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PREPARATORY COMMITTEE FOR THE
UNITED NATIONS CONFERENCE ON NEW
AND RENEWABLE SOURCES OF ENERGY
Third session
30 March - 17 April 1981
Item 2 of the provisional agenda

REPORT OF THE SYNTHESIS GROUP

81-06501

CONTENTS

PART I. ORGANIZATIONAL MATTERS

A. Opening of the session

1. In accordance with decisions 2(II) and 3(II) of the Preparatory Committee for the United Nations Conference on New and Renewable Sources of Energy,[1] and taking into consideration paragraph 15 of General Assembly resolution 35/204 of 16 December 1980, the Synthesis Group met at United Nations Headquarters from 17 to 27 February 1981.

2. The session was opened by the Secretary-General of the United Nations Conference on New and Renewable Sources of Energy. In addition, the Chairman of the Preparatory Committee for the Conference addressed the opening meeting.

B. Membership and attendance

3. The session was attended by the members of the Synthesis Group, who had been invited by the Secretary-General of the Conference to attend in their capacity as individual experts, and by representatives of various concerned United Nations bodies and specialized agencies, as well as by observers from other intergovernmental and nongovernmental organizations. For the list of participants, see annex I to the present report.

C. Election of officers

4. At the opening meeting, the Synthesis Group elected the following officers:

Chairman:	L. JAYAWARDENA (Sri Lanka)
Vice-Chairmen:	I. CISSE (Senegal)
	C. THAM (Sweden)
Rapporteurs:	W. CHARTERS (Australia)
	F. DAGHESTANI (Jordan)

D. Adoption of the agenda

5. The Synthesis Group considered and adopted the following draft provisional agenda (SYN/I/1):

1. Opening of the session

2. Election of officers

1/ A/35/43 (part II), Chap. VII.

3. Adoption of the agenda and organization of work

4. Development and utilization of new and renewable sources of energy with a view to contributing to meeting future over-all energy requirements, especially those of developing countries.

5. Assessment of the potential for the exploration, development and utilization of new and renewable sources of energy:

   (a) Technologies currently available and prospects for the future
   (b) Comparative technical and economic analysis of these technologies
   (c) Potential for the utilization of new and renewable sources of energy;
   (d) Social and environmental considerations.

6. Identification of measures necessary for the exploration, development and utilization of new and renewable sources of energy with regard to:

   (a) Financing
   (b) Information flows
   (c) Research and development and transfer of technology
   (d) Education and training
   (e) Others.

7. Sectoral issues related to the exploration, development and utilization of new and renewable sources of energy:

   (a) Rural energy, including the utilization of energy in agriculture;
   (b) Industrial issues, including the utilization of energy in transportation and allied sectors;
   (c) Others.

8. Recommendations to promote the development and utilization of new and renewable sources of energy

9. Adoption of the report.

E. Documentation

6. As requested in decision 2(II) of the Preparatory Committee, the Synthesis Group based its work on the reports of the eight Technical Panels and six Ad Hoc Groups of Experts which had been established by the Secretary-General to assist in the preparations for the United Nations Conference on New and Renewable Sources of Energy[2/] and which had met during the preceding months. The Group also had before it a draft

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2/ See resolution 2(II) of the Preparatory Committee for the United Nations Conference on New and Renewable Sources of Energy.

version of the synthesis of the reports of the Technical Panels[3/], which had been prepared by the secretariat for submission to the Preparatory Committee, and a draft synthesis document of 16 February 1981 (non-symbol document) which had been prepared by the secretariat as the basic working document for the Synthesis Group. For a list of the documents before the Synthesis Group, see annex II to the present report.

F. Opening statements

7. In his introductory statement, the Secretary-General of the Conference thanked the participants for their willingness to assist in the preparations for the Conference. He recalled that much work had been accomplished in recent months in preparation for the Conference, which dealt with a subject currently of fundamental concern to all Governments. He noted that during the past decade it had become generally recognized that conventional energy resources were being rapidly depleted; that the relatively brief period of cheap energy had come to an end; and that energy problems threatened to place a particularly severe burden on developing countries, especially on the traditional sectors of their economies.

8. The Secretary-General noted that the decision to convene the Conference, contained in General Assembly resolution 33/148 of 20 December 1978, was one of several initiatives taken by the United Nations in recent years to consider the many implications of future energy supply and use throughout the world, and the need for a transition to new energy patterns. He stated that while the transition was both essential and practicable, it would be more complex than similar changes in the past and would take different forms in different countries. Everywhere, however, greater efficiency in the use of energy was essential.

9. While emphasizing that one of the major tasks of the Conference was therefore to examine the nature of the transition to new energy patterns, the Secretary-General noted that the problems and needs of developing countries required equal consideration. Energy policy had to be considered as an integral part of national development strategies, which meant that energy policy might become more of a driving force for development than it had been in the past. In his view, the Conference was likely to concentrate on five major tasks: (a) increasing general awareness and understanding of the need for a global energy transition; (b) increasing knowledge of the energy resources, technologies and strategies available to national Governments; (c) definition of short-term needs (especially those related to the fuelwood crisis in developing countries) and long-term research and development on new and renewable sources of energy; (4) stimulation of international co-operation in the transfer of new technologies; (5) promotion of a major co-ordinated response by the United Nations system. In conclusion, he stated that the work of the Synthesis Group should provide a solid foundation for the Conference in all those areas.

3/ To be issued as A/CONF.100/PC/42.

10. The Chairman of the Preparatory Committee for the Conference then addressed the group. He emphasized that the Conference would be the first major intergovernmental conference dealing with the technical, scientific, economic and political aspects relating to the field of new and renewable sources of energy. He stated that it would be necessary for the Conference to adopt a concrete programme of action which would guide the international community, particularly for the benefit of developing countries which were not blessed with conventional energy sources.

11. In describing the recent and future activities of the Preparatory Committee the Chairman recalled that the second session of the Committee had identified specific points to be addressed in the final reports of the Technical Panels; similarly the Committee had defined six specific sets of issues to be taken up by the Ad Hoc Groups of Experts. He indicated that preparations were now at a transition stage, and that the Synthesis Group provided a bridge between the technical and other detailed preparatory investigation that had been undertaken. He stated that the recommendations or findings of the Synthesis Group would have a very considerable influence on the future course of deliberations on the programme of action at the third and fourth sessions of the Preparatory Committee. He believed that the Committee was expecting the Synthesis Group to provide some ideas on what should be the most important elements of the programme of action, paying special attention to the needs and goals of developing countries in the short, medium and long terms. In conclusion, the Chairman stressed that the Conference would be an important test of the ability of the United Nations to contribute to the solution of a vitally important problem that was universal in character.

G. Review of the draft synthesis document

12. The draft synthesis document of 16 February 1981 (non-symbol document) was briefly introduced by the Deputy Secretary-General of the Conference, who explained that it represented an abbreviated synthesis of the reports from the Technical Panels, Ad Hoc Groups of Experts, and consultants (see annex II to the present report). It was pointed out that all those reports would go forward as individual documents to the Preparatory Committee and the Conference. A separate, and more detailed, summary of the work of the Technical Panels had been prepared for the Preparatory Committee by the secretariat and draft copies of that summary had been made available to the Synthesis Group for its information.4/ The Draft Synthesis Document was to be regarded only as a working paper for the Synthesis Group; the Group should alter or restructure it to whatever extent was appropriate.

13. During a first reading of the document in plenary, many general and specific comments and suggestions were made by the Synthesis Group concerning proposed improvements. It was therefore agreed that the members of the Synthesis Group should revise the document in two drafting groups. At the request of the Chairman, C. Tham (Vice-chairman), assisted by W. Charters (Rapporteur), acted as convenor of the drafting group concerned with chapters

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4/ To be issued as A/CONF.100/PC/42.

I and II of the draft synthesis document. I. Cissé (Vice-chairman) and F. Daghestani (Rapporteur) acted in similar capacities for the drafting group that revised chapters III and IV. Both groups worked on an open-ended basis, and observers and representatives participating in the meeting were invited to contribute to the work of the drafting groups. After the drafting groups had completed their work, the Draft Synthesis Document was again considered in plenary in its revised form. Further improvements were suggested, and it was agreed that the members of the Synthesis Group should submit written proposals to the Rapporteurs, who would take responsibility for incorporating them into the document, as appropriate.

H. Conclusions

14. During its discussion of the draft synthesis document of 16 February 1981, in the form prepared by the secretariat, the Synthesis Group noted that it would be necessary to complete the document by adding a final chapter (chap. V, corresponding to item 8 of the agenda of the Synthesis Group). The Chairman introduced the discussion of this topic by circulating an informal paper containing proposals on the list of topics that should be included in that chapter. The Synthesis Group agreed that the informal paper provided a suitable basis for its work, and an open-ended drafting group was constituted, under the leadership of the Chairman, to prepare a draft chapter.

15. After the drafting group had completed its task, the draft of chapter V was considered in plenary. It was agreed that both the form and content of the draft required improvements. Members of the Synthesis Group agreed to provide the Rapporteurs with written proposals for changes. Representatives and observers were also invited to submit suggestions. The Rapporteurs were requested to make any necessary stylistic improvements.

16. Following the revisions, chapters I to V of the draft synthesis report of 16 February 1981 were considered and accepted by the Synthesis Group. The Group agreed that those chapters should be incorporated in the report of the meeting, together with appendices to chapters II and V. The Synthesis Group decided to append several pages extracted from the reports of the Technical Panels and Ad Hoc Groups which contain recommendations of those meetings; by attaching the pages as an Appendix, the Synthesis Group should not appear to be endorsing the recommendations.

I. Adoption of the report

17. The report of the Synthesis Group, as amended, was adopted on 27 February 1981.

PART II. SYNTHESIS REPORT

CHAPTER I. BACKGROUND AND INTRODUCTION

Why a Conference on "New and Renewable" Sources of Energy?

18. In the two decades since the United Nations convened in Rome a conference on new sources of energy, immense changes have taken place in the supply of energy, its use and future prospects. In 1961, it was considered desirable to explore the "state-of-the-art" with respect to sources of energy that could be alternatives to oil. It was clear that, at some time in the future, the rapid growth in world oil consumption would have to slow down; exponential growth could not be sustained indefinitely. Oil had grown from an insignificant source at the beginning of the century to account for about half the world's energy consumption by the mid-1970s. Its convenience in terms of use, transport and transformation, the low cost of its extraction, as well as the illusion of an apparently infinite supply, led to a shift to oil that was historically unprecedented in its speed and magnitude.

19. Before the decade of the 1970s was over, it was evident that drastic changes were taking place and that alternatives to petroleum-based fuels would have to be considered as a matter of great urgency. It soon became apparent that the rate of increase in oil consumption would have to slow down significantly, and that oil is likely to reach its peak as the dominant global energy source before the year 2000. The world community will, sooner than previously visualized, have to make a relatively rapid transition to radically new energy mixes. This means higher energy prices, environmental problems of different kinds, a major change in energy use, and development of new energy sources, conventional and non-conventional alike.

20. The magnitude of the problem and the degree of urgency can be illustrated as follows:

(a) to cope with the increasing energy bill and scarcity of some conventional energy sources, Governments will need policies of energy conservation and improved energy efficiency, as well as increased investment in non-conventional sources of energy. In spite of this, it is foreseen that oil will remain an important component in the energy balance of all countries until beyond the year 2000.

(b) To achieve their economic development targets, developing countries will need an increasing share of the world energy supply , including oil. Commercial energy use in the next two decades is expected to grow by a factor of 1.3 in developed countries. If reasonable levels of economic growth are to be achieved, energy consumption in developing countries will have to grow by a factor of about 3 at least.

21. The impact of energy prices on the economies of developed countries is severe, but the problems for lower income developing countries are even more severe. In their attempts to expand their own commercial energy supplies, the following factors are important:

(a) Lack of investment capacity to develop their own conventional resources, or the unavailability of such resources in many countries, have strongly increased the dependence of developing countries on imported energy. This dependence will continue unless renewed efforts are made to expand their energy from both conventional and non-conventional sources. In the interim period the deep imbalances and economic agonies, that already characterize for many countries the transition process to a more realistic energy situation, are likely to intensify in the absence of international action in economic and financial areas to provide adequate long term financial support to facilitate the process of adjustment. Without this, the world economy faces the prospect of an intensification of world recession affecting developed and developing countries alike.

(b) The export earnings of the lower income developing countries have not expanded commensurately with their energy import requirements, or with the impact of inflation on their balance of payments. Moreover, in present world circumstances, and given the very great imbalance between the large oil import needs of all countries and the relatively limited import needs of some major oil-exporting countries, there seems to be little likelihood that this problem can be solved simply by resorting to the expansion of exports to third markets, to more borrowing or by even more reliance on official development assistance (ODA). The dependence of these countries will continue to grow together with greater world economic imbalances, unless great efforts are made, along new energy paths, to expand their indigenous energy supplies from both conventional and non-conventional sources.

