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UC/IRA/93/032

ISLAMIC REPUBLIC OF IRAN

Technical report: Research and development activities related to the petrochemical industry*

Prepared for the Government of the Islamic Republic of Iran
by the United Nations Industrial Development Organization

Based on the work of Gheorghe Ivanus,
expert in petrochemical industry

Backstopping Officer: M. Sanchez
Chemical Industries Branch

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* This document has not been edited.

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CONTENT

ABSTRACT

From May 3rd to May 30 th 1994 the author was member of an expert team to visit the Islamic Republic of Iran. The aim of this study group was:

- an assessment of the work done and the capabilities available at the Iranian Research institutes;

- to give advise to the Ministry of Industry on how R + D results could be optimally transferred to industrial enterprises to contribute to the country's welfare in various disciplines.

In the course of making the study, many petrochemical units and research and development institutes were visited and contacts with persons and institutes arranged.

It could be found that there is a remarkable potential of scientific capabilities and a large amount of practical knowledge, ability and motivation.

The research institutes could be important with respects to many issues, in :

- new type of petrochemical products assimilation to satisfy domestic market and to penetrate on the international market, in the regional area;

- quality improvment for the existing petrochemical products to be on line with the international strandards;

- supporting the Iranian Government by means of making preparatory studies and providing a scientific basis for the process of decision making;

- better utilization of the crude oil and natural gases resources, to prevent the exhaustion of suche reserves in non profitable chemical processes.

This report describes the situation, of the country, possible ways which could be used to exploit, to link petrochemical units to Research and Development Institutes, and the capabilities of the Research and Development Institutes to speed-up the technology transfer from the research to commercial scale.

Some organisational and structural modification might be necessary to bring closer the connections between the governmental entities and the research institutes, as well as to develop the cooperation between them and the Iranian petrochemistry.

Dr. Gh. Ivănuş

Tehran, 30 May 1994

LIST OF ABRAVIATIONS

M.O.I.	Ministry of Industry
M.O.	Ministry of Oil
N.I.O.C.	National Iranian Oil Company
N.I.G.C.	National Iranian Gas Company
N.P.C.	National Petrochemical Company
R.I.P.I.	Research Institute for Petroleum Industry
G.N.P.	Gross National Product
P.P.P.	Purchasing Power Parity
L.P.G.	Low pressure gases
N.L.S.	Natural Liquefied Gases
M.T.B.E.	Methyl tertiay butyl ether
T.P.A.	Terephthalic acid
P.E.T.	Polyethylene terephthalate
D.A.P.	Diammoniu phosphate
D.O.P.	Dioctylphthalate
E.D.C.	Dichloroetane
V.C.M.	Vinylchloride monomer
P.V.C.	Polyvinylchloride
D.D.B.	Dodecylbenzene
L.D.P.E.	Low density poiyethylene
LLDPE	Linear low density polyethylene
H.D.P.E.	High density polyethylene

P.P.	Polypropylene
S.B.R.	Butadiene styrene rubber
P.B.	Polybutadiene rubber
P.I.	Polyisoprene rubber
N.R.	Natural rubber
Tt.R.	Nytril rubber
B.R.	Butyl rubber
P.S.	Polystyrene
H.I.	High impact
G.P.	General purpose
E.P.S.	Expended polystyrene
A.B.S.	Styrene acrilonytrile copolymers
H.M.D.	Hexamethylene diamine
M.E.K.	Methyl-Ethyl-Ketone
M.S.B.R.	Methyl-Styrene-Butadiene-rubber

1. INTRODUCTION

1. A month consultancy visit was undertaken from May 3rd to Mai 30th, 1994, to provide advice and assistance to the Government of the Islamic Republic of Iran in assessing the present capabilities of the national research and development institutions to assist national petrochemical industry on its development plans.

2. The consultancy was undertaken by GHEORGHE IVANUS Professor Doctor in the field of petrochemistry, Polytechnic University - Bucharest, Romania.

3. The specific objectives of the mission were:

- evaluation of the present capabilities of the research development institutions to assist the national petrochemical industry, both in public or private sectors, in its development, utilizing the locally available indigenous raw materials, and to indicate those activities which require improvements;
- estimated costs and contributions of the parties involved, possibilities of better industrial utilization of locally available raw materials for energy production;
- aspects related to the treatment of effluents and environment protection;
- demand of the selected products both on local and international markets;

- estimated costs for performance of research works and future industrial production;
- availability of qualified personnel for the performance of research and future industrial production.

