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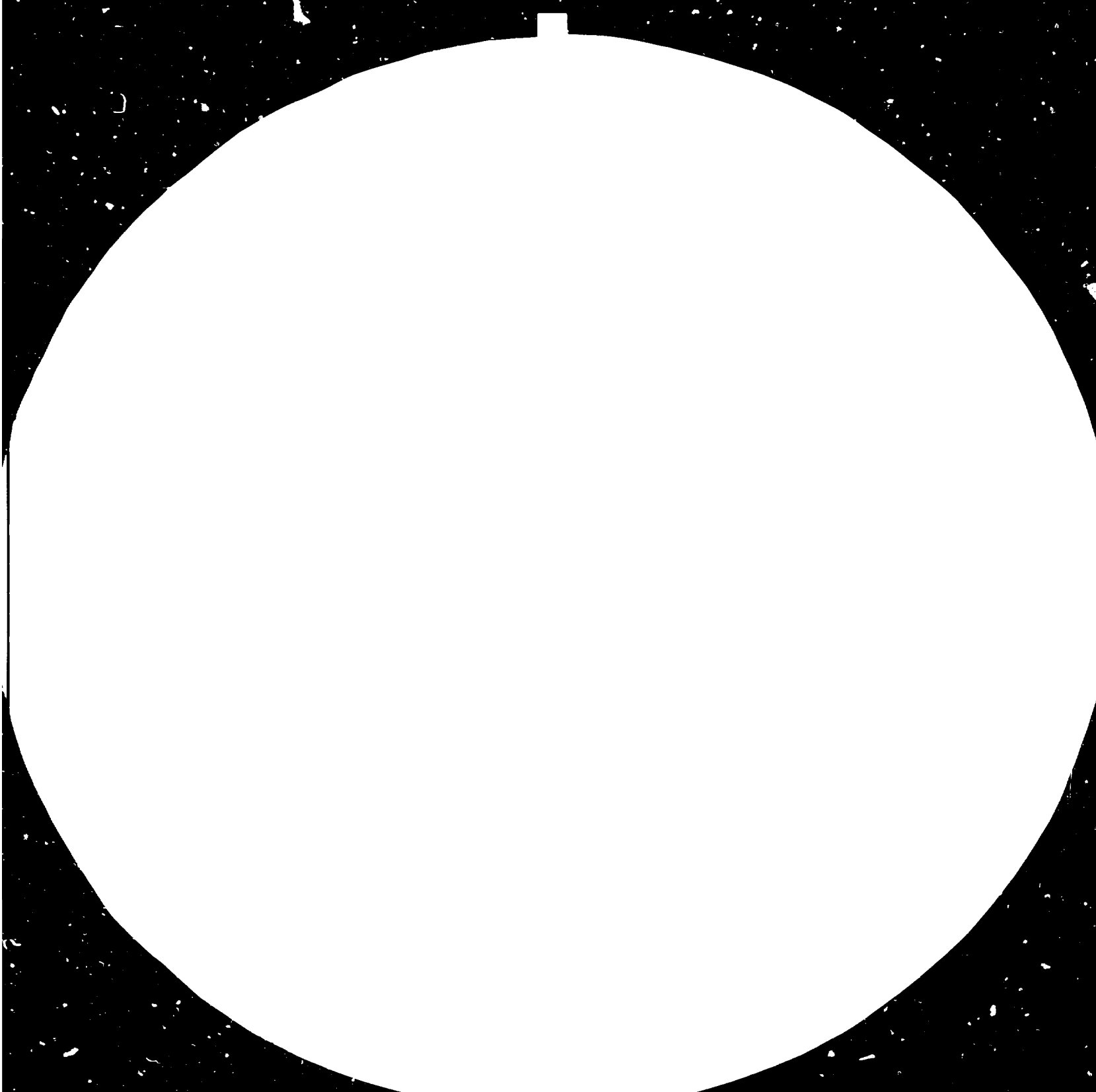
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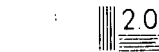
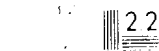
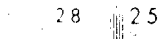
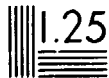
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STATUS OF TECHNOLOGICAL INSTITUTIONS  
AND STRUCTURES IN DEVELOPING COUNTRIES\*

prepared by

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## I. INTRODUCTION

An intensive dialogue has been underway which relates to the ability of developing country industrial and technological institutions to utilize on-going and anticipated technological advances. These technological advances are gaining momentum in the developed countries, and have a potential for impact on the industrialization and economic development objectives of the developing countries.

In order to achieve full and effective utilization of the technological advances, however, the need exists to transfer information, know-how, understanding, and applications of the new technologies in terms of appropriate in-country needs, conditions, and constraints. Not all of the technological advances, under consideration during this workshop, are immediately appropriate to each developing country, particularly where these countries are in initial (and possibly intermediate) stages of industrial development. There must exist an infrastructure which will support transfer and application of the technology - government technology policy, skilled human resources, facilities, and a targeted recipient or end-user who will use the new technologies.

