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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INTERNATIONAL FORUM ON APPROPRIATE INDUSTRIAL TECHNOLOGY

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WORKING GROUP No.1

APPROPRIATE TECHNOLOGY FOR HEAVY INDUSTRIES

APPROPRIATE TECHNOLOGY FOR THE CHEMICAL INDUSTRY.

Background Paper.

APPROPRIATE TECHNOLOGY FOR THE CHEMICAL INDUSTRY

by

J. Giral B.
UNIDO consultant

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METHODOLOGY FOR HANDLING APPROPRIATE CHEMICAL TECHNOLOGY

INTRODUCTION

Since 1968 the Group for Development of Technology (Graduate School of Chemical Engineering, National University, Mexico) under my direction has been doing research on Appropriate Chemical Technology for Mexico. During the past 4 years a methodology has evolved that has been published in several papers and handbooks (attached, in the Appendix, is the most recent one). Work has also been done in applying this methodology to micro and macro planning of the Mexican chemical industry, developing quantitative models analyzing the period 1977-1982 in terms of technological requirements as well as financial and human resources, all categorized according to relevant breakdowns.

As a result of all this work, we have gathered some evidence in support of three key issues:

1. TECHNOLOGY IS NOT AN AMORPHOUS CONCEPT. It can be characterized, classified, analyzed in terms

of potential for adaptation, etc. There is a methodological approach to assist doing so (see Appendix).

2. INDUSTRIAL DEVELOPMENT MUST BE PLANNED FROM A TECHNOLOGICAL AS WELL AS ECONOMIC POINT OF VIEW. Traditionally macro planners are concerned with the economic implications of industrial development. It is necessary to incorporate additional planning criteria, such as social impact, environmental impact, competitive strength, etc., and evaluate the technological implications. Examples are shown of how this has been done in Mexico for the chemical industry.

3. TECHNOLOGICAL PLANNING CAN BE STARTED WITH MINIMUM INFORMATION. It is a task that can become as sophisticated as any other one, but it can be started with very limited information and still produce valuable insights for policy making, as illustrated by the current experience in industrial promotion in Mexico.

To facilitate reading of this paper, a summary has been prepared that describes the overall structure with some continuity. The Appendix has chapters describing each key piece in more detail, as referred in the summary.

Chloropropylates, mono-croto-phos

Polyamides

Melamine and formaldehyde

WITH PRODUCT TECHNOLOGY

Epoxy resins

Chloroparaffins

Propylene glycol, substituted phenols, non-ionic detergents

Polyethylene glycol derivatives

Propylene glycol dibenzoates

Cyclohexane, acetyl-sulphonic peroxide

Phenates, detergentes, inhibitors

Monochloroacetic acid

Phthalic anhydride

Formaldehyde

Alpha and beta naphthol

Dioctyl phthalate

Acrylamide

Polyvinyl alcohol

Dialquil phthalates

Alquil-phenols

Plastifiers

(i.e., a technology is considered appropriate when it can lead to a commercial project competitively efficient in low-scale markets with high capital costs, abundant labor and many other basic differences intrinsic of each economy).

The 60's and the early 70's were rich in activity leading to the recognition of a need to have a methodology for handling (selecting, negotiating, transferring, adapting and developing) appropriate technologies. International agencies and local governments funded many studies and meetings to try to better understand the elements of this methodology.

Chemical industry has been considered by many of these studies as one of the most difficult to tackle. This paper describes some of the findings of the last 10 years of the Group for Development of Technology (Appropriate Chemical Technology in Mexico).

These findings addressed themselves to three key areas:

1. The need to characterize technology.

2. The need to plan industrial development from a technological point of view.

3. Techniques to start technological planning with minimum information.

1. THE NEED TO CHARACTERIZE TECHNOLOGY.

One of the pitfalls of most of the work done in the past 15 years is to treat technology as an amorphous concept and deal with the problems realted in a general way. We have found that technology has many dimensions that permit a distinction of different types of technologies. This is not only a scientific curiosity. Each type of technology requires of different methodologies for its selection, negotiation, transfer, adaptation and development, as described in Chaper 1 of the Appendix.

we feel the state of the art is now at a level where this distinction is imperative if we want to make further progress. The next steps include adoption by all international agencies and local governments of a commong language for characterization and handling of the different types of technologies, plus the adoption of some of the specific instruments described in Chapter 1 of the Appendix. This is specialized work that has to be undertaken by groups of specialists for each industrial section.

2. THE NEED TO PLAN INDUSTRIAL DEVELOPMENT FROM A TECHNOLOGICAL POINT OF VIEW

Most of the macro-economic planning done now-a-days tend to neglect the technological implications of adopting specific strategy for industrial development. The result of this neglect at the macro level is that then, in a second stage, at the micro level, requirements are imposed on the technologies that are very difficult if not unrealistic to meet. The writer has seen economic plans that after defining the macro strategy for economic development and the national priorities by industrial sector then specify requirements from those industrial sectors that are incompatible as, for instance, the need to create jobs via labor intensive technologies in the petrochemical industries or the need for technological autonomy in industries where it does make economic sense to spend money in local development of technology.

We feel that there is a need for a technological planning activity to bridge macro and micro economic planning, i.e., to analyze the implications of adopting a given development strategy with the compatibility of achieving specific goals in job creation, utilization of local resources, achievement of technological autonomy, etc.

Chapter 2 illustrates the application of some of these concepts to a specific case: the planning of the chemical industry in Mexico for the period 1977-1982.

3. TECHNIQUES TO START TECHNOLOGICAL PLANNING WITH MINIMUM INFORMATION.

Although this may be considered as part of the prior section (The Need for Technological Planning), we have heard so many criticisms to the feasibility of this approach in countries traditionally poor in information, that we feel it deserves specific attention. This is a task that eventually can become very sophisticated, as sophisticated as the information available and the existing tools allow it to become. However, our practical experience is that with a minimum of existing information a group of qualified experts in a field can develop a logical framework using known relationships, that can be refined by a trial and error procedure that can evolve into a very useful tool for planning.

The work described in Chapter 2 is an example of how this can be achieved: by gathering a group of experts that can draw on the experience of the past 20 years both from Mexico and from industrialized countries, reliable coefficients and relationships, such as those illustrated in Tables D and F can be developed. By making a casuistical study of what is logical to expect by extrapolation of trends, knowledge of specific plans and application of common sense, realistic scenarios can be outlined that can be cross-checked several ways. The gaps that cannot be filled in following the techniques just described can then be taken care through brainstorming, Delphi approaches and technological forecasting. The end result of this first approach is usually a model with hard logic but soft data. Methods based on sensitivity analysis identify then the key data that need refinement because of their impact in the overall model. Resources can then be applied to refine only those specific data.

CHAPTER 1

CONCEPTS, DIMENSIONS AND ELEMENTS OF APPROPRIATE TECHNOLOGY

A FRAME OF REFERENCE

INTRODUCTION.

Appropriate technology is a concept that has been defined in many ways, some conflicting with each other. We feel that the appropriateness of the technology is a function of the time, the place and the specific sector, and unless these parameters are well defined and specified no analysis can point to a clear solution.

The field of appropriate technology, as any complex field, has many components and dimensions, all very interrelated. In our opinion, most of the work done so far in the field of appropriate technology is either too specific (mostly describing a case story relevant to one specific sector, at one specific place and at one specific time) or too generic (suggesting a general solution applicable at any time, any place or any sector). The purpose of this chapter is to make a first attempt at bridging this gap and outline a frame of reference to go from the generic to the specific and to be able to characterize one specific differently from another.

The work on which this chapter is based represents the experience of some dozen technologists over the past ten years. The frame of reference described here has been tested for several years in industry and is now being tested by the Mexican Government through its industrial development and technology agencies.

II. - BASIC DIFFERENCES

We said in the introduction that the appropriateness of a technology is a function of a certain place, time and sector as different from others, and what is appropriate in one place, time and sector is not necessarily so for a different one.

It is only logical, then, to start defining what is different in that country and industrial sector, so that when selecting a plan for industrialization we know it will be based on a good knowledge of what is different and how can we best use it to our benefit.

After several years of working with this concept we have found that there is a series of basic differences for a country or a geographic region (a part of a country or of a continent) and relevant to a specific industrial sector that are repetitive enough to grant documenting them properly. We have found that this effort pays handsomely by sensitizing newcoming engineers, specialists, technologists to the differences they have to be aware of, either to take full advantage of them or to try to minimize their impact. This is specially important when transfering technology from country to country, an activity that usually involves nationals of at least those two countries, because seldom are they fully aware of those basic differences.

We recommend that the Government both in preparation of its industrialization plan and as part of its industrial promotion services, puts out a definition of the most general basic differences, and supports more specific work done by professional societies, sectorial industrial chambers or geographic (state) industrial chambers. Any such work should state very clearly that it is not exhaustive but illustrative, and that the project engineer must do his homework as related to a specific project.

Following are some examples of general basic differences taken from Mexico in 1977-78:

<u>Mexico has:</u>

Markets 4-12% the size of the U.S. market.

Labor cost 15-30% of U.S. equivalent in quality and productivity (and high unemployment, mostly unskilled).

Capital cost (interest rate) of 18-22% in Pesos vs. 8-9% in dollars.

Local equipment and raw materials at costs 15-50% above U.S.

A reliable infrastructure as defined by

Electric supply at 20% below U.S. cost with comparable reliability (at 60 cycle, usually 130, 23 or 6 megavolt, etc.)

Energetics at 15-40% below U.S. cost with comparable quality and reliability of supply. The only exception is usually higher sulfur content in fuels.