2. ACTIVITIES

The expert was interviewed in Vienna on May 3rd, 1994, and arrived in Tehran on May 4rd, 1994. Here was introduced to:

Mr. Ali Tofigh - National Project Director

Mr. Nade Niktabe - National Counterpart

Mr. Mir Mohammadi

and

Mr. F. Kovats - Chief Technical Adviser Project

The expert was assigned to Ministry of Industry of the Islamic Republic of Iran.

3. BACKGROUND INFORMATION

3.1. Crude Oil production

The Ministry of Oil was formed after the revolution, in 1981, to supervise the oil industry and to co-ordinate the various activities like natural gases and petrochemistry.

The Ministry of Oil has 3 affiliate companies, like:

N.I.O.C. - National Iranian Oil Company

N.I.G.C. - National Iranian Gas Company

N.P.C. - National Petrochemicals Company

In determining Iran's G.N.P., oil is regarded as an important resource, meeting the contry's financial and industrial needs, as illustrated below:

Foreign trade (million US $)*:

	1986	1987	1988	1989	1990	1991
Total export FOB of crude oil and	7,256	11,219	10,242	13,600	18,800	16,732
products	6,261	10,098	9,210	10,809	17,300	15,280

** Source: OPEC Annual Statistical Bulletin*

Crude oil and products normally account for more than 90% of all export. Other exports are mainly traditional items - fruits, carpets, leather, cotton, a.s.o.

Evolution of crude oil production in Iran, in OPEC countries and in the world can be seen in the Annex 5. The average annual growth of the crude oil production is forecast to reach 3.7% in the 10 year plan: 1989-1999. The crude oil used as feedstock for Iranian Refineries increased from 92.875 to/day in 1989 to more than 162.500 to/day in 1994, with an annual growth rate of 15%. This is planned to be attained in 1994, with an annual grouth rate of 15%, by completion and commissioning of the Bandar Abbas, Arak, Abadan, Bandar Taheri refineries and raising of active capacity of existing refineries.

The option to increase the domestic crude oil processing in Iran has to be a better utilization to the benefit of future development of the petrochemical production.

3.2. Petrochemical Production

The Iranian petrochemical Industry was born in 1964 by operation of a small fertilizers complex, and now there are ten manufacturing companies, located in: Ahwaz, Shiraz, Razi, Farabi, Kharg, Abadan, Esphahan, Bandar- Imam, Arak and Pazargad, mainly producing fertilizers, ammonia, nitric acid, methanol, sulphuric acid, phosphoric acid, caustic soda, chlorine and some real petrochemical products: polyvinyl chloride, phthalic anhydride, LPG, xylenes and carbon black, as shown in the Annex 6.1.

The programme of development of petrochemical industry in the second five year plan: 1994-1998, which is now currently under review, includes: new olefin complex for basic petrochemical products, such as: polyolefins, methanol, methyltertiary-buthyl ether, terephthalic acid, acrylates, polycarbonate and epoxyresins, as shown in the Annex 6.1.

This development plan emphasizes on export orientation, profit maximization and privatization of some petrochemical units.

In accordance with the new policy of privatization of industry in Iran, the National Petrochemical Company has already issued several licences to private sector investors to execute petrochemical units, like: petroleum resins, polyvinyl chloride, styrene copolymers, synthetic fibres, synthetic rubbers a.s.o., as shown in the Annex 6.1.

To promote these projects and to attract private investors, both sides, domestic and foreign, N.P.C. will provide necessary feedstock of 20% below the Persian Golf FOB, existing prices.

The prospects of the development of petrochemical industry in Iran have to be analysed in the context of the existing and future production of

main petrochemicals in the world and Middle East for the year 1990 and 2000.

Table 1.

Production capacities of major petrochemicals* (million of tons)

Region	1990	2000
World	428.0	542.0
Middle East	13.0	32.0
Iran	1.4	6.3
Share of Iran in the Middle East	10 %	20 %
Share of Middle East in the World	3 %	5.8 %

Middle East : Iran, Saudi Arabia, Bahrain, Kuwait, U.A.E., Yemen, Jordan, Syria, Lebanon, Iraq.

Major products: Ammonia, Aromatics, Monoolefins, Methanol, Plastics, Synthetic Rubbers, Synthetic Fibres.

* *An overview of Petrochemical Industry in I.R. of Iran UNIDO Consultation on Downstream Petrochemical Industry, Tehran 7-11.XI.1993.*

The estimated growth rate of the petrochemical production, up to the year 2000, is quite substantial, equivalent to an average annual growth rate of 16%, seven per cent more than the regional average.