22. The energy problems of many developing countries centre on their great dependence on draught animal power and fuelwood. These are estimated to account for about 10 per cent of total world energy consumption but, more important, they are the primary energy resources for the rural sectors of developing countries in which close to half of mankind lives. Due to the general increasing reliance on oil there has been little effort made to improve the efficiency in production and end use of traditional renewable sources of energy, such as wood, agricultural and animal residues, or animal and human muscle power. Increased energy demands, together with the difficulties of shifting to commercial fuels, have resulted in the rapid degradation and depletion of natural resources such as forest vegetation for fuelwood requirements. This, along with the inefficient and inappropriate use of crop and animal residues, and draught animal power, has aggravated the situation. There is, fortunately, ample scope for improving the supply and use of traditional renewable sources of energy which are at present not fully utilised for the benefit of the rural poor who have little or no access to other energy sources for their welfare and future development.

23. There is a manifest common interest to set in motion a series of measures which will enable all countries to assure the necessary energy supply for their development needs over the next few decades and possibly to move towards a greater degree of energy self-sufficiency . This is especially true of the least developed countries. In order to counter the increased pressures that might follow if the world continues to rely on the prevailing structures of energy supply, adequate measures should be devised to identify and develop alternative major energy sources. Thus far, neither national policy formulation nor international co-operative efforts have been adequate to bring about the global changes required; planning, financing, priority-setting, popular acceptance and consultation all take time, and policy decisions are therefore urgently required to bring into use alternative sources of energy. Fortunately, many of these sources because of their decentralized nature are readily applicable to the rural areas where half of the world's population still lives.

24. In this context, the major challenge for mankind in years to come will be to implement a coherent series of policies at national, regional and world levels during a transitional period of time, aimed at moving from the present energy limited basis to a more sustainable and diversified structure of energy demand and supply. The transition period is obviously critical, and all the more so for developing countries. Over the longer term, without sacrificing the development objectives of both the developing and developed countries, the challenge is to accelerate the shift from oil to other energy sources. This will take a few decades, and will involve very profound structural changes on a global scale. It is, however, highly probable that many of these changes will be eventually beneficial, bringing about a better balance among regions and within groups of countries at different levels of development. Developed and developing non-oil producers as well as oil exporters have a common, convergent interest in making this shift as rapidly, orderly and equitably as possible, to ensure a better and more balanced world economy with fewer tensions and a greater propensity for peaceful relations and a better balance of world trade.

25. These are among the considerations leading to the decision by the United Nations General Assembly in 1978 to convene the Conference on New and Renewable Sources of Energy which will take place at Nairobi in August 1981. It is hoped that the Conference, in meeting the objective established for it in General Assembly resolution 33/148, will provide a forum for analysis and for generating, within a long-term perspective, action proposals to increase the contribution of new and reneable energy sources and related energy technologies, while responding to the problems relating to the escalating costs of commercial energy and to the fuelwood crisis. It is the purpose of this report to lay a realistic foundation for the programme of action to be considered by the Conference.

CHAPTER II. TECHNOLOGICAL AND ECONOMIC PROSPECTS

A. Introduction

26. The uncertainties associated with the supply of conventional energy sources have highlighted the need for diversification and prompted increased research world wide into sources which are potential alternatives. Any assessment of the future role of new and renewable sources of energy must be based on a mixture of known facts and reasonable assumptions. The technical panels, composed of experts on different forms of new and renewable sources of energy, have endeavoured to make reasonable judgements concerning the technologies likely to be significant within the next two decades. Although the panels could feel quite confident about statements of fact regarding "mature" technologies, an element of doubt necessarily enters with respect to technologies which have been demonstrated only on the basis of a few pilot projects. There is still more doubt about estimates of the start-up or manufacturing costs, and the life-cycle costs, of these demonstrated technologies. Inevitably, the judgements of the technical panels had to be even more tentative in regard to unproven technologies, both with respect to purely technical aspects and even more so in regard to cost economics and the prospects for their actual use in competition with other sources of energy.

27. Nonetheless, it is essential to make some assessment and evaluation of technologies from a technical perspective taking into account comparative costs and market penetration problems and prospects.5/ Together with these evaluations in this chapter attempts are made to classify the principal technologies and to identify the principal application areas for the emerging technologies. The complete list of these technologies will be found in the Appendix to this chapter. References to specific technologies in this chapter are for purposes of illustration only; several other technologies described in the Appendix may have similar characteristics, including readiness for immediate use. So far as possible technologies that, in the opinion of the technical panels, will not have a significant impact before the year 2000 are not discussed in this chapter, or are mentioned only briefly.

5/ In making these comparisons, it is essential to use units of measurement that enable a realistic appraisal of the energy contributions of different technologies. The basic unit for measuring energy is the joule (J); among the frequently-used multiples of the joule are the kilojoule (kJ or 1000J), megajoule (MJ or 10^6J) and gigajoule (GJ or 10^9J). Although heat energy is normally measured in joules, the energy content of liquid fuels is also frequently indicated in metric tonnes of oil equivalent (toe), where 1 toe is approximately equivalent to 40GJ or 7 bbl. Similarly, electrical or mechanical energy is usually measured in kilowatt hours (kWh), where 1 kWh = 3.6MJ.

B. Factors in technology evaluation

(1) Interchangeability of energy sources

28. Existing and new energy demands can be satisfied in many forms. Although it is generally feasible to convert available energy into a variety of forms each conversion process involves a degradation of the original energy and there is often a corresponding economic cost associated with these conversion processes. For the purpose of these evaluations a decision has been made to assess each potential energy source in the light of the prospective end use as this may well dictate the form in which the energy is finally used. For particular regions the preferred energy mix may well result from discrete energy policy decisions taken in conjunction with the local energy supply/demand situation.

29. Liquid transport fuels. Liquid fuels can usually be substituted one for another. For example, synthetic crude oil from tar sands or from oil shale can be used in place of conventional crude oil. Ethanol, methanol and vegetable oils can substitute for refined petroleum products such as gasolene and diesel oil.

30. Central electric power. (Greater than 1 MW) Central electric power is supplied to end-users through a distribution grid. Such grids cover most of the developed countries and urban-industrial areas of developing countries, but are sparse in rural areas especially in developing countries. The supply to the grid can come from many sources, the most important being fossil fuel or nuclear thermal power stations or hydropower stations, and new and renewable sources of energy can potentially be substituted indirectly in the form of fuel (biomass or peat); fuel substitute (solar energy, ocean thermal energy conversion) or directly as energy (e.g. from wind turbines).

31. Decentralised electric or shaft power. (Less than 1 MW) Small engines are widely used in all countries, especially for automotive purposes. In rural and remote areas not reached by the electric power grid they take on a special importance, since they are the only sources of mechanical energy other than draught animal power which is possibly the most important single power source in rural areas with the additional advantage of providing agricultural fertilizer. The fuel for such engines can come from conventional or new sources, and the engines themselves may be a substitute for draught animal power (or vice versa). The upper limit of 1 MW for this classification is rather arbitrary, since there is considerable technological overlap between small and large systems.

32. Heating and cooling for habitat; process heat for agriculture and industry. Heat is in effect the lowest quality of energy; in some cases the waste heat normally produced in the generation of mechanical and electrical energy can be utilized as process heat, and this can represent an important source of usable heat energy. This combined process is called cogeneration. Although higher temperature forms of heat are readily substituted for lower temperature forms, the converse is not true. Fuels can normally be used to produce heat at any normal required temperature

but some other heat sources such as solar and geothermal heat may be restricted in their upper temperature limit, so that they are substitutable mainly in low temperature end-uses (e.g. up to 150°C.)

33. Fuelwood and biomass for domestic cooking and heating. While domestic cooking and heating needs can in principle be met by heat from various sources of energy in the rural areas of many developing countries, the possibilities of substituting for combustible biomass (including fuelwood and its derivative charcoal, and animal and crop residues) are severely limited in practice. This problem justifies a separate consideration of fuelwood and biomass for domestic cooking and heating.

(2) Site specificity

34. As with some conventional energy sources such as brown coal, most new and renewable sources of energy are, to varying degrees, site specific. Large scale production of liquid fuels, for example, requires the availability of a nearby tar sands, oil shale, or biomass resource, although synthetic liquid fuels can subsequently be transported to a demand centre by tanker, pipeline, rail or road. Most of the new and renewable sources used for electric power generation are similarly restricted in terms of power generation. Oil shale, peat and biomass for direct combustion are low energy content fuels and power stations based on them must be located close to the resource. Similarly hydropower, geothermal power, and ocean thermal energy conversion (OTEC) are highly site specific although the generated power may be transmitted to the potential demand centre. Draught animal power, in contrast, is normally widely distributed and the by-products, such as manure, may be usefully used locally.

35. The economics of windpower is highly sensitive to average windspeed and hence surveys to locate suitable sites are necessary. Average annual insolation (solar radiation flux) varies by a factor of three between sunny desert regions and cloudy temperate or cloudy equatorial regions. Much of the cost of utilizing solar energy is the materials cost of collectors and storage, and the higher and more regular the insolation, the smaller the system need be to produce a given quantity of energy. Prospects exist for cogeneration at particular sites where a mixed local demand exists.

(3) Technological maturity

36. The new and renewable energy technologies reviewed by the technical panels range from conceptual projects such as solar power satellites, through large scale wave power and other technologies not expected to become economically viable before the year 2000. In this spectrum of development ranging from research and development through to full commercialization, there are a few which may be taken to be completely mature, such as hydropower. The following classification of technologies illustrates the known situation at the beginning of the 1980s. Details are to be found in the Appendix to this chapter.

37. "Mature" technologies. Conventional hydropower and tidal power are typically technologies which are fully mature, although there is only one major tidal power plant in operation. Competent engineering organizations can design and build hydropower projects using equipment and skills readily available on the market, with reasonable assurance that the project will work according to specification and within the design price. Geothermal power plant is commercially available in plant size from 1-110 MW at costs varying from $0.02-0.06/kWh.

38. "Arrested development" technologies. Some formerly mature technologies passed for a time into a state of arrested development. For various reasons (usually the advent of cheap oil or of rural electrification) they stagnated and in some cases now may no longer be available in a form and at a cost suitable for current needs. Small wind-driven pumps, mini hydropower, wood burning steam engines, oil-shale plants, biomass gasifiers and other techniques were widely used in the past. With rising energy costs, improved designs and modern equipment (especially if the the latter can be manufactured locally in developing countries), they are now taking on a new lease of life.

39. Promising technologies. Several technologies are available or becoming available commercially but are still undergoing rapid development that is leading to declining costs and increasing cost-effectiveness. Some forms of biomass conversion technologies (producing ethanol, biogas and producer gas), wind turbines and, most strikingly, solar photovoltaic cells are examples of these trends. Solar cells have been forecast to fall in cost from around $10/W in 1980 to less than $1/W by 1990 at constant dollars, although complete system costs are expected to show a smaller decline from $20-30/W to $3-5/W. These predictions, based on market penetration studies, assume the existence of an expanding market, since a significant proportion of the decline in costs will be achieved through large scale production. However, the expectation of declining costs in the future appears at present to be holding back the buyers needed to expand the market. A number of technologies may be regarded as technically promising and may even already be viable economically; but they still await practical demonstration. Methanol liquid fuel from biomass and OTEC are typically cases where development has already reached the point that an economically viable project will probably be operational within a few years.

40. Research and development technologies. Several other technologies, at various stages of conceptualization, research and development, have been reviewed by the technical panels. Since they are not likely to become economically viable before the year 2000, they are not given further consideration here, although several might deserve continuing support from a long-term perspective.

(4) Scale of production

41. Scale of production may be relevant to new energy technologies in two ways. On the one hand there are those technologies which show marked economies of scale with project size, such as large scale synthetic crude oil production, or large hydropower projects. On the other hand a number

of the new technologies are essentially modular in nature, with only small economies of project scale. In actual use, therefore, they may be well adapted to dispersed siting as decentralized systems. Nevertheless it should be noted that these same technologies may have marked economies of scale as far as equipment production runs are concerned. Examples are photovoltaic cells, solar thermal collectors, biogas digesters, gasifiers and wind turbines.

(5) Energy efficient end-use

42. For all energy technologies there are very great benefits to be derived from looking at the demand side and, whenever appropriate, investing resources in improving the efficiency of energy end-use. In many cases the same level of production or of comfort can be achieved with less energy, and this will usually decrease the cost to the consumer and the social cost of supplying the energy.

43. One example is the introduction of more efficient cooking stoves or charcoal kilns in developing countries. These can reduce the time spent in collecting firewood by rural families and also reduce the rate of deforestation, with its attendant problems of erosion and desertification. Considerations of energy efficiency may also indicate the desirability of substituting draught animal power for fossil-fuel systems in appropriate circumstances. In many developing countries draught animals may be the most economic means of transporting small loads over distances up to about 40 kilometres, and in farming operations for small farms up to four hectares.