Adequate transportation at competitive rates. Railroad hopper cars are difficult to obtain, and box cars become scarce at crop times (they are allocated to moving grains).

Etc.

In terms of climate

The central area is desertic, no freezing all year round except in the north (no need to bury piping beyond frost line; no need to calculate roofs and foundations for snow loads); low average humidities (ideal for natural convection or forced draft tray drying without additional heat), etc.....

The plateau is at an altitude of 5,000 to 7,000 ft., which reduces boiling temperatures 6-10 °C, which in many reactions almost doubles reaction times; it also reduces air intake (mass per unit of volume) for compressors, dryers, etc., from 25 to 40%.

A good description of basic differences for a country would be an ideal starting point and perceived by industry as a genuine desire on the part of the Government to share the reasoning behind a certain industrialization plan as well as to help industry identify its pros and cons. Also, provincial, regional or state descriptions of basic differences, if done objectively and not as advertising of the wonders of the area, can do more good than all the tax incentives typically offered.

Finally, any major individual project should have, right from the first prefeasibility study, a section thoroughly describing those basic differences that may have a noticeable effect on the project.

III.- PLANNING BASE

This paper does not attempt to deal with the elements of national planning for appropriate development, but to deal with the problem of appropriate technology it is necessary to refer, however briefly, to the planning activity, where all this is started.

It is our personal opinion that too detailed national industrialization plans only stifle what they try to help; they quickly become obsolete and are a cause of confusion, conflict and frustration.

The lack of planning is obviously highly undesirable also, because many resources are wasted and efforts duplicated to no avail.

In our opinion the planning function must satisfy one item: the DEFINITION OF NATIONAL PRIORITIES, clearly enough to leave no doubt in anybody's mind so that all can start planning and working from the same premises.

The most effective approach we have found is to describe first no more than half-a-dozen economic goals for the country, and to give them a weight or relative priority. It is evident that a good exercise in defining the basic differences of the country constitutes an excellent base to define these economic goals in a coherent manner:

Typical examples of economic goals are:

- Employment
- Balance of payments
- Use of local raw materials
- Ownership/control of industry by nationals
- Productivity
- Income distribution
- Competitiveness (local vs. international prices)
- Decentralization (promotion of less developed areas of the country)
- Etc.

The definition of national priorities, to really be operational, has to go one step further and select some priority sectors of the economy, through whose development the Government expects to maximize the goals indicated above. In doing so, the mission of each sector must be specified to the extent possible, i.e., indicating whether it is expected to maximize all the economic goals or only certain of them. Following are some examples:

FOOD.- Not expected to generate foreign exchange.

CAPITAL GOODS.- Not expected to promote decentralization.

AUTOMOTIVE.- Not expected to be owned/controlled by nationals.

PETROLEUM & PETROCHEMICALS.- Not expected to generate employment.

STEEL.- Not expected to generate employment nor to promote decentralization.

PHARMACEUTICAL.- Not expected to generate foreign exchange.

Etc.

Thirdly, to complete the basic information for planning, the Government must indicate the instruments it expects to use to promote development in the selected priorities. Following are some examples:

Control of imports through prior permit

Import duties

Export incentives

Support to negotiate sectorial bilateral multinational trade agreements

Investment incentives

Subsidies to raw materials, energetics, services in general

Low cost, long term financing

Etc.

IV.- CRITERIA OF PLAUSIBILITY

The explicit description of the Basic Differences of a country, together with the explicit statement of the nation's economic goals, priority industrial sectors and instruments to be used in fostering industrialization is in itself a great step forward, both in providing a common reference to all Government Agencies and in giving a guideline to industry on how and where to plan its growth.

A second step in this direction is the elaboration of a check-list of criteria of plausibility that allows both Government and industry to establish a dialogue on a very objective and structured basis.

We use the word plausibility to differentiate from feasibility. Investors are interested in the economic feasibility of a project as a basis to define where to invest their money. Governments are interested in the socio-economic impact, or plausibility of a project. A good example is Spain's slogan, referring to an effort to reduce excessive consumption of gasoline "Maybe you can afford it, but your country cannot".

One of the functions of taxes and incentives is precisely that of making feasible the plausible projects that were not in a first instance, as well as discouraging investors towards projects that are feasible but not plausible.

This concept started with the use of more complete checklists of criteria of plausibility. The Mexican industrial development agency, however, after careful study of over 30 different criteria of plausibility, opted a simplified version for its first formal checklist, which is currently being followed experimentally in the chemical and related sectors. The advantage of this simplified checklist is that it can be interpreted easily by everybody and it can be amplified as needed:

	Weight	Basis for Quantification
Employment	25%	$ of investment/job created
Balance of payments	20%	From a deficit to a surplus
Competitiveness	20%	Mexican vs. U.S. prices
Local integration	15%	Percent of local value added
Decentralization	10%	Location of industry in one of five predefined regional areas
Local control/ownership	10%	Percent of local equity and participation in the administration

Application of these criteria takes into consideration the mission of an industry (as described in Section III - Planning base) and its relative priority in modifying the grading obtained from the above checklist. The industry presenting the manufacturing program (which is the document used to present its plans to the Government for evaluation) is then informed of the Government's perception of the plausibility of the project and suggested ways to improve it; for instance: relocation of the plant to a higher priority area, higher local equity, higher local content, etc.; after this iteration takes place and industry feels it has done all it can to improve the plausibility of the project then the Government uses this information to decide the amount of protection, subsidies or incentives to be given to promote this project.

Although the system has been in operation only a short time, the reaction of industry has been very positive. Also, it allows seven interacting Government agencies to share a common system for project evaluation.

V.- CHARACTERIZATION OF THE TECHNOLOGY

The identification of BASIC DIFFERENCES, the establishment of a PLANNING BASE and the implementation of CRITERIA OF PLAUSIBILITY constitute the macro part of the frame of reference.

Proper use of these three tools should help Government and industry do a better job in selecting projects appropriate for the develcpment needs of the country.

In this chapter we shall describe the dimensions of the technology that make it possible to characterize each project from a technological point of view and deal with it accordingly. This characterization is the base for the acquisition, selection, transfer and adaptation of the technology; the following chapters describe each of these activities.

In this particular chapter we want to describe a methodology which we have found very useful in practical experience as a way to unify criteria, identify differences of opinion and reach agreement on how each piece of technology should be treated.

We say that there are three principal dimensions that characterize a technology:

- COMMERCIAL MISSION
- DIFFICULTY OF ASSIMILATION
- TYPE OF TECHNOLOGY

- COMMERCIAL MISSION

The main purpose of this characterization methodology is in helping to better handle (select, acquire, transfer, adapt) technology appropriate for the development of a country. In doing so, our major concern is to find out how flexible a technology can be to better adapt it to local conditions. In our experience, we have found that such flexibility is directly related to the commercial mission of the technology. This has been the basis for the classification described below:

a) EXPORT ORIENTED. - Typically a project is export oriented - and by that we mean that a substantial (30-70%) part of its capacity is being justified on account of exports - because it has some local advantage (raw materials, labor, etc.) and it is felt that it can be competitive internationally. This in a way limits the flexibility of the technology because

- Plant size has to be comparable to world largest.
- Product specifications have to match those of competition.

in order to be fully competitive.

b) LOCAL MARKET ORIENTED.- When a project is being justified on the basis of import substitution or satisfying the needs of a growing local market then there is an increased flexibility to handle the technology, because there can be changes in product specifications in a closed market and some diseconomies of a smaller scale can be accepted via some degree of protectionism against foreign competition. The plants can be smaller, and the products made can be modified to suit better the local conditions and to simplify their manufacturing process.

c) ORIENTED TO SATISFY A LATENT OR POTENTIAL NEED.- Most developing economies have large population groups of limited resources whose needs are not being properly satisfied with the product mix accessible to them in the market. This is one of the causes leading to purchasing aberrations such as color TV's or expensive appliances in adobe shacks (a few hundred dollars of available income but no appropriate product to acquire with that money).

This is one area that needs much more attention; it is full of opportunities to improve quality of life of the population and eventually should be where the bulk of our efforts in technology are concentrated.

Since both product and manufacturing process design are required it also offers the widest flexibility as to product specifications, plant sizes, etc.

- DIFFICULTY IN ASSIMILATION

The purpose of this dimension is to characterize the degree of sophistication of the technology, not from the stand point of the original development but from the stand point of local assimilation, because it is our experience that unless there is an adequate capacity to assimilate the technology there is no hope to reach any kind of autonomy or capacity for local adaptation. The three levels chosen for this dimension are described below:

i) HIGH.- Technologies with high sophistication and high difficulty in assimilation usually require of an internal technical organization of over 10 technicians.

ii) INTERMEDIATE.- These technologies require of the participation in their assimilation of some technicians and/or people with some technical knowledge.

iii) ELEMENTARY.- In here typically there is a high administrative content and unless there is some technical capability to assimilate a strong audit function will be required.

We have found in our practical experience that recognition of the level of this dimension is essential for effectiveness. We have also found that it is relatively simple to reach agreement as to the specific level (high, intermediate, elementary) of a given technology. Unfortunately we have not been able to generate adequate information to describe better these 3 levels.

- TYPE OF TECHNOLOGY

In handling technologies from different industrial sectors we have found that they fall into one of four types of technology:

1) EQUIPMENT BASED TECHNOLOGY.- Where the technology required to operate the plant is mostly implicit in the equipment and acquired with it, and the raw material suppliers complement whatever technical information is required.