Availability of rich resources of crude oil and associate gases as well as potential domestic demand are incentives for the development of petrochemical industry in Iran.

There are obviously some constraints, among which:

a. - Capital constraints

b. - Technological barriers

c. - Human resources

d. - International market

e. - International constraints

a. Capital constraints

Development of Petrochemicals Industry required substantial amounts of investments, both in local currency and foreign currency. To have an idea about the huge necessary efforts, some figures on few petrochemical units should be mentioned just for orientation:

- Steam cracking unit (olefins production) Ethylene	- 400.000 t/y	700 millionsUS $
- HDPE/LLDPE unit	- 200.000 t/y	350 millions US $
- Polypropylene unit	- 100.000 t/y	200 millions US $
- S.B.R. unit	- 100.000 t/y	250 millions US $
- Methanol unit	- 800.000 t/y	800 millions US $
- M.T.B.E. unit	- 600.000 t/y	200 millions US $

In spite of the economic consequences of the imposed war of eight years with Iraq (1980-1988) and due to the prices on the international market, Petrochemical Industry, as a priority sector, has received considerable attention to the extent of seven billion dollars foreign exchange requirement for on-going projects, and another four billion dollars has been supplied internally and N.P.C. has been given the authorization to provide the balance from International Sources of Funds, through finance at by-back schemes.

b. Technological barriers.

In the petrochemical field there occured the most dynamic improvement of the existing processes and the discovery of the new catalysts and technolgies, usually concentrated in most industrialized countries, and experience shows that usually some technologies are not easily supplied. Technologies like: short residence time furnaces for steam cracking unit, fluid bed catalytic system for the production of LDPE, LLDPE and HDPE, mass polymerisation of styrene to produce polystyrene high capacity reactor for polymerisation of V.C.M., butyl rubber, polybutadiene, composite materials, are only a few examples in the field. But the most important barriers can be to neglect the domestic research and development activities, so that the preoccupation of the Ministry of Industry to establish a "Master plan for the development of national research institutions and their contribution to the development of the industry" has full justification.

Establishing and development of the centers for research, development and engineering activities for processes elaboration, projects preparation, appraisal, engineering and construction would facilitate the process of technology transfer (domestic or/and external) from the research activity to the commercial stage.

c. Human resources

Specialized and competent human resources are required for the development of a modern petrochemistry, both for projects implementation and for operation and maintenance of technological units. The human resources in Iran, with relatively well developed institutions of higher

education and technical training centers, can be accomplished in medium term planning stages.

Tradition of acquiring degree and/or post.gr fellowships.

d. International market

The strategies of development of the petrochemical industry are based on import substitution and export orientation. It is obvious that to supply on to the internal market should be the first priority in development of the petrochemical industry, in countries such as Iran with an already established internal market for petrochemicals.

In Iran, due to highly developed down-stream petrochemicals industries for plastics processing such as P.E., P.V.C., P.S., the import substitution policies have been applied so far for planning the new capacities.

