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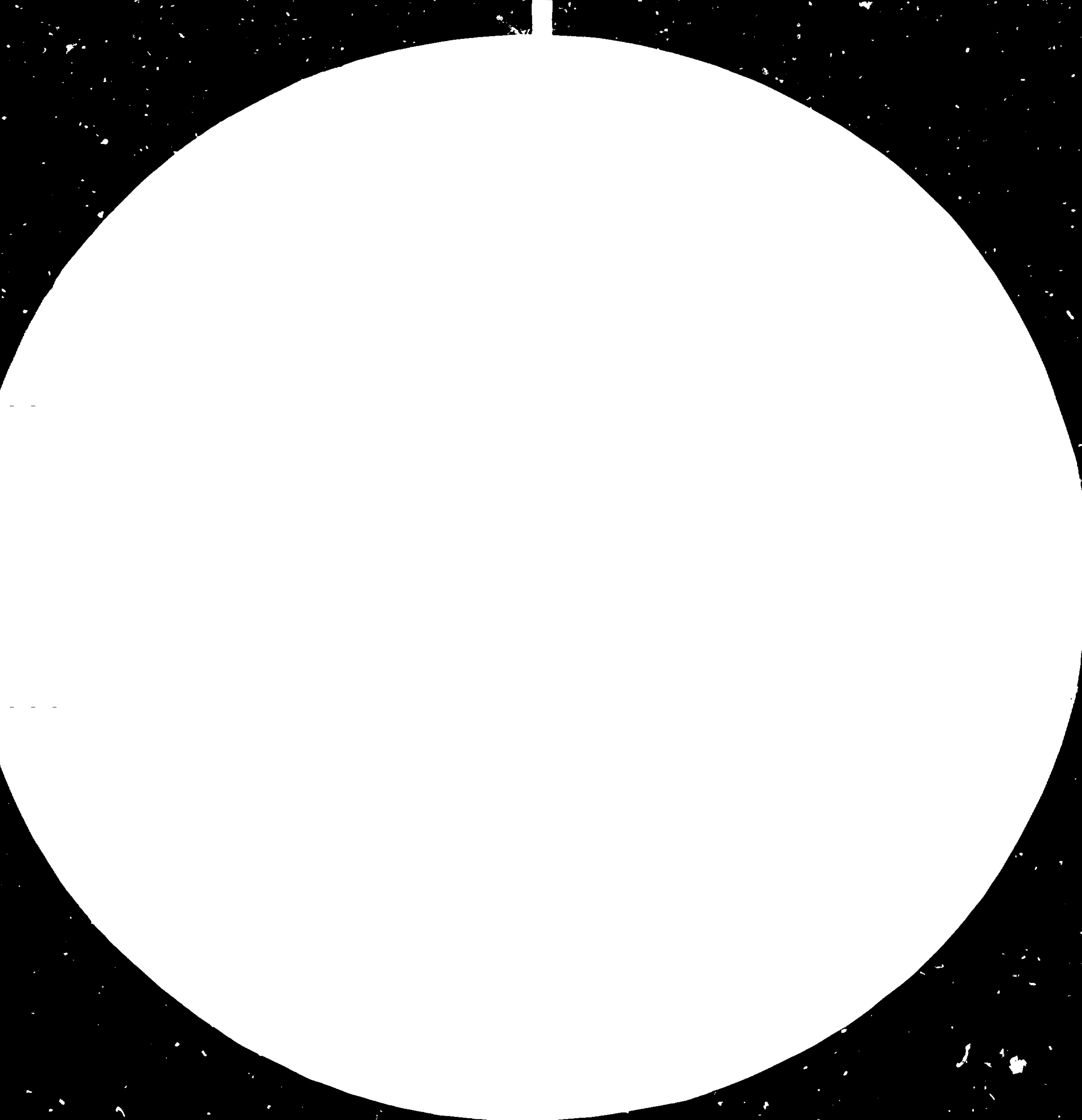

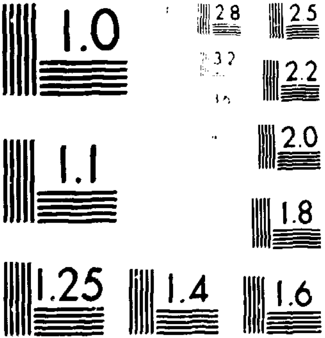

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Expert Meeting Preparatory to International Forum on Technological Advances and Development
Moscow, Union of Soviet Socialist Republics,
29 November-3 December 1982

REPORT* (Meeting on technological advances).

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CONTENTS

## INTRODUCTION

1. The Expert Group Meeting Preparatory to the International Forum on Technological Advances and Development was held at Moscow from 30 November to 3 December 1982 in co-operation with the USSR State Committee of Science and Technology. The list of participants is given in Annex I and the list of documents in Annex II.

2. The meeting was opened by Academician J.M. Gvishiani who underlined the importance of emerging technological advances the implications of which, he pointed out, extended beyond science and technology to society as a whole. An independent assessment by experts of the implications of those advances for developing countries was necessary. He congratulated UNIDO on having taken the initiative in this respect since, in his view, it was an area which should form an important part of UNIDO's activities.

3. Academician Gvishiani pointed out that in the light of the emerging technological advances, technological progress could no longer be judged simply in terms of large and gigantic projects but in terms of the contribution that it could make to development. Investment policies might also have to be viewed differently since human resources, particularly software, were assuming a new significance in the context of the technological advances. It was therefore important for the scientific community to consider in depth how the advances could be utilized for development, particularly of the third world.

4. In this context, the experience of the USSR was relevant. The Government of the USSR had prepared a Twenty-Year Comprehensive Programme of Scientific and Technological Progress. Work was currently under way to prepare a more detailed Comprehensive Programme for 1986-2005. Methodologies adopted for the preparation of the Programme would be of interest to other countries, in particular developing countries. The USSR was willing to share its experience in science and technolcgy with other countries.

5. Academician Gvishiani suggested that the International Forum on Technological Advances and Development should provide an objective and independent assessment, evaluating the state-of-the-art of important technological advances, the possible future developments and the implications for

developing countries, which should lead to recommendations for practical action on the part of developing countries and of the international community as a whole. He hoped that the results of the Forum would provide an important input to the Fourth General Conference of UNIDO.

6. Speaking on behalf of the UNIDO secretariat, Mr. G.S. Gouri, Director, Division for Industrial Studies, conveyed the good wishes to the meeting of Dr. Abd-El Rahman Khane, Executive Director of UNIDO, and welcomed the experts who represented a wide range of disciplines. He referred to the activities of the UNIDO programme on technological advances which had clearly confirmed the usefulness of sensitizing developing countries in this area, particularly in regard to policy actions and the building up of technological capabilities. At the same time it was clear that further in-depth examinations should be made and developing countries should be helped to make their own assessments with reference to their conditions and requirements. It was to facilitate this process that the International Forum on Technological Advances and Development was planned to be held in April 1983 at Tbilisi, USSR. The results of the Forum were expected to make a significant contribution to the Fourth General Conference of UNIDO.