The above suggests that it is of paramount importance for developing country governments, with the assistance of UNIDO, to examine carefully the immediate as well as future potential of those technological advances which can relate to their development needs. The governments should assess, on a priority basis as well as in terms of development costs, resources, etc., the realistic versus imagined need for applications of such new technologies in national industries.

As an example, while many developing countries can benefit in the near-term from institutional capability in areas such as energy from biomass and industrial applications of biotechnology, it would be unrealistic for most developing country technological institutes to attempt to develop a capability to produce components for photovoltaic cells.

## II. INTEREST OF TECHNOLOGICAL INSTITUTES IN NEW TECHNOLOGIES

A cursory knowledge about the new technological advances probably exists within the technological institutions and organizations in most developing countries. This knowledge, and related interest, can be shown by the following data from UNIDO's Industrial and Technological Information Bank (INTIB).

A Directory<sup>1</sup> of 250 technological institutions in developed and developing countries, includes information about 158 single-branch or multi-branch technological institutes in 41 developing countries in Asia, Africa, the Middle East, Central and South America. A questionnaire was used to determine areas of technology interest and specific projects scheduled for 1980. These interests, which relate to the technological advances being considered during this workshop, have been summarized in terms of indicators (key words) and numbers of institutes. See Table I.

TABLE I

### SELECTED INTERESTS OF TECHNOLOGICAL INSTITUTES IN DEVELOPING COUNTRIES

<u>Expressed interest in area and number of institutions</u>	<u>Specific projects scheduled in 1980</u>
biogas	3
biomass	4
electronics	2
electronic equipment	16
energy	19
micro biology	7
petro chemicals	0
renewable energy	2
solar energy	9
solar cells	3
124	65

It must be realized that a number of weaknesses exist in this cursory analysis. An expressed interest does not necessarily imply an institutional

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<sup>1</sup>Directory of Industrial and Technological Research Institutes, UNIDO/IS.275, 4 January 1982.

capability. A scheduled project does not necessarily mean that the project will be: undertaken; completed; relevant to a development need; or used by the productive sector. There unquestionably is some duplication in the areas of, for example, energy, renewable energy, solar energy, biomass. Finally, university research centers are not included in the survey. Activities of these research centers, if included in the analysis, would probably increase the numbers of institutional involvement, although not necessarily the relevance of the projects.

An additional Directory<sup>2</sup> has been prepared by UNIDO which includes 177 technological institutions and university research centers in 32 African countries. A similar cursory analysis of expressed interest, number of organizations and specific projects is presented in Table II.

TABLE II

SELECTED INTERESTS OF TECHNOLOGICAL INSTITUTES AND UNIVERSITIES IN AFRICA

<u>Expressed interest in</u>	<u>Insti- tutions</u>	<u>Uni- versities</u>	<u>Specific projects in</u>	<u>Insti- tutions</u>	<u>Uni- versities</u>
biogas	13	7	6	13	7
biomass	9	6	3	7	4
electronics	10	2	8	6	1
energy	21	9	12	14	6
micro processors	4	1	3	3	1
petro chemicals	2	2	0	2	2
renewable energy	20	7	13	20	7
solar energy	40	10	30	36	8
solar cells	5	2	2	4	2
	123	46	77	105	38

While the same weaknesses exist in the data for Table II, there does appear to be a trend which indicates that universities are more involved in electronics and energy projects than are the technological institutes. Again, it must be emphasized that there is no way to ascertain, from these data, whether the projects are relevant to development needs of or interest to end-users.

<sup>2</sup>Directory of Industrial and Technological Research Institutes in Africa, UNIDO/IS.299, 23 March 1982.



It would be desirable, although perhaps not possible, to undertake a more rigorous survey of technological institutions and organizational structures in developing countries. Specific data needed, which would be useful in devising mechanisms for strengthening the ability of such institutions to respond to technological advances, could include the following:

1. clearly defined areas of interest, including significant sub-areas, e.g., instrument repair, maintenance and design, micro electronics, genetic technology related to agriculture as contrasted with food technology (fermentation), semi-conductor development versus applications of photovoltaic devices, etc.;
2. interaction between technological institutions and end-users for specific projects;
3. cooperation between technological institutions and university research centers on specific projects;
4. real versus imagined institutional capabilities, individually or jointly, to actually undertake projects in the new technologies;
5. attitude of government relative to priorities for inclusion of new technological advances in national development strategies and plans.

### III. STATUS OF TECHNOLOGICAL INSTITUTIONS IN DEVELOPING COUNTRIES

It seems clear that all technological institutions and organizations, by their nature, will profess interest in new technologies. However, expressed interest and capability to actually implement, adapt, or transfer new technology are not always achievable. The ability of these institutions to undertake relevant projects, related either to old or new technologies, is frequently constrained by a number of factors, some of which are within their own control, and some of which are external to the institution and thus beyond their control.