44. As another example, high standards of thermal insulation in housing may enable a large percentage of space heating and domestic hot water needs to be supplied by solar energy, even in cold climates such as that of Northern Europe. With more traditional standards of insulation the solar contribution may represent only a minimal percentage of heating needs. This has implications for the decision as to whether to incorporate a solar system, even though its heat output in absolute terms would be the same in both situations. In a well-insulated house, the additional heat required is small and can be provided simply and cheaply; in the other case a more expensive back-up system is required, and the separate solar system may become uneconomic. Other aspects of efficient end use of energy worthy of consideration in specific situations are the utilization of cogeneration for combined power and process heat or the use of district heating schemes.

(6) Resource Base

45. Much improvement can be expected for many of the new and renewable sources of energy through an extended knowledge of the resource base. This general statement applies to sources such as mini-hydro, geothermal, OTEC, peat, and solar but particularly to biomass where both quantitative effects in the form of yields and qualitative effects in the form of new species could lead to substantial increases in over-all production. It is vital to consider the mobilization of the resource as a continuous link from production through conversion to end-use as a unified system.

(7) Fixed charge rates

46. As with conventional energy technologies, many new and renewable energy technologies are capital-intensive. Cost comparisons are therefore critically dependent on the cost of capital, including depreciation. In the comparisons used in this chapter, capital and maintenance costs have been assumed to represent an effective fixed charge rate of 20 percent annually. In practice, however, fixed charges vary widely from country to country and may even vary markedly within one country.

(8) Financial incentives for renewables

47. In some countries an array of financial incentives has been put in place or is under consideration to speed the widespread adoption of renewable energy technologies. Incentives include direct rebates (sometimes very high), and tax benefits. In addition, regulatory powers may be used so that, for example, in the USA owners of renewable sources of electrical energy may now connect to a grid and sell excess power to the local utility at the utility's marginal cost for new power. Where these marginal power costs exceed the total costs of power generation by the renewable system, a clear financial incentive for use of such technologies exists.

C. Relationship to the panel reports

48. Because the many technological applications of new and renewable sources of energy considered by the technical panels have been grouped by principal energy forms, the work of each technical panel is normally represented in more than one place in the preceding discussion. For example, the work of the Biomass Panel is included in no fewer than eleven applications under all four headings; ocean energy, on the other hand, is included only under the heading of central electric power, with three applications. Table I summarizes the analysis in terms of the different technologies.

D. Present and future costs and potential for substitution

49. (a) In the long run, the global price of energy will be determined by the cost of alternative energy forms. For the foreseeable future, however, until these new forms are available in such quantities as to influence world prices the price of conventional fuels will continue to be the principal determinant of world energy prices. Substitution will not reach the point where it seriously affects world energy market conditions until discrete policy decisions are taken to accelerate the introduction of new technologies. During the transitional period, since among the promising new technologies some have costs within or near the reference price ranges, in specific instances there should therefore be significant substitution in coming decades. It is not possible to predict now, however, at what point new technologies will make significant inroads in conventional fuel use. The reduction in demand below historical trend lines brought about by improved energy efficiency could greatly affect the rate of this substitution.

Table 1. New and renewable energy technologies and application

Energy sources	Liquid transport fuels	Centralized electric power	Decentralized power	Heat
1. Solar		Thermal electric Photovoltaic Solar pond	Thermal electric Photovoltaic	Solar passive Solar pond Solar flat plate Evacuated tube Solar cookers Solar concentrators
2. Geothermal		Geothermal electric	Geothermal small power	Geothermal Direct heat
3. Wind			Wind electric	Wind electric Wind shaft
4. Hydropower		Hydropower (including small hydro)	Mini hydro	
5. Biomass	Ethanol Methanol Vegetable oils	Direct combustion	1. Diesel with liquid biofuel 2. Diesel with producer gas 3. Diesel with biogas 4. Direct combustion 5. Fuel cells based on liquid/gas fuel	1. Direct combustion 2. Biogas 3. Producer gas
6. Fuelwood and charcoal		Direct combustion		Direct combustion of wood and charcoal
7. Oil shale and tar sands	Syn-crude	Shale burning		Liquid fuel for cooking
8. Ocean energy		Tidal OTEC Wave	Wave	
9. Peat	Methanol	Direct combustion	1. Direct combustion 2. Gasification	Direct combustion
10. Draught animal			Traction and shaft power	

(b) The availability of competitive alternatives to conventional fuels is essential for the restoration of energy price predictability and supply stability, necessary conditions for a return to world economic equilibrium and higher rates of development for all countries.

(1) Costing Basis

50. The present costs of new and renewable energy sources are indicated in the previous sections and more fully in the Appendix to this chapter, to the extent that they are readily available in a comparable form. Since the viability of alternatives will be determined for some time by future fossil fuel costs, a projection of such costs is helpful in assessing the potential for substitution once alternative forms are readily available.

51. If it is assumed that the price of fossil fuels (both oil and coal) will increase at an average rate of 2.5 per cent[6/] annually above the general inflation rate until the year 2000 (by which time it will have increased by a factor of 1.64) then the reference sources used in the appendix will have in the year 2000 the following costs (in 1980 dollars):

- World market price of crude oil: $10.2/GJ ($410/tonne or $56/barrel)
- electric power: $0.100/kWh (fuel $0.075/kWh and fixed charges $0.025/kWh)[7/]
- small diesel power: $0.30-0.60/kWh
- heat: $10.2/GJ

(2) Technological Prospects

(a) Liquid fuels

52. There will be significant production of synthetic crude oil from oil shale and from tar sands in a few countries. The longer-range development will probably be limited by the restricted number of sites with major

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6/ 2.5 per cent is perhaps the most conservative assumption reasonable. However, it is considered by some that the actual rate of increase will exceed this, and be as much as 10 per cent annually above inflation at least for the coming decade.

7/ In some parts of the world the marginal cost of new power generation facilities is as high as $2500/kW. In such a case, at a 20 per cent fixed charge rate and 70 per cent capacity factor, the levelized busbar cost associated with the capital cost alone would be $0.082/kWh. If the cost of renewable energy is compared with the cost of conventional capacity at the margin, the situation for renewables may be more favourable than implied by the more conservative of the assumptions. However, there is evidence that, even at a lower range of projected costs and oil price increases, renewable sources of electrical energy and fuels can be competitive over the coming two decades with conventional sources in areas of good resource availability. A very detailed study has validated this assertion for the specific case of Hawaii, for instance.

resources. Ethanol and methanol will be produced on a significant scale in a number of countries (including ethanol from non-food biomass). Longer range promise appears to be considerable for both fuels. Vegetable (including hydrocarbon) oil production is only significant as yet on a local scale but if expected progress in high-yielding crops is realized there could be rapid development thereafter.

(b) Central electric power

53. Hydropower, which already makes an important contribution to world power resources, will continue to be the major growth area, particularly in developing countries where the main remaining potential is located. Tidal energy could be employed on a few particularly suitable sites.

54. Present cost goals for commercial solar thermal-electric power systems are in the range of $1100-2500/kW, with a 50 per cent annual capacity factor. This is for systems which incorporate thermal storage, have an overall conversion efficiency of 15-20 percent, and operate in ideal insolation environments. At a fixed charge rate of 20 percent, these figures imply a levelized busbar cost of $0.05 - 0.11/kWh. However, such costs cannot be directly compared to the electricity costs from a system able to provided electricity on demand. The actual economic worth of electrical energy from a variable source such as wind or solar will depend on the characteristics of the integrated utility system in which such units are embedded. In those sunny regions where it is applicable, solar thermal power has a potential for rapid growth if the cost goals can be attained.

55. Solar photovoltaic power is likely to be more costly, because of lower conversion efficiencies, than solar thermal power, in locations where the latter is feasible. However, the greater flexibility of solar photovoltaic power, which can be used in highly decentralized modules and in less sunny regions, will assure an increasing role for it, provided that anticipated cost goals in the production of semiconductor material are met.

56. Wind power, which has cost goals of $0.035-0.045/kWh onshore in locations of at least 5 metres per second average annual wind speed (rather windy sites), and around $0.08/kWh offshore in shallow waters, will start to make a significant contribution in a specific number of locations.

57. OTEC, with cost goals of $0.06-0.12/kWh, has the potential to become significant at specific sites.

58. Geothermal power, which already meets costs in the range of $0.02-0.06/kWh, has a significant potential in several countries.

59. Direct combustion of oil shale, peat and biomass for power will continue to be significant although in certain regions limited by the number of sites where it is cost-effective. It may be that short-rotation forestry and the use of wood wastes will make biomass direct combustion significant in some areas.

c) Decentralized mechanical and electric power

60. For autonomous power the picture is quite favourable to new technologies. If cost goals are reached for solar photovoltaics (as low as $1000/kW peak system cost, corresponding to about $0.13/kWh in an average location with 20 per cent fixed charges), this may become the preferred power source, except perhaps in some locations where slightly lower costs may be obtainable from wind turbines or mini-hydropower.

61. It is important to note that these projected costs assume essentially year-round operation. In practice, load factors are likely to be much lower. For example, an irrigation application may require only 400-800 hours of pumping annually, implying a much higher (10-20 times) cost per unit of useful power. In these situations the diesel generator may continue to enjoy an advantage, since its cost is largely that of fuel which is expended only when the energy is needed. In such circumstances, however, it will prove economical in many areas to use a non-conventional liquid or gaseous fuel. Especially where there is available combustible biomass, the gasifier diesel set may be the power source of choice, subject to the difficult question of reliability. The latter is a serious drawback of diesel systems, and might eventually favour photovoltaic systems if these prove more reliable in service than the diesel.

(d) Heat

62. Finally new surces of energy also show great promise for the supply of heat energy . Various passive and active solar systems will be able to provide low temperature heat energy at well under $10/GJ. Similarly, thermal energy from the direct combustion of biomass and peat, producer gas (based on dry combustible biomass) and from biogas (based on wet biomass, possibly including energy crops such as aquatic vegetation) should all be applicable in appropriate situations at costs below those of fossil fuel alternatives.

E. Fuelwood and biomass for domestic cooking and heating

63. Fuelwood is believed to be the fourth largest contributor to world energy supply after petroleum, coal and natural gas. Close to half the world population, especially those living in the rural and urban areas of developing countries, depends for cooking and heating on firewood, its derivative charcoal, or on agricultural and animal residues. A substantial portion of the fuelwood consumed is not handled commercially and may not be adequately accounted for in normal energy statistics.

64. For this reason it is important to differentiate in a policy sense when dealing with this particular energy form. In many places where population growth and urbanization are rapid, forest resources have been heavily depleted, bringing adverse environmental conseguences as well as a severe shortage of firewood. In semi-arid or mountainous areas in particular, deforestation generates serious problems of erosion, siltation and desertification. The preliminary results of a study of fuelwood supply and needs indicate that about 100 million people in developing countries live in areas where there is already an acute shortage of firewood. About

another 1000 million are able to meet their minimum firewood requirements only by cutting in excess of sustainable supply. Under current trends of population growth, of fuelwood demands and of depletion of tree resources, over 2,300 million rural people in developing countries will need, within two decades, to be provided with large supplies of alternative fuels.

(1) Fuelwood

65. Because large scale substitution of fuelwood by other renewable or non-renewable energy sources is difficult in view of the technical, organizational and socio-cultural difficulties involved, it is essential to promote actively the more efficient production and use of the resource, through the following measures.

(a) Intensification of the productivity of existing fuelwood resources. This less costly and immediate plan should be implemented for natural forests, shrub and waste lands and existing plantations, particularly as it concerns the modified management needs of those areas with respect to fuelwood supply. The active involvement of rural communities in control and management of this resource will commit them to its protection and to a sustained fuelwood production.

(b) Creation of new forest resources. These are required to supply fuelwood either as a main product or as a by-product, particularly in village community woodlots, large scale plantations, or in forestry integrated with agricultural practices. Self-help and externally financed schemes have been carried out successfully in several countries. The potential of familiar and novel species (e.g. fast growing trees, coppicing trees) for fuelwood production should be investigated, especially the planting of certain fast-growing leguminous shrubs on degraded land near villages. This would simultaneously improve soil fertility and stability, produce more fuelwood, and greatly reduce the time and the human and animal power that have to be expended in gathering and hauling.

(c) Pre-processing of fuels, especially the twigs, branches and dried leaves that result from logging operations but are seldom used because of their rapid and different burning rates. Combustion improvement by drying, pressing into bundles, agglomeration and compaction is possible by simple techniques and should be introduced where economically feasible.