7. Academician Gvishiani (USSR) was elected as the chairman and Mr. G.S. Gouri (UNIDO secretariat) as the co-chairman of the meeting.

8. The meeting discussed the question of technological advances and development with specific reference to microelectronics, genetic engineering and biotechnology, materials, petrochemicals, and solar and biomass energy. To facilitate the discussions, working groups were formed for each of those areas and in addition a working group on policy issues discussed the overall policy aspects involved. The working groups reported the results of their discussions to the plenary meeting. The present report incorporates briefly the substance of the discussions which took place in the working groups and in the plenary sessions.

## I. GENERAL CONSIDERATIONS

9. The meeting noted that the world was in a period of transition towards a new set of emerging or advanced technologies, many of which could be considered as "breakthroughs" in the sense of leading to improvements in existing practices and techniques greater than the gradual improvements that characterized the normal evolution of technologies. Outstanding examples were genetic engineering, microelectronics, and new materials which were the result of scientific discoveries related in particular to the internal structure of matter, cells etc.

10. These technical advances were taking place in an economic and political environment conducive to their development and application and, also, in several cases, in the context of government policies that had assisted the emergence of new technologies in developed countries. The role of the private and public sectors, and that of the "pull" of the market forces and the "push" of scientific discoveries had been different in specific sectors and countries, but it should be noted that in all cases direct or indirect government policies had played an important role in fostering these advances.

11. Furthermore, a process of integration and cross-fertilization was under way among different groups of advanced technologies, with areas of application beginning to overlap. Taken as a whole, the combined first and second order effects of those technological advances were creating new opportunities for social and economic progress in all countries. They might provide the basis for different styles of development, new ways of organizing economic activities, and the possible use of under-utilized natural resources, and this could alter significantly the distribution of economic and social activities in the world in the coming decades.

12. There was a need for determined action at the national and international levels to preserve the possibilities of using and mastering the new technologies by all countries, so that the extreme degree of technological dependence that characterized present technology markets could be avoided, at least by those developing countries that made an effort to establish their own capabilities and gain access to technological advances. However, preserving these options required immediate action, for advances

were proceeding at a rapid pace, market structures appeared to be shifting constantly in a direction unfavourable to the third world, and developing countries might see their opportunities rapidly closed as a consequence of inaction and hesitation.

13. In the above context, the meeting commended the initiative taken by the UNIDO secretariat in implementing a programme on technological advances and in particular in bringing the issues into focus through the proposed International Forum on Technological Advances and Development. It was noted further that the results of the Forum would be placed before the Fourth General Conference of UNIDO so that the Conference could consider the problems of industrialization in the context of the dynamic technological trends which were in evidence now and which would continue to influence development in the present and coming decades. Appreciation was expressed for the documentation provided by UNIDO which constituted a good basis for presentation of the issues to the Forum. It was agreed that the points already made in the documents would not be discussed again, that observations made in the meeting were intended to amplify, modify or carry forward the analysis and suggestions contained in the documentation.

14. The meeting noted that the Forum should be so designed as to result in two key outputs: (a) outputs for action at the national level by developing countries which policy-makers could take back to their respective countries and (b) outputs for international action and action by UNIDO. Both these types of outputs would also be carried forward to the Fourth General Conference of UNIDO incorporating suggestions for international co-operation both among developing countries and between developed and developing countries.

15. It was emphasized that the participants in the Forum should be high-level policy-makers and the issues should be so presented as to sensitize policy-makers to the potentials and implications of technological advances and lead to practical policy actions. Policy-makers in developing countries could be expected to seek answers to the question of the implications of technological advances for several aspects of development such as economics, employment, equity, environment, energy, efficiency, and enterprises. They would also want to know the impact of the emerging technologies

on existing technologies and industries, the financial investments needed and other information essential for taking strategic policy decisions. Such information would cover assessments involving aspects such as:

(a) State-of-the-art in a specific sector in terms of the frontier technologies, normal and traditional technologies;
(b) The trends of technological development and the implications of the interaction of several technologies;
(c) (i) The levels of competence required for:
   - autonomous decision-making;
   - adapting or modifying technologies to local needs;
   - producing innovations through R and D.
   (ii) The time horizons needed for (i) above;
(d) The social impacts of technologies;
(e) Existing industrial infrastructure for the development and application of technologies;
(f) Integrating the various levels of technology;
(g) The implications for international trade and comparative advantage.

The information would then be used for decisions, taking into account the priorities of each country.

16. In this connection it was emphasized that the impact of technological advances on individual sectors could only be considered as the first order of impacts. The significance of the technological advances, extended beyond the first order of sectoral impacts to the long-term economic and social structure of the countries including urbanization, learning, recreation, trade and international specialization, and cultural patterns. A parallel was drawn to the impact of the automobile which extended beyond providing an alternative means of transport to a wide range of other social and economic impacts.

17. The meeting noted that it was considering in its discussions only the technological advances and not the whole spectrum of technologies. It proceeded to consider the implications of a few selected technological advances taking into account the importance of those advantages and their potential impact on developing countries.

## II. SPECIFIC TECHNOLOGICAL ADVANCES

### A. Microelectronics

18. The meeting discussed the paper of the UNIDO secretariat on the subject [1/] (ID/WG.384/5) and endorsed it in general; in addition, it made further observations.

19. The meeting noted that microelectronics was an extremely important system of related technologies which could play a significantly beneficial role in the economic and social development programmes of most countries. Application of microelectronics-based systems improved manufacturing efficiency and the quality of products and could lead to significant improvements in various fields like agriculture, education, health and transport which had a direct bearing on the quality of peoples' lives. It was necessary for each country to examine its own needs and review what microelectronics had to offer.

20. The meeting drew attention to the importance of applications since they provided immediate benefit, had a demonstration effect and provided a base for further manufacturing activities. As a large proportion of the population in developing countries lived in rural areas, special emphasis needed to be put on applications of microelectronics in villages. In this connection, it was pointed out that the microelectronics programme of India envisaged the use of microelectronics for improving agricultural production (e.g. by developing instruments to measure the humidity of the soil); improvement of education by providing educational programmes on television; improvement in health care by providing better communication links and electronics-based diagnostic services. Another example of an application programme was that of the USSR which was aimed at improving industrial efficiency and scientific research through the preparation of standard equipment and software suited to process control, computer-aided design, and scientific laboratory automation. It was emphasized that as a general rule application experts should be involved in the development of applications together with the electronics engineers. Once an application was developed, the users should be trained in its use.