#### Status of IRSIs

Many multi-branch, multi-purpose Industrial Research and Service Institutes (IRSIs) have been established in developing countries during the past 10-25 years. Usually, these have been organized along traditional lines, such as engineering, food technology, chemistry, textiles, materials, analysis and testing. Single branch IRSIs have also been created, in many cases, to serve

a particular industrial sector, such as food technology, textiles, etc. Usually, these IRSIs are more effective than multi-branch IRSIs, since they are responding to a well-defined need and demand for services. Multi-branch IRSIs often are intended to provide a spectrum of services and expertise which is too broad for their institutional capability.

The legislative acts which establish such IRSIs usually state that the primary goal of the institution is to provide services to industry and government clients, and to support and promote the national economic policies and strategies for industrial development. Usually, these legislative acts define the institutional objectives as follows:<sup>3</sup>

- the improvement of existing industries by providing a variety of technical services which may include technical information, chemical analysis and physical testing of materials and products, extension services to industry oriented to plant trouble shooting, improving plant layout, improving productivity through process changes or maximizing equipment capabilities, improving product quality, reducing production costs, etc.;
- the transfer of technology by providing and assessing technological information on processes, equipment and products; demonstrating new technologies; training industry personnel in new technologies; and providing R & D services for maintaining and improving transferred technologies;
- the adaptation of technology to local conditions;
- development of new technologies by R & D activities to avoid inappropriate or expensive technology transfers or to serve needs for which technology has not yet been developed;
- the industrial utilization of local raw materials and natural resources.

The IRSI functional activities usually are defined in such a way as to implement the institutional objectives. Performance of these functional activities varies greatly, depending on institute management, staff skills, and other operational considerations. Admittedly, a uniform model cannot be applied in each developing country, due to differing local conditions, needs of the productive sector, government policies, etc.

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<sup>3</sup>Program Advisory Note on UNDP - Financed Technical Cooperation for Industrial Research and Service Units, UNDP/PPM/TL, 22 November 1982.

As mentioned earlier, technological institutes are confronted with a number of constraints which frequently impede ability of the institute to provide effective services and solve problems for the productive sector. These include:

1. absence of a well defined government policy for the role of technology in development (although many developing countries have Science and Technology Councils, these are often more science oriented than technology oriented, and do not always have the stature necessary to implement, or impact on, development policies);
2. lack of understanding by the government concerning the long-term commitment (as such as 25 years) in development of human resources and facilities, and the need for continuing, massive financial support while the IRSI is developing the capability to provide contract services for fees to the productive sector (there are virtually no IRSIs, either in developed or developing countries, who do not require some government support, either by grants, subsidies or in the form of contracts);
3. lack of industrial experience of IRSI staff which, in turn, constrains their ability to recognize, understand and solve industrial problems;
4. absence of a strong industrial liaison and industrial extension activity, which is essential to understand and develop rational problem-solving ideas for consideration by the productive sector (this should be part of an IRSI marketing function, which exists only in a few IRSIs);
5. lack of adequate technological information, particularly know-how information, and an industrial information dissemination system which assures that information on new technologies and their potential applications is distributed to possible end-users;
6. limited cooperation between the IRSIs and other in-country technological institutions (universities, Bureau of Standards, commercial testing laboratories) and with other regional IRSIs;
7. a civil service employment system which creates problems in terminating the services of unsatisfactory performers, and yet is not effective in retaining the services of excellent performers who frequently are able to obtain more rewarding employment in other countries;
8. lack of a market which understands or needs research services, which is willing to pay for such services, and which is convinced that local research services are equivalent to opportunities to transfer technology from transnational or other sources (in most developing countries, the preponderance of productive sector needs are for analyses, testing, quality control, and simple problem-solving);
9. the tendency of IRSI staff to continue research initiated during postgraduate study, or undertaken on the premise that the concept, if successfully developed, should be of interest to the productive sector or important to the national development process (this relates, of course, to inadequate management direction, government policy, lack of information, industrial liaison, or all of these).

Admittedly, the above are generalizations, and do not apply across the board to all IRSIs. The Joint UNDP/UNIDO IRSI Evaluation Study,<sup>4</sup> however, showed clearly that in many cases, IRSIs do not interact effectively with the productive sector. Their research activity is not always relevant to national development needs, except as a form of long-term institution building and staff development.

However, where the IRSI enjoys autonomy in management and operational procedures, and where the IRSI is required to earn a sizeable portion of its annual operational expenditure through contracted services, the performance of such IRSIs is greatly improved. Usually, in such cases, these IRSIs are better informed about need of the productive sector and can more easily adjust their activities to relate to clients' needs. These IRSIs are also usually able to enter into new areas of technological advances, since they have, or can obtain, discretionary funding and opportunities to provide staff training in the new technologies. Since the staff of such IRSIs are acutely aware of the necessity to perform contracted services, they usually work more aggressively to provide services which are of interest to potential clients, either the government or the productive sector.