(d) Fuelwood distribution organization. Because of the importance of insuring access to continuous supplies, special emphasis should be placed on adequate transport and communication facilities especially for more distant sources, the implications of legal restrictions on access to forest lands, and the relation between financial and other costs to society and acceptable prices to users.

(e) Development and introduction of improved stoves. This might possibly double traditional combustion efficiency. It is important to note that, because of the great differences in fuels, fuel availability, materials, skills, foods, cooking habits and requirements, etc., cooking methods are specific to each local area and therefore improvements have to be developed locally and disseminated through adequate extension services.

(2) Charcoal

66. As a general rule, in fuel-deficient areas, charcoal making should be discouraged because the technology wastes wood; in traditional charcoal manufacturing processes at least 60 percent of the joule value is lost. However, where fuel has to be transported over distances greater than about 100 km, charcoal tends to become more economic because of its higher joule-to-weight ratio and, consequently, lower transport costs per unit of heat in end-use. In those cases, more efficient charcoal production methods, such as the use of brick or portable steel kilns, should be promoted. Improvement of the total charcoal yield by simple briquetting of charcoal dust should also be considered.

(3) Substitution possibilities

67. In some cases, substitution is the obvious policy alternative, either as a temporary measure or to replace exhausted or rapidly diminishing supplies. Substituting for fuelwood becomes essential in situations where existing resources are insufficient to meet even minimum domestic energy requirements either as a temporary or a permanent measure. Fuelwood programmes and strategies for substitution should be incorporated as an integral part of national energy programmes and policies. Substitution in situations of acute shortage may require the implementation of emergency programmes. Substitution by fossil fuels (e.g. kerosene, bottled gas, coal) is limited by costs and is normally feasible only in urban areas and for higher income groups. Peat and shale oil are found in many countries and could provide a cheap and simple substitute on a small scale. Biomethanation is an environmentally acceptable and promising technology which yields biogas, a clean gaseous cooking fuel, not only from animal manure but also from a wide variety of residues and crops. It has been introduced successfully in a number of countries and programmes are being implemented in others. Success depends on designs adapted to local conditions, appropriate management and maintenance, the lack of which has, in the past, led to the failure of some biomethanation schemes. Different types of solar cookers have met with difficulties of consumer acceptability. Countries producing ethanol from agricultural products or methanol through wood gasification would have a product comparable in use to kerosene. Agricultural residues are the substitute to which rural people naturally shift when fuelwood becomes scarce. However, the diversion of large quantities of agricultural and animal residues to fuel uses, by processes other than bioconversion, decreases the availability of organic fertilizers and affects soil productivity for future crops. Nevertheless, certain selected agricultural and processing plant residues that do not have alternative uses are available. Examples include ground nut shell, maize cobs, coconut shells, coffee or rice husks.

68. For domestic heating needs, several solar-powered passive and active systems are nowadays commercially available, and may be cost effective in suitable climates. In many parts of the world traditional housing is well adapted for providing winter warmth and summer coolness, and some modern developments can also be adapted for low-cost rural housing. Solar-heated domestic hot water can be produced, if required, at relatively low cost especially where ambient temperatures remain well above freezing. Active solar cooling of habitat is not yet cost effective, but may become so in the future.

F. Conclusion

69. Finally, to examine the issue in terms of additions to total world energy supply and rates of penetration provides only a partial understanding. In the first place, a seemingly modest assumption about the rate of penetration of new energy technologies implies, over the next two decades, a substantial increase in absolute terms. To focus on statistical relationships is to obscure the importance of making quickly available fuelwood and new energy technologies that are applicable to the rural sector where the bulk of the world's population lives, and where every per capita increment of energy can make a marked contribution to welfare in terms of health and education. The small-scale modular forms of energy technology seem ideally suited to make this contribution quickly, and on a significant scale in terms of the number of people who will benefit.

APPENDIX

COMPARATIVE COSTS AND PROSPECTS OF SOME NEW AND RENEWABLE SOURCES OF ENERGY

The comparative costs and prospects of the different technologies that seem promising during the next 20-30 years are presented in this Appendix with a brief review of the promising technologies available. In the light of the points raised in Chapter II, it cannot be emphasized too strongly that estimates of costs and prospects should be treated with extreme caution. They are likely to be more valuable when used to rank technologies relative to one another rather than as precise economic evaluations. When no price estimates are quoted, it is generally because the particular technologies are well advanced and competitive with the reference sources.8/

A1. Liquid Transport Fuels

(a) Reference source - world market price of crude petroleum. At the time of writing this was $250/tonne ($34/barrel) or around $6.2/GJ.

(b) Ethanol from biomass. Brazil is a major producer and the World Bank is prepared to finance ethanol plants in some other countries where raw material opportunity costs are low. The potential will be increased with the development of a world-wide economic method for saccharifying ligno-cellulose or fibrous materials (non-food biomass). Small rural distilleries may contribute to rural energy supplies. Commercial with tax incentives.

(c) Methanol from biomass. Methanol (wood alcohol) can be produced by thermochemical gasification and indirect liquefaction of biomass, especially forest residues and peat. This appears to be a promising technology which needs demonstration and appears to be economically viable. Methanol (and also ethanol) can be converted to synthetic gasolene, and in some cases this may become a viable alternative.

(d) Synthetic crude oil from tar sands. Commercial production is in Canada with expansion planned. Other countries are known to have this resource. Production prices in the range of the reference source.

(e) Upgraded shale oil. Several countries have a significant shale oil resource and are presently conducting pilot plant studies or small scale production. In some countries major synthetic crude oil production is planned before the year 2000. Production prices in the range of the reference source. Small-scale shale oil production for rural energy use is planned for Morocco and may be viable elsewhere.

8/ The data are based on the reports of the Technical Panels unless otherwise stated.

(f) Vegetable oils (including hydrocarbon). Currently viable in special cases with good prospects by the year 2000, especially if high-yielding species can be developed e.g. for semi-arid lands where competition with food crops is not an issue.

A2. Central Electric Power (More than 1 Megawatt)

(a) Reference source - large coal-fired power station. Costs taken to be $0.05-0.07/kWh based on $1000/kW investment cost and fuel at $2-4.3/GJ.

(b) Hydropower. Fully mature and great potential in the entire range of sizes from very small to very large. The largest unexploited hydropower resources are now in the developing countries.

(c) Geothermal. Almost mature for dry and wet steam fields with costs $0.02 - 0.06/kWh. It is a commercally viable source of power with plant sizes from 1-110MW. 30 countries have one or more geothermal fields under investigation or development.

(d) Biomass (direct combustion). Mature technology for installations to 50MW. World Bank prepared to finance projects. Costs $0.06-0.11/kWh. The development of high-yielding (short rotation) tree plantations for direct combustion and electric power has good prospects. Large cost reduction with cogeneration costs $0.01-0.03/kWh.

(e) Peat (direct combustion). Mature technology. Largely developed in the USSR, Finland and Ireland. Prospects point all location of resources with power costs as low as $0.03/kWh. Large cost reduction with cogeneration.

(f) Oil shale (direct combustion). Almost mature technology. In the USSR, plant sizes as large as 1600MW. Prospects good at location of resource. Large cost reduction with cogeneration.

(g) Tidal. One 240MW plant in operation since 1966 in France. Similar facility constructed today would have costs about $0.08/kWh. About 40 suitable sites world-wide.

(h) Wind. Large wind turbines (1-5MW) now being built in the USA, and other countries and technology approaching full economic viability at favourable sites with annual wind average at least 5 metres per second (m/s). Likelihood of large arrays onshore in the 1980s and offshore before 2000 (islands and coastal areas). $0.05-0.06/kWh.

(i) Solar photovoltaic cells. Converts sunlight directly to electrical power. Expected to be commercially viable by 1990.

(j) Solar thermal electric. Solar thermal (central tower or distributed receiver systems) are under development with some pilot plants being built. Sun-tracking concentrator systems have good prospects towards 2000 in sunny regions.

(k) Solar ponds. Shallow lined ponds can reach close to boiling temperatures at the bottom. Pilot plants are being built in Israel. Good prospects by 1990 in suitable locations.

(l) Ocean thermal energy conversion. Pilot plants are projected within a few years with sizes between 10-40MW and a number of commercial size plants are expected to be completed before 1990. Tropical islands and coastal areas adjacent to deep water have good prospects. One experiment is running. OTEC could provide potable water as a by-product, and also nutrients for aquaculture experiments.

A3. Decentralized Electric and Shaft Power (less than 1 Megawatt)

(a) Reference source - diesel engine. Cost, with diesel oil at $0.45/litre, taken to be in the range $0.20 - 0.50/kWh according to size and load factor.

(b) Diesel- or gasolene-type engine using non-conventional liquid fuel. Partial or total substitution of ethanol, methanol or vegetable oils, for diesel oil or gasolene is already cost-effective in certain circumstances.

(c) Diesel- or gasolene-type engine using biogas or producer gas as fuel. Both diesel and gasolene engines can be adapted to use biogas from biomethanation or producer gas from thermal gasification of biomass and peat. Considerable experience with both fuels has been gained in the past, and it is highly promising as a source of rural shaft power.

(d) Minihydropower. Recent development of small low cost water turbines has opened up new possibilities particularly in hilly regions with running water. China has made major progress in this field with as many as 88,000 installations.

(e) Wind power with diesel back-up. Operation of small to medium size wind turbines with diesel back-up is close to becoming economically viable in suitable locations. $0.1-0.2/kWh.

(f) Small-scale wind power for pumping and grinding (less than 10kW). Considerable historic experience. Recent designs suitable for low-cost manufacture in developing countries can provide pumped water at acceptable commercial cost in suitable locations (average wind speed greater than 3 m/s). $0.2-1.0/kWh.

(g) Small biomass-fired external combustion engines. Conventional source in the past. There are commercial models currently available. Use of peat is possible.

(h) Solar photovoltaic cells, usually with battery storage. Small solar cell systems usually with battery storage are commercial. $1-3/kWh. With major cost reduction foreseen, are expected to enter into widespread use in the 1990's.

(i) Solar thermal power. Small systems using sun-tracking concentrators have good prospects for 1990s.

(j) Fuel cells. These devices which can convert biomass-derived liquid or gaseous fuels to electrical energy are under development and have prospects for cost-effective operation before the year 2000.

(k) Small geothermal fluid engines. Geothermal fluids at temperatures ranging from 90°C-150°C can be used with small organic Rankine-cycle engines. This technology is utilized for developing large units up to 50MW.

(l) Animal and human draught power. Utility and efficiency of this most basic energy source is being extended by improvements in breeding, feed developments, implements and harness, use of pneumatic rubber-tired wheels, infrastructure and pedal and chain drive for human-powered devices.

A4. Heating-Cooling for Habitat; Process Heat for Agriculture and Industry.

(a) Reference source - World market price of crude petroleum. At time of writing: $6.2/GJ ($34/barrel)

(b) Biomass. Direct combustion of fuelwood, crop residues, dried manure, etc. Fuel price cost $1-4/GJ for that part which enters into the commercial sector. Commercial.

(c) Peat. Direct combustion of peat is a source of heat in countries where resource is available. Milled peat for boiler firing can be produced for $1/GJ commercial.

(d) Charcoal. As much as 10 per cent of fuelwood is converted into charcoal in many developing countries. Despite conversion losses, the process may be justified by portability of charcoal vis-à-vis fuelwood. Commercial costs $5-13/GJ for charcoal delivered near to point of production.

(e) Producer gas. Low-value (joules/cubic metre) gas from thermal gasification of biomass. Fuel price costs: $2-5/GJ. Renewed commercial interest.

(f) Biogas. Intermediate value gas produced by biomethanation (anaerobic digestion) of biomass, usually in wet form. Family-sized digesters have achieved success in countries like China. Prospects are good for large scale biomethanation of residues (immediate) and of energy crops especially of aquatic biomass (mid-term). Commercial. Collateral benefits, improved sanitation and fertilizer value. $2-12/GJ.

(g) Geothermal. Hot water and steam at 50°-150°C, mainly suitable for space, agriculture and process heating, has significant potential in more than 50 countries. Present use for non electrical purpose over 8000MW thermal. Commercial $1.5-2.0/GJ.

(h) Solar passive heat. Solar passive systems incorporated into habitat and agriculture (greenhouses, "plastic" agriculture). Gives 20°C temperatures in climatically-appropriate habitat. $1/GJ.

(i) Solar flat plate collector. Various stationary solar thermal collectors (with either water or air flow for heat transport) are commercially available for space heating, water heating, crop-drying, desalination, etc. Temperatures achieved are from 30°C to 90°C depending on sophistication of collector. Costs for standard insolation of 5GJ/sq.m/yr in range $5-20/GJ.

(j) Evacuated tube collector. Now becoming a viable technology for temperatures up to 150°C, which is above the limit of more conventional non-tracking collectors. $5-20/GJ.

(k) Solar pond. Can supply heat at favourable locations on a continuous basis (inherent storage) in range to 90°C at costs of around $1-2/GJ. Good prospects for 1990.