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1/ Microelectronics and Developing Countries: Towards an Action-oriented Approach (ID/WG.384/5).

21. Standardization on the 'building block' level (computer/microprocessor family/CAD/CAM [2/] graphics presentation, software languages for real time control etc.) co-ordinated with major standards in the other branches of industry - instrumentation, machine tools, telecommunications - would help to create the effective mechanisms for technology transfer in the most critical application areas. Such mechanisms would facilitate a wide choice of options in developing countries and circumvent the problems of frequent retraining for the growing user base.

22. To assist in standardization, a 'menu' approach might be adopted where the government by bulk purchase, easier import and availability and perhaps fiscal concessions and subsidies might encourage the use of a standardized range of chips, which ultimately might be manufactured in the country.

23. Manufacturing involvement might range from design and production of systems using foreign components to manufacture, starting from relatively simple components right up to advanced microelectronics components. In this connection, the establishment of silicon foundries was mentioned as a possible easy way of countries acquiring the capability to manufacture chips for specialized needs. In this connection, it was pointed out that a silicon foundry required a broad industrial infrastructure, large inputs of highly skilled specialist labour and a large investment of capital. The manufacture of relatively simple components might lead to a training and development process which could eventually lead to the manufacture of more complex components. In this context, it was urged that developing countries needed a capacity to design chips for their own applications in addition to the use of standard components and, in view of the increasing incorporation of software in hardware, a level of manufacturing capacity was needed. Countries might also wish to enter manufacturing as a strategic activity.

24. The Microelectronics Monitor published by UNIDO was considered an excellent first step in the right direction in promoting current awareness. It was felt that its scope and coverage should be extended; experts from India and the USSR offered to help in this regard.

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2/ Computer-aided design; computer-aided manufacture.

B. Genetic Engineering and Biotechnology

25. The meeting discussed the UNIDO secretariat paper [3/] and generally endorsed its contents and made further observations.

26. The meeting noted that genetic engineering could be regarded as the third microcycle of innovation in the field of bioengineering, preceded by enzyme engineering and microbial protein. As such it could benefit from the interactions of the earlier cycles. Its potentialities could be seen over a wide spectrum including energy, agriculture, minerals, human and animal health and industry. The meeting examined some of the developments in this regard.

27. In regard to energy, the role of microorganisms in enhanced recovery of oil had been emphasized as a means of not only augmenting oil production but also of enhancing the quality of the oil recovered. Biomass-derived energy held out promise for developing countries. However, in view of the competition between energy and food and fodder applications in this respect, the improvements in biogas production were particularly relevant. Further, the utilization of cellulose-containing materials was regarded as the most promising one, in view of the fact that the world's natural production of cellulose was somewhere between 100 and 700 billion tons annually. A vital scientific and technological goal was, therefore, the development of methods to convert cellulose (a) from its inedible form to sugars; (b) from a native (or waste) state to motor fuel; and (c) to single cell protein, particularly for use as fodder. Bioconversion of cellulose appeared to offer a flexible approach to developing countries. The degradation of cellulose to glucose required much "softer" conditions than acid hydrolysis or gamma irradiation, and the sugars obtained consequently contained far fewer toxic by-products.

28. The processes for which effective technologies were currently being developed were (a) enzymatic production of glucose from cellulose-containing raw materials (industrial and agricultural wastes); (b) bioconversion of cellulosic and lignocellulosic materials into ethanol; (c) hydrolytic (possibly oxidative hydrolytic) destruction of plant biomass to enhance

3/ Genetic Engineering and Biotechnology and Developing Countries: Directions of Action (ID/WG.384/4).

its nutritive value for livestock; and (d) enzymatic or microbiological destruction of lignin to obtain alkylphenols, oxyphenols and other phenol derivatives as likely primary products of polymer chemistry. It was believed that the processes (a) and (b) would be implemented industrially in the next 10 years and (c) and (d) in the following decade. The effective implementation of the biotechnological processes largely depended on progress at the molecular level (basic) and on the development of improved techniques for the fractionization of various vegetable materials.

29. The meeting noted, however, that the problems regarding the development of biotechnology in return to lignocellulose were associated with at least four factors:

- raw materials
- enzymes
- processes
- engineering.

Since raw materials were regional, the profile of their use might vary from country to country. The other three factors could be solved best by joint efforts involving various scientific and applied centres in different developed and developing countries.

30. In agriculture, in regard to nitrogen fixation, genetic improvement of the nitrogen-fixing symbiotic bacteria (rhizobia) that modulate leguminous plants was considered a rational goal. Genetic engineering also held promise for production of biological pesticides. Fundamental improvements in plant characteristics was a long-term goal that would possibly be reached only in the 1990s. Another area was the upgrading of agriculturally important animals. Taken as a whole, the future impact of genetic engineering in agriculture was expected to be far-reaching and profound.

31. In regard to geomicrobiology, the microbial leaching of mineral resources and other metals had been developed. Special microbiological methods for fixing the methane content both in coal beds and in the mine atmosphere had been developed in the USSR.

32. Recent developments generated optimism relating to the synthesis of drugs and vaccines with regard to diseases such as malaria and leprosy, and in regard to population control, and simple and reliable diagnostic kits for doctors and veterinarians.

33. Genetic engineering also expanded the possibilities for constructing and producing strains which formed the basis for efficient industrial production of many important compounds including antibiotics, amino acids, enzymes etc.

C. Materials and New Technology

34. Drawing attention to the important role of materials for economic and social well-being in contemporary society, the meeting emphasized that the economic growth of developing countries required positive materials development and utilization activities. For this purpose both new technologies and new materials, as well as traditional materials where new and better technologies could be applied, were relevant. Materials were diverse including inorganic materials (concrete, brick, ceramics) natural (timber) and synthetic organic (polymers) materials, metallic materials and reinforced composite materials of many kinds.

35. Steel, plastics, powder metals and composite materials were considered illustratively in view of their potential importance for developing countries. The meeting recommended the attention of the developing countries to the new advances in steel, particularly since steel was basic to an industrial economy. Among the many significant accomplishments in steelmaking practices and in the product area, the family of high-strength low-alloy steel was particularly noteworthy since it provided superior combinations of strength, toughness, formability and weldability and had diverse applications.