These IRSIs frequently have close working relationships with universities and other technological institutions in their countries or regions, and enter jointly into projects which involve scientific as well as technological development aspects of the new technologies. Examples are: Korean Advanced Institute of Science and Technology (KAIST); Instituto de Pesquisas Tecnologicas (IPT) in Brazil; Instituto de Investigaciones Tecnologicas (INTEC-CHILE); Marmara Scientific and Industrial Research Institute in Turkey. Technological institutes in India offer technical assistance to a considerable number of IRSIs in developing countries. A significant number of more established IRSIs have cooperative agreements with universities and technological organizations in Europe, the United States and Japan.

These cooperative agreements provide an excellent mechanism for acquiring information about new technologies, for training in such technologies, and for joint projects which can utilize the combined resources of the cooperating

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<sup>4</sup>Joint UNDP/UNIDO Evaluation of Industrial Research and Service Institutes, ID/B/C.3/86, 28 August 1979.

institutions. The opportunities inherent in such cooperative agreements or twinning arrangements between technological institutions in developing countries is of paramount importance to transfer of new technological advances, and will be discussed in greater detail later in this paper.

#### The Status of Universities

Universities in developing countries are a valuable resource in the transfer of new technologies, but this resource base is not always used effectively. The first principle for faculty promotion in a university involves the publication of scientific papers in peer journals. Thus, the faculty research efforts are usually directed towards projects which will yield a paper acceptable to international journals. Secondary consideration is given to application of the research results to development needs. Further, the universities do not always have laboratory facilities in which to undertake applied research, so that university research tends to be more theoretical than experimental.

At the same time, faculties in the universities frequently obtain information on new technological advances through journals, attendance at international seminars, and correspondence with colleagues in other countries. It appears, from the data in Table II, that in Africa at least, universities have a stronger interest in, and specific projects underway than do the IRSIs. This probably occurs also in other regions.

It seems clear that with appropriate coordination, the faculty members of universities could make important contributions to collaborative projects with IRSIs, where experimental equipment may be available, and where some knowledge may exist regarding potential end-users of collaborative research results.

Similarly to increased recognition of the functional responsibilities and the role that IRSIs can play in national development, governments need to recognize the potential of universities for contributions to the development process by providing alternate career ladders for promotion through involvement in applied R & D and by providing laboratory facilities to engage in such R & D. Governments should also develop policies which will encourage, if not require, cooperation between universities and IRSIs.

#### Current Activities Related to New Technological Advances

Shortages of foreign exchange and lack of spare parts for industrial instruments is impeding increases in industrial productive capability in many

of the developing countries. Thus, an increasing number of technological institutions are developing capabilities to provide electronic and mechanical instrument repair and maintenance services to industry. As an example, the Tanzania Industrial Research and Development Organization (TIRDO), which was established in 1979, repaired industrial electronic process control equipment valued at US \$40,000 during the period November 1982 through March 1983. This capability can be seen as a precursor to eventual capability in micro electronics and micro processors.

Similarly, there is an increasing need to substitute locally available raw materials for imported processed and semi-processed feedstock in developing country industries. The need for substitute materials covers a broad spectrum, e.g., fertilizer components, petrochemicals, inorganic and organic industrial chemicals, kaolin clays, textile dyes, essential oils, pharmaceutical components, coke for foundries and steel-making, ingredients for food products, and a number of other materials. While exploitation of local raw materials has usually been a stated objective of nearly every developing country IRSI, economic conditions and shortages of foreign exchange to purchase imported feedstocks have forced governments in many of the developing countries to demand that increased efforts be devoted by their IRSIs to develop or adapt appropriate technologies to utilize locally available raw materials. This appears to be an appropriate time, then, to transfer use of new technologies in materials processing to technological institutions in developing countries.

Increasing costs of petroleum fuels, along with the requirement for foreign exchange, are causing nearly all developing country governments to search for methods to reduce the cost of imported fuels and to identify alternative sources of energy. As indicated in Tables I and II, a large number of technological institutions are involved in this problem. Of immediate importance are industry energy conservation audits, which can demonstrate, both to government and to industry, ways to conserve fuel or to use alternative fuels. In Tanzania, for example, TIRDO has conducted ten energy audits of heavy energy consumers. These ten industries have been shown how to collectively save energy costs in the amount of US \$3 million annually, through improved combustion efficiency, insulation, recycling of steam condensate, pre-heating of fuel, etc. Similar energy audits are being conducted by institutes in Africa, the Middle East, Asia and Latin America.