(l) Solar cookers. Simple reflector type solar cookers have been developed in a number of countries. Many experimental projects are under way. Prospects good for institutional cooking.

(m) Sun-tracking and concentrating systems. A variety of sun-tracking and concentrating systems (dish reflectors, trough reflectors and fresnel lenses) can deliver heat at above 150°C (up to 1400°C or higher). Pilot plants are being built in a number of countries. Good prospects for 1990 onwards.

CHAPTER III. PROBLEMS INVOLVED IN THE APPLICATION OF NEW AND RENEWABLE ENERGY TECHNOLOGIES

A. Introduction

70. The preceding chapter indicates that, in economic and technological terms, general world-wide application of new and renewable energy technologies is now practicable. Several of these technologies are already feasible and call for rapid development, while others are in widespread use. Those technologies that have a modular character have inherent technical, social, economic and political advantages, and can be of great benefit to the rural populations of developing countries by virtue of their potential for delivering energy within reasonable lead times.

71. The potential for the development and use of these technologies at the desired level exists in both developed and developing countries. However, there are difficulties associated with their "newness" which may require appropriate effort to assimilate them into the social and cultural life. This also applies to the traditional forms of renewable energy, which require recognition, reappraisal and technological input if they are to fulfill their potential. These barriers are further reinforced by other factors of inertia, such as the absence of proper regulatory measures and the influence of institutionalized interests vested in the established forms of energy.

72. The evaluation of the potential development and use of these technologies should go much further than conventional financial cost-benefit analysis to include a comprehensive appraisal of social costs and benefits, despite the methodological problems involved in providing quantified assessments. Account must be taken of the needs of those who will be the end-users of these technologies. This means the public at large (with special attention given to the role of women); it also requires assessment of the future energy needs of the next generation. Other factors such as cultural and social acceptance of change, and the relevant political, economic and social structures and processes should be considered through a comprehensive systems approach to the supply and use of energy in all forms. However it needs to be emphasised that the constraints which are discussed in this chapter are not absolute barriers to the greater use now of new and renewable sources of energy in any country; they can and should be tackled effectively through appropriate and urgent national, regional and international action.

B. The principal constraints: policy, planning and institutional issues

73. There is a need for long-term (twenty years or more) as well as short- and medium-term national energy policies that take into account the development and use of new and renewable sources of energy as a whole. Such policies should recognize the role of energy as an important element and as a driving force for development. A long-term policy is essential because there is usually a long time-lag between decisions related to energy and the implementation of these decisions. It is necessary also

because there must be a long-term political commitment by governments to tasks such as research and development or raising awareness if new and renewable sources of energy are to be widely adopted. Energy technologies and applications, for new, conventional and traditional sources, affect practically all social, cultural and economic issues at national and international levels.

74. The key issue in the role of energy in development is proper policy development and planning. Relatively few developed and developing countries have so far formulated and implemented proper national energy policies. In many cases energy plans, when they exist, are characterized by the following features:

(a) plans and projects are often still based on the assumption of relatively cheap energy sources, and on established consumption patterns of oil and electricity;

(b) estimates of future needs for energy are seldom based on an adequate analysis of the demand side of the energy equation, and rural energy demand is particularly liable to be neglected;

(c) plans for energy and plans for other sectors of the economy are made independently of each other, thus resulting in a mismatch between the objectives of energy planning and the objectives of overall social and economic development;

(d) energy plans often neglect the present contribution and future potential of both new and traditional renewable sources of energy and frequently do not take account of the favourable foreign exchange implications that such new sources may have;

(e) energy plans frequently do not fully take into account technological innovation and changing patterns of conservation.

75. Proper energy planning requires energy assessment and its integration into energy planning to meet the objective of overall social and economic planning. There is a need for a detailed and comprehensive energy assessment on the national, regional and international levels. This requires, among other things, the inventory of current and potential resources and uses of new and renewable sources of energy. Adequate inventories often do not exist, particularly in developing countries. Energy assessment also requires data and information on future trends and long-range objectives of the overall development effort, together with an understanding of how energy can contribute to the fulfillment of these objectives.

76. National energy plans that are related to social and economic development and are based on proper energy assessment, including new and renewable sources, are key elements in identifying necessary actions and priorities, e.g. those related to programming, finance, coordination and institutional structures. Once these are clearly outlined and identified, the constraints discussed in the following section fall into their proper perspective. The correct identification and definition of the problem is the first long step towards its solution.

C. Additional constraints on the development and utilization of new and renewable sources of energy

1. Research, development, and the transfer of technology

77. The limited human, technical and financial resources that are available greatly limit the scope of research, development and demonstration projects which can be undertaken by many developing and developed countries. This is especially true for new and renewable sources of energy, due partly to the newness of these technologies, as well as to the fact that most research and development institutions have not integrated these areas into their objectives, consequently resulting in little effort. Moreover, concentration of most of the world's research and development activities in industrialized countries has resulted in the design of technological systems primarily applicable to the developed countries. If developing countries are to benefit from this work, through the adoption of techniques and systems that meet their specific needs, they must find ways to participate actively in current scientific and technological efforts. Effective collaboration in research and development of new energy technologies between developed and developing countries, or among developing countries themselves, has so far been attempted only on a limited scale. It should also be recognised that research and development activities should be started at an early stage, due to the long lead time between research and experimental development and the use of its results in industrial production.

78. For developing countries to benefit from such co-operation, or to benefit from their own research and development efforts, a vital requirement is the prior definition of research and development needs, through the policy and planning mechanisms discussed in Section B. The research and development work that is undertaken should be aimed at improving the productivity of the national resource base, and must be clearly relevant to the needs of end-users, whether these are in the traditional or modern sectors of the economy. The research requirements of different technologies vary considerably in terms of personnel, facilities and time; clear definition of real needs at the local and national level may be a key factor in avoiding unnecessary delays and costs in the development and adoption of effective technologies.

79. The transfer to developing countries of new energy technologies may be seriously hampered by the proprietary character of the technologies and by restrictive conditions attached to their transfer. In the past technological transfer has often led to long-term technological dependence. To avoid this, special attention must be given to the development of technologies adapted to the specific conditions of developing countries. Industrialized countries should, in addition to facilitating the transfer of technology, help to strengthen the research and development capacity of developing countries, and the capacity to select, acquire, apply and adapt new energy technologies so that they can be fully assimilated in the countries to which they are transferred. Governments of developing countries should also recognize their role in strengthening these capacities. Such action at the international level

would be consistent with the relevant provisions in paragraph 13 of Resolution 112(V) of the United Nations Conference on Trade and Development (UNCTAD).

80. In order to facilitate research and development on new and renewable energy technologies, attention should be given to improving the primary data base. In many cases the data are scanty, incomplete, inaccurate and not on a standard format. This is particularly the case for site-specific energy resources such as wind and solar energy.

81. In addition to research and development on energy technologies themselves, further work may also be required to develop suitable end-use equipment to utilize energy from new and renewable sources so that it can have the maximum economic and social impact. For example, electricity from solar sources may be provided most easily in the form of direct current. Yet most equipment now available is usually designed to utilize alternating current supplied through electricity grids. There is also a need to develop efficient and low cost energy storage facilities to overcome the intermittent nature of energy supply from some of these technologies and to ensure the continuous availability of energy for domestic and productive uses. If research and development requirements are defined through a comprehensive review of probable end-use applications, such related needs can be identified earlier and more easily.

82. The problem of adapting both imported and local energy technologies to meet local conditions must be given due recognition. This is a most important constraint which requires applied research, development and demonstration at the local level. It is usually made more difficult by the absence of testing facilities and quality control of both local and imported equipment. Hence insufficient attention is often paid to the analysis of end use needs, to the social, environmental and economic impact of new technologies and to the infrastructure requirements of actual applications. This is especially true in rural areas; isolated trials and demonstrations cannot produce useful results, unless they are seen as integral parts of rural development strategies, taking account of the relevant socio-economic and environmental factors. Testing and evaluation facilities and methodologies are important for this emerging field of technology relevant to rural areas. Several promising technologies that are adjusted to the ecological and socio-economic conditions of rural areas have been developed in developing countries. The transfer of such technologies among developing countries should be promoted and supported.

2. Education and Training

83. In the preceding section, research and development needs were seen to be determined primarily in terms of the probable end-uses of the new sources of energy. The end-users, however, are in many cases the whole population. It is not, therefore, only a matter of training those who will be concerned with the development and supply of new and renewable energy; there is an immense task required in all countries to ensure that people are aware of the opportunities that new sources offer for meeting

their energy needs, often through relatively simply techniques. To create this widespread awareness will require the imaginative use of many forms of communication, from demonstration projects to the mass media.

84. It is also necessary to recognize the vital role that can be played by the system of formal education in each country, if new energy technologies are to play an expanding role in future decades. There is a need to develop and adapt training programmes, facilities and materials at the university, secondary and primary levels, as well as in the training of technicians. For the effective adoption of many small-scale applications of new sources of energy, the number of people who need to be reached by training and education programmes may involve almost all the population. This objective carries with it an important time constraint. Education and training for small groups of the population can be provided relatively quickly and inexpensively, but changes in the attitudes and habits of the population may require some time to have a significant impact.

85. There are also educational needs in relation to specific groups of the present adult population. For example, unless more efficient techniques for harvesting and use of fuelwood are utilized and become the accepted norm for millions of people, little impact will be made on the present crises of supply and environment. Extension services represent a practical and well tried method of assisting rural communities, including individual farmers and biomass producers. They may also have a significant role to play in promoting the adoption of other forms of new and renewable energy. The potential role of extension workers needs to be given greater recognition and practical incentives, and efforts should be made to equip them with the appropriate information and training that they can pass on to others.

86. To ensure adequate education and training of personnel involved in the building, operation, maintenance and dissemination of new energy systems requires a consolidation and expansion of the existing education infrastructure.

(a) In developed and developing countries alike there is a need to modify or develop curricula to include the basic concepts important for new and renewable energy resources. The modifications are required at professional and sub-professional levels, as well as at the level of the layman.

(b) Although several institutions exist in industrialized countries that already train scientific and technical personnel in new and renewable energy technologies, there are very few institutions yet capable of playing this role in developing countries. It is vital to strengthen these institutions and to form strong links between them to ensure fruitful collaboration in this educational endeavour.

(c) There is a need in developing countries for programmes and for "centres of excellence" that can play a role at the national and regional levels in the training of trainers, planners, managers, scientists and technologists.

(d) Special training needs often arise in the related professions that are critical for applying new energy, e.g. land-use planners, architects, agricultural engineers and even small business operators.

(e) Educational and training materials concerning new and renewable sources of energy at all levels need to be developed and used.

3. Financing

87. It is difficult to assess the precise financial requirements for future energy development in the widest sense (including supply and demand considerations as well as upstream and downstream activities), especially for new sources of energy in both developing and developed countries. The difficulty stems from a variety of factors inherent in forecasting, including the uncertainty of energy prices and the investment requirements and operating costs of new sources of energy.

88. Nevertheless, several estimates of the energy investment requirements of developing countries have been made in recent years, some of which include consideration of new and renewable sources:

(a) the World Bank has estimated investment requirements for commercial energy and fuelwood during 1981-1990 to amount, in 1980 dollars, to:
-$450 billion for non-oil developing countries;
-$700 billion for all developing countries;

(b) UNCTAD has estimated that the annual investment requirements in the year 2000, for all developing countries, may be divided as follows:
- new and renewable sources of energy9/ excluding large hydropower will account for 12 per cent of total investment in the energy sector ($24 billion per annum out of a total of $200 billion per annum, in 1980 dollars)
- large hydropower projects will account for a further 28 per cent of annual investment in the energy sector ($56 billion out of $200 billion)
- conventional sources of energy will therefore account for 60 per cent of total investment in the energy sector ($120 billion out of $200 billion).

Whatever their quantitative uncertainty, the prospective investment requirements in the energy sector in general, and in new and renewable sources of energy in particular, present formidable problems of financing for all countries.

89. Specific issues that need to be tackled effectively and urgently, if the necessary finance is to be provided, include the following:

(a) Individual countries will need to undertake pre-investment studies to determine where financial investments are likely to yield the greatest benefits. This will also require consideration of forms and uses of energy that have attracted little investment in the past, but where small improvements may have widespread effects on large groups in the population (e.g. charcoal kilns and draught animal power.)

9/ The estimates include nine of the fourteen sources of energy before the Conference; draught animal power, peat, marine energy, tar sands and oil shales are omitted.

(b) Financial requirements from external sources should be determined after taking into account the national energy resource base, the national investment potential and national policies in regard to the use of external financial resources.

(c) Some technologies may require less external capital - and may therefore be more attractive in the overall context of national development - because the technologies are decentralized and therefore lend themselves to community self-help projects, with much of the needed investment (of labour as well as capital) coming from within the community itself.