36. Because of increasing energy costs and the necessity to conserve petroleum feedstocks, emphasis was given to the use of fillers in plastic materials where some important new advances had been made and there was good potential for further improvements. Fillers might be classified as inorganic and organic, both natural and synthetic. The inorganics included materials, such as slags, quartz sands, wastes from ore and metal processing and fly ash from thermal power stations. The organics included wood flour, ground nutshells,

rubber powder, and polymer scrap. As part of the new technology in this area a non-conventional technique had been developed whereby monomers were mixed with the appropriate filler and polymerization took place on the surface of the filler particles. Another significant advance was a new milling technique which combined shear with pressure at elevated temperatures. Originally developed for use on polymeric material, the technique was applicable in several other fields such as milling flour from bran and other grains, the production of wood flour as a more reactive feedstock, and to reclaim rubber in the form of powder from waste rubber.

37. The meeting drew attention to the potential advances of powder metallurgy because:

(a) It was a highly flexible technology and provided a useful supplement to conventional fusion metallurgy;

(b) There was a well developed state-of-the-art, some of which should be useful to developing countries;

(c) The opportunity existed to develop facets of the field which were particularly suitable for the developing countries;

(d) Entry in the powder metal industry could be done on an incremental basis starting with a partial activity and subsequently expanding the process and product scope.

38. The meeting noted that fibre-reinforced composites had emerged as a new class of materials in which a desired combination of properties could be obtained. The range of composite material systems was broad and continuing to expand with further research and development. The meeting drew attention to several important composites such as:

(a) Newly-developed basalt fibres with properties comparable with glass fibre and amenable to processing in several desired forms. These were very inexpensive, and had an abundant raw material base and wide application in concrete and insulation material;

(b) Glass fibre-reinforced plastic, which was already a mature commercial material;

(c) Aromatic polyamide fibres;

(d) Carbon fibres, which were suited for high performance applications but were at an earlier stage of technical and commercial development than fibre glass and more expensive.

39. In addition, the meeting emphasized the importance of composites reinforced with materials made from biomass. Several examples of successful applications existed such as fibre-reinforcement of concrete, bamboo fibres reinforced by plastics for silos, reactors, etc., bamboo columns for immobilized cell technology, etc. In general, the use of composite technology of this type could be practised in a labour-intensive manner by fabricating materials, suitable for small and moderate size markets and involving modest capital investment, by hand lay-up and press moulding.

D. Petrochemicals

40. The meeting noted that the role of petrochemical products in a wide variety of sectors was increasing in both the developed and the developing countries.

41. The new technologies included not only new ways of obtaining final petrochemical products, but also new ways of obtaining intermediate feedstocks such as ethylene, propylene and the aromatics from which practically all polymeric materials came.

42. The basic feedstocks that were used, and likely to be used in the future in the field of petrochemicals, were similar or identical to those used for energy. Therefore technical and economic developments in each field would interact.

43. The differences in needs of material and technology for petrochemicals varied greatly between oil-producing developing countries and those developing countries without adequate natural resources of petroleum.

44. Petrochemical technology which utilized abundant low-cost raw materials such as petroleum residues, coal and biomass or even natural gas as a feedstock was very attractive to those countries without indigenous oil supplies.

45. The key technological research work at the international level on petrochemicals, with the greatest relevance to the developing countries, was:

(a) the conversion of methanol to ethylene and propylene; (b) the conversion of synthetic gas to chemical intermediates; (c) the production of coal liquids by hydrogenation; (d) the conversion of methanol directly to petrochemical end-products, and (e) biomass as a source of petrochemical feedstock.

46. For the production of intermediate petrochemical feedstock, improved technologies for producing synthetic gas, methanol, lower alcohols of the Fischer-Tropsch type and lower olefins from cracking were considered the most important. Most of these technologies were under development by the USSR and the developing countries might have this reservoir of technology to draw upon.

47. The development of technologies for the large-scale utilization of methanol feedstock for the production of ethylene and propylene should be pursued. In this connection it was noted that world production of methanol was increasing rapidly and that senior Soviet experts had forecast that the trend was for methanol to become a major international feedstock. In the Soviet Union itself methanol production was estimated to reach 30 million tons per annum by 1990 compared to the present production level of 2 million tons.

E. Biomass Energy

48. Biomass energy was a usable form of energy derived from all plant and animal material. It included forest-wood, agricultural crops and residues, animal manure, industrial and municipal wastes, fresh and saltwater plants.

49. The quantities of biomass available for energy were very large, renewable and included an energy storage mechanism. The biomass productivity potential of the forests of the world had an energy content of nearly three times the world's current energy use.

50. In most developed countries the biomass resource base was unmanaged. There were a number of ways of increasing and improving the energy content of biomass resources. These included: (a) large-scale forestry biomass production and collection in terms of land area and wood output levels;

(b) improved utilization of agricultural and forest residues and industrial and municipal wastes; (c) aquatic biomass production; (d) improvement in plant species for energy use by the application of biotechnolcgy.

51. Peat and lignite, although not renewable, were new and rich energy forms and there might be deposits, even if relatively small, in many developing countries.

52. There were a number of new technologies related to the conversion of biomass into energy. These ranged from the very simple, low-level technologies, which were available at present and had wide application in many developing countries, to the very sophisticated technologies which were still at the research stage and would only be suitable for specific countries.

53. Direct combustion of biomass using stoves and charcoal kilns could be considered as the low-level technologies; biogas production might also be considered as a simple technology although it involved biological processes which were not completely understood. The conversion of sugars and grains into ethanol was also a well-known technology and a wide range of methods of improving the efficiency and reducing the costs was available.

54. Pyrolysis, gasification, direct liquefaction and ligno-cellulosic fermentation by enzymes were all technologies which were only at the research and development stage.

F. Solar Photovoltaics

55. The meeting noted that a photovoltaic power system typically consisted of a solar cell array, energy storage and regulation and control devices.

56. One very important feature of solar photovoltaics was that the cost per unit of energy generated did not depend drastically on the capacity of the unit installed. Therefore it was very suitable for small-scale rural and decentralized applications, making it highly relevant to developing countries.

57. The four basic areas of activity in the development of the engineering and technology of solar photovoltaic systems were (a) basic raw material, particularly silicon; (b) solar cells and modules; (c) balance of system components; and (d) complete systems engineering.

58. The major areas of technological development in photovoltaic systems were: (a) fundamental research on solar cells; (b) R and D on solar cells to reduce the number of fabrication steps and hence the cost; (c) mass production of solar cells, again to reduce the cost; and (d) reduction of component costs.

59. First generation technology for photovoltaics was already on the market, but at a high cost per unit of electricity produced. Several approaches were being followed to reduce the cost of solar cells and it had been projected that for photovoltaic panels made from amorphous silicon or other thin films, the cost could be less than US $ 1 per peak Watt. But this was still a projection and would depend on the success of current research and development.

## III. POLICY ISSUES

60. The meeting agreed that developing countries had as general objectives: improving the welfare of their population, achieving equity in the distribution of benefits derived from economic growth, and making more efficient use of their resources. However, there were a variety of ways and many possible approaches to the achievement of these general objectives, and each country placed emphasis on different specific goals and roads to the achievement of these general objectives.

