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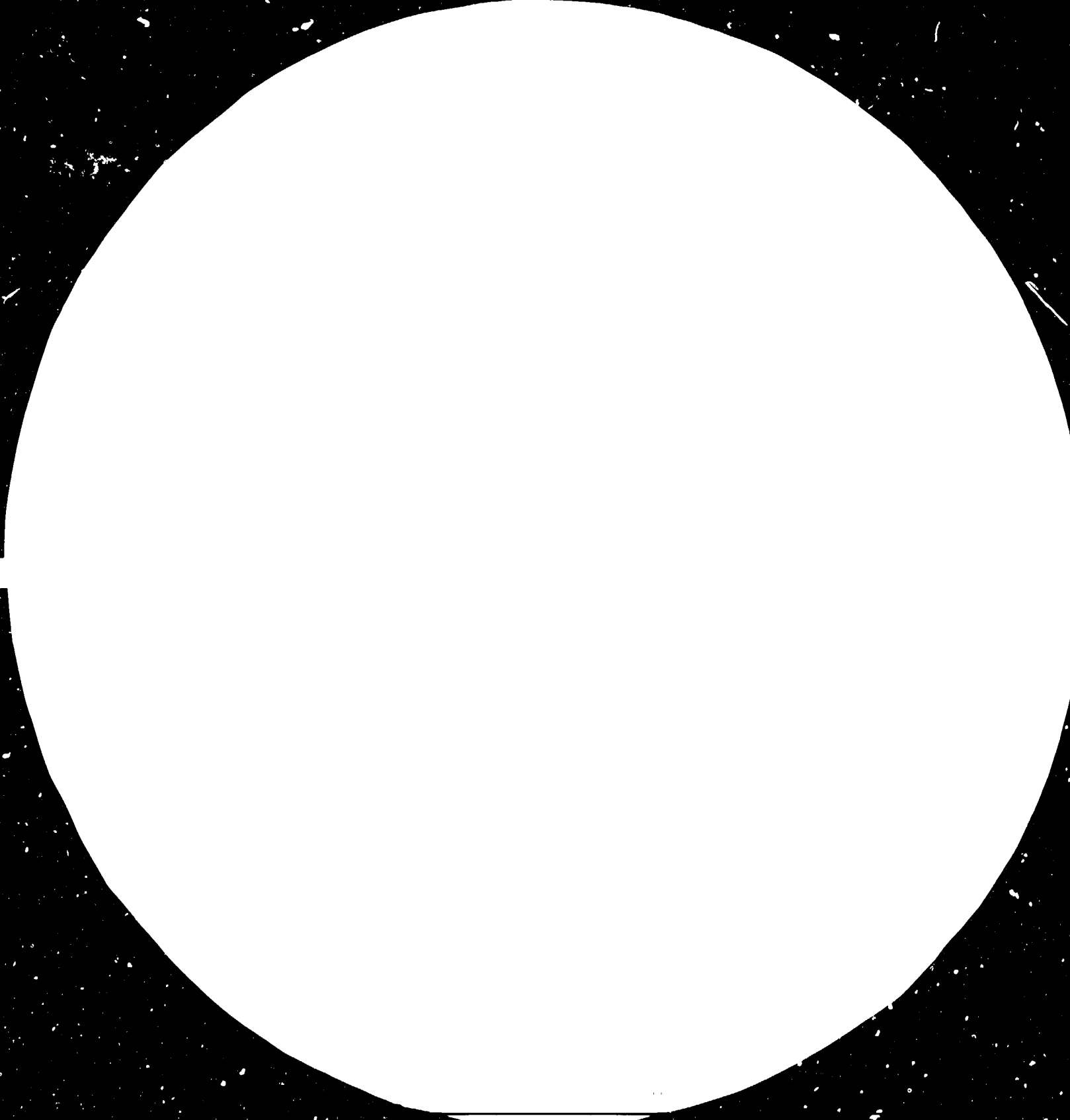
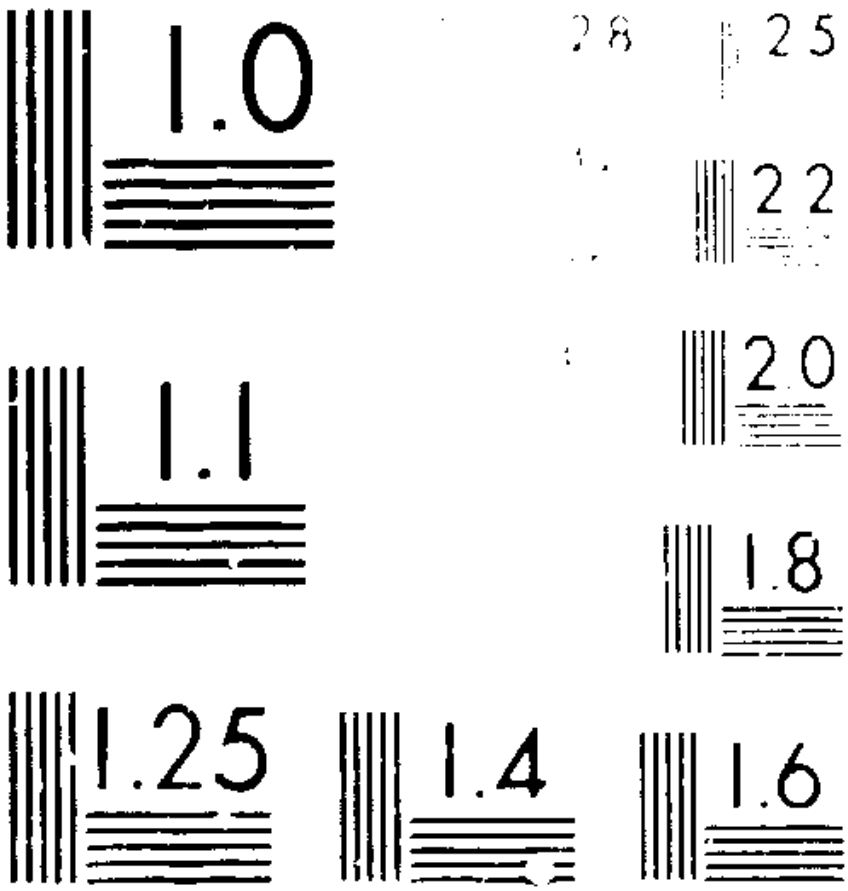
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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GUIDELINES FOR THE CREATION OF INDUSTRIAL RESEARCH AND SERVICE INSTITUTES IN THE LEAST DEVELOPED COUNTRIES