(d) National policies on the pricing of energy should be examined to ensure that they do not have the effect of discriminating against new and renewable sources of energy, especially where these are integrated with conventional sources.

(e) Special incentives may be required in the early stages, even where new energy technologies seem to offer clear financial and other advantages.

4. Information flows

(a) Problems related to users

90. The demand for information arises from a heterogeneous community ranging from scientists and technologists, public officials, planners and managers, to the public at large. Since most existing information systems and services are oriented towards users in industrialized countries, access to this information for people in developing countries is costly and difficult. In addition, in the developing countries planners, policy makers and technologists, and training and extension personnel, face an unmet need for practical and relevant information on the development and use of new and renewable sources of energy, and the experience of other developing countries which have comparable conditions to their own.

91. Existing data banks are mainly focussed on conventional commercial sources of energy and have been most useful for energy systems in industrialized countries. They are of limited use for integrated energy planning purposes. Economic data needed for policy and investment decisions are not readily available for use either in industrialized or developing countries, nor are the evaluative and comparative data on various new energy technologies available. Generalized data for resource assessments are being collected for many parts of the world, including developing countries. What is not available is the detailed data necessary for in-depth assessments connected with programme and project preparations.

92. In both the industrialized and developing countries little attempt has been made to initiate and sustain effective mass media programmes to promote public awareness of the merits of new forms of energy. This scarcity of popularized technical information intended for the general public is a hindrance to acceptance of the application of new energy technologies for both domestic and institutional use.

(b) Characteristics of information related to new and renewable sources of energy

93. A large amount of valuable information on non-conventional energy sources has existed for many years, but has remained unused because there was little incentive to use it when low-cost liquid fuels were available and seemed limitless. The body of general and of scientific and technical information related to new and renewable sources of energy is growing so fast that even specialists find it difficult to keep track of progress in their specific fields through conventional means. At the same time it is becoming increasingly important that information on currently developed, as well as newly emerging, technologies and their specific potential be made accessible and shared, especially with developing countries. Several surveys of evolving technologies have been undertaken as part of export promotion programmes, but the data and analysis are withheld; these and other types of proprietary information need to be made generally available.

94. Despite the fact that large files of systematized information are maintained by many organizations, and sophisticated information processing and telecommunication technology is available today, the demand for information on new and renewable sources of energy is not satisfied, especially on the part of users in developing countries. The main reasons for this shortfall are the fact that existing information systems and services do not accommodate the variety of new user requirements; the high costs of customized systems development, coupled with the scarcity of experienced systems designers; and, most importantly, the lack of useful factual (non-bibliographic), quantitative and statistical data collected and stored in anticipation of future requirements.

95. Consequently, although relevant scientific and technical information, including patent information, is abundant, it is not readily available to potential users in developing countries and often is not available at all in their language. Some developing countries are already harnessing various technologies, traditional and modern, in the field of new and renewable sources of energy and have access to information, through their own research and development activities, pilot and demonstration projects and links established with external sources of information and advice. But such information is not accessible to those developing countries which lack information delivery infrastructure and have limited access to seminars, conferences, study tours and other information exchange facilities. In most developing countries also, specifications of patents are not published.

5. Other constraints: cultural issues, regulations and environmental concerns

96. In addition to technical and institutional problems of the kind examined by the technical panels and ad hoc groups of experts, there may be other significant constraints on the development and wider use of new and renewable sources of energy. For example, socio-economic conditions affect individual behaviour and perceptions in regard to the use of energy. Cultural traditions must be respected, and energy proposals incorporated into such patterns. Any technological innovation should enrich the culture and the heritage, not destroy them. Laws and regulations (especially in regard to electricity supply) may deter the adoption of new and renewable sources in ways that were

neither intended nor foreseen when the statutes were drafted. Environmental considerations also need to be considered, as they do with all forms of energy development. Like the constraints already described, such factors need not be permanent barriers to the use of these sources of energy, but their influence cannot be underestimated. In some circumstances considerable time and effort may be required to overcome their effects.

97. The time constraint is indeed a key factor that must be considered in planning the introduction of new energy technologies. It may require in some cases considerable time for the habits and behaviour of large numbers of people to be changed on the required scale. This may be true particularly in the case of non-commercial use of energy. Where the price mechanism operates, patterns of behaviour may change relatively quickly if alternatives are available.

98. The existence and potential of unconventional sources of energy have been recognized by large numbers of people in both industrialized and developing countries for a long time, yet even now it is difficult for many people to appreciate that it is both desirable and possible for these energy sources to be developed and widely applied relatively quickly, especially in small-scale applications under the direct control of the end-user. A particular form of this gap between perception and reality is the implicit assumption that development must be closely associated with the increasing use of conventional energy, such as oil and electricity. Given the existence of such attitudes, attempts to promote the use of some renewable sources of energy can too easily be perceived as an attempt to prevent particular groups in the population, or even groups of countries, from gaining access to "advanced" energy sources. Such problems are likely to be transitory, but they may cause significant delays, particularly at the initial stages of the large-scale adoption of these energy sources.

99. Regulations and other legal or quasi-legal impediments can cause delays in implementing new energy technologies that are difficult to foresee. For example, the development of large-scale wind systems and other new and renewable sources of energy may require the removal of restrictions on local electricity utilities that limit their ability to buy surplus power produced by such privately-owned facilities. Efforts to promote the introduction of active or passive solar systems have sometimes encountered barriers provided by planning or building regulations (e.g. preventing the best orientation of a building on a site). Legal and quasi-legal instruments, such as codes of practice, regulations, norms and standards, and quality control are needed at national and international levels to promote increased energy efficiency, conservation and the use of new and renewable sources of energy. For example, the introduction of passive design and energy-saving concepts in building codes can, often at no extra cost in construction, result in a considerable energy saving in both developed and developing countries.

100. Environmental factors vary according to both the type of energy and the local conditions in which it is utilized. It seems probable, however, that land-use is a particularly important environmental consideration in the development of several forms of new and renewable sources of energy. Tar sands and oil shale developments imply substantial strip-mining activities; large-scale hydropower developments may entail flooding of large areas; and

biomass farming for energy similarly may affect the ecological balance over wide areas, especially if maximum biomass productivity becomes the objective. Active solar systems and wind systems may raise similar land use problems. Overall, there seem to be reasonable grounds for concluding that the environmental problems associated with the use of new and renewable sources of energy may be no more severe than those encountered with conventional energy development. Appropriate use of local, renewable energy sources can however have positive environmental benefits compared to conventional fossil fuels. This is largely by off-setting environmental impacts from the conventional alternative pollution emissions from fossil-fuel combustion. Clearly, analysis of environmental considerations of these kinds, like other considerations mentioned in this section, should be weighed in the process of energy assessment and the preparation of overall plans for the development of new and renewable sources of energy.

101. In the light of the constraints mentioned in this chapter, there is a need for national institutional structures that contain focal points at appropriate levels of government to promote the development and use of new and renewable sources of energy within the framework of national developmental activities.

CHAPTER IV. ENERGY AND DEVELOPMENT: RURAL, URBAN, INDUSTRIAL AND OTHER SECTORAL ISSUES

A. Introduction

102. The events of the past decade have brought to light the close links between energy and development. It is apparent now that the rate and character of development are strongly influenced by the availability, form and cost of energy. The abundance and the low cost of energy in the past provided a number of countries with an adequate base for rapid development. It is practically impossible, for developing and developed countries alike, to pursue the same path of development within the present constraints of the scarcity and price of conventional energy resources. For the next two decades, perhaps, the decisions on various development strategies must feature energy as the cardinal point. Alternative development patterns may be pursued by both developed and developing countries. The role of new and renewable sources of energy should come into prominence and feature highly in future development plans. One feature of new and renewable sources of energy is that several are particularly well suited for decentralized development to meet needs for social and economic progress, especially in rural areas of developing countries where other forms of energy may be difficult or expensive to provide. This is in sharp contrast to conventional energy systems which have required heavy initial capital investment since they are most efficient as large systems.

103. Significant changes within major economic sectors are already occurring as new forms of energy are introduced. The shift may be important for the relationship between rural and urban areas, in terms of the living standards of the population in these areas and in terms of their economic productivity, which is closely related to the availability and use of energy. Decentralized approaches to energy supplies for populations in rural areas may now be desirable in many developing countries; links to centralized supplies can be considered at a later date if this appears desirable.

104. This chapter considers the relationship between energy and development and the development opportunities in agriculture, industry and the tertiary sector that new and renewable sources of energy may offer.

B. Rural development, including agriculture

105. The gap in living standards separating the affluent countries from the poor countries, and affluent regions from poor regions, can be closely correlated to inequities in energy supplies, indicated both by the quantity of energy available and by the efficiency with which it is used. Technological and institutional measures to improve the access of rural regions to energy should focus on improving the end-use efficiency of conventional sources; greater efficiency in the use of traditional energy; and increased use of new and renewable sources. These efforts should be closely related to the purposes for which energy is used.

106. Studies undertaken by the Food and Agriculture Organization (FAO) show that agriculture consumed in 1972 about 3.5 per cent of the global supply of commercial energy. In its 1980 report on energy in developing countries, the World Bank estimated that agricultural production typically accounts for less than 5 per cent of a country's commercial energy consumption. Although the amount of commercial energy used in agricultural production is small, it is important that this energy is assured, so as not to disrupt agricultural yield increases in developing countries during the transitional period. Much of the food in developing countries is produced, transported and processed by human and animal power, both of which may be categorized as renewable forms of energy, often used very inefficiently in economic terms, and representing time-consuming drudgery from a social viewpoint. The potential economic and social benefits from more effective use of traditional and the development of new and renewable energy sources are thus tantalizingly great.

107. Draught animal power is and will continue to be for a long time the main source of energy for small farmers and small-scale transportation in developing countries. There is a need to improve its efficiency through modernization of breeding, feed, health and equipment, and to integrate it with other systems such as crop , meat, milk, fibre, fuel and fertilizer (dung) production, etc.

108. Although agriculture is of primary importance for rural communities, and the educational, health and other services discussed below are also essential, energy is urgently required to create gainful non-farm employment in rural areas, particularly in agrobased industry. Even when three crops a year can be harvested, a large population of landless labourers may remain unemployed for one-third to one-half of the year in many developing countries. Schemes to process local raw materials with the aid of locally available energy sources need to be developed as quickly as possible.

109. There is great potential for increasing efficiency in household use of energy, which is of major importance to those living in rural communities. A variety of more efficient stoves could reduce the amount of firewood needed to cook the evening meal by a factor of three. If effectively distributed and used, these stoves could dramatically slow down the rate of deforestation and reduce the time needed to gather fuelwood which now can amount to as much as five hours of effort per day, mainly by women and children. There is a social

as well as an energy opportunity: if the women and children were not required to spend so much of their time gathering fuelwood they might then have time and energy available for education, training and other beneficial and productive activities.

111. Elementary education is another activity that would clearly benefit from increased energy availability. Widespread literacy is an important pre-condition for socio-economic development, yet rural people in developing countries suffer from a lack of access to the institutions and equipment required as an integral part of programmes for development of literacy. Small photovoltaic systems, for example, may provide the small amounts of power needed for laboratory instruments and for radio and television receivers used in remote rural areas.

112. The delivery of primary health care makes demands, directly and indirectly, for energy. Energy for the provision of clean water and sanitation systems to rural areas comes to mind in the first instance; transport, refrigeration of drugs and pharmaceuticals and sterilization of surgical equipment are other important end uses. The energy needed to make a major impact on health conditions is minor in terms of annual kilowatt hours per capita, but can have a major impact in welfare terms. A carefully arranged combination of energy technologies on a local scale provides reliability and flexibility with substantial and beneficial effects on the character and quality of life for those billions who live in the rural sectors of the developing world beyond the reach of electricity grid systems.

113. The expanded development of energy sources in rural areas, even in very limited quantities, could lead to substantial economic and social benefits, e.g. the alleviation of rural poverty through the creation of employment; improvement of working conditions, particularly for women and children; and thus increase the opportunities to achieve a more equitable distribution of income. Very small increases in the supply of electricity or fuels can bring substantial changes in the character and quality of local life, including increased productivity, development of local industry, provision of reliable water supplies, improved communication and education and improved health. It is from this perspective that the use of new and renewable sources of energy should be seen; cost advantages may also favour the use of these small-scale autonomous sources, but it is in broader social and economic terms that the benefits must be assessed.

114. The selective use of small scale integrated energy systems in the rural regions of the developing world to address these important and urgent human needs directly could be one of the most significant early additional applications of new and renewable energy sources. If schemes are available through which individuals in developing countries can be encouraged to construct their own energy-producing facilities, with much of the cost covered by their own labour input, then these systems become feasible and can aid the development process; other energy technologies which appear more convenient and more attractive are options possible at a higher level of development. Biomethanation, improved cooking stoves, simple windmills and other energy technologies can make a vital contribution at this level of energy use for, literally, hundreds of millions of people.