61. In spite of the diversity of ways and approaches, there was at least one feature common to all developing countries: at the close of the twentieth century it was impossible and even dangerous to disregard scientific and technological issues in the design of development strategies. If autonomy in the choice of objectives and the capacity to achieve them were valued, it became imperative for a country to have at its disposal at least a minimum level of technological capability in the critical areas and fields of importance to the development strategy.

62. The fact that there had been significant technological advances in the highly industrialized nations, and that they presented opportunities that were in many senses unique for the third world, did not mean that developing countries must follow blindly the high technology path opened by the industrialized nations. There were many difficulties and pitfalls associated with the acquisition of capabilities in advanced technology fields. High technology was not an escape route from the problems of underdevelopment, and there was no hope of making a reasonable start in the fields of advanced technology unless basic capabilities in more general areas of modern science and technology were established. This required significant investments in human resources at the technical and scientific levels; the establishment of a basic institutional infrastructure, and the provision of financial resources in a significant and continuous fashion. Furthermore, it was necessary to avoid excessive or exclusive concentration on high technology options, focusing rather on the whole range of available technological options,

from traditional to advanced, and learning to manage the "technological pluralism" that would be optimal in the light of the objectives, possibilities, and limitations of a particular developing country. Special attention should be given to the difficulties faced by the least developed countries, either in terms of income or of scientific and technological capabilities, for advances in high technology might be combined with traditional or conventional technological practices in unique ways that might be better suited to achieve their development objectives.

63. From a scientific and technological point of view, the first task should be to build a minimum level of endogenous capabilities in fields and problem areas of key relevance to the development strategy of a country. At the same time, it must be realized that the establishment of these capabilities required that several measures be taken - not only in science and technology policy - but also in related areas such as education, industry, finance, foreign trade, general economic policies. These measures should create the basic conditions for the generation, importation, adaptation and use of technology in a continuous and self-reinforcing fashion. Furthermore, taken as a whole, these measures would amount to significant transformations in the social and economic structure of most developing countries.

64. Technological advances, and the products these new technologies generated, introduced changes in values, consumption habits, and even ways of thinking. These changes might be negative, as in the widespread adoption of patterns of consumption linked to high income levels, or positive, as in the possibilities they created for decentralization of economic activities and decision-making. In considering this high technology option, the pitfalls associated with it, if any, should be identified, while exploring at the same time new paths to the integration of technological advances into the design of development strategies and plans, and the definition of policies for scientific and technological development in general.

65. Policy-makers in developing countries should be aware of the need for a selective and differentiated approach to the formulation and implementation of technology policies in the different groups of advanced technologies. There was no unique set of policies appropriate to fields as varied as

genetic engineering, microelectronics, and photovoltaic energy conversion, and the specific scientific and technological features of each field introduced constraints into the policy-making process. However, while acknowledging these differences, interactions and cross-fertilization should be taken into account, as well as the need to design and put into practice policies to develop a common foundation of scientific and technological capabilities for all fields. Furthermore, the selection of fields on which efforts should be concentrated should be made in the light of development objectives.

66. The particular characteristics of individual developing countries imposed the need for different treatments at the policy level. Factors such as size of the country, the existing level of technological capabilities, the economic strengths and weaknesses, and the resource endowment would influence the content of policies to develop scientific and technological capabilities. However, one characteristic common to all developing countries was that the development of these capabilities in the advanced technology fields would only come about as a result of deliberate government intervention, and these policy intervention measures must encompass not only specific science and technology activities, but the broader spectrum of economic, social, educational and even cultural policies, so as to make them congruent with the development of advanced technology capabilities.

67. A decision of fundamental importance for each field of technology referred to the level of capabilities that should be developed, and these levels might vary from one field to another. At a minimum level there was the capacity to adapt and absorb technology; while at a more substantive level, there was the capacity to generate the advanced technologies, particularly in some areas of the biotechnology field. Furthermore, the specific content of each of these levels must be reinterpreted for each group of advanced technologies, and policies must be adopted with regard to the levels of development of capacities in each case.

68. When referring to technology policies for individual activities linked to new advances in technology, it was necessary to consider at least four lines of action: (a) the generation of technology; (b) the importation of foreign technology; (c) the absorption of technology by the productive sector; and (d) the promotion of demand for local technology. These

four lines of action would serve in different ways in the diverse advanced industrial technology activities in order to achieve the levels of capability described in the preceding paragraph. Two complementary lines of action related to the information and training aspects that were common to the generation, importation, absorption and demand for industrial technology.

69. The design of policies to acquire high technology capabilities should take into account the level of resources required for this purpose. In so far as possible, detailed assessments of human resource requirements should be made (at the scientific, technical, support, industrial and policy-making levels); the infrastructure requirements should be specified (institutions, services, equipment, materials, facilities etc.): and overall estimates of financial requirements must be made, so as to base the strategic decision to develop technological capabilities on a firm basis. However, the very nature of the new technological advances, and the uncertainties associated with them, made the precise estimation of these parameters a nearly impossible task, and there was a need for improving methodologies for assessment, and project evaluation procedures to take these uncertainties into account. But in no way should this need for improved methodologies and procedures be considered as an excuse to delay making the crucial decisions that were required at present, if the opportunities presented by technological advances were to be grasped by the developing countries. Time pressures to take advantage of the present situation and opportunities in the new technologies precluded a leisurely approach.

70. The integration across fields, levels of technological capacities and lines for technology policies would provide an overall strategic perspective for the policies relating to high technology fields. The strategy adopted should combine the definition of priorities and the continuity of efforts in a particular field, with flexibility and the capacity to react quickly to new developments and changes in technology.

71. A key component of any strategy and set of policies to deal with advanced technologies in developing countries would be the dimension of international co-operation, particularly co-operation among developing countries. In this regard the example of the International Centre for Genetic Engineering and Biotechnology (ICGEB) was one that should be closely followed with the aim of extending its approach to international co-operation into other areas of interest to the developing countries.

72. Policy-makers should be aware also that to do nothing or to delay decisions with regard to the development of advanced technology capabilities constituted in effect an implicit strategy for which the opportunity costs were very high for developing countries. Moreover, it must be realized that successes in mastering advanced technologies would also enhance capabilities in conventional modern technologies and in traditional technologies.

73. Finally, policy-makers should also be aware that the development of advanced technology capabilities was a viable and concrete proposition, not a utopian dream or a goal that was out of reach. These capabilities were being acquired by some developing countries and in many areas did not necessarily involve huge investments in financial or human resources. Furthermore, if developing countries did not acquire those capabilities that were within reach, in the near future, the resulting situation when they bought the products of those technologies from the industrialized nations, or imported the technology wholesale in a packaged form, would only repeat and reinforce the technological dependence patterns that had characterized North/South relations.