Rich H. Westergaard*

* Central Institute for Industrial Research, Oslo, Norway

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The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO.

Preface

UNDP and UNIDO have made a great effort to find out to what extent industrial research and service institutes (IRSIs) have succeeded in promoting industrialization. The findings of this evaluation work are extremely important, particularly for the least developed countries.

In the least developed countries many IRSIs have not been able to attract and keep competent staff and/or have not been able to maintain the equipment provided. Even where there are qualified people and equipment, the institutes have achieved little because they have had unrealistic ambitions or have failed to serve government and industry in a meaningful manner.

Resources in the least developed countries are scarce; thus they should be utilized efficiently. Too often in the past, both the United Nations and Governments have applied models developed in more advanced countries without sufficiently considering the circumstances prevailing in a particular developing country. The United Nations system has failed to guide the least developed countries in their research policy, and Governments have too often been over-optimistic or guided by prestige rather than realism. These guidelines are an attempt to contribute to a better use of resources. They do not try to discourage establishment of IRSIs in least developed countries, but to make sure that these institutes suit the special situation of these countries.

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INTRODUCTION

Modern times and technology have also reached the least developed countries. Problems related to agricultural chemicals, pollution, health, telecommunications, aviation and automobiles and increased dependence on imports - all these and many other features of modern life make it necessary even for the least developed countries to have certain technological facilities, particularly if the political goal is to promote industrialization and exports. The most important components of technological infrastructure are:

Education: academic personnel, technicians, vocational training
Standardization
Quality control, testing and chemical analysis
Techno-economic studies (feasibility studies)
Techno-economic information services
Trouble-shooting in industry
Engineering
Research, process and product development (called R and D)

These components need to be organized carefully based on a survey of existing capabilities and future needs. If most of these components are lacking or inadequate, it may be possible to put them together under the umbrella of an IRSI.

I. IRSI TERMINOLOGY

Some terms used in this document are explained below. It should be mentioned first that the term "Research" relates to industrial research.

IRSI. Industrial research and services institute. Research means acquiring new knowledge by laboratory experiments and/or theoretical investigations. Services means application of existing knowledge: engineering, testing and analysis, surveys, feasibility studies etc. The distinction between research and services is not very clear. Some projects have a high content of research, others have little.