These energy audits are seen as a necessary precursor to convince government and industry of the potential for replacing imported fuels by solar energy and biomass energy, particularly if it can be shown that local adaptation of new technologies for solar energy and biomass can further reduce imported fuel costs and provide an equivalent fuel source and efficiency. It seems clear that energy conservation audits are a logical partner with projects in alternative energy use.

#### IV. MECHANISMS TO ASSIST IN TRANSFER OF NEW TECHNOLOGIES TO DEVELOPING COUNTRIES

IRSIs and universities in developing countries are seen as logical agents to implement transfer of new technologies into the industrialization process. In the more advanced developing countries (Brazil, India, Egypt, Korea, Mexico, for example) technological organizations are already involved, to an appreciable extent, in assimilating and transferring of these new technologies. In the least developed countries, such efforts are minimal, although the potential exists, if priorities can be determined, government interest is established through appropriate policies, and if appropriate training, facilities, and direction can be provided.

Thus, three categories of technological organizations exist for the transfer of the new technologies, and consideration of these should be made when mechanisms are devised to assist in the transfer process. These are:

1. IRSIs in advanced developing countries who are already involved in the new technologies, who are cooperating with their national universities in specific projects, and who are cooperating with other national and regional IRSIs and with IRSIs in developed countries. This category of IRSIs is a resource base for transfer of know-how to IRSIs in lesser developed countries through the mechanisms of TCDC, linkages and regional cooperation programs;
2. IRSIs in less developed countries who are conducting activities on the fringes of the new technologies (e.g., electronic instrument repair, biomass, natural resource exploitation, etc.), but who require assistance in training opportunities, access to technological information, as well as access to laboratory facilities. IRSIs in this category can benefit materially from linkage agreements with IRSIs in advanced developing countries.
3. The universities who either possess theoretical knowledge about the new technologies or who have access to such knowledge, but who lack facilities and opportunities to conduct applied research in the new technologies. Universities should be partners in, and contributors to, IRSI linkages and regional cooperation agreements.

### Linkage or Twinning Agreements:

A linkage is an agreement established between two IRSIs (or between an IRSI and a university) to work together on specific projects. Linkages between north-south institutions have been shown to be effective mechanisms for technology transfer.

The mechanism for creating a linkage should be focused on the following components:<sup>5</sup>

- Technical information and know-how exchange;
- Staff training and two-way flow of staff;
- Availability of specialized, expensive, but infrequently used equipment;
- Opportunity for transfer or adaptation of technology;
- Joint R & D on specific and, at the same time, common problem areas such as utilization of raw materials or natural resources, alternative energy sources, food technology, etc.

The nature of the linkage may vary in accordance with the level of sophistication and needs of each participating institution. However, in each case, the linkage should be specifically directed toward assisting the institution in its own institutional development so that the institution will be able to improve and enhance its inter-relationships with the public and private developmental and industrial sectors it is intended to serve. Linkages, in order to be successful, must be long-term in nature and must be funded and provided with continuity for a period long enough to carry the project through to completion.

Before institutions in developing countries can cooperate effectively with institutions in other developing countries, they must attain a certain level of experience and capacity which can either: 1) take place only through a considerable number of years of experience and operation; or 2) take place through the mechanism of gaining training and technical assistance (thus, appropriate experience) through interaction with an institution in the more advanced country. Thus, the contributions of a north-south relationship cannot be overlooked. Initial linkages between institutions in advanced countries and institutions in developing countries can lead to the establishment

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<sup>5</sup>Joint UNDP/UNIDO Evaluation Studies of IRSIs, *ibid*, p. 101.



of skills and capabilities within the institution in the developing country which can, in turn, be transferred at a later date through providing assistance to institutions in other developing countries.

Furthermore, in the course of a linkage between an institution in one developing country and an institution in another developing country, if one of these institutions still maintains a working agreement with an institution from an advanced or developed country, the opportunity exists for obtaining particular short-term technical assistance, information, training, and advice and counsel on conduct of joint R & D which may be underway between the two developing country institutions.

As mentioned earlier, such linkages have been shown to be effective linkages in the transfer of technology. Unfortunately, the establishment of more than a few linkages has been constrained by the fact that institutions in developed countries as well as in a number of advanced developing countries must recover a major portion of their annual operational expenditures through contracted services to clients, and thus are only infrequently able to provide technical assistance or training through a linkage agreement, unless the costs for such services can be recovered. It seems unfortunate that governments, when planning activities for use of their IPF funds, have not considered following the examples of Brazil, India, Indonesia, and a few other countries in earmarking a portion of these funds for cooperative agreements with other countries. The general reluctance of governments to commit IPF funds for projects which may take place totally, or in part, outside of their country boundaries is perhaps understandable. At the same time, advantage can be taken of the "tied-aid" aspects of such funding, which brings external capabilities to bear on the internal capabilities of the country.