# IV. CONCLUSIONS AND RECOMMENDATIONS

## A. CONCLUSIONS

### Policy Issues

74. The meeting concluded that the development and application of new technologies by developing countries to meet their needs and conditions was feasible and might not necessarily involve heavy investment in human and financial resources. The opportunity cost for developing countries of overlooking the technological advances was high, both in terms of potential benefits forgone and in terms of the acquisition of inappropriate technologies and the aggravation of their technological dependence. There was an urgent need for developing countries to take policy actions, in view of the lead time required for development of the requisite technological capabilities and to avoid expensive and inappropriate imports of products and technologies.

75. To realize the potential benefits of the technological advances, developing countries needed to develop capabilities to select and acquire advanced technologies; to adapt them to their needs and conditions; and to develop innovations responding to their socio-economic needs and requirements. For this purpose each developing country should formulate and implement policies suitable to its context and selected and differentiated according to the nature of each technological advance.

76. In formulating the policies the immediate as well as long-term economic, social, cultural and political implications of the technological advances and possible changes in consumption patterns should be kept in mind. Policy actions should be derived from the development policies and integrated with the technology policies as well as industrial, fiscal and commercial policies. Technological trends should be monitored so as to facilitate both project- and policy-level decisions. Policy response to technological advances should be viewed as a strategic activity, lending itself to the management of structural changes where needed.

77. International co-operation, particularly co-operation among developing countries, might promote the development of the requisite technological capabilities. Co-operation among developing countries could also lead to the

harmonization of policy actions and strategies.

Specific Technological Advances

1. Microelectronics

78. The most important feature of microelectronics was the great variety of its applications. It was therefore essential that each country should take steps to be well informed on the potential of the technology and should consider it in the context of its own specific problems, needs and capabilities.

79. The needs of developing countries were very different from those of the developed countries and therefore applications suited to them needed to be developed. Equally their own assessments of wider social impact needed to be made. There were complex trade-offs between labour-saving potential and microelectronics and benefits to be gained through increased efficiencies. These needed to be considered in each specific context and case.

80. In view of the rapid development of technology in this area, conscious decisions needed to be taken to protect investments for specific time frames and a constant monitoring system should be evolved. As far as possible, parallel research and development should be encouraged to develop existing technology.

81. The commonality of application areas and the shortage of technically qualified people in developing countries and the benefits of economics of scale made the microelectronics industry suited for implementation of the technical co-operation among developing countries (TCDC) concept and regional co-operation.

82. The manufacture of relatively simple components might lead to a training and development process which could eventually lead to the manufacture of more complex components. In this context it was emphasized that developing countries needed a capacity to design chips for their own applications in addition to the use of standard components and, in view of the increasing incorporation of software in hardware, a level of manufacturing capacity was needed.

83. The Microelectronics Monitor published by UNIDO was considered an excellent first step in the right direction in promoting current awareness. Its scope and coverage should be extended.

2. Genetic Engineering and Biotechnology

84. The use of bioengineering might reduce the scale factor dependence, the centralization trends and the capital requirements that were characteristic of many traditional industrial practices. In this sense, it offered additional and diversified possibilities for industrialization which were uniquely suitable for developing countries. Genetic engineering applied in the energy, agricultural and health fields could add new options for settlement planning and act as a total catalyst for social innovations with a positive effect on the environment.

85. Research and development work in genetic engineering and biotechnology in developing countries was particularly essential in view of the fact that they had clear advantages in terms of local biomass resources which could be exploited for their benefit. Science and technology policy and educational planning related to bioengineering were of particular relevance to developing countries with a high photosynthetic potential, a strong economic dependence either on single cash crops like sugar or metal resources that could be upgraded or increased by microbial means. Educational planning should encompass all training levels.

86. In view of the benefits that they could obtain through genetic engineering and biotechnology, developing countries should correspondingly plan the generation of biomass in a systematic manner that would facilitate their realizing the full potential of their natural resources.

3. Materials and New Technologies

87. It was almost axiomatic that the economic growth of the developing countries required a positive materials development and utilization activity. Such activity would include traditional materials to which new and better technologies could be applied, as well as new materials and new technologies.

88. The materials examined in the meeting (steel, plastics, composite materials and powder metals) offered new building blocks for the industrial economy and also good added value. The investment requirements varied widely. Though steel was capital intensive, to a country with an existing capacity, the high-strength low-alloy steels offered the producer a higher value product than the plain carbon grades they replaced and were more cost-effective in service. Composites might be produced with a modest capital investment.

89. The developing countries should initiate the careful assessment of the potentialities of advances in the materials area taking into account their raw material position, the availability of energy and the existing production capability in the country. They could also choose between fully integrated or non-integrated production.

4. Petrochemicals

90. There were unlikely to be major hurdles to the development of new petrochemical technologies, but without developing country action the introduction of new technologies would be dependent upon the economic and resource situation in the developed countries.

91. The situation for developing countries was that they could continue to import the conventional technologies and/or materials from the industrialized countries or they would have to act individually or jointly to develop new technologies. A third possibility was that the developing countries induce the industrialized countries to develop the new technology.

92. Many developing countries' research capabilities had not yet reached the stage where they could undertake autonomous research and development in the field of new petrochemical technologies and they might require external assistance.

5. Biomass Energy

93. Biomass energy in its many different forms had many competing uses. It competed with wood for pulp and paper and construction material. Sugars, grains and other agricultural crops competed with food and animal feed

production. Therefore it was essential that the energy, food and material potential of biomass was balanced in an integrated approach in line with the needs and resources of the countries in question.

94. There was a major difference in the energy supply systems needed for large urban areas in developing countries, which needed centralized systems, and the rural areas for which decentralized systems were appropriate. Biomass energy was generally better suited to small-scale decentralized applications although it could be used for large scale power generation.

95. The introduction of scientific-based low technology in the form of improved stoves and charcoal production might not appear very important. In fact, the reverse was true; such improvements were immediately available and an increase in energy efficiency from 5 per cent to 30 per cent for some 250 million people in rural areas of developing countries was of major importance.

96. The number of biogas plants in existence throughout the world was very large (seven million in China alone) but there was very little information on their performance characteristics. It was possible with small improvements in design, operating conditions and selection of suitable bacteria to greatly improve their efficiency.

97. The ethanol fermentation of sugars, grains, etc., although a commercial technology, was only considered suitable for countries with surplus crop production.

98. If the research work on lignocellulosic fermentation by enzymes led to successful commercial operations, it would be a major contribution to biomass energy. This was because the process was very attractive in terms of energy efficiency and use of raw materials. It opened up new ways to produce ethanol, i.e. a liquid fuel from forest wood.