R and D. Research and development. Research means experiments etc. needed to create a new or improved technology. Development is short for process or product development, such as engineering, pilot plant studies, plant design, and establishment of production.

development. Growth in the economy, increased gross national income etc. It should not be confused with the definition used in "R and D".

basic and scientific research. Aims at discovering new phenomena and shedding light on the laws of nature without having specific uses of the knowledge as an explicit motive. It is in principle not industrial research and not included here.

applied research. Research aimed at achieving a result that can be exploited. It can have a high content of advanced research, using the same methods as in basic research, or it can be more related to engineering, product development or desk work and field surveys.

short-term (tactical) research. Aims at solving specific problems for a client, who ought to be motivated to pay the full cost. The client can be a private enterprise or a public enterprise or agency.

long-term (strategic) research. Aims at solving larger, more long-term problems and at creating preparedness to meet the future. Sometimes the beneficiary is an enterprise, sometimes a branch. When no particular beneficiary can be clearly identified, the beneficiary may be said to be the country. Strategic research has a high economic risk and a long payback time and is usually financed, at least in part, by the Government to promote and stimulate industrial development.

government-financed projects (grants). Are most often applied, but may be more long-term and more broad in nature. Such projects tend to be strategic rather than tactical. They are funded by the Government for one or several of the following reasons:

- To strengthen the capabilities of an IRSI
- To establish new national capabilities in science and technology
- To prepare the ground for technology transfer
- To develop natural resources
- To spearhead and stimulate development of technologies believed to have a good potential
- Occasionally to help an R and D project based on a good idea, and believed to have a good potential, but for which a financial sponsor cannot be found.

economic platform money. Financial foundation for operating an IRSI. An IRSI can charge its clients only for work that benefits them directly, but the IRSI needs money also for its establishment; maintenance and growth; and for internal projects to develop skills, test new ideas and prepare the ground for new client-financed projects. Platform money usually comes from the Government, sometimes from a foundation.

IRSI self-financing. The percentage of the budget collected from clients and government grants (on the assumption that government grants are justified by expected results rather than being disguised subvention). The degree of self-financing varies considerably from one IRSI to another. Self-financing is easier for institutes serving one branch of industry and if the research is short-term. Self-financing beyond, say, 70 per cent, indicates that strategic research is being neglected and that the IRSI is overexploiting its human and physical resources because the economic foundation is insufficient. Self-financing is a yardstick of efficiency but not necessarily of national benefit.

research subsidizing. Policy adopted by some countries, particularly the less developed, to enable the IRSI to sell its services for less than actual cost, or even provide them without charge. More advanced countries, particularly the smaller capitalistic ones, often promote research in the private sector by sharing the cost of "high-risk-good-potential projects". Often this is done in the form of a government grant to a project to be executed jointly by an enterprise and an IRSI. The motive can also be to stimulate the development of a less developed region or to create employment (social benefits).

in-house research. Projects defined and executed by the IRSI without external control. They are financed from the platform money. Motives for in-house projects are to employ staff lacking external projects, to prepare for new projects, to develop new capabilities and to follow up good ideas or inventions.

mono-branch IRSI. One serving a particular branch, such as pulp and paper, metallurgy, leather or textile industry.

multi-branch (multidiscipline, multipurpose). One serving several branches. In developed countries such IRSIs concentrate on sophisticated specialities, often related to computers, electronics or costly equipment. In the least developed countries they are more often generalists in the fields of engineering, laboratory services and economics. In other words, the less developed a country is, the more is the emphasis on service rather than on research. In a less developed country the IRSI will have laboratories for various branches, such as textiles. In developed countries branch IRSIs do this work.

II. INDUSTRIAL RESEARCH POLICY

IRSIs became common in the developed countries after the Second World War. The developed countries have gradually learned the potential and limitation of IRSIs. Many mistakes have been made, but gradually the institutes have become more and more cost-effective and useful. An investigation carried out by UNDP and UNIDO found that the IRSIs in developing countries in most cases functioned poorly, particularly in the least developed countries. These guidelines, it is hoped, can help these countries in their IRSI operations.

Political and economic conditions

One of the reasons for unsuccessful IRSIs is that the political and economic conditions in individual countries were overlooked when the IRSIs were designed. What is good IRSI policy in a developed capitalistic country may be totally out of place in a socialistic least developed country. Characteristics of the Western IRSIs are a high degree of autonomy and a high degree of self-financing achieved by actively selling its services in a competitive, open market. In a country with central planning and state-owned industry such an IRSI may have very few clients. Integration with industry is here more important than autonomous status. In a country where most of the industry is owned by foreign companies it is difficult to find clients. Tough business competition creates the best climate for an autonomous IRSI. A protected home market, a sellers' market, price control etc. remove the motives for R and D.