#### Networking of Technological Institutions

Networks are most frequently formed to focus on a specific problem of importance to a region (agriculture networks are numerous and have been highly successful). Networks of IRSIs in some regions (Southeast Asia and Brazil) are broad in nature; to date only a few such regional networks are known to exist, which concentrate on a specific technological problem area.

The philosophy behind creation of a technological institution network should be to:

- Improve national capabilities through regional cooperation;
- Join forces, pool resources, and share information or results so as to maximize the inputs into the research or other effort;
- Insure contribution by each network participant to the extent of its capability;
- Share equally in network results.

Networking of technological institutions should not necessarily restrict participation in the network of research institutes or universities in advanced or developed countries, and which cooperation has included the components of training, technical assistance, joint R & D and institution building.

The contribution of an experienced technological organization from an advanced country is of particular importance in linkage or network projects with institutions in lesser developed countries. It appears that a major problem confronting technological institutions in developing countries is articulation of specific projects and the effective undertaking of the proposed research. An institution in an advanced country can contribute measurably to this process, so that the institution in a lesser developed country not only gains experience for future use, but is able to perform the proposed research in an effective manner.

#### Regional Organizations for Cooperation in Industrial Research

While linkages and sometimes networks can be established between institutions (although these sometimes require government approval) creation of regional umbrella organizations to stimulate and coordinate joint projects of regional interest is clearly the responsibility of regional governments. Such regional programs require financial as well as policy support by governments if they are to be successful.

If properly organized and managed, regional organizations for cooperation in R & D can be very effective in integrating the experiences and capabilities of more advanced technological institutions with the needs of less advanced institutions. The usual activities include training, sharing of facilities, joint R & D projects, and regional sharing of research results.

Thus, regional organizations are seen as an effective vehicle for transferring new technological advances to potential end-users in the region.

The Regional Government Organization - ASEAN

The Association of South East Nations (ASEAN) was established in 1967 by five member countries - Indonesia, Malaysia, the Philippines, Singapore and Thailand - with the purpose of accelerating economic growth, social progress and cultural development and based on the premise that the ASEAN countries jointly are self-sufficient. Funding for cooperative programs is provided by each ASEAN country, but with some external funds from Australia, Netherlands and Japan.

While the ASEAN program is broad and is designed to impact on economic, societal and cultural problems in member countries, of relevance to the objectives of this workshop is the permanent committee on science and technology and several other committees which include elements of science and technology.

The long-term objectives of the science and technology components of the ASEAN programs are:

1. The identification of areas where regional programs in science and technology can provide significant impact on the development of the ASEAN region in countries which are included in ASEAN;
2. The building up of the institutional infrastructure for research and development and for scientific and technological supporting services on the national level and where appropriate, linkages on the regional (ASEAN) level which will support national and regional projects in these areas;
3. The development of the needed human resources to implement these projects through strengthening of training facilities, normally at the national level, but with a regional dimension;
4. The strengthening and reinforcing of the capacity for decision-making in choice of technology in all areas related to science and technology.

Joint projects can include allocation of components of the research to each country, provision of laboratory and pilot plant scale equipment, regional meetings to exchange results and plan research at the various institutions involved. Research leaders visit laboratories in other countries. There is direct regional exchange of data and information.

Following is a list of science and technology cooperative program areas:

- Food and Agriculture

Farming inputs, post-harvest technology, food and crop production, livestock, fish and fisheries, non-food crop production, forestry and forest products and food.

- Natural Resources  
Mining, quarrying and extraction, processing raw materials, land and soil use, minerals, water, energy resources and organic resources.
- Energy  
Power production, new sources of energy (geothermal, solar, etc.), bio-conversion of wastes, alternative fuels, energy conservation.
- Industrial Development  
Various industries, basic metal industries, metal fabrication industries, non-metallic mineral industries, chemical industries.
- Transportation and Communications  
Transport network development, road building, muscle-powered vehicles, boats, aircraft, cargo and material handling equipment, communication network development and equipment.
- Health  
Diseases, population control, mother and child care, community health, building and equipment, pharmaceuticals production.
- Rural Community Development  
Sanitation, minimum nutritional standards, adequate and inexpensive housing, improvement of rural agricultural and transport, small agro-based industries.
- Education and Training  
Teaching technology, curricula and textbook development.

The success of ASEAN is due, in large part, to the political will of the governments, but is also due to the determination of technological organizations to resolve regional and national technological development problems. ASEAN clearly is a viable mechanism for transfer of new technological advances on a regional as well as on an inter-country basis.

The Latin American Regional Program - PRDCYT

The Organization of American States (OAS) "Regional Scientific and Technological Development Program" (PRDCYT)<sup>6</sup> was established by mandate of the Presidents of the Latin American countries in 1968, who issued a joint declar-

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<sup>6</sup>Ten years of the Regional Scientific and Technological Development Program of the Organization of American States, SG/Ser. P/IV. 1, 1978.

ation indicating a clear expression of the will of the countries regarding priorities for scientific and technological development in their national plans and in hemispheric programs. It was decided to: establish and expand national programs and implement a regional program; establish advanced multi-national training and research institutes and strengthen those in existence in Latin America; and participate in the exchange of scientific and technological knowledge.