115. New and renewable sources of energy may also play an important role in relation to a factor of energy supply that has hitherto received too little attention. "Resilience" is the capability of a system to continue functioning under stress, failing in stages rather than suddenly and catastrophically. In many parts of the developing world, for example, there are diesel engines and pumps that are no longer working. While the reasons for their failure are manifold, the consequences are the same. In any system relying totally on a single technological unit, failure of the unit means failure of the system and of the services (e.g. clean water) that it provides. In the case of electricity grids or other integrated supply systems, this resilience is provided through interconnexions among a number of energy sources. In autonomous systems, other ways must be found to ensure resilient operation. One is through the use of several small units to provide the required amount of energy, rather than one large unit. The fact that several solar and other new technologies are likely to be as efficient when operated as small units as they would be in larger facilities makes them potentially attractive here. Alternatively, or additionally, resilience can be achieved if the required energy is provided by a number of different energy sources, all of which are unlikely to fail simultaneously. New sources of energy may therefore be utilized in conjunction with conventional ones.

116. The validity and the importance of the preceding discussion needs to be tested and demonstrated through large-scale pilot experiments that should include the whole of a development block, such as a rural development unit in a particular country. Analysis of the present use of energy in all forms in the unit would lead to the identification and introduction of appropriate approaches and technologies for using new and renewable sources of energy, in conjunction with traditional and commercial energy. This prior assessment would help to ensure that techniques matched the needs and capabilities of the area, and would identify the problems to be tackled in developing and promoting these techniques on a large scale.

C. Industrial, urban and transport aspects

117. The industrial and transport sector is a major consumer of commercial energy. Assessments of the impact of new sources of energy on the industrial and transport sectors must take into account the quantity, cost, type and quality of energy required by different industrial processes and transport modes. The urban areas of the developing world are in general growing much more rapidly than the total population and most cities in developing countries are already well beyond their capacity to provide adequate and reliable services to their inhabitants. In order for the urban systems to function well, they need reliable access to the most adequate energy sources, according to the quality of the energy requirements. They need both secondary energy forms such as electricity and high quality liquid and gaseous fuels, as well as the use of new and renewable energy sources such as solar energy, vegetable wastes, biogas, wood briquettes, geothermal energy, etc.

118. It is expected that the need for energy will increase rapidly in developing countries as they set up major industrial plans. Such plans, however, may have been conceived without adequate consideration of the constraints on energy that exist in each country it is not uncommon, in both developed and developing countries, to find that even the quantities of energy currently used by existing industries are not known by development planners.

To ease the pressure on conventional sources of energy, it may be necessary to review national industrialization strategies in terms of available energy supplies, including the role that may be played by new and renewable sources in industrial development. This in turn may require consideration of the need for sub-regional co-operation and planning.

119. The energy requirements of the transport sector also need to be analysed in the same way. In industrialized countries transportation accounts for 15-40 per cent of direct energy use. The proportion is slightly higher in middle income developing countries; in low income developing countries transport accounts for only about 10-20 per cent of total energy consumption with about three-quarters of this used for road transport. Nevertheless, energy requirements of the transportation sector present a major financial burden for most of the non oil-producing countries. For such countries, the proportion of the total foreign exchange earnings allocated to cover crude oil import costs has risen from below 15 per cent in 1973 to well over 40 per cent in 1980 in some instances. Some renewable energy options, such as methanol from gasification, synthetic fuels from liquifaction, and oils from hydrocarbon plants, can contribute to the solution of this problem. These options should receive greater developmental support. However, other renewable technologies such as the use of ethanol, vegetable oils, and producer and biogas engines, are currently available. Greater use may be made of alcohol-powered internal combustion engines (as in Brazil), provided that this does not lead to undesirable competition for land with other crops, and of transport systems that use electricity from alternative sources of energy. Attention should also be given to improving the efficiency of traditional rural transportation systems based on draught animal power, since it will remain in use for some time in the future.

120. Conventional commercial energy supply in practically all countries is an elaborately organized system. The emphasis is on reliability and continuity of service; although interruptions and breakdowns occur, they are generally tackled quickly because the organization has the mandate and the resources to solve the problem. Similar arrangements and responsibilities need to be established in regard to the use of new and renewable sources of energy, taking into account the small-scale and decentralized character of many applications. The organization of regular maintenance, repair and the supply of spare parts should probably therefore also be based on a decentralized approach.

121. Distribution systems that already exist over wide areas have to be taken into account in planning the transition to greater use of alternative sources of energy. These systems may represent a relatively static way of doing things that is reinforced by inertia. Changes cannot be made easily but there seems no doubt that the necessary changes can ultimately be achieved, if the will is there. Once again, it is a matter of comprehensive planning of energy needs and supplies, based on a thorough understanding of the present role that all forms of energy play in the present economy and society, as well as on a knowledge of what new opportunities are available or anticipated.

CHAPTER V. CONCLUSIONS

A. Overview of energy situation and prospects

122. The cost and availability of energy affect the prosperity and development of every country as well as the balance of the world's financial and monetary system. There is a manifest common interest to set in motion the process needed to lay the foundation for an orderly, equitable and rapid transition from a world economy based on oil as the dominant energy source to one relying on energy mixes in which renewable sources of energy will have to play an increasingly important role. The challenges confronting all nations in making this transition are substantial, although they loom particularly large for energy-deficient developing countries. The inevitable difficulties that lie ahead can be overcome through careful planning and cooperation, if they are given the urgent attention of the world-wide community. Establishing a more secure energy future through diversification of energy sources will depend on decisions taken by governments, investors and consumers today.

123. The transition to a new energy mix also presents opportunities for both developed and developing countries, and especially for the latter. Fortunately, some at least of the developing countries have advantages regarding renewable sources of energy. For example, possibilities exist to introduce energy technologies that are particularly suitable for decentralized applications that can be a stimulus for new patterns of industrial and especially rural development. Furthermore, while the energy transition presents all nations with both technological and development strategy options, the choices open to developing countries provide them, in principle, with a unique if challenging opportunity to increase their technological self-reliance as well as to determine the pattern of their future development based on a flexible energy-development relationship.

124. It is generally estimated that the present contribution of NRSE to the total energy supply, on a world average, amounts to some 15 percent. However, this figure is uncertain due to the unrecorded contribution of some commercial and non-commercial traditional energy sources, particularly draught animal power and biomass. Most projections contend that, if even modest development objectives are to be realized, energy consumption in developing countries will need to rise by about threefold in the coming twenty years and that the contribution of new and renewable sources to world energy supply will need to rise from the present level to about 25 per cent, i.e. almost doubling its percentage contribution. In the coming decades this amounts to a five-fold or six-fold increase in absolute terms. The implications of this challenge are far-reaching, involving structural changes in the world economy, particularly with respect to financial flows and socio-economic and technological factors. This has profound implications for the rural sector where even a relatively small *per capita* increment will result in a major improvement in quality of life in terms of improved health, education and income for those billions who will be directly affected.

125. A broad review of technologies which are mature, under arrested development, or promising, was presented in the Appendix to Chapter II. It was found that conventional renewable sources of energy such as fuelwood, biomass and draught animal power already play a significant role in many parts of the world. These resources are currently the only energy supplies accessible to many rural people and the urban poor. They require, in addition to new inputs of technology, proper recognition under government policies.

126. Among new and renewable technologies, minihydro, small-scale solar and biomethanation are already feasible and available for rapid proliferation in a decentralized mode. Large-scale hydro, geothermal and, to some extent, tidal power will continue to play important roles in centralized networks which principally benefit urban areas. The prospects for other biomass and peat technology such as the production of solid, liquid and gaseous fuels are of considerable interest. Provided that there are no conflicts with food production, the scope is fairly wide even in the short-term perspective. Small-scale solar technologies for water pumping and distillation, low temperature heating, cooking, crop drying and power generation are available and are expected to play a significant role in the near future. Small and medium size windmills used by decentralized mode are already cost-competitive in many areas whereas medium and large windmills are expected to be attractive enough for autonomous and integrated modes of operation in windy areas.

127. Other new and renewable technologies such as OTEC, geothermal energy, large scale solar power, tar sands and oil shales are very promising; with suitable support for research, development and demonstration these could emerge as significant options in short to medium-term time frames.

B. The relationship between energy and development

128. Customary relationships between energy and economic development have altered throughout the world. In particular, in developing countries it is becoming accepted that modernized traditional and new energy technologies can assist in the development of the rural, urban, industrial and transportation sectors on account of their characteristics which permit decentralized as well as centralized mode of utilization. The decentralized mode provides greater opportunities for accelerating the pace of rural development since these technologies can be developed without elaborate distribution networks.

129. Agricultural development can take advantage of new energy sources for additional irrigation, crop drying, fertilizers, etc., while at the same time using conventional renewables such as draught animal power, fuelwood and biomass more effectively. The task of rural development cannot be tackled effectively unless additional employment and income opportunities are generated. The problem of inefficient production, conversion and use of fuelwood and biomass requires immediate attention, including the production of efficient equipment. More attention should similarly be given to the efficient use of draught animal power. Education, health care, and other welfare measures can profit significantly through small but vital inputs of energy in the form of electricity or shaft power. In view of the very limited purchasing power of the population in many rural areas, alternative ways to provide energy have to be devised. The long-run economic and social benefits to be obtained from the application of new and renewable sources of energy should be considered, even where the initial capital cost is higher than that of energy from conventional sources. The fact that energy can be made available to large numbers of poor people relatively quickly should be of overriding importance. These programmes can be better assimilated in rural areas if local people are involved in their development, fabrication, operation and maintenance.

130. Even in the urban sector advantage can be taken of new and renewable sources in domestic and industrial tasks while at the same time improving the effectiveness of conventional renewables. Existing distribution systems can be supplied by inputs from large hydro, tidal power, windmills, OTEC, solar sources, etc., in order to supplement conventional power generation. Although it might not be easy to change the pattern of development in urban areas, the availability of decentralized energy sources might help to evolve alternative approaches to urbanization. Transportation is a major consumer of liquid hydrocarbons for which only few alternatives are available. The most important one at present is ethanol, but possibilities are emerging for the production and use of vegetable oils, methanol and other gaseous and liquid hydrocarbons. Nevertheless the problem faced by many energy-deficient developing countries is so acute that a major proportion of their export earnings is being used to pay for oil imports. In addition to the development and use of new energy resources, conservation is an essential element in short-term and long-term planning in all countries.

C. Key elements needed to achieve increased use of new and renewable sources of energy

131. It must be stressed at the outset that increased efforts are called for on national and international levels and that both must be mutually reinforcing. Already much is being done; at the national level many countries have initiated significant programmes to develop and utilise new energy sources. Similarly extensive work on various aspects of new and renewable energy is already underway in many bodies and agencies of the United Nations system, as well as in other intergovernmental and non-governmental bodies.

1. Areas requiring national attention

132. Coherent national energy policies and plans need to be formulated that provide a framework for defining the role of alternative sources of energy in the economy, for determining priorities among the various technologies, and for assigning resources accordingly. These energy policies and plans must constitute integral parts of broader development strategies and take adequate account of the nature of the end-use of the energy.

133. All countries will need to pay particular attention to the strengthening of their policy formulation, development planning and project management capabilities. This will particularly assist developing countries to increase their absorptive capacity for assistance in the field of new and renewable sources of energy, and promote external financial and technological flows into these sources.

134. It is important to use existing, or create, appropriate institutional frameworks to serve as a basis for activities in research, development, planning, production and use of new and renewable sources of energy.

135. A reliable data base must be established to permit the effective evaluation of resources which may serve as alternative sources of energy. In the assessment of solar and wind energy potential, for example, adequate meteorological data bases should be provided by National Meteorological Services, with the understanding that these data bases should be improved and

complemented in space and time, as appropriate. Once the character of the resource base has been established, pre-investment studies will be required to determine whether attractive investment opportunities exist, the extent of equipment adaptation necessary and problems of acceptability.

136. The development of a strong research and development capacity in developing countries would be an important step in facilitating the evaluation of available technologies and in adapting and innovating suitable technologies for new and renewable sources of energy. As with all technical innovation, new developments in this field in developing countries would be facilitated by the presence of effective national industrial property systems. The research and development capabilities of developed countries might also make contributions to meeting the particular needs of developing countries.

137. As part of the development of a national information programme, appropriate extension services are necessary to encourage and promote the acceptance and use of new and renewable energy sources.

138. An appropriate national agency should be designated as a focal point for a broad range of responsibilities for information (inventories, data bases, communications, etc.), so as to meet the needs of specific user groups. A first step might be a detailed analysis of the existing local information infrastrcture and its capability to meet demands for information about new and renewable sources of energy. This analysis would then be used to ensure adequate funding for future information activities.