6. Solar Energy

99. Because of the high level of solar radiation available in many of the developing countries and because of the need for decentralized systems, solar photovoltaics had considerable potential in developing countries.

100. Technology development in the field of solar cells was in a highly dynamic state resembling the semiconductor industry some years ago. It was therefore likely that the costs would continue to fall. In such a situation it was a difficult question as to if and when developing countries should enter the market.

101. Even if developing countries decided against the production of the solar cells it was possible for them to develop indigenous capabilities in the building of the system. With the anticipated reduction in the cost of the solar cell the proportion of the value added by the system became greater.

102. The major research and development work in the field of solar photovoltaics was being carried out by the industrialized countries. But the major market for this equipment would be the developing countries because of other abundant solar energy potential. This provided the developing countries with a certain bargaining strength.

103. Since large-scale applications of photovoltaic technologies would appear to be still a decade away, it was important that developing countries utilize this period effectively in building up their capabilities, carefully assessing alternative technologies, undertaking pilot projects and achieving technological self-reliance in this area. Thus the 1980s and particularly the next five years would be a crucial one for developing countries and for the nature and direction of the development of the industry as a whole.

## B. RECOMMENDATIONS

### Policy Issues

104. Each developing country should establish appropriate mechanisms to monitor and assess technological trends and their implications for their social and economic development, and develop, formulate and implement policies to maximize the potential benefits of the new technologies and avoid their adverse consequences.

105. Developing countries should promote co-operation among themselves to build up technological capabilities in advanced technologies and to harmonize their policies.

106. UNIDO should continue and expand its Programme on Technological Advances, to assist developing countries in regard to the above, inter alia, by:

(a) Sensitizing policy-makers, scientists and enterprises in developing countries;

(b) Carrying out further assessments in the fields considered in the meeting and by examining new fields as appropriate;

(c) Assisting developing countries in carrying out national-level assessments, formulating policies and establishing monitoring mechanisms in the field of new technologies;

(d) Providing advisory services, on request, for the selection and acquisition of advanced technologies;

(e) Assisting developing countries, on request, in developing technological capabilities in new technologies through promotional activities and technical assistance;

(f) Promoting international co-operation including co-operation among developing countries in this area of activity; and

(g) Mobilizing the co-operation of high-level scientists and technologists and professional associations in developed and developing countries in the task of applying the technological advances for development.

Specific Technological Advances

1. Microelectronics

107. The scope and coverage of the Microelectronics Monitor should be extended.

108. In view of the need to extend information services including those of UNIDO in this area, and to lead to setting up new data banks and making arrangements with existing data banks on microelectronics applications, a special meeting of experts on this topic should be arranged. Host facilities for organizing such a meeting in India under the sponsorship of UNIDO were offered. With regard to information on applications, the work

done in India on the potential applications in a number of industrial sectors would be provided as a contribution from India to the forthcoming International Forum.

109. UNIDO, in co-operation with the International Standards Organization (ISO), should work towards standardization in this industry, whereby the latter could promote standards and the former assist in the creation of application possibilities.

110. The UNIDO secretariat should examine the possibility of setting up a task force of experts to examine further the concept of establishing silicon foundries as an instrument for acquiring the capability to manufacture chips for specialized needs.

111. The TCDC concept should be regarded as the first option whenever external assistance of any kind was to be provided to a country. This was particularly so for training, consultancy, software development, maintainence and other activities which were highly manpower-oriented. The same concept might be extended to manufacture and trade in components and end-products. This would help economies of scale which made such activities economically viable and help in developing self-reliance in the developing countries.

112. As part of the TCDC concept, regional centres and perhaps one international centre as the nodal agency should be set up primarily for the development of microprocessor-based applications, equipments and systems. R and D centres based on similar lines also could be considered. All such regional centres should be set up only in developing countries.

113. As TCDC and regional co-operation was a very major cornerstone of developing the microelectronics industry in all its aspects, a co-ordination agency with representatives of the participating countries within the United Nations framework might be set up to co-ordinate activities and draw up and implement various plans. This agency should have a scientific and technical secretariat to assist its activities.

2. Genetic Engineering and Biotechnology

114. Decision-makers in developing countries should:

(a) Develop national committees capable of evaluating such developments in genetic engineering and biotechnology that might be relevant to their countries, be they in terms of participation in international activities or related to the national centres designated as their counterparts;

(b) Utilize all training facilities and communicable channels that were available, in particular those that were specifically geared to the needs of developing countries such as the International Centre for Genetic Engineering and Biotechnology proposed by UNIDO; and

(c) Initiate research programmes geared to their national needs.

115. Simultaneously, intergovernmental and non-governmental organizations active in the promotion of science and technology for development should:

(a) Note the significance of genetic engineering and biotechnology for leap-frogging some of the hurdles that were inherent in traditional approaches to industrialization, agricultural development and health care delivery;

(b) Promote the exchange of information between developing countries about the experience gained, and between scientists in developing countries and those in the industrialized countries that could contribute to the solution of current problems by the application of the knowledge which was now generated. Special attention should be given to ligno-cellulosic waste materials as a resource for rural development in poor countries;

(c) Develop a network of co-operation laboratories around a 'node' in the form of an International Centre for Genetic Engineering and Biotechnology with resources for advice and advanced training as well as for the innovative research and troubleshooting that was necessary to optimize the impact of genetic engineering and biotechnology in areas such as agriculture, geomicrobiology and fossil fuel management.

116. Finally, UNIDO should:

(a) Continue its efforts to establish the International Centre mentioned;

(b) Act as a catalyst for international activities aimed at the application of science and technology to development;

(c) Make an effort to demonstrate that a systematic utilization of the potential of genetic engineering and biotechnology could serve as a powerful introduction to rural industrialization carried through high technology.

(d) Continue the publication of Genetic Engineering and Biotechnology Monitor and extend its coverage.

3. Materials

117. The meeting recommended that the UNIDO secretariat should prepare an information bulletin on materials technology similar in nature to the existing quarterlies on microelectronics and genetic engineering and biotechnology (the Soviet participants offered to prepare summaries of information from the USSR for use by UNIDO). The meeting further recommended that:

(a) UNIDO should convene an expert working group on selected materials and related technologies;

(b) Promote training activities in this field;

(c) Examine the necessity and feasibility for establishing an international mechanism in the area of materials science and technology;

(d) Promote regional co-operation in the field of selected materials.