The objectives of PRDCYT are to:

- Train scientists and technicians in Latin America;
- Establish better data systems;
- Strengthen institutions for planning, research, teaching, and for scientific and technological development at the highest existing level;
- Develop or create other new institutions;
- Plan and manage human and financial resources that exist and direct them so that they can be used to maximum advantage.

PRDCYT is characterized by the fact that it has been largely a regional action carried out in the countries themselves. A unique feature of PRDCYT has been recognition that scientific and technological development in the various countries in the region require different modes of action. Thus, PRDCYT has classified the countries of the region into three major groups with respect to their scientific-technological status:

1. Countries that have a sufficiently complete and developed scientific-technological system;
2. Countries that still have insufficient scientific-technological capacity, but have the potential to develop it up to a level comparable with the countries of the first group;
3. Countries that can achieve on their own a limited scientific-technological capacity.

PRDCYT is focused on two program areas. The regular program concentrates on: basic sciences; applied sciences; technological development; policy and planning; technical change; and technology transfer. The "Special Projects for the Application of Science and Technology to Development" was established in 1974 to relate science and technology more directly with development. A list of special projects, funded over a six year period in the amount of \$16,110,000, shows the nature of these projects and the potential impact on the region:

- Ecology of the Tropical Humid Forest;
- Coking and Gasification of Coal;
- Reconstruction of Managua;
- Biopharmaceutical Evaluations;
- Sugarcane By-products;
- Oil Shales;
- Genetic Control of Livestock;
- Food Technology;
- Low-income Housing;
- Solar Energy;
- Ecology of Arid and Semi-arid Areas;
- Computer Technology;
- Polymerization of Olefins;
- Information and Technical Assistance to Industry;
- Wool Technology;
- Utilization of Sea Lions;
- Marine Biological Resources;
- Metrology;
- Industrial Metallurgy;
- Cytogenetics;
- Evaluation of Seismic Risk;
- Fiber Resources in the Andean Region;
- Activation Analysis;
- Non-conventional Energy Sources;
- Quality Control;
- Seismic Protection in the Andes;
- Extractive Metallurgy of Copper;
- Instruments for the Study of Rainfall and Winds

PRDCYT is clearly an example of successful regional technical cooperation. The governments support PRDCYT, national institutions share experiences, know-how, and conduct joint R & D, and lesser developed Latin American countries receive technical assistance from their more advanced neighbors and benefit accordingly. The Latin American infrastructure for science and technology is strong. Virtually all of the Latin American countries have national

agencies for coordinating and planning scientific and technological development. Most of these entities participate in decision making in national economic planning and investment plans. The PRDCYT model could well provide guidance to the African region, as an example of the mechanisms needed by African nations to better coordinate and develop their planning process to establish programs between African and other nations.

#### The African Regional Programs

Unlike the well-coordinated OAS/PRDCYT program in Latin America, there is at present no over-all regional mechanism for coordination of science and technology activities in Africa. Too many institutions exist, covering a broad spectrum of sectoral projects, and compete for funds and scarce skilled resources. Most African countries now have science and technology policy-making bodies (more oriented towards science than technology), so that the principal elements exist for creating a permanent inter-governmental, regional mechanism to form an African regional science and technology policy-making and planning body similar to FRDCYT.

In addition to the operations of the Science and Technology Unit of the Economic Commission of Africa, UNESCO's Regional Office for Science and Technology in Africa (ROSTA), and the Science and Technology Unit of the Organization of African Unity, the following industry-related inter-governmental, regional science and technology centers exist in Africa:<sup>7</sup>

- African Network of Scientific and Technological Institutions (ANSTI)  
To promote close and active collaboration between African engineering, scientific and higher educational institutions involved in post-graduate training and research. The network will be engaged in a wide spectrum of engineering disciplines--civil, chemical, electrical, mechanical, energy, water, mining and geological, and metallurgical engineering;
- African Regional Center for Technology (ARCT) - for the transfer, adaptation and development of technology;

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<sup>7</sup>Application of Science and Technology to Development in Africa, TCDC/AF/7, 24 March, 1980, p. 17 ff.