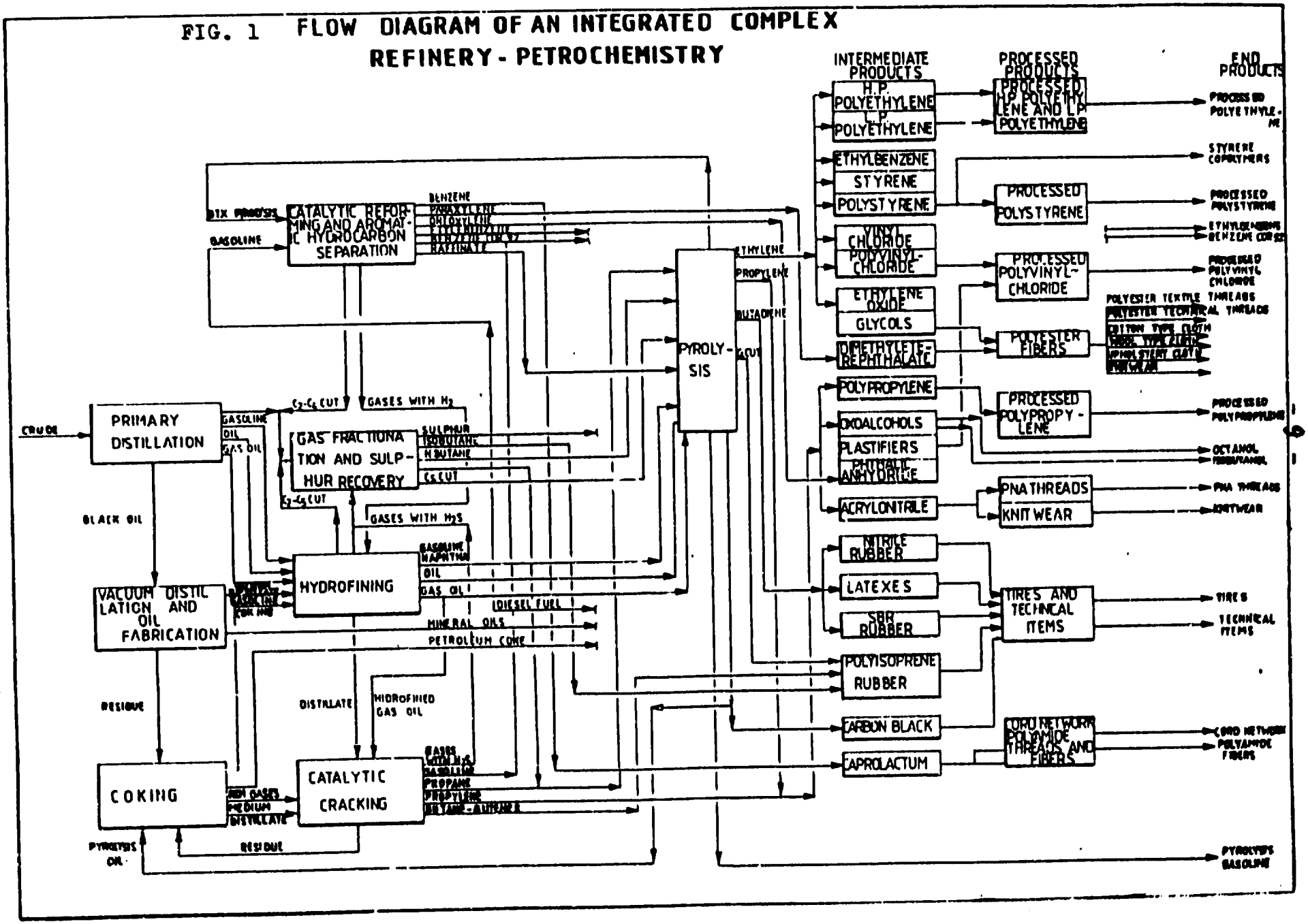
For future petrochemical projects for export orientation and penetration to the international market there has to be done systematic marketing studies for the regional countries like Pakistan, Iraq, India, China and also Western European countries and Japan.

Penetration into the international market, obviously would require extensive logistic investment as well as development of information systems, marketing network and highly specialized manpower.

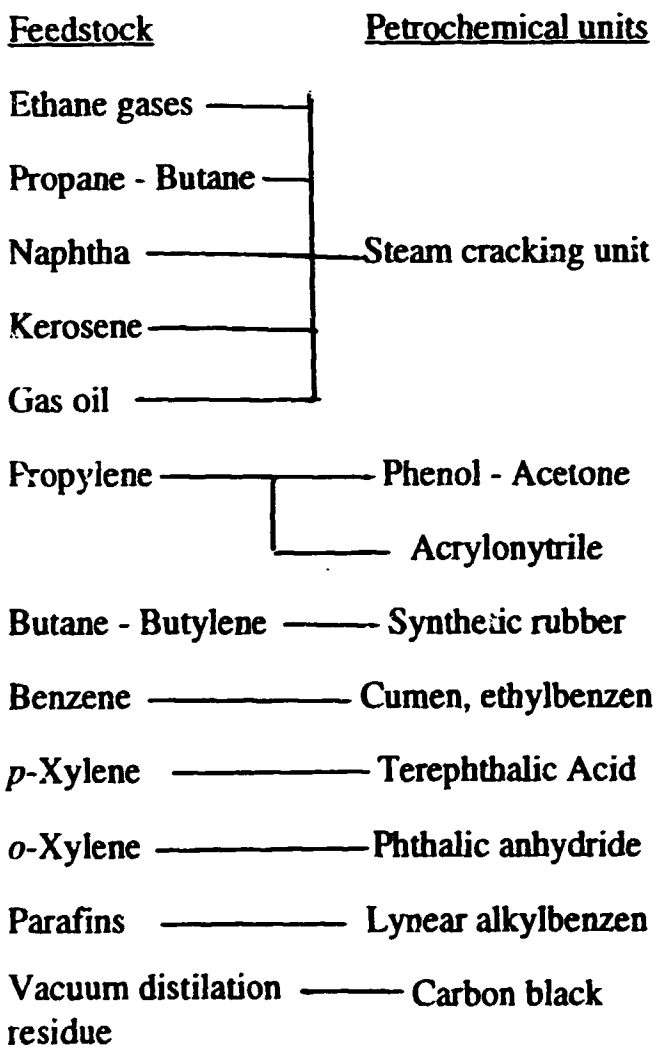
3.3. Interface between crude oil processing and petrochemistry.