4. Petrochemicals

118. In terms of technological development, it was recommended that the following three areas should be emphasized:

(a) R and D, and most importantly the development of technologies, for creating metal-tolerant catalysts for the utilization of heavy petroleum residues and for the deep-refining of heavy oils for petrochemical feedstocks, an aspect which had equally important implications for energy materials;

(b) New catalyst systems for the production of materials from syngas should be pursued so that the temperatures and pressures at which methanol was produced could be very substantially reduced. In this connection it was recognized that such development would aid developing countries which were able to obtain syngas from biomass, coal, heavy petroleum residues, etc.

(c) The development of technologies for the large-scale utilization of methanol feedstock for the production of ethylene and propylene.

119. In terms of institutional mechanisms, it was necessary to examine the establishment of regional and international centres (including development consortia) for technology development and for the establishment of consultative bodies which the developing countries could approach for specific advice. However, the feasibility and direction of either of these centres should be examined in a situation when the opinion of several developing countries could be obtained. It was, therefore, imperative that UNIDO should make an effort to convene, at the earliest opportunity, a meeting of representatives from developing countries and obtain direction and priorities from them.

5. Biomass

120. The actions which should be taken were complex and multidisciplinary; therefore it was essential to take into account the ongoing and future developments of each of the component disciplines.

121. Action at the national level:

(a) Organizing wide application of improved methods of direct burning of fuel wood and charcoal production;

(b) Promoting public awareness and information programmes relating to new energy technologies;

(c) Strengthening education in the relevant areas in universities, schools and training centres;

(d) Identifying those biomass-energy and solar photovoltaic technologies for which each country had a relative advantage;

(e) Adapting existing local manufacturing plants for the production of equipment for biomass-energy and solar photovoltaic energy conversion;

(f) Providing for local research and development and manufacturing capability in selected and appropriate areas of biomass and photovoltaic energy conversion.

122. Action at the international level:

There were a number of options for international action relating to biomass energy technology, for example:

(a) An international centre for biomass technology covering all aspects from production to utilization;

(b) Centres of excellence in selected developing countries;

(c) Links between R and D bodies in developing countries and developed countries;

(d) Worldwide and regional networks of research institutes working in the field;

(e) A monitoring and information system for advances in the various technologies concerned.

123. Action by UNIDO and other relevant United Nations agencies:

(a) To actively assist developing countries in the field of new and renewable energies for industrial applications;

(b) To provide information on advanced energy technologies and "low technology" based on scientific approaches;

(c) To set up special funds for financing of research development and demonstration in the field of new energy technologies;

(d) To promote co-operation for R and D programmes between developing countries, and between developing and developed countries.

## 6. Solar Energy

124. In view of the long-term importance of solar energy to developing countries, the feasibility of establishing a consultative group on solar energy, research and application (SERA) should be examined by UNIDO. That group could draw upon the experience of top-level specialists in the field as well as development specialists; stimulate co-operation among research institutions, particularly in developing countries; assess the experience of projects in developing countries; and identify sources of funding for research and development including the development of appropriate systems.

ANNEX I

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# ANNEX II

## LIST OF DOCUMENTS

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| ID/WG.384/1 | Implications of New Materials and Technology for Developing Countries<br>A Preliminary Approach<br>by UNIDO Secretariat |
| ID/WG.384/2 | Emerging Photovoltaics Technologies: Implications for Developing Countries<br>Note by UNIDO Secretariat |
| ID/WG.384/3 | Policy Responses to Technological Advances<br>Some Illustrative Cases<br>Note by UNIDO Secretariat |
| ID/WG.384/4 | Genetic Engineering and Biotechnology and Developing Countries<br>Directions of Action<br>Note by UNIDO Secretariat |
| ID/WG.384/5 | Microelectronics and Developing Countries<br>Towards and Action-oriented Approach<br>Note by UNIDO Secretariat |
| ID/WG.384/6 | Implications of Biomass Energy Technology for Developing Countries<br>prepared by UNIDO Secretariat |
| ID/WG.384/7 | Provisional Agenda |
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| ID/WG.384/10 | Some Significant Advances in Materials Technology<br>by Edward Epremian |
| ID/WG.384/11 | New Materials, New Technology<br>by N.S. Enikolopov and S.A. Volfson |
| ID/WG.384/12 | Development and Application of New Materials: A Prospective View by<br>N.A. Makhutov |
| ID/WG.384/13 | Biotechnology of Enzymatic Conversion of Cellulose: Fundamentals and Applied Aspects<br>by A.A. Klesov |
| ID/WG.384/14 | Reports of Working Groups |
| ID/WG.384/15 | Methodological Problems of a Comprehensive Programme of Scientific and Technological Progress in the Soviet Union<br>Preliminary Note by Academician J.M. Gvishiani |

Background documents

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| | Aide-Mémoire |
| UNIDO/IS.230 | Technological Perspectives in Machine Tool Industry with Special Reference to Microelectronics Applications by S.M. Patil |
| UNIDO/IS.242/Rev. 1 | Report - Exchange of Views with Experts on the Implications of Technological Advances in Microelectronics for Developing Countries, Vienna, Austria, 10-12 June 1981 |
| UNIDO/IS.246 + Corr. 1 | Implications of Microelectronics for Developing Countries: A Preliminary Overview of Issues |
| UNIDO/IS.254 | The Establishment of an International Centre for Genetic Engineering and Biotechnology (ICGEB) Report by a Group of Experts |
| UNIDO/IS.260 | Genetic Engineering : The Technology and its Implications by Saran A. Narang |
| UNIDO/IS.261 | The Potential Impact of Microbiology on Developing Countries by Carl-Göran Hedén |
| UNIDO/IS.350 | Emerging Petrochemicals Technology : Implications for Developing Countries by V.R.S. Arni |
| UNIDO/IS.351 | Microprocessor Applications in Developing Countries by James M. Oliphant |
| ID/WG.372/1 | Prospects of Microelectronics Application in Process and Product Development in Developing Countries by Michael Radnor |
| ID/WG.372/2 | Microelectronics and Government Policies : The case of a developed country by Ernest Braun, Kurt Hoffman and Ian Miles |
| ID/WG.372/5 | Microelectronics: Its Impacts and Policy Implications by J.F. Rada |
| ID/WG.372/17 | Report on the UNIDO/ECLA Expert Group Meeting on Implications of Microelectronics for the ECLA Region |
| A/CONF.101/BP/IGO/13 | Background paper - United Nations Industrial Development Organization (UNIDO) - Potential Applications of Space-related Technologies to Developing Countries |

<u>Background documents (cont'd)</u>

UNIDO Microelectronics Monitor, Issue No.1
UNIDO Microelectronics Monitor, Issue No.2
UNIDO Microelectronics Monitor, Issue No.3

UNIDO Genetic Engineering and Biotechnology Monitor, Issue No.1
UNIDO Genetic Engineering and Biotechnology Monitor, Issue No.2
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