- Associations of African Industrial Technology Organizations (AAITO) - promotion of cooperation among African countries by establishing links between African institutions; concerned with industrial research and development; cooperation among African industrial and technological research institutes, relevant departments and units of universities, and the organized industrial sectors; contribution towards the coordination and planning of industrial and technological research and development; and contribution towards upgrading the level of skills of personnel in the development of man-power requirements for industrial and technological R & D in Africa;
- East African Mineral Resources Development Center (EAMRDC) - mineral resources development activities, particularly within the context of the technical aspects of such activities which the nations' Geological Surveys or mining corporations cannot undertake for lack of manpower or specialized laboratories and equipment.
- Industrial Property Office for English-speaking Africa (ESARIPO) - set up a Patent Documentation and Information Center which will assist the countries to gain access to and utilize the large volume of technological information contained in patent documents.
- Regional Center for Engineering Design and Manufacture - to provide regional facilities for education and training in engineering and industrial design specifically based on the cultural and socio-economic needs of Africa, and to include materials testing and research; tool design and production; pilot-plant design and construction; standardization and quality control, time study and cost evaluation; extension and consultancy services; and education and training;
- Regional Center for Solar Energy Research and Development - development of non-conventional sources of energy by providing a wide range of activities covering the strengthening of existing Research and Development Centers, training of manpower, provision of equipment, and convening of seminars.

In addition, a number of non-governmental and industrial organizations exist in the African region which are attempting to provide mechanisms for cooperation in scientific and technological development within their own countries, and which could contribute to overall regional cooperation. Thus, from



the above, it may be seen that the potential for regional programs in Africa through a more effective mechanism is large. Unfortunately, most of the above-listed organizations are in the formative stages, some countries have provided little or no financial or staffing assistance. The urgent need, as stated earlier, is for the creation of an umbrella organization to coordinate the activities of the several industrial-related science and technology organizations, along with appropriate industrial-related science and technology organizations, along with appropriate and adequate funding to assure implementation of the important regional programs. This, however requires a strong political will on the part of the African States; in the absence of such political commitment from participant governments, regional cooperation will probably not succeed in the African region.

#### V. CONSIDERATIONS FOR ASSISTING IN THE TRANSFER OF NEW TECHNOLOGICAL ADVANCES TO DEVELOPING COUNTRIES.

In addition to promoting deliberate and voluntary sharing, pooling or exchange of technical resources, knowledge, experience, skills and capabilities between two or more developing countries, UNIDO can help to diversify and expand the technical resources available to each country which relate to utilization of the new technological advances. In providing assistance to these countries, however, a number of questions should be asked about utilization of each new technology:

1. First and foremost, will the new technology be relevant to the specific needs, and compatible with the conditions in the recipient country?
2. Is the technology phased to the state of development as well as the human and other resources available in the country?
3. What possibilities exist to gain access to the new technology?
4. To what extent will the new technology diversify, enlarge and institutionalize the technical resources of the country? Will the technology promote better and more intensive utilization of available institutional and private sector resources?
5. Is the potential impact marginal or substantial? Are there other social or economic benefits?
6. Does the technology address a problem of common interest and thus provide new information useful to more than one country?

7. Is the technology one that will attract any necessary funding for implementation?
8. Are governmental policies appropriate to assure use of the new technologies in national development plans and by end-users?

The proposed International Center of Genetic Engineering and Biotechnology will be an important step forward in providing initial impetus and support to national efforts in this new technological advance. Similar centers for micro electronics, materials and energy would be expected to be equally effective. However, it seems clear that outputs from such centers will be limited in the immediate future. Thus, it is important to ascertain the contributions that technological institutions in the more advanced developing countries can make to training and technical assistance in these new technologies. A survey of such institutions could pose the following questions:

1. What are the current and near-term capabilities, experience and facilities available to engage in the adaptation and transfer of the new technologies?
2. To what extent is the institution willing to provide training, technical assistance, use of facilities, etc., to institutions in other developing countries?
3. Does the institution have cooperative agreements with institutions in other countries?
4. Does the institution have funds available (e.g., IPF funds) to support such technical cooperation?
5. What are the institutional costs which must be recovered in order for the institution to participate in such technology transfer projects?
6. Does the institution's government have technical cooperation agreements with governments of other countries?

Answers to these questions could perhaps assist in initiating action in transfer of the new technologies rather quickly, particularly in the exchange of information and training.

Full use should be made of existing regional organizations to stimulate the transfer of new technologies, if this is not already underway. Perhaps, inter-regional cooperation should be examined with a view to expanding the applications of new technologies from regional to global use.

Linkages and networking of technological institutions is also a valid mechanism for bringing less experienced institutions up to a level of capability which will enable them to adopt the new technologies to their own country conditions.

Steps should be taken to increase the involvement of universities in adaptation of the new technologies, through direct project support in the universities, but also through encouragement to become partners with IRSIs by means of linkage agreements or networking.

Finally, assistance should be provided to governments in revising or creating appropriate policies which will encourage adaptation of the new technologies into national development plans. These could include funding of specific R & D projects with technological institutions, tax holidays or rebates for industries who use the new technologies, clear definition of priorities for application of the new technologies, and management procedures to assure that adoption of the new technologies impacts on the national development process.