139. Education and training regarding new and renewable energy sources should be incorporated in formal programmes at all levels, and programmes should also be developed to encourage the public at large to contribute to the widespread use of these sources.

140. Measures to intensify market penetration of new and renewable energy technologies in all countries would facilitate the conservation and equitable sharing of available conventional energy supplies.

141. It is important to examine the effect of existing laws and regulations on the development and use of new and renewable sources of energy, and to introduce new legal and quasi-legal mechanisms to encourage their use.

142. Financial incentives, for example subsidies, tax rebates, etc., may be necessary to stimulate user and producer interest in new and renewable sources of energy, especially where energy from conventional sources is not priced at economic levels.

143. All countries should make every effort to enhance their mobilization of domestic investment resources for new and renewable sources of energy (including supportive investments in infrastructure and energy-related sectors) and developing countries should take steps to benefit fully from international financial co-operation in this area. Imaginative and innovative schemes for financing energy investments at the small-scale and local level should also be explored and implemented whenever possible.

144. It is also important to recognize that programmes aimed at enhancing the use of NRSE should include adequate energy pricing systems and appropriate allocations of resources for the different investment purposes, both through public and private channels. In that respect innovative policies should be pursued to increase the investment capacity of different sections of the population through mobilization of natural and human resources.

2. Areas requiring attention of the international community

145. Inadequate energy planning and inadequate integration of such planning with national industrial or other development policies have been major impediments to international cooperation in new and renewable energy technologies. National policies to improve project formulation and evaluation and better training, infrastructural and institutional support, like improved assessments of the potential for new and renewable energy, increased research and development and improved information flows, are the prerequisites to greater international co-operation.

146. However, national policies to encourage the rapid adoption and greater use of new and renewable energy technologies should be accompanied by corresponding international action. Governments will wish to consider what steps should be taken at the policy-decision level throughout the UN system, including the specialized agencies, and in other international organizations to reflect the strengthening resolve of the world community to give greater emphasis to these energy sources. In particular, the medium-term plans and policies and the programmes and projects and other financial outlays of these institutions should take full account of the greater potential of new and renewable energy which is now warranted on technological, economic and other grounds. Fully multilateral, limited regional and even bilateral cooperation efforts will need to be drawn upon: in some cases, nothing more than technical or financial support of national endeavours such as the preparation of national energy data, may be needed; but in others, more complex collaboration will be necessary - for example, where collective financing or risk taking is of a magnitude surpassing national capabilities, or where joint efforts in commercialization, large scale or local, will be made speedier and more effective.

147. In order to adapt and adopt both transferred and indigenous technologies that meet specific energy needs, an effective system of collaboration between countries is required. This would enable developing countries to strengthen their research, development and demonstration resources, and the international community should ensure that this receives due recognition in all energy programmes. Such collaboration may take the form both of direct technical and financial support to strengthen national, and in particular developing country, research and development programmes, and of support for bilateral, regional and international programmes in areas where co-operative research efforts are likely to prove particularly effective. This may focus on the adoption and adaptation of both imported and indigenous techniques that meet specific energy needs. Twinning arrangements between developed and developing and among developing countries themselves would be a means of ensuring such collaboration. This twinning can take place between research and development institutions, field stations, universities and technical institutes, and commercial firms.

148. Developing countries should be assisted in strengthening their capacity to develop suitable equipment which will have maximum economic and social impact. This could include systems engineering, demonstrations, fabrication and distribution techniques.

149. There is a clear need to improve the productivity and use of existing national energy resources especially those most relevant to end users. Both energy and financial efficiencies should be considered in this context in addition to the importance of attaining a degree of national energy independence. International assistance could clearly stimulate such research and development. An example is the use of the existing international and national agricultural and forestry research institutes for selecting and breeding high-yielding and stress-resistant energy crops and trees, and for developing better breeds of draught animals. It is also important that suitable data bases in such areas as biomass, solar and wind energy be available or generated. International collaboration involving agencies such as the World Meteorological Organization (WMO) could be very effective here.

150. An international awareness should be created of the opportunities which exist in the field of new and renewable sources of energy. The media should be used to bring this message to all those from the end-users up to the decision-makers, managers, planners and local entrepreneurs. The non-governmental organizations (NGOs) have an important role to play in this education, in training and in implementation programmes and this should be encouraged by the international community.

151. Currently there are few courses or training programmes in new and renewable sources of energy available anywhere in the world, and there is a known significant shortage of qualified manpower in this field. The expansion or creation of national, regional and international centres could play a vital role in implementing these needed education and training programmes. Training courses aimed at specific groups could have considerable impact. Such groups would include professionals such as scientists and technologists, energy planners, educators, extension officers, technicians and public users of new and renewable energy technologies.

152. In order to provide practical and relevant information about new and renewable sources of energy, and their application, to planners, policy-makers, technologists and educators in all countries, sustained information analysis and evaluation activities should be established. Such information on currently available and emerging technologies sould be especially helpful to developing countries.

153. Existing data banks on energy could be expanded to include adequate data on new and renewable sources of energy and to collate the information from national and regional energy surveys already available or in the process of being performed. Mechanisms could perhaps be developed to link these sources into an effective international information system.

154. National and regional centres for new and renewable sources of energy should be developed and strengthened. These centres should be given responsibility for resource assessment; evaluation; research, development and demonstration of appropriate technologies; information dissemination; and training. There is a need to develop regional co-operative network programmes

based on regional needs and linking such centres, to accelerate the development and use of new and renewable energy sources. Such a system would require only a small administrative infrastructure, which could be provided at reasonable cost. The establishment and interlinking of national and regional networks will facilitate and encourage the widespread dissemination of new and renewable energy technologies and permit their commercial application as rapidly as possible.

155. In order that all countries, especially developing countries, can begin to take greater advantage of traditional and new and renewable sources of energy, demonstration projects should be organized with some urgency, preferably on a commercial scale. These could be in terms of small-scale technologies for stand-alone operation in rural areas; autonomous operation of a mix of various traditional and new and renewable energy technologies on a small and medium scale; and in conjunction with integrated electricity networks.

156. The Conference may wish to consider the precise forms and areas of particular collaborative efforts which might be encouraged. In addition to the possibilities noted above, Governments may wish to examine, in the light of on-going efforts, the priorities of the various organs, organizations and bodies of the UN system, to bring international and regional co-operative activities into line with a new thrust in favour of new and renewable energy technologies. The Conference may also wish to consider institutional arrangements appropriate to such international co-operation, although the Synthesis Group has not examined these aspects in any detail. However it has considered the general question of financing in relation to its other conclusions, and has made a number of preliminary observations; these are set out in the following paragraphs.

157. The investment required to develop new energy technologies calls for significant additional financial efforts. From examination of World Bank estimates for the period 1981-1985, and other estimates, it appears that the financial resources needed for investment in new and renewable sources of energy other than large hydropower in developing countries alone could amount to as much as $12 billion. Some of the financial resources may be derived as the world community makes progress on disarmament and international security, and towards international economic equilibrium and growth.

158. Existing and prospective sources of international finance for new and renewable sources of energy include bilateral and multilateral sources of development finance. Co-operative activities among developed countries, developing countries in balance-of-payments surplus and socialist countries, like co-operation among developing countries, have been initiated and should be intensified. In relation to the financing of co-operation between non-oil developing countries and the rest of the world:

(a) Developed countries should increase their official development assistance (both capital aid and technical assistance) and their non-concessional flows for new and renewable sources of energy. Concessional assistance should increasingly be concentrated on low-income developing countries which have limited access to commercial sources of finance and have a significant potential for new and renewable sources of energy.

(b) Developing countries in balance-of-payment surplus should maintain their high levels of aid to other developing countries, strengthen their multilateral aid institutions and recognize new and renewable sources of energy as an important policy focus in their assistance efforts.

(c) Socialist countries should pay more attention to the new and renewable sources of energy needs of developing countries within the context of their contribution to the Third United Nations Development Decade.

(d) Multilateral development lending institutions have an important role to play in financing the development and application of new and renewable energy technologies particularly in the developing countries. They need to increase their support for these sources of energy in general, and to meet rural energy needs in particular. This could be achieved partly by according new and renewable sources of energy a higher priority within the sectoral allocation of available funds. Beyond this re-allocation of policy priorities, additional resources in the form of equity capital will in all probability be needed, in order to enhance their ability to obtain funds for development lending by borrowing on world markets. It is also likely that additional resources for concessional lending for new and renewable sources of energy will be required to meet the development needs of the poorest countries. This applies to the institutions already highly active in the energy field (including pre-investment activities), such as the World Bank (and its proposed Energy Affiliate), the regional development banks, and the agencies of the United Nations system (notably the United Nations Development Programme and perhaps the United Nations Revolving Fund for Natural Resources Exploration), as well as to existing institutions with a potentially significant role in this field, such as the International Fund for Agricultural Development.

APPENDIX

RECOMMENDATIONS MADE BY THE TECHNICAL PANELS AND AD HOC GROUPS OF EXPERTS

(Because of its length, this appendix will be circulated as an addendum to the present report.)

Annex I

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United Nations system

OFFICE OF THE DIRECTOR-GENERAL FOR DEVELOPMENT AND INTERNATIONAL ECONOMIC CO-OPERATION

DEPARTMENT OF INTERNATIONAL ECONOMIC AND SOCIAL AFFAIRS

DEPARTMENT OF TECHNICAL CO-OPERATION FORDEVELOPMENT

ECONOMIC COMMISSION FOR EUROPE

ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

ECONOMIC COMMISSION FOR LATIN AMERICA

ECONONIC COMMISSION FOR AFRICA

ECONOMIC COMMISSION FOR WESTERN ASIA

WORLD FOOD COUNCIL

UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNITED NATIONS ENVIRONMENT PROGRAMME

UNITED NATIONS CENTRE FOR HUMAN SETTLEMENTS (HABITAT)

UNITED NATIONS DEVELOPMENT PROGRAMMES

UNITED NATIONS INTERIM FUND FOR SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

UNITED NATIONS INSTITUTE FOR TRAINING AND RESEARCH

UNITED NATIONS UNIVERSITY

SECRETARIAT OF THE UNITED NATIONS CONFERENCE ON NEW AND RENEWABLE SOURCES OF ENERGY

Specialized agencies

INTERNATIONAL LABOUR ORGANISATION

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

WORLD BANK

WORLD METEOROLOGICAL ORGANIZATION

WORLD INTELLECTUAL PROPERTY ORGANIZATION

Other organizations

INTERNATIONAL ATOMIC ENERGY AGENCY

Intergovernmental organizations

EUROPEAN ECONOMIC COMMUNITY (EEC)

LATIN AMERICAN ORGANIZATION OF ENERGY (OLADE)

INTERNATIONAL ENERGY AGENCY (IEA)

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

ORGANIZATION OF PETROLEUM EXPORTING COUNTRIES (OPEC)

Non-governmental organizations

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INTERNATIONAL YOUTH CONFERENCE FOR THE HUMAN ENVIRONMENT (IYCHE)

SOCIETY FOR INTERNATIONAL DEVELOPMENT

Annex II

LIST OF DOCUMENTS

SYN/I/1	Provisional agenda for the Synthesis Group
A/CONF.100/PC/23	Report of the Technical Panel on Geothermal Energy
A/CONF.100/PC/24	Report of the Technical Panel on Wind Energy
A/CONF.100/PC/25	Report of the Technical Panel on Ocean Energy
A/CONF.100/PC/26	Report of the Technical Panel on Oil Shale and Tar Sands
A/CONF.100/PC/27	Report of the Technical Panel on Solar Energy
A/CONF.100/PC/28	Report of the Technical Panel on Biomass Energy
A/CONF.100/PC/29	Report of the Ad Hoc Group of Experts on Financing
A/CONF.100/PC/30	Report of the Technical Panel on Hydropower
A/CONF.100/PC/31	Report of the Ad Hoc Group of Experts on Information Flows[a/]
A/CONF.100/PC/32	Report on the use of peat for energy[a/]
A/CONF.100/PC/33	Report of the Ad Hoc Group of Experts on Education and Training[a/]
A/CONF.100/PC/34	Report of the Technical Panel on Fuelwood and Charcoal[a/]
A/CONF.100/PC/36	Report of the Ad Hoc Group of Experts on Industrial Issues[a/]
A/CONF.100/PC/37	Report of the Ad Hoc Group of Experts on Research and Development and the Transfer of Technology[a/]
A/CONF.100/PC/38	Report of the Ad Hoc Group of Experts on Rural Energy, including Utilization in Agriculture[a/]
A/CONF.100/PC/39	Report on draught animal power[a/]
A/CONF.100/PC/42	Synthesis of the Technical Panel Reports[a/]
Non-symbol document	Draft synthesis document

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a/ These documents were available to the Synthesis Group in draft form.