Use of scarce resources for an IRSI - questionable

A small, poor and underdeveloped country that sets up an IRSI may draw too heavily on human and financial resources (particularly foreign currency). It is therefore important to assess the expected costs and benefits realistically.

If a research institute is to serve industry, do high-level work, and be a "centre of excellence", it has to have good personnel with a salary level between that of universities and industry and interesting work. If there is a shortage of such personnel, they will have to be taken from government or industry, where they may be more useful.

Unrealistic R and D

The most difficult IRSI undertaking is R and D. Many overambitious and unrealistic projects are started in developing countries. Often such projects are related to use of natural raw materials such as upgrading unsuitable iron ore, or using waste materials that are unsuitable for the purpose or not economic to transport to the factory. Some want to "reinvent the wheel" because they do not want to buy a licence.

Industrial research problems

Most countries spend a substantial amount of money on industrial research. This is true for both capitalistic and socialistic countries. In capitalistic countries, it is easier to distinguish between industry financing and government financing. The idea of government-financed industrial research

is relatively new. Few of the research institutes are more than 30 years old. Some mono-branch institutes are older. The benefit to the country in terms of favourable industrial development varies considerably from country to country, and the issue of how to organize such research is subject to continuous discussion and evaluation. There are many pitfalls:

(a) If financing is too liberal, efficiency tends to drop;

(b) What was intended to be industrial research often ends up to be purely academic;

(c) Attempts to apply research often result in inventing impractical and useless products or processes and in solving problems nobody except a scientist is interested in;

(d) Attempts to apply strict control tend to kill initiative and creativity and make the institutes less dynamic and less able to exploit opportunities;

(e) Attempts to involve industry tend to result in too much short-term work like trouble-shooting. The strategic research intended to meet the challenges of the future may be neglected;

(f) It is extremely difficult to control research by means of a central organization, even if it is assisted by committees of academics and practical persons. On the other hand, some national control and setting of research priorities are necessary.

Despite all these difficulties, industrial research is useful and becomes more so as the country industrializes. Only to a limited extent does research create industry; the less developed a country is and the smaller it is, the more true is this statement. Research is first of all instrumental in improving existing industry, supplying special know-how, and solving discrete problems rather than providing turnkey facilities.

Without government support, it is more or less impossible to create a research system that will have much national impact. Industrial enterprises want to pay only for projects of immediate use to them. Long-term strategic research becomes impossible. High-level sophisticated skills and facilities will not result, and the country will not progress beyond being a second- or third-rate industrial country highly dependent on others.

Government-financed research is more critical for small poor countries than for the large and rich. The large countries, with their transnational companies and well-endowed universities and foundations, may do well without government-financed industrial research.

The medium-sized countries such as Canada, the Netherlands and the Scandinavian countries and some of the new industrial countries in Asia (Japan, Republic of Korea, Singapore) have benefited most from government-funded industrial research.

Benefits of having a good IRSI

A good IRSI can promote industrialization by:

(a) Producing highly skilled engineers and scientists who can undertake difficult tasks;

(b) Making available sophisticated equipment for R and D;

(c) Solving special problems for industry;

(d) Developing new products and processes jointly with industry;

(e) Improving quality control;

(f) Mapping of national resources;

(g) Promoting rationalization and automation, which can make industry more competitive;

(h) Upgrading imported technology and preventing it from becoming obsolete too early;

(i) Making import and transfer of technology more efficient and avoiding poor investments.

It can bring substantial social benefits such as:

(a) Creating more employment;

(b) Increasing the standard of living;

(c) Creating interesting jobs, thus preventing emigration of gifted personnel, particularly high-level academics;

(d) Improving the quality of the environment by reducing pollution, better community planning etc.

The most important benefit of an IRSI may be indirect and difficult to quantify such as, for instance, increasing the number of qualified persons and bringing about an awareness of the importance of quality.

Government control

A central organization can never be staffed with sufficiently capable persons to execute detailed guidance and control of industrial research. Industrial and public clients should provide guidance for 70-80 per cent of the activities.

The State (in consultation with the users) should control the rest, identify long-term goals and initiate larger research programmes. Even in highly industrialized countries, central bureaucratic control is difficult. In less developed countries, it is even more difficult.

Branch IRSI or multidiscipline, multi-branch IRSI?