Between efinery and petrochemistry there are a lot of products exchanges, in the field of raw materials for petrochemistry and feed back from petrochemistry to refineries, as shown in fig. 1.

FIG. 1 FLOW DIAGRAM OF AN INTEGRATED COMPLEX REFINERY - PETROCHEMISTRY



The main products which come as petroleum feedstock from refinery to petrochemistry are:



So that there are many reasons to pay attention to those methods, procedures or technical improvements to select the raw materials for petrochemistry corresponding to specific quality standards or norms.

The bigger thek factor Nelson (the complexity of the refineries as equivalent capacity in catalytic cracking) - the better the quality of the feedstocks allocated to the petrochemistry.

There are also many products which have to be returned to refinery for better use like: C_4 fractions, aromatics fractions and residue from steam cracking units.

From the logistic, qualitative, financial and environmental protection, the solution offered by the integrated refinery - petochemistruy complexes could be a modern concept for the newly planned development of the petrochemistry in Iran.

Normally, the use of the hydrocarbons potential is related to the proportion of the crude oil fractions allocated to the petrochemistry, and the net profit.

Table 2 shows the products obtained from 1.000.000 tons heavy crude oil processed in the standard refinery for carburants production from heavy Iranian crude oil.

The main refinery products are: Mogas - cargasoline (16.5%), gas oil (29.79%), black-oil (25.51%), internal heating fuel (6%) and a lot of the other components go to the petrochemistry, between 4-8%, depending on the complexity of the refinery and also of the petrochemical units.

Table 2.

Products obtained from 1.000.000 tons crude oil processed in refineries

		t/1.000.000	t %
1.	Ethane gases	314.7	0.03
2.	Propane	7,102.9	0.71
3.	Propylene	5,885.3	0.58
4.	n-Butane	6,226.3	0.62
5.	i-Butane	3,026.5	0.30
6.	Butene	6,388.2	0.63
7.	Blue-gas	7,155.9	0.71
8.	Benzene	4,255.9	0.42
9.	Toluene	8,679.4	0.86
10.	Ethylbenzene	1,191.2	0.11
11.	Orthoxylene	2,005.9	0.20
12.	Paraxylene	3,764.7	0.37
13.	Nahpthol	66,091.2	6.60
14.	n-Hexane	235.3	0.02
15.	Extraction gasoline	794.1	0.07
16.	Car gasoline	162,558.8	16.25
17.	Reactor oil	6,500.0	0.65
18.	Total oil, of which petrochemical processing w.s. solvent	18,352.9 3,161.8 1,058.8	1.83 0.31 0.10
19.	Total gas oil, of which for chemical processing	297,947.1 1,950.0	29.79 0.19
20.	n-Paraffines for L.A.B.	473.5	0.04
21.	n-Paraffines for bioproteins	2,400.0	0.24

		t/1,000.000	t %
22.	Total paraffines, of which for chemical processing	9,235.0 617.6	0.92 0.06
23.	Oil	18,617.6	1.86
24.	Greases	461.6	0.04
25.	Vaseline	82.4	0.008
26.	Aromatic extract	3,994.1	0.39
27.	Bituminous earth	16,629.4	1.66
28.	Black oil	265,170.6	25.51
29.	Electrodes coke	4,705.9	0.47
30.	Acicular coke	947.1	0.09
31.	Sulphur coke	5,882.4	0.58
32.	Petroleum sulphur	1,805.9	0.18
	Total	**938,882**	**94**

Note: Grude having 82,2% C; 12,8% H; 2% S; 1% N; 2% O. The balance representing coke procedures on catalyst and refinery phases.

3.4. Synthetic rubber production

The most important raw material to produce synthetic rubbers are C_4 cut and C_5 cut, available both from the crude oil processing in refineries and from steam cracking units belonging to the petrochemical units. As in the next period, N.P.C. intends to develop a new type of synthetic rubbers, one can see in the attached fig. 2 C_4 cut utilization and in fig. 3, C_5 cut utilization, already realized in modern petrochemical complexes in Europe.

These two flow diagrams can be considered as a recommendation to be taken into account by N.P.C. and R + D homogeneous institutes for the development of an updated rubber industry in Iran.

Fig.2 C_4 FRACTION UTILIZATION