2) PRODUCT BASED TECHNOLOGY.- Where the key aspect of the technology is in the chemical composition or physical shape or structure of the final product and not in the manufacturing process and where typically a technician with experience in that industrial subsector can design an adequate manufacturing process if he has access to the product technology and patent.

3) PROCESS BASED TECHNOLOGY.- Where both the final product and the equipment are well known, and the proprietary value is in the fine details of the

process, such as a materials balance, an energy balance, a flowsheet, etc. Typically these technologies are of a continuos process nature, mostly related to chemical industry.

4) OPERATIONS BASED TECHNOLOGY.- Typically these are the oldest and most developed technologies, and they present a mixture of the other three types of technology (equipment, product and process). They close the circle in the sense of being borderline with the equipment based technologies or, to put it in a different perspective, as the equipment based technologies become more developed and with a larger volume they fall into this fourth type of operations based technology.

As can be seen from the attached table in every one of these four types the original technology was developed differently, there is a different mechanism of protection of the technology, a different mechanism for transfer and licensing and a different type of adaptation potential.

CHARACTERISTICS OF THE FOUR TYPES OF INDUSTRIAL TECHNOLOGIES

TYPE OF TECHNOLOGY	EXAMPLES OF INDUSTRIAL SUBSECTORS	DEVELOPMENT OF THE ORIGINAL TECHNOLOGY	PROTECTION AND/OR AVAILABILITY OF THE TECHNOLOGY	MECHANISMS OF TECHNOLOGY TRANSFER	ADAPTABILITY *
Equipment Technology	Food packaging Plastics conversion Textile Rubber Pharmaceutical forms	By the equipment manufacturer and the raw material supplier	Available with the purchase of the equipment and/or the raw material, usually with an implicit payment in the over-all purchase price	Instructions for equipment use	Direct use of the equipment Control simplification Replacement of automatic operat[illegible] by manuals Minimum adequate specifications Design of new products adequat[illegible] Mexico
Product Technology	Food processing Metal mechanic (bicycles, farm machinery, typewriters) Pharmaceutical Cosmetics Organic chemical (dyes, pigments, agrichemicals) Soft drinks	By the product manufacturer	Patents Registered trade marks Some licensing and franchising	Use specifications of raw materials Physicalchemical parameters Reaction kinetics Process handbook	Batch processes, with several p[illegible] and phase changes Moderate pressures and temp[illegible] Adaptation of reaction conditio[illegible] simplify separation Rationalization of patented alt[illegible] native processes to syntheti[illegible] analog products
Process Technology	Petrochemical Steel Petroleum refining Detergents Fertilizers	By engineering firms (and by the manufacturers)	Much licensing Flexibility in the level Important to know what to negotiate	Process handbook Plant handbook Equipment design Operation handbook	Continues processes High pressures and temperatures High level of optimization Separation represents 60% of to[illegible] investment and operating cost (exclusive of raw materials)
Operation Technology	Mining and metallurgy Electrochemical Automotive Metalworking	Evolution over a long period. Mix.	Fundamentally know-how	Plant handbook Equipment design Operation handbook Operating tricks (experts)	Processes and equipment well kn[illegible] Relatively easier to adapt than Group III Availability of raw materials

* In the copy submitted by the author, some of the words in this column are not legible.

VI.- FORMS OF ACQUISITION OF THE TECHNOLOGY

There really are as many forms for acquisition of the technology as people's imagination can create. From our practical experience we like to talk about five forms that are distinctly different because of the actions taken in each case:

PURCHASE. - When all the information is acquired, already processed, from one single supplier, with minor modifications to fit local needs (as in buying a ready-made suit).

INTEGRATION. - When technology is acquired in two or more modular packages, easy to integrate with one another and with minimum ad hoc design (as in buying the pieces for a stereo music set and integration the set).

ADAPTATION. - When the base technology is acquired and adapted to the local basic differences, and the detail engineering is developed according to this adaptation (as in buying paper patterns for a dress, buying a piece of fabric and cutting and sewing the dress, changing length of sleeves, lightness of material, etc., to fit local fashion and climate).

DEVELOPMENT.- When the need for a base technology is conceptualized from scratch and all the ensuring steps are implemented (as in designing a dress from scratch).

CONTRACT-DEVELOPMENT.- As an alternative to the above, emphasizing the simple but very important concept of contracting outside for the development of a technology appropriate to our needs (as in retaining a tailor or a couturier).

We do not use the term INNOVATION as such because we feel is an increasing component of all the above alternatives.

The following table shows how the characterization of technology links with the selection of a form to acquire the technology.

As can be seen, the mission of the project and the degree of sophistication required to assimilate the technology give a good idea of what is the best form to acquire the technology.

The type of technology has more influence on the packages themselves and the mechanisms for transfer and local development.

FORMS OF ACQUISITION OF THE TECHNOLOGY

DEGREE OF SOPHISTICATION REQUIRED TO ASSIMILATE THE TECHNOLOGY

MISSION OF THE PROJECT	SOPHISTICATED	INTERMEDIATE	ELEMENTARY
EXPORT ORIENTED	Purchase Integration	Integration Adaptation	Administrative & Logistic Problem
LOCAL MARKET ORIENTED	Adaptation	Adaptation/ Development	Adaptation/ Development
ORIENTED TO SATISFY A LATENT NEED	Contract Develop-ment	Development	Development, Education and Training

Also, a general policy leading to the adoptation of one strategy or the other may affect the preference of a particular form of acquistion of the technology.

Thus, if the strategy is defined as one of self sufficiency, obviously the preferred form will be local development and innovation; with the corresponding expenditure of funds to develop an adequate infrastructure for R&D. On the other hand, if the strategy is defined as one of self determination, under some circumstances direct purchase or contract development may be the preferred forms.

VII.- SELECTION AND NEGOTIATION OF TECHNOLOGY PACKAGES

In the preceding chapters we have described how, within the proposed methodology, the planner can go from defining the basic differences of his environment, interpreting the country's priorities, evaluating the project alternatives from the point of view of the country's interests and, once having selected by this procedure one or several project opportunities, how they are characterized in terms of their mission, sophistication and type of technology to define, amongst other things, the best form of acquisition of technology, whether purchase, integration, adaptation or development.

The next step consists in selecting and negotiating the technology packages, which are the elements used to acquire and transfer the technology.

The tables shown in the following pages do not pretend to be exhaustive; they are illustrative of the most common packages and payment formulas used in Mexico in the past 8 years*.

We have shown only those packages frequently used; obviously there are many other possibilities as well as combinations of those shown.

TYPICAL TECHNOLOGY PACKAGES

EQUIPMENT BASED TECHNOLOGY

I. BASIC INSTALLATION PACKAGE	PAYMENT PROTECTION AND FORMULA	SUPPLIER & TYPICAL RESTRICTIONS
1. Civil, mechanical and electric specifications. 2. Maintenance requirements. 3. Proposed layouts. 4. Operating suggestions.	Implicit in the acquisitions of the equipment. Supplier may send expert during installation and charge fee plus expenses.	Equipment manufacturer. Very few restrictions in general. Some in export competition.
II. OPERATING PACKAGE		
A.1. Operating and maintenance instructions. 2. Instructions for equipment check-up and adjustment. 3. Instructions on failure detection and correction.	A. Implicit in the acquisition of the equipment. Supplier may, at buyer's request, put together a more comprehensive Operating Manual and/or send operating consultant, at a fee.	Equipment manufacturer. Very few restrictions.
B.1. Raw material use specifications. 2. Final product suggestions.	B. Implicit in cost of raw material. Service by experts is never charged.	Raw material supplier. No restrictions.
III. TECHNICAL ASSISTANCE		
1. Operating support. 2. Quality control. 3. Productivity analysis. 4. Product design and improvement.	Payment usually as % of sales or as cost plus fee. Only product design and key methods for productivity improvement protected by patent.	Usually equipment maker. Also co-manufacturers from other non-competitive areas. Occassionally engineering and consulting firms.

TYPICAL TECHNOLOGY PACKAGES

PRODUCT BASED TECHNOLOGY

I. PRODUCT FRANCHISING OR LICENSE	PROTECTION AND PAYMENT FORMULA	SUPPLIER & TYPICAL RESTRICTIONS
1. Tradename usage. 2. Use of logos and basic design regulations. 3. Advertising pattern.	Franchising. Product patent (not in all countries). License of registered trade-name and of patent. 1 to 5% of sales. Lump sum.	Product producer. Export limitations. Diversification limitations. Requirements of free feed-back of technological improvements in some cases.
II. PRODUCT DESIGN PACKAGE		
1. Blueprints, sketches, design details, fabrication specifications (or, if a chemical, chemical structure and basic physical chemistry).	Royalty (1-6% of sales) or payment per unit produced or sold. Patent rights and manufacturing rights are usually licensed, not sold.	Same as above.
2. Considerations on flexibility of product design, tolerances, quality control.		
III. OPERATING PACKAGE		
1. Manufacturing process or fabrication technique. Safety and environmental considerations. Productivity indicators.	Usually included in the payment for product design package. May cost 1-2% more, especially if technical support included.	Same as above.
2. Quality control.		

TYPICAL TECHNOLOGY PACKAGES

PRODUCT BASED TECHNOLOGY

IV. BASIC INSTALLATION PACKAGE	PAYMENT PROTECTION AND FORMULA	SUPPLIER & TYPICAL RESTRICTIONS
1. Equipment description. 2. Civil, mechanical and electric specifications. 3. Maintenance requirements. 4. Proposed layouts. 5. Operating suggestions.	May be negotiated separately as a lump sum, or as part of the engineering detail package. May amount to 10% of investment.	Product producer seldom. Engineering firm more often. Few restrictions.
V. TECHNICAL ASSISTANCE		
1. Operating support. 2. Quality control. 3. Productivity analysis. 4. Product design and improvement.	Payment is usually 0.5% of sales or per man-day used plus basic lump sum fee.	Either product producer or engineering firm. Restrictions on diversification, requirements of free feed-back on innovations.

TYPICAL TECHNOLOGY PACKAGES

PROCESS BASED TECHNOLOGY

	PROTECTION AND PAYMENT FORMULA	SUPPLIER & TYPICAL RESTRICTIONS
I. PROCESS KNOW-HOW 1. Basic process data. 2. Flowsheets. 3. Materials of construction.	Patents. Licensing on a 10 yr. basis. Payment as lump sum (about 10% of investment) or royalties (1 to 2% of sales).	Producer and/or engineering firm. No sublicensing. Exports and total amount limitations.
II. BASIC ENGINEERING 1. Basic process data. 2. Flowsheets. 3. Materials of construction. 4. Equipment description. 5. Plant layout.	Same as above.	Same as above.
III. DETAIL ENGINEERING Same as above, plus: 1. Equipment specifications 2. Piping, electrical, instrumentation diagrams. 3. Civil and mechanic blueprints. 4. Material take-offs. 5. Piping, insulation, painting specifications.	Same as above, plus payment for engineering on a man-hour basis or on lump sum.	Few restrictions, if any, from firm doing engineering work. All restrictions come from licensor.

TYPICAL TECHNOLOGY PACKAGES

PROCESS BASED TECHNOLOGY

IV. OPERATING PACKAGE	PROTECTION AND PAYMENT FORMULA	SUPPLIER & TYPICAL RESTRICTIONS
1. Step by step operating procedures on all key equipment. 2. Safety and environmental. 3. Quality control.	Not patentable. May be negotiated together with above packages or separately. Usually costs 0.5 to 1% on sales.	Few explicit restrictions, except those associated with above packages.
V. TECHNICAL ASSISTANCE		
1. Operating support. 2. Quality control. 3. Productivity analysis. 4. New materials of construction. 5. New auxiliary equipment.	Payment is usually 0.5% of sales or per man-day used plus basic lump sum fee.	Requirements on free feed-back of innovations. Secrecy agreements. No sublicensing.

TYPICAL TECHNOLOGY PACKAGES

OPERATIONS BASED TECHNOLOGY

	PROTECTION AND PAYMENT FORMULA	SUPPLIER & TYPICAL RESTRICTIONS
I. KNOW-HOW PACKAGE 1. Basic operational data. 2. Flowsheets and plant diagrams. 3. Key steps in the operation.	Patents cover some. The rest is protected by secrecy agreements. Lump sum or around 1% on sales.	Producer and/or engineering firm. Limitations vary with value of proprietary information to competitors.
II. PLANT CONSTRUCTION PACKAGE 1. Key equipment specifications. 2. Procurement assistance. 3. Detail engineering (See Process II) coordination. 4. Supervision and expediting.	Very limited if any protection. Payment as lump sum or cost plus % fee.	Engineering firm. Few restrictions beyond secrecy agreements.
III. OPERATION AND TECHNICAL ASSISTANCE 1. Step by step operating procedures. 2. Quality control. 3. Safety and environmental. 4. Productivity.	Limited protection beyond secrecy agreement. Lump sum or fee as % of sales.	Producer and/or engineering firm, usually through experts in the field. Few restrictions.

In the selection and negotiation of a technology package it is important to keep in mind the importance of the assimilation capacity.

Whenever possible the engineers and technical people from the licensee should participate in gathering the information and preparing the package together with the engineers and technical people from the licensor. This reduces the cost and broadens the capability for further adaptation and assimilation.

Also it is usually advisable to visit other licensees to find out the weaknesses and problems in time to correct them as well as to obtain helpful hints.

VIII. - METHODOLOGY FOR ADAPTATION OF TECHNOLOGY

As we have indicated in previous pages we make no distinction between adaptation and innovation from a technological stand point, since we feel that even the most revolutionary innovations have adapted 90% of the technology needed for the final product, and the crudest form of transfer of technology has some degree of local adaptation. The problem of innovation and creativity is touched upon briefly in the next chapter.

From our experience in adapting over two dozen of technologies to Mexico we have developed a methodology that we feel is helpful for adapting any type of technology, although perhaps much more for equipment and product based technologies, somewhat less for operation based technology and still less for process based technology, (which is, we feel, the general degree of adaptation difficulty any how).

The foundation of our methodology is very simple: in today's sophisticated industrialized world technology is developed by teams of experts, specialists on increasingly narrower fields, that have lost the overall perspective of the problem. To ask them to adapt a full technology to basic differences in another country is usually beyond the capabilities they have been trained for. One must develop a new specialization for effective adaptation; this new specialization must be based on a broad picture of all the elements that have an influence in the performance of the technology.

This general broad picture is generally lost in the early stages of the development of a field of technology. In our opinion, in the metal-mechanic industry it was found last in the mechanic engineer of England and France late last century, when the inception of the automobile and the creation of machines for industry were well on their way. In the chemical industry the broad picture was lost with the German chemist of the 1920's, who was the last to develop a reaction in the lab and then tell the industrial chemist and the engineer how the larger plant should be built.

In today's world, perhaps with the exception of nuclear industry with which the writer is not familiar, most technologies upon which current industry is based are so far developed that there is an abundant supply of specialists, but only a handful of generalists.

If we stop to think that the successful adaptation of a technology requires:

- Knowledge of the market.
- Knowledge of the product.
- Knowledge of the process.
- Knowledge of the availability of raw materials.
- Knowledge of the country's differences in general and, in specific, in terms of their impact on the industrial infrastructure.
- Knowledge of labor skills and idiosincracies.

  Etc.

It is obvious that we need a capability for administration of all these skills and an effective orchestration of all the information produced. One might argue this is so also in the industrialized countries, but remember that they went through this in the early stages of the development of that technological field and from there onwards there was a general structure upon which to continue the development.

In addressing ourselves to the adaptation of such a developed technology to our conditions we have to make sure that three conditions are satisfied:

1. That there is indeed the need to adapt.
2. That the technology selected can be adapted with good probabilities of success.
3. That we have the resources to do a good job of adaptation.

We have included in the following chart the concepts we consider most important within the following three conditions:

CONDITIONS FOR ADAPTATION OF TECHNOLOGY

NEED, as a function of

- Industry mission.
- Availability of an appropriate technology.
- Direct and indirect costs of acquisition of the technology.
- Ecologic considerations and social impact.

ADAPTATION POTENTIAL, as indicated by

- Cost sensitivity to scale.
- Level of sophistication.
- Degree of development.
- Availability of the information.
- Flexibility of the licensee to make morphological changes.

CAPACITY TO ADAPT

- Human resources - Experts in

  Market (uses, applications, size).
  Morphology (chemical or physical) of the technology.
  Design and development (product and process).
  Detail engineering.
  Administration and organization.

- Economic resources

  To pay for the adaptation.
  To finance the plant.
  To operate during the first years.
  To correct and optimize.

- Time

  To maintain a market position.
  To fight obsolescence.

Once we are satisfied that these three conditions are met, then we can proceed to select the technology packages we need (described in the previous chapter) and try to adapt them to produce a technology appropriate to our needs.

We have developed a technique which we have found very useful in adapting: keeping in mind the mechanic engineer of England of last century and the German chemist of the twenties, we decided that what was needed was a frame of reference to force the engineer to keep in mind all the variables relevant to the problem.

We group all these variables in five categories, which are:

1. PRODUCT

Demand vs. specifications.
Market and competitive dynamics as a function of price and time.

2. RAW MATERIALS

Cost vs. specifications.
Availability of supply.

3. TRANSFORMATION

If chemical:

Rate of reaction and equilibrium as a function of key physical-chemical variables.

Influence of catalists, mixing, concentration, rate of addition, etc.

If physical:

Key methodology for change of shape, size and conditions.

Influence of metallurgical changes, temperature, etc.

4. SEPARATION AND/OR FINISHING

Cost vs. specifications.
Trade-off in specifications of product coming out of transformation vs. cost of separation/finishing (including assembly).

5. AUXILIARY SYSTEMS

Energy Control Pollution Safety	As a function of basic differences

For the sake of brevity and conciseness we will not elaborate into the interrelationships, well known to the reader, of these basic modules. Enough to say that if and when one is capable of summarizing in a single picture all the relevant pieces of information, then the trade-offs of these interrelationships become more apparent for the adaptation team, who can capitalize on them to do a good job of adaptation.

One simple way to conceive of the objective of adaptation is to keep in mind that the name of the game is to attain the minimum adequate specifications both in the plant and in the product. Anything above that represents an unnecessary expenditure; anything below that ceases to be adequate.

The true measure of having attained the most appropriate technology, then, is the ability to meet the minimum adequate specifications.

We made reference also to the importance of competitive dynamics, because as the Governments become more aware of the importance of reaching satisfactory levels of productivity and efficiency it is more important for the industrialist to make sure that his project will meet minimum standards of competitiveness.

We are using a model for analysis of competitiveness based on the work of L. Rodríguez and S. González Ramírez, at the Chemical Manufacturers Association, that classifies competitiveness in three categories:

EXOGENOUS COMPETITIVENESS, when the excess cost is attributable to the need to acquire overpriced inputs such as

Raw materials

Shadow prices

Taxes

ENDOGENOUS COMPETITIVENESS, when our inefficiency is due to a poor conception of the project, as evidenced by using the wrong

Scale

Technology

PROJECTED COMPETITIVENESS, where the project may be expected to be competitive in today's environment but it can already be visualized that it will soon lose its competitiveness due to

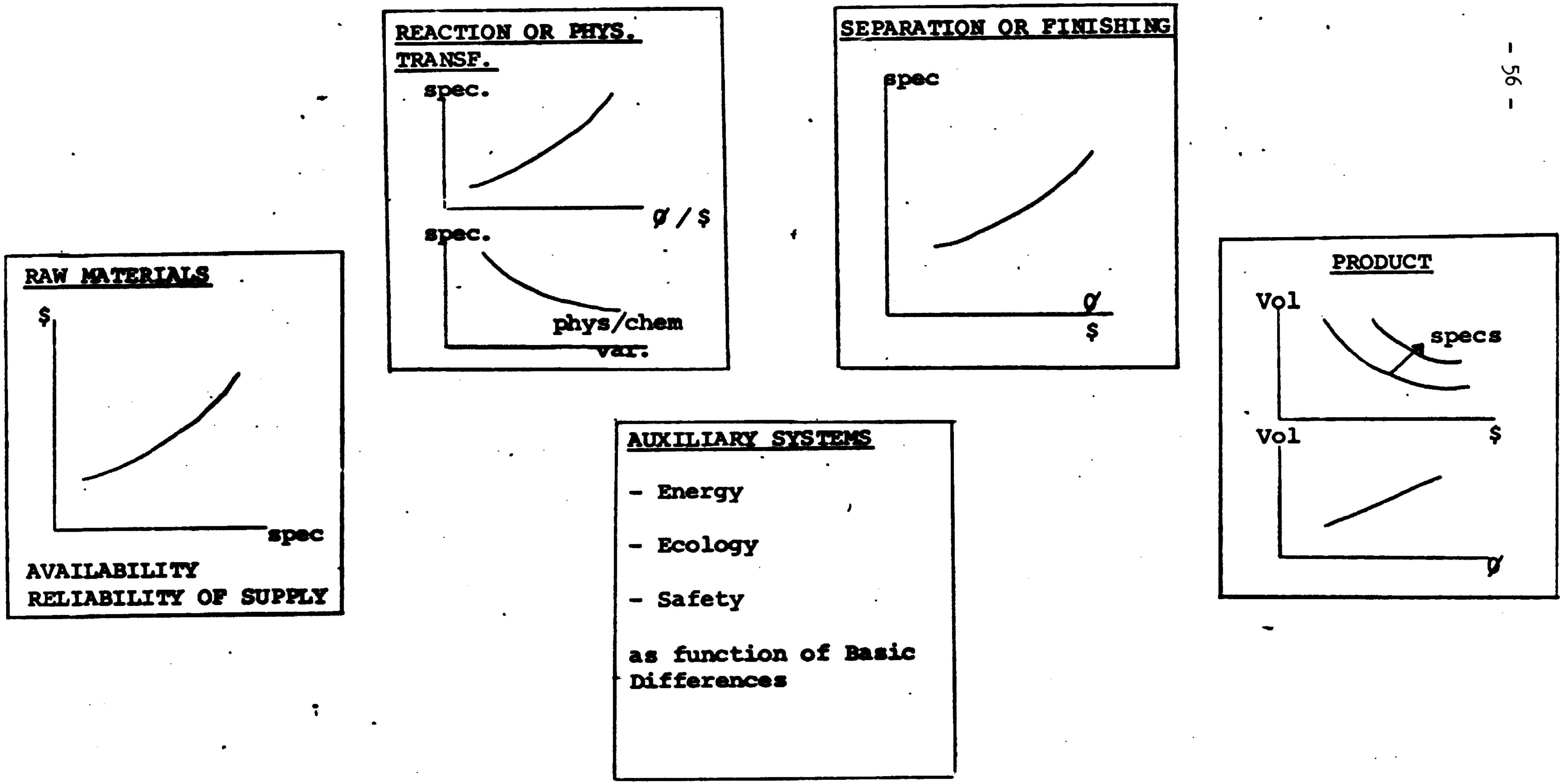
Obsolescence

Technological innovation

World trends

and our ability to identify these trends will determine how competitive our whole economy is in the next decade or two.

BASIC MODULES



MINIMUM ADEQUATE SPECIFICATIONS

MOST APPROPRIATE TECHNOLOGY

IX. - CREATIVITY, INNOVATION AND ENTERPRENEURSHIP

To our knowledge there is no methodology to create or innovate per se, although there are already several courses offered on the subject, and most of them give helpful guidelines and hints on how to proceed.

From our point of view the lack of creativity and innovation in our culture is more a socio-cultural problem, of a very complex nature, and indeed worth studying in detail by people adequately trained. We will limit ourselves to some comments based on practical experience, only to recognize the importance of these aspects as part of the general subject of this paper:

- It seems to us that there is something common in most underdeveloped countries in the sense that religion and family style present a similar cultural moves whether we are looking at a catholic Latin American country, a muslim arab, middle-Asiatic or African country, or any-other combination: Children are taught to accept dogma and father's authority and infallibility.

- Most elementary schooling is done by ill-prepared teachers who, lacking judgement and capacity, hide themselves behind what the book says. Lack of economic resources makes it difficult to do any experimental or manual work.

- High level education, including universities, has had to face such an increase in demand that professors, classrooms and laboratories are overwhelmed by ten times more students than they should have.

- Theory is taught from books written for industrialized countries, sometimes translated and most often in the original language, mostly English. Students are taught subjects they never will have an opportunity to use; very often they know that will be the case and lose any motivation to learn well.

- From the beginning of their actual work in industry, whether as workers, craftsmen or engineers, they are asked to follow closely the operating instructions and severely reprimanded when trying to explore some potential improvements.

- There is no system in industry or Government to compensate the individual who is capable of overcoming all these obstacles and develop an improvement of commercial value. On the other hand, the punishment for failure if this is attempt is severe.

- Most developing countries suffer from inflation, lack of adequate financing and poor infrastructure. These three factors have been long recognized as key for the development of small industry. Only big industry can survive in this environment in the long term.

And we expect creativity, innovation and enterpreneurships from our people?

X.- MECHANISMS AND ORGANIZATION FOR APPLICATION OF APPROPRIATE TECHNOLOGY

This is another very important dimension of the problem that needs breaking down into its main components.

In our opinion, the bulk of the work done in the past in the field of appropriate technology has tended to neglect the consideration of who will take care of the application, and takes it for granted that these organizations will emerge espontaneously. Practical experience has shown us the contrary: the creation of adequate Government policies on one hand and of trained human resources on the other are conditions necessary but not sufficient.

One breakdown we have found practical to classify the organizations needed is the following:

1) Research
2) Development
3) Engineering
4) Equipment manufacture
5) Production

in addition to

a) Government institutions
b) Human resources (universities, etc.)

1) <u>Research</u>. - The way we like to differentiate research from the rest of the organizations is that research institutions have the capability to concentrate on one piece of a more general problem without the need to justify the study on the basis of short term profitability. This does not imply that the opposite is not desirable, i.e., making every research study coherent with a general working line and economically justifiable; it only says that a research institution has a broader flexibility and a greater capability of continuity even if there is no short term success.

Under this definition then it is evident that developing countries do indeed need research, but oriented in a different direction: not necessarily to invent or discover a new alloy, a new polymer, a new drug; oriented to the design of a product mix adequate to improve the quality of life of the local population.

This implies the need for a better definition of the objective: How does one measure quality of life? Experience of the past 30 years has taught us that GNP, or % literacy, are not the ideal indicators. We have to keep control of how many fishermen are aware of the need to respect biological cycles of the species not to exterminate them, farmers, before they learn how to read, should learn more about adequate seed selection, adequate fertilization, crop rotation, etc. We should keep statistics of how many people have minimum adequate sanitary facilities - and, before that, we have to define what minimum sanitary facilities are. And so on and so forth.

Having defined that, local research institutions have to concentrate then in the design of products to satisfy those newly defined requirements, and the manufacturing techniques to produce them.

2) Development.- If we define development as the first integrated effort to put some technical knowledge to practical use with a commercial or business objective then it is evident that in the developing countries we have few such organizations, and mostly due to one of two reasons:

- Either they are not fully integrated nor can do an efficient job (typically we are crowded with projects started with good intentions that were never completed).

- Or the final objective of producing an adequate amount of products of adequate quality and cost is not clearly perceived and as a result is not attained.

In the past 10 years the increasing amount of meetings, conferences and panel discussions on the subject has served one very important purpose: it has identified who is the people reliable and well prepared technically. What is lacking now is a mechanism for integrating their skills for a good, productive, objective.

3) <u>Engineering</u>.- Speaking from our experience in México, this seems to be the area better covered by local organizations, both in quality and quantity. The only observation worth making is that the weakest spot is usually in engineering a local development, as opposed to the handling of a transfer of technology from one engineering group in one country to another engineering group in another country.

4) <u>Equipment manufacture</u>.- The research limitations towards innovation find in here their biggest obstacle. All ideas have to end up being adapted to the available equipment.

In our opinion local manufacture of equipment is important not because of its savings of foreign exchange (some hidden costs make this often questionable) but because of the need to integrate this area to the local organization and mechanics in applying appropriate technology.

A thorough analysis of the policy towards promotion of local manufacture of equipment should start by a technological characterization similar to the one described in Chapter V, but defining the mission of the equipment in terms of

- Use of labor
- Increase of productivity
- Improvement of quality
- Improvement of safety, environment, etc.

5) Production. - Production is the recipient of all the efforts of the organizations described above, and has a key role as a testing ground, a lab and a pilot plant if properly used.

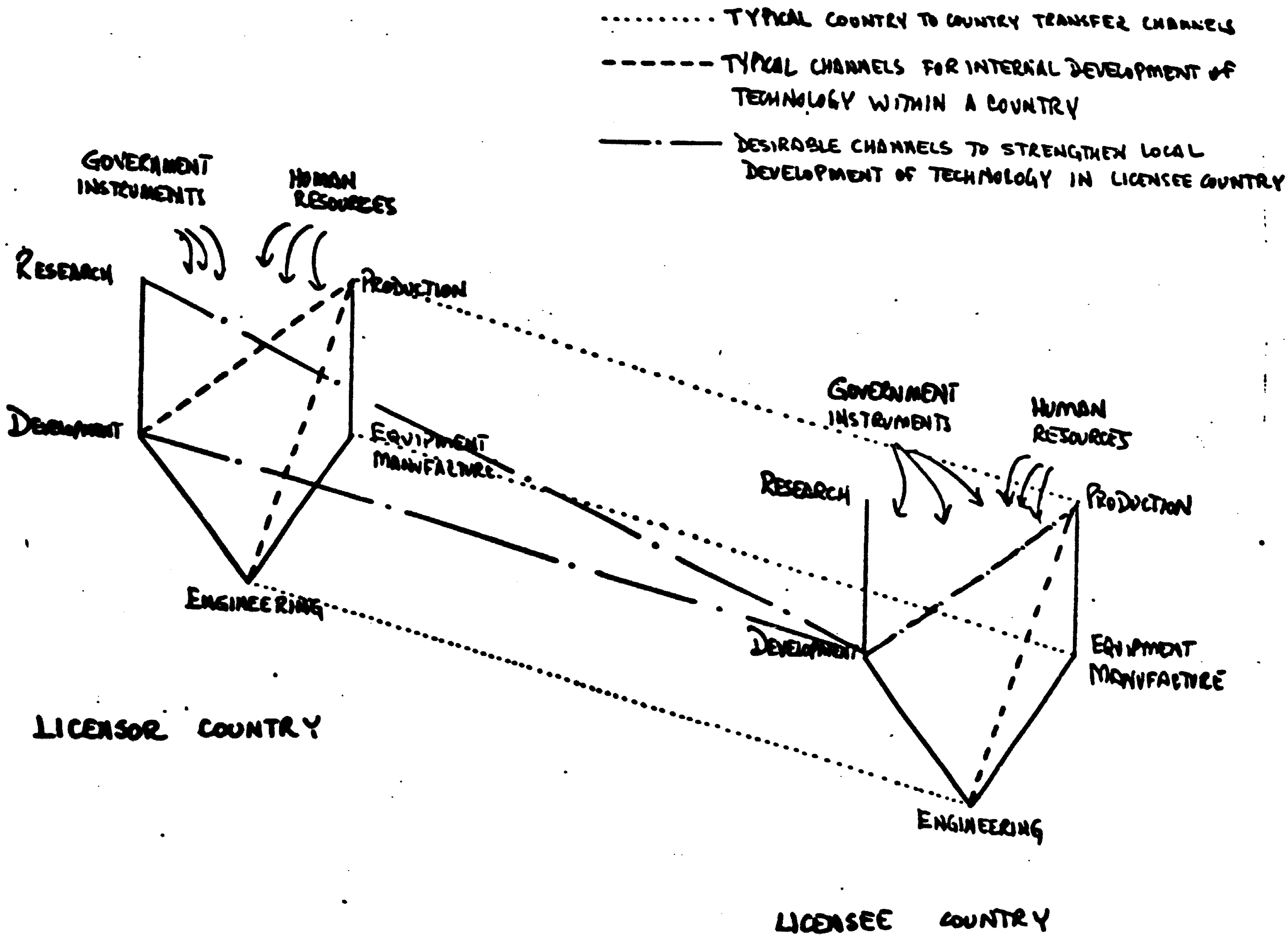
For every innovation born in a lab several innovations were born in a plant. And the reason is simple: there is more people working at production, there is more incentive (in (terms of short term benefits) to innovate and there is less risk, because testing of the innovation is a highly reversible process, i.e., if the result is below expectation it is relatively easy and inexpensive to return to the prior conditions.

To this respect we have been using a classification we have found useful, which is self explaining; technological innovation in production can fall into one of five categories:

- i) Solution of explicit problems.
- ii) Identification (and then solution) of implicit problems.
- iii) Optimization (as a systemic approach, different from troubleshooting).
- iv) Adaptation.
- v) Innovation - Basic Technological Development.

The diagram in the next page illustrates the key channels of transfer between all the organizations described above.

Although it is obvious that there is transfer between every two or more organizations within a country or between countries we have marked only the most frequent.


TYPICAL COUNTRY TO COUNTRY TRANSFER CHANNELS
TYPICAL CHANNELS FOR INTERNAL DEVELOPMENT OF TECHNOLOGY WITHIN A COUNTRY
DESIRABLE CHANNELS TO STRENGTHEN LOCAL DEVELOPMENT OF TECHNOLOGY IN LICENSEE COUNTRY
GOVERNMENT INSTRUMENTS
HUMAN RESOURCES
RESEARCH
PRODUCTION
DEVELOPMENT
EQUIPMENT MANUFACTURE
ENGINEERING
LICENSOR COUNTRY
GOVERNMENT INSTRUMENTS
HUMAN RESOURCES
RESEARCH
PRODUCTION
DEVELOPMENT
EQUIPMENT MANUFACTURE
ENGINEERING
LICENSEE COUNTRY

CHAPTER 2

TECHNOLOGICAL PLANNING OF INDUSTRIAL DEVELOPMENT THE CASE OF THE CHEMICAL INDUSTRY IN MEXICO

Chapter 1 describes the general model for technological planning applicable to any industrial sector. Because of the background of the Group for Development of Technology in terms of the experience and information accumulated, the chemical industry was selected as a case study to test this model. This Chapter presents a brief summary of the information developed for technological planning of the chemical industry in Mexico 1977-1982.

The first part of the study consisted of a macro analysis of the chemical industry within the overall economic context of Mexico. Macroeconomic projections both from econometric models (Wharton Diemex) and from estimates from different government and industrial agencies. This lead to an overall estimate of the new investment for the Mexican chemical industry, in the six-year period, 1977-1982, of approximately 90 billion constant pesos or 3.9 billion dollars at Dec. 76 parity rates (23 pesos/dollar) which compares with an estimated 124 billion dollars for total investment in Mexico in the same period (i.e., the investment in chemical industry represents slightly over 3% of total investment). Table A shows the components of this projected investment.

TABLE A

BREAKDOWN OF THE PROJECTED 6-YEAR (1977-1982) INVESTMENT IN THE MEXICAN CHEMICAL INDUSTRY

(Billion Pesos)

	Dec. 76 Constant Value	%
Petrochemicals	50	55
Basic Chemicals	24	27
Agrichemicals	7	8
Others	9	10
	$90	100%

As a second setp in the study, information was gathered on individual projects expected for the 77-82 period.

The main sources for this information were: Number 1, and most important, the published plans of Petróleos Mexicanos (the official government industry) on basic petrochemistry; in second place, the announced plans of public and private industries regarding secondary petrochemical projects (since Mexican law requires obtainment of petrochemical permit, this information is readily available); this information was complemented by a survey that covered the key members of the chemical industrial association and the major engineering firms (results of this part of the study have been treated confidentially and used only for statistical purposes); and finally, several sessions were held within the research team at the Group for Development of Technology, studying the logical next steps on the chemical industrialization of Mexico and cross-referring this information with as many sources and bits of data as we could gather.

From this information, the following list of key projects was prepared. This list represents 80% of the total expected investment (the remaining 20% to be invested in small projects or expansion); it was realized that some of these projects will not take place during the period studied, but they will be substituted for other projects which, for statistical purposes, are morphologically equivalent.

LARGE INVESTMENT PROJECTS

(Over 10 million dollars each)

WITH PROCESS TECHNOLOGY

Urea

Acetic Acid

Dimethyl formamide, methyl amines

Polystyrene

Polyethylene glycol terephthalate

Terephthalic acid

Furfural (2 projects)

Sulfuric acid (several projects)

Fertilizer projects (11 projects under Fertimex)

Acetaldehyde

Acrylonitrile

Ammonia

Carbonic Anhydride

Sulfur

Benzene

Cumene

Vinyl chloride

Dichloro ethane

Dodecyl benzene

Heavy alquil-aryls

Styrene, ethyl-benzene

Ethylene

Criogenic plants

Sweet ening plants (desulfurizers)

Methanol

Ethylene oxide

Perchloroethylene

Para-xylene

Polyethylene

Tetramer

Carbon tetrachloride

Acrilic acid

Propylene oxide

Polypropylene

Butadiene

Ortho xylene

Toluene

WITH PRODUCT TECHNOLOGY

Aminoacids

Silicium carbide

Pentaerythritol

Formaldehyde/Pentaerythritol/Sodium formiate

Diphenyl methane diisocyanate

Ethylene and propylene glycols, and glycol ethers

WITH OPERATIONS TECHNOLOGY

Parathion nitro-phenol salt

Carbon black

Cellulose pulps

Industrial gases

Graphite electrodes

Caustic and chlorine

WITH EQUIPMENT TECHNOLOGY

Polypropylene filament

Plastics conversion, molding and extrusion (several projects)

TOTAL INVESTMENT IN LARGE PROJECTS: $ 3.3 BILLION DOLLARS

MEDIUM SIZE PROJECTS

(Between 1 and 10 million dollars each)

WITH PROCESS TECHNOLOGY

Aliphatic amines, ammonia salts

Polyurethane

Nitrile polyacrylates

Methyl, ethyl, butyl and 2-ethyl-hexyl acrylates

Mono-, di- and tri-ethylene glycols

WITH PRODUCT TECHNOLOGY

Fatty acids

Epoxy resins

Acrylonitrile, styrene-butadiene

2, 4-Dichloro phenoxy acetic acid

Aniline

Paratoluidine, anthraquinone, several acids and derivatives

Polystyrene resins; copolymers and terpolymers

Glycerine and fatty acids

WITH OPERATIONS TECHNOLOGY

Caprolactam polymerization

Guayule rubber

WITH EQUIPMENT TECHNOLOGY

Oxygen, argon, nitrogen

Plastic products

Rubber products

Plastics

TOTAL INVESTMENT IN MEDIUM-SIZE PROJECTS: $ 72 MILLION DLLS

SMALL SIZE PROJECTS

(Below 1 million dollars each)

WITH PROCESS TECHNOLOGY

Gramoxone

Chlorinated paraffins

Carboxy-methyl-cellulose

WITH OPERATIONS TECHNOLOGY

Chemicals from vegetables

Insecticides

Fertilizers

Industrial paints

WITH EQUIPMENT TECHNOLOGY

Polystyrene

Industrial oils

Lubricating oils

Nylon parts

TOTAL INVESTMENT IN SMALL PROJECTS: $ 12 MILLION DOLLARS

The third phase of the study, now that we had the estimated overall investment for the chemical industry in Mexico for the period 1977-1982, and also had it broken down into the key projects, consisted in running this data basis through the different steps proposed in the model described in Chapter 1. Following is a description of the most relevant steps:

The work previously done by the Group on Basic Differences for Mexico, that has been published elsewhere, was used as a basis for this study.

Since the writer is a member of the National Advisory Council of Promotion of Chemical Industry, his participation on those meetings provided an up-to-date information regarding the Planning Base, specifically regarding industrial sector priorities and areas of national interest.

The above information was also very useful in developing a Set of Criteria of Plausibility that reflected the current government thinking. As a result of the analysis of plausibility, which was run by several researchers of the team, following the Delphi Technique, the numbers shown in Table B were obtained:

TABLE B

DISTRIBUTION OF PLAUSIBILITY RATINGS OF 85 PROJECTS STUDIED

BASIS FOR RATING:	RANGE
Market Criteria	0-10
Economic Criteria	0-10
Finance Criteria	0-10
Technological Criteria	0-10
TOTAL	0-40

RATING	N° OF PROJECTS	% OF PROJECTS	INVESTMENT (Million Dollars)	% OF INVESTMENT
40-36	7	8	139	15
35-31	8	9	106	12
30-26	26	31	360	39
25-21	30	36	173	19
20-16	13	15	95	10
15-0	1	1	47	5

CHARACTERIZATION OF TECHNOLOGY

Knowing individually 80% of the projects for the next 6-year period lead to the results shown in Tables C and D (due to significant weight of projects on basic petrochemicals, which is not representative of a trend, projects were analized with and without Pemex investment in basic petrochemistry).

As to the Forms of Acquisition of Technology, the analyses indicated that the most logical outcome is that:

67% should be purchased and directly transferred.
16% should be purchased and adapted.
5% should be integrated from known technologies, and
12% should be developed based on existing technologies but with an important local addition.

These results reflect the important influence of large-scale, export oriented, process technologies required for the petrochemical expansion program, which should be purchased and transferred directly.

TABLE C

CHARACTERIZATION OF TECHNOLOGY (INCLUDING PEMEX PROJECTS)

TYPE OF TECHNOLOGY	INVESTMENT (Millions of Dollars)	% OF INVESTMENT	NUMBER OF PROJECTS	% OF PROJECTS
Operations	236	7	13	8
Process	3,024	88	100	66
Product	128	4	31	20
Equipment	33	1	10	6
LEVEL OF COMPLEXITY				
Sophisticated	3,073	90	100	65
Intermediate	283	8	42	27
Elementary	65	2	12	8
FORMS OF ACQUISITION OF THE TECHNOLOGY				
Purchase	2,299	67	103	65
Adaptation	542	16	30	20
Integration	54	5	2	3
Development	526	15	19	12
Innovation	0	0	0	0

TABLE D

CHARACTERIZATION OF TECHNOLOGY (EXCLUDING PEMEX PROJECTS)

TYPE OF TECHNOLOGY	INVESTMENT (Millions of Dollars)	% OF INVESTMENT	NUMBER OF PROJECTS	% OF PROJECTS
Operations	236	26	13	16
Process	524	56	31	36
Product	128	14	31	36
Equipment	33	4	10	12
LEVEL OF COMPLEXITY				
Sophisticated	573	62	31	36
Intermediate	283	31	42	49
Elementary	65	7	12	14
FORMS OF ACQUISITION OF THE TECHNOLOGY				
Purchase	549	60	52	61
Adaptation	292	32	24	28
Integration	54	6	5	6
Development	26	3	4	5
Innovation	0	0	0	0

As to the 12% that requires local development, it is felt that the first three years the number will be smaller and it will grow towards the end of the period.

The study was stopped here with regards to selection and negotiation of individual technology packages, or adaptation of specific technologies, since it is felt that these two steps have to be conducted for each individual project by the people who will ultimately will be responsible for their commercial implementation. Information was gathered on known processes (a collection of the most important flow sheets for these process was published as an outcome of this study) as well as on some general market data, price and cost structure, etc. (another corollary of this study is a research currently in process analizing the competitiveness of the Mexican chemical industry as compared to the U. S.).

On the other hand, to take advantage of the statistical data bank already gathered, the study was continued in two further aspects: Human resources required and capital goods required for such an investment program. Table E shows the basic coefficient of man-hours required for the different scales of people and for the different types of technology (based on the accumulated experience of private chemical firms and engineering firms in estimating, designing and constructing over a billion dollars worth of chemical projects for Mexico), and Table F shows a summary of the results of applying such coefficients.

Table G shows the technological coefficients for equipment required by the different investments (it was taken from the confidential study of over 1 billion dollars worth of chemical investment estimated designed and constructed for Mexico) and Table H shows the results of applying the coefficients shown in Table G to the data base developed as described above.

TABLE E

PERCENT AND COST OF MAN-HOURS OF DIFFERENT SKILLS REQUIRED TO CONSOLIDATE AN APPROPRIATE TECHNOLOGY IN A PROJECT

	LARGE (Over 10 Mill/Dlls)	MEDIUM (1-10 Mill/Dlls)	SMALL (Below 1 Mill/Dlls)	AVER. COST Dlls/Man Hr.
Selection, negotiation and transfer (1)	2%	2%	1.5%	25
Adaptation	1% (2)	5%	6 %	18
Development	5%	10%	10 %	18
Basic Engineering (3)	5%	5%	5 %	18
Detail Engineering (4)	75%	58%	52.5%	10
Construction and Start-ups (5)	12%	20%	25 %	15
T O T A L	100%	100%	100 %	

(1) Includes only technical man-hours. Excludes time involved in legal and bureaucratic red-tape.

(2) This figure is small because in Mexico adaptation in large chemical processes is minimum.

(3) Most of this basic engineering is not performed in Mexico but abroad, usually at the countries of the Licensor.

SUMMARY

The need for appropriate chemical technology can be traced back essentially to the early 50's, when as a result of the Second World War two things happened: There was a clear distinction between developed and less developed countries, and a motivation for the latter to speed up their development. That motivation was fostered by availability of foreign exchange reserves accumulated during the war years and complemented by aid funds provided by the developed countries.

However, in a world of rapid technological refinements tied to large-scale markets and high labor cost coupled with a relative abundance of capital, the less developed countries soon found out that to have the economic resources and the drive to develop faster was not enough: the technologies available were not appropriate to the size of their markets and their relative cost of labor and capital. It is in this context that we use the term "appropriate technology",

(4) Includes all engineering specialties (about 28% of this total is chemical engineering).

(5) Includes only engineer-hours (about 10% correspond to chemical engineers). As the size of the project decreases there is a shift from hours spent at the draft-board, in detail engineering, to hours spent in field supervision, as construction and start-ups.

SOURCE: Confidential Study based on over 1 billion dollars worth of projects studied in Mexico by the leading chemical industries and engineering firms over a 20 year period.

TABLE F

CASE 1: HUMAN RESOURCES REQUIRED IN THE CHEMICAL INDUSTRY ASSUMING THE SAME TECHNOLOGICAL FACTOR AND EXCLUDING PEMEX

ESTIMATED PERCENTAGE OF MAN-HOURS PER ACTIVITY	SELECTION, NEGOTIATION AND TRANSFER	ADAPTATION	DEVELOPMENT	BASIC ENGINEERING	DETAIL ENGINEERING	CONSTRUCTION AND START-UPS
Large Investment	1.5	1	2	5	78.5	12
Medium Investment	1.5	3	4	5	66.5	20
Small Investment	1	4	5	5	60	25

ENGINEERING COST (Percentage for the list of Projects)

Large Investment	(885.94)	(0.06)	=	50.16 MM Dlls
Medium Investment	(71.87)	(0.09)	=	6.47 MM Dlls
Small Investment	(12.50)	(0.12)	=	1.50 MM Dlls

CONNECTED ENGINEERING COST (Average for all expected investments)

Large Investments	(60.16)	(1.72)	=	86.28 MM Dlls
Medium Investments	(6.47)	(1.72)	=	11.13 MM Dlls
Small Investments	(1.50)	(3.45)	=	5.18 MM Dlls

COST DISTRIBUTION (percentage)	SELECTION, NEGOTIATION AND TRANSFER	ADAPTATION	DEVELOPMENT	BASIC ENGINEERING	DETAIL ENGINEERING	CONSTRUCTION AND START-UPS
Large Investments	3.26	1.91	3.13	7.82	68.23	15.65
Medium Investments	3.05	5.36	5.85	7.31	54.04	24.38
Small Investments	1.97	6.94	7.10	7.10	47.32	29.57

ENGINEERING COSTS BROKEN DOWN BY ACTIVITY (Million of Dollars)

Large Investments	2.81	1.65	2.70	6.75	58.87	13.50
Medium Investments	0.34	0.60	0.65	0.81	6.01	2.71
Small Investments	0.10	0.36	0.37	0.37	2.45	1.53

MAN-HOURS AND NUMBER OF PEOPLE REQUIRED FOR EACH ACTIVITY	SELECTION, NEGOTIATION AND TRANSFER	ADAPTATION	DEVELOPMENT	BASIC ENGINEERING	DETAIL ENGINEERING	CONSTRUCTION AND START-UPS
Large Investments	112,400	91,667	150,000	375,000	5,887,000	900,000
Medium Investments	13,600	33,333	36,111	45,000	601,000	180,667
Small Investments	4,000	20,000	20,556	20,556	245,000	102,000
TOTAL MAN-HOURS	130,000	145,000	206,667	440,556	6,733,000	1,182,667
MAN-MONTHS (at 160 hrs/m.m.)	813	906	1,292	1,754	42,081	7,392
MAN-YEARS	67	75	107	230	3,507	616
MAN-YEARS/6	12	13	18	39	586	103
PRODUCTIVITY FACTOR	1.5	1.8	1.5	1.5	2.0	2.0
REQUIRED NUMBER PEOPLE	18	23	27	58	1,160	206

TABLE F (Continued)

Following the same methodology, but changing the pertinent coefficients, different cases are computed. The following summary illustrates a comparison of four cases:

	CASE 1	CASE 2	CASE 3	CASE 4
Selection, transfer and negotiation	18	23	43	55
Adaptation	23	27	46	48
Development	27	64	60	144
Basic Engineering	58	56	142	138
Detail engineering	1,160	1,222	2,948	2,730
Construction & Start-ups	206	200	470	456
T O T A L	1,492	1,592	3,709	3,571

CASE 1: Excluding Pemex. No change in technological factor.

CASE 2: Excluding Pemex. Higher local development of technology.

CASE 3: Including Pemex. No change in technological factor.

CASE 4: Including Pemex. Higher local development of technology.

TABLE G

TYPICAL BREAKDOWN OF THE INVESTMENT IN A MEXICAN CHEMICAL PROJECT FOR DIFFERENT TYPES OF TECHNOLOGY (Data in Percentages)

		TYPE OF TECHNOLOGY											
		PROCESS			PRODUCT			OPERATION			EQUIPMENT		
		L	M	T	L	M	T	L	M	T	L	M	T
1.1	Process Equipment	3	17	20	4	26	30	2	8	10	2	8	10
1.2	Process Machinery	-	10	10	-	15	15	-	25	25	-	30	30
1.3	Pumps and Compressors	-	5	5	-	5	5	-	10	10	-	10	10
1.4	Auxiliary Equipment	2	8	10	1	4	5	3	12	15	2	8	10
1.	TOTAL EQUIPMENT	5	40	45	5	50	55	5	55	60	4	56	60
2.1	Civil and Mechanical Installation	2	-	2	3	-	3	5	-	5	3	-	3
2.2	Piping, Valves and Fittings	4	6	10	4	3	7	2	1	3	1	1	2
2.3	Insulation and Painting	1	1	2	1	1	2	1	-	1	1	-	1
2.4	Instrumentation and Control	2	8	10	1	3	4	-	1	1	1	2	3
2.5	Electrical Installation	2	3	5	2	2	4	3	4	7	4	4	8
2.	TOTAL INSTALLATION COSTS	11	18	29	11	9	20	11	6	17	10	7	17
3.	BUILDINGS AND STRUCTURES	8	3	11	10	3	13	6	2	8	10	5	15
4.	DESIGN	8	-	8	6	-	6	7	-	7	4	-	4
5.	FIELD ADMINISTRATION	7	-	7	6	-	6	8	-	8	4	-	4
	T O T A L	39	61	100	38	62	100	37	63	100	32	68	100

L = Labor, M = Materials, T = Total

T A B L E H

SUMMARY OF EXPECTED EXPENDITURES BY THE MEXICAN CHEMICAL INDUSTRY, 1977-1982, IN PROCESS EQUIPMENT, PROCESS MACHINERY, PUMPS AND COMPRESSORS AND AUXILIARY EQUIPMENT (Data in Millions of Dec 76 US Dollars)

INVESTMENT	PROCESS		PRODUCT		OPERATION		EQUIPMENT		T O T A L	
	Mll/Dlls	%	Mll/Dlls	%	Mll/Dlls	%	Mll/Dlls	%	Mll/Dlls	%
PROCESS EQUIPMENT										
Large	607.6	88.7	20.8	3.0	19.6	2.9	1.2	0.2	649.2	94.8
Medium	8.8	1.3	16.9	2.5	2.9	0.4	1.8	0.2	30.4	4.4
Small	0.8	0.1	4.5	0.7	0.2	0.02	0.4	0.1	5.9	0.9
T O T A L	617.2	90.1	42.2	6.2	22.7	3.32	3.4	0.5	685.5	100.1
PROCESS MACHINERY										
Large	357.4	75.8	11.9	2.5	61.2	12.9	4.3	0.9	434.8	92.1
Medium	5.2	1.1	9.7	2.0	9.2	2.0	6.8	1.4	30.9	6.6
Small	0.5	0.1	2.6	0.6	0.6	0.1	1.6	0.3	5.3	1.1
T O T A L	363.1	77.0	24.2	5.1	71.0	15.0	12.7	2.6	471.0	99.8
PUMPS & COMPRESSORS										
Large	178.7	80.4	3.9	1.7	24.5	11.0	1.4	0.6	208.5	93.8
Medium	2.6	1.2	3.2	1.4	3.7	1.6	2.2	1.0	11.7	5.3
Small	0.2	0.1	0.8	0.4	0.3	0.1	0.5	0.2	1.9	0.8
T O T A L	181.5	81.7	7.9	3.5	28.5	12.7	4.1	1.8	222.1	99.9

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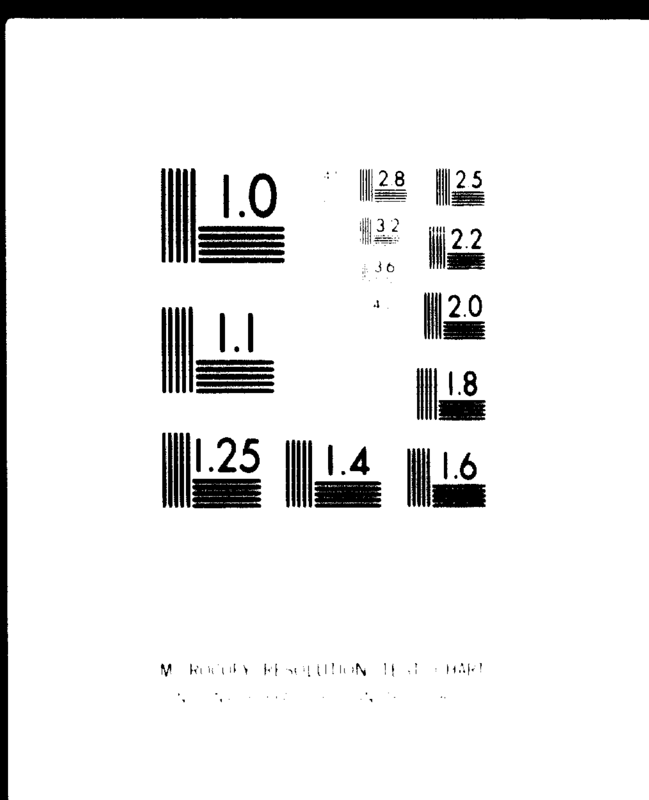

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TABLE H (Continued)

INVESTMENT	PROCESS		PRODUCT		OPERATION		EQUIPMENT		TOTAL	
	Mll/Dlls	%	Mll/Dlls	%	Mll/Dlls	%	Mll/Dlls	%	Mll/Dlls	%
AUXILIARY EQUIPMENT										
Large	285.9	85.5	3.2	1.0	29.4	8.8	1.2	0.4	319.7	95.6
Medium	4.2	1.3	2.6	0.7	4.4	1.3	1.8	0.5	13.0	3.9
Small	0.4	0.1	0.7	0.2	0.3	0.1	0.4	0.1	1.8	0.5
TOTAL	290.5	86.9	6.5	1.9	34.1	10.2	3.4	1.0	334.5	100.0

TYPICAL PROCESS EQUIPMENT

- Decanters
- Heat exchanges
- Columns & Towers
- Atmospheric tanks
- Pressure vessels
- Reactors
- Condensers
- Evaporators
- Dryers
- Furnaces
- Crystallizers
- Conveyors

TYPICAL PROCESS MACHINERY

- Filters
- Agitators & Mixers
- Fans and blowers
- Centrifuges
- Extruders & Expellers
- Mills, Breakers, Crushers

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