Mono-branch IRSIs serving a few enterprises are more often successful than the multi-branch IRSI because the staff of a mono-branch IRSI has a high level of expertise in a certain field and close contact with its clients. If a country has one or a few dominating industrial branches of reasonable size, branch institutes should be considered.

A small country with little and diversified industry will start with a multi-branch IRSI giving services rather than doing research. At a later stage of development mono-branch institutes can be created.

Scope and ambitions

A rich developing country can provide for present and future needs by establishing a sophisticated multi-branch IRSI. A poor country cannot afford to do so. If the market for the IRSI services is small and there is a lack of qualified people and paying competitive salaries is not feasible, it is often better to invest in a university by giving it equipment and some financial support. When the level of activity is high enough to justify an independent IRSI of notable size, the time may be right to set one up.

III. EVALUATION OF IRSIs

How successfully an IRSI has been established is simple to assess by comparing the results with the plans. The most important elements are:

Qualified staff at all levels
Adequate premises
Administrative machinery for handling projects, personnel, accounting, board of management, lines of authority, various forms to be used for reporting, purchase etc.
Stock of materials and spare parts
Workshops, repair and maintenance
Library
Various laboratories and services with equipment etc.

The main yardstick of success in operation is that industry and government agencies are using the services. The other main yardstick is the extent to which the fees paid cover the costs. Willingness to pay shows the value of the services. Willingness to accept free services proves nothing. In addition, various achievements and their economic impact can serve as an indication of success.

Yardsticks of efficiency are needed, such as:

(a) Mode of financing distributed between three categories in percentage:

(i) Clients' fees, possibly subdivided in services and research;
(ii) Government controlled and financed research grants (strategic research);
(iii) Direct government support, including in-house projects; heavy support indicates poor efficiency;

(b) Staff efficiency in terms of percentage of total time available, used on:

(i) Work paid by clients;
(ii) Work on government financed research projects;
(iii) Work on in-house projects
(iv) Time not charged to projects: miscellaneous, administration, idling, sick-leave, etc.

IV. PLANNING A NEW IRSI

The exact need for R and D, consulting, engineering etc. cannot be established in advance. One approach is to compare the industrial output of the country with that of other countries and assume that the need for IRSI is a function of the industrial level. The need increases more than proportionally with industrialization, and the country should compare itself with countries not too different from itself. In addition to the level of industrial production, diversification and degree of sophistication must be considered.

Then come the duties the Government may assign to the institute, such as mapping of national resources, providing environmental protection services and exercising quality control of exported and imported goods. These activities can be planned without complications.

Usually the IRSI will be built in phases and future expansion can be based on experience.

But the scope of the first phase should not be so small that the institute cannot be viable. An IRSI with fewer than 50 persons may not be viable. In that case the needs should be met by expanding various existing institutions such as university facilities, government testing laboratories, materials testing institutions or a bureau of standards.

Within the institute the scope of the various activities should also have a certain size. Sophisticated instruments should, for instance, be in almost continuous use.

What IRSIs cannot do

When planning an IRSI it is not very useful to make long lists of shortcomings in the country and think the IRSI can do everything that needs to be done. A small IRSI staff cannot possibly do for industry all the things industry itself should do. IRSIs must first of all help industry to establish its own quality control, maintenance, planning and administration. The task of an IRSI is not primarily to produce various outputs, but to provide seeds that will sprout and grow in industry. Only in this way can the IRSI have a national impact. The IRSI must function like a catalyst in chemistry. An IRSI with a few (hundred) persons cannot be expected to do the job of several thousand.

UNIDO assistance

UNIDO assistance to an IRSI falls in two categories (which to some extent overlap - still the distinction is useful). The two are:

(a) Direct support

- Providing consultants to do a job for government or for industry
- Providing equipment
- UNIDO staff working as IRSI employees instead of training counterparts

(b) Assistance in building institutions

- Planning the IRSI in co-operation with the receiving country
- Helping to select equipment and procuring it
- Helping to plan the various laboratories and activities
- Training counterparts on the job
- Training national staff on fellowships

To use UNIDO experts as IRSI staff without proper counterparts can be compared to baking bread of the seed grain instead of sowing it. Still, sometimes it has to be done.

UNIDO responsibility for institution building

The responsibility of UNIDO for building institutions varies greatly. In some cases UNIDO has the overall responsibility. In other cases UNIDO experts give only some ad hoc advice. Sometimes UNIDO is concerned only with limited tasks related to one of several IRSI departments or some highly specialized services, such as scanning electron microscopy. It can be strengthening something that already exists or planning from scratch. The project document and progress reports should clearly define the role of UNIDO as institution builder and the progress made.

V. REGIONAL VERSUS NATIONAL IRSI

When countries are too small to have a viable IRSI (above the critical mass) they may consider creating a regional IRSI together. This idea looks better on paper than in reality. Some of the problems UNIDO has identified are:

(a) The country in which the IRSI is located benefits much more than the other participating countries;

(b) The multinational governing body tends to be an inefficient decision-maker;

(c) The weakest partners will often vote against necessary expenses, which they cannot afford to share;

(d) Language barriers may aggravate the situation.

An alternative to a single regional IRSI can be having some kind of smaller IRSI in each country plus a regional IRSI handling the more sophisticated tasks on behalf of the national IRSIs.

Based on past experience regional IRSIs should not be encouraged.

VI. THE FEASIBILITY OF SOME POSSIBLE IRSI ACTIVITIES

Some of the possible IRSI activities are uncomplicated; others create problems and are of little use. Some IRSI activities are examined below.

Process and product development (R and D)

If there is not a substantial industry already, there will not be much of a market for the R and D component of an IRSI. It is an illusion to believe that an IRSI can create industry to an extent that will have a national impact. The achievements that do have a national impact are always the result of a joint effort between existing enterprises and the IRSI. Industrialization is mainly based on transfer of already established technology. Research can assist the development. The least developed countries can benefit less from R and D than the more developed.

Adaptation of foreign technology

The adaptation of foreign technology is often mentioned as an IRSI objective, but this activity is mainly suitable in agriculture and for unsophisticated products and processes. Modern process technology is difficult to modify or scale down.

Feasibility studies

Carrying out feasibility studies is a normal IRSI activity and can be successful if it relates to simple processes with emphasis on raw material quality and availability, logistics, local market, cost analysis. When the import of foreign, sophisticated technology is under consideration, only prefeasibility studies can be made by an IRSI. Complete studies require highly sophisticated specialists who must come from abroad and co-operate with the IRSI.

Help to small industries and cottage industries

Help to small industries and cottage industries has a high priority in least developed countries, but it is not a primary task for an IRSI. It is the job for productivity centres, a matter of vocational training, organizing the marketing etc. The IRSI can address problems common to a group of enterprises. The problems can be identified by the IRSI, a productivity centre or the industry itself. While extension services are important in agriculture, they are less feasible in industry in general. A branch IRSI can provide such services to a limited number of enterprises.

Testing and analysing, the most important activity (service - not research) of an IRSI in a least developed country

Even the least developed countries need laboratories for chemical analysis, microbiological investigation, testing of materials and capability to identify causes of substandard quality. This need is often the main justification for establishing an IRSI. The equipment and human skills may in addition be used to do some research and consulting.

Engineering services

In the developed countries most IRSIs have abandoned giving engineering services, but may do some engineering in connection with ongoing R and D projects; otherwise, engineering is left to industry and engineering firms (consulting firms). In some least developed countries there may be no engineering services offered, and the IRSI can to advantage provide them for unsophisticated products and processes.

Information services

Every IRSI has a library and offers various types of information services related to international literature. It is usually no problem to respond to specific requests for information, but preparation and wide distribution of abstracts prepared by the IRSI are not cost-effective. If most of the receivers do not read English, such (blind) distribution of information becomes even more wasteful.

Standardization and metrology

Standardization is sometimes one of the duties of the IRSI in small or less developed countries. This arrangement may work, but a separate standardization body is better in a country having a capitalistic economy. The reason is that conflicting interests can keep industry from using an IRSI that is also a bureau of standards and may have a policing function.

The IRSI may function as a metrology laboratory. The need should not be overestimated. Many least developed countries have beautiful metrology laboratories that are seldom used.

Vocational training

Sometimes IRSIs also run vocational training centres, e.g., welding, machining and ceramics. This may be a good arrangement.

Training of personnel from industry

Since one of the main purposes of an IRSI is to upgrade industry, it should regularly run symposiums or courses for personnel from industry on such topics as quality control, use of analytical and testing equipment, management topics, food-processing hygiene, food conservation, food packing and post-harvest treatment of agricultural crops. United Nations experts should give lectures both to the IRSI staff and personnel from outside.

Problem solving

In industry many problems occur that are related to the quality of raw materials and process water, corrosion and mechanical failure. An IRSI can often be of great help in solving these and similar problems.