigid and heavy infrastructure that does not provide for efficient use of existing energy systems. Least developed countries, on the other hand, face the challenge of small ageing power plants, obsolete urban electricity grids or inadequate distribution networks in rural areas; all these factors raise the cost of delivered energy. Thus, resolving problems related to energy storage, distribution and/or transportation are important elements in harnessing available energy resources to meet rising requirements.

(iii) *The need for differentiated solutions*

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[11] While no energy sources or technologies were *a priori* excluded, the discussion focused on renewable energy sources/systems as sustainable alternatives to fossil fuels. Thus, nuclear energy and large-scale hydro-power projects, which have been under broad criticism over many years, were not specifically addressed by the experts.

18. Changing energy systems is a complex task that often requires changes in the entire economic structure of a community. For example, in economies in transition, local communities often survive economically because of existing, albeit inefficient, energy systems. Even when a new and profitable energy system is commercially available, considerable difficulties, ranging from sub-optimal use of resources to socio-political factors, need to be overcome. The fast growth of energy demand combined with financial constraints can lead some countries to continue using or even to select energy systems that are neither cost effective nor environmentally benign simply because better alternatives are not readily available. Thus, energy solutions should be differentiated according to individual country needs and possibilities and should consider factors such as geographical situation, level of development etc. An energy system that is appropriate for one country at a certain stage of development may not be right for another. A right mix of energy should be found for each country.

(iv) *The need for increased flexibility and integration of multiple energy systems*

19. Given the increasing availability of new energy systems, it is hard to predict which energy form will ultimately be dominant, most efficient, profitable and also environmentally benign. Therefore, a flexible approach is needed that allows for different options to be pursued rather than embarking on large-scale projects that may require huge investments but may not be viable economically, ecologically and socially in a few years' time. Energy systems that can be adjusted relatively easily to changing market conditions might be the most cost-effective approach to meeting energy demand in the present situation. Integrated systems consisting of both conventional and alternate energy options offer more possibilities for adjustment to new technological developments. They allow the mix of primary energy sources, the combination of centralized and decentralized systems, and can be kept relatively small. Moreover, they can be linked effectively to other systems such as water management and parts of the food sector. Investment costs for integrated systems, however, remain high since they are based on complex installations while, on the other hand, their operating costs are often low. However, studies of energy systems that cope successfully with interlinked networks of different energy sources have been reported in the literature.

(v) *The need for an energy policy*

20. Most OECD countries have *de facto* energy policies. [12] Similarly, economies in transition and most developing countries have made considerable investments in the development of national energy infrastructures and the formulation of national energy strategies. The sustainability of energy systems became the focus of concern worldwide when world crude oil prices spiralled upwards during the 1970s and early 1980s. This interest resulted in significant energy savings and improvements in the efficiency of energy use. However, more recently, interest in new energy technologies, and in energy more generally, seems to have waned in

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[12] One expert expressed doubts about the extent tto which this assertion applied to the United States where he felt that policies were reduced to certain regulatory functions rather than to a conscious energy development strategy.

many countries as concerns about supply security and costs are no longer as strong as they were during, and immediately after, the energy crises of the 1970s. Yet, as the discussion showed, there are important technological and economic issues which call for coherent energy policies both at the national and international levels. The availability, cost and diffusion of sustainable energy technologies will depend strongly on policy, including on energy-costing policy that allows environmental impacts to be reflected in pricing structures. The integration of many different energy systems and the optimization of their size are complex issues which also need to be addressed by policy.

D. Potential areas of work by the CSTD

21. The discussions in the previous sections point to the crucial role of policy in providing incentives, raising awareness and developing appropriate infrastructures. In order to formulate policy in a technologically and economically dynamic environment, continued monitoring and analysis at the national and also the international level are needed. The globalization of environmental concerns, the growing linkages among different energy systems and the increasing variety of traded energy forms and technologies open up more possibilities for, as well as necessitate new forms of, international cooperation in this area. By focusing its work on energy and sustainable development, the CSTD can contribute to these objectives.

22. The experts identified a number of areas where further work is needed, which the CSTD may wish to consider. These include the following:

(a) Reviewing current R&D on energy and analysing it from the point of view of its contribution to developing environmentally safe/sound, and economically equitable, energy paths, paying particular attention to the needs of developing countries;

(b) Exploring the broad set of innovative possibilities available through integrated and flexible systems that link traditional and alternate energy options and examining their relevance for developing countries. These possibilities have not been investigated thoroughly. Here, new ground could be broken by the Commission. This work should be complemented by demonstration activities and technological capability-building activities in energy management, especially in the area of efficiency improvements;

(c) Addressing infrastructural problems of countries having structures that need wide-ranging adjustments as well as of those where infrastructures have not yet been developed;

(d) Reviewing national experiences with energy policy-making;

(e) Identifying and analysing energy issues relating to specific sectors such as *the transportation sector.* The experts considered that this is a sector where improvements could contribute the most to reducing the stresses on the environment and to a more efficient use of energy. It was felt that the CSTD should address the issues of transportation systems rather than energy use by specific transportation means;

(f) Identifying and analysing energy issues relating to specific energy sources such as *modern biomass technologies,* which are attracting considerable attention for their potential of providing significant amounts of renewable energy. It is important to evaluate the magnitude of this potential and to dispel fallacies surrounding it. There is also a need to address biomass management at the global level.

ANNEX

INFORMAL MEETING ON SCIENTIFIC AND TECHNOLOGICAL ASPECTS
OF SUSTAINABLE ENERGY SYSTEMS
(Geneva, 24 and 25 October 1996)

Annotated Agenda

Item 1: Introductory statements

The Chief of the Innovation and Investment Policies Branch will open the meeting, followed by brief presentations by Mr. Busch, member of the Commission on Science and Technology for Development (CSTD), and by the secretariat, on the mandate of the Commission, the objectives of the report to be prepared and the task of the present Expert Group. At this point, Mr. Shane, member of the secretariat of the Committee on New and Renewable Sources of Energy and on Energy for Development, will brief the Group about the Committee's work programme and activities.

Item 2: General discussion

- The conceptualization of sustainable energy systems:
  - current thinking on this issue;
  - energy and development nexus;
  - the energy dilemma: the gap between the current energy consumption patterns and the unsustainability of current pattern of supply;
  - criteria of sustainability.

Item 3: Supply-side issues

- Scientific and technological aspects of primary energy supply and energy transformation:
  - the role of technology in making primary energy production environmentally friendly;
  - technology and the development of new sources of energy;
  - technological solutions to the energy dilemma: scenarios for the 21st century;
  - the special case of electricity.

Item 4: Demand-side issues

- Scientific and technological aspects:
  - in improving the efficiency of energy use as a means of attaining sustainable energy systems;
  - in reducing environmental impacts of improved energy use.

Item 5: Infrastructure requirements and policy issues

- Infrastructure requirements as a determinant of sustainable energy systems:

  - interconnected systems;
  - decentralized systems.

- Energy-related technological infrastructure:

  - the capacity to upgrade technologies;
  - the capacity to acquire, adapt, effectively use and modify imported technologies;
  - the capacity to undertake R&D and diffuse new technologies;

- Policy-related issues:

  - the need for national energy policy;
  - international cooperation in promoting sustainable energy systems: effective ways of addressing issues such as proprietary rights, financing schemes and joint development and transfer of technologies.

Item 6: Identification of main elements for the report: synthesis of discussion covered under items 2-5

List of participants

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(Geneva, 24 and 25 October 1996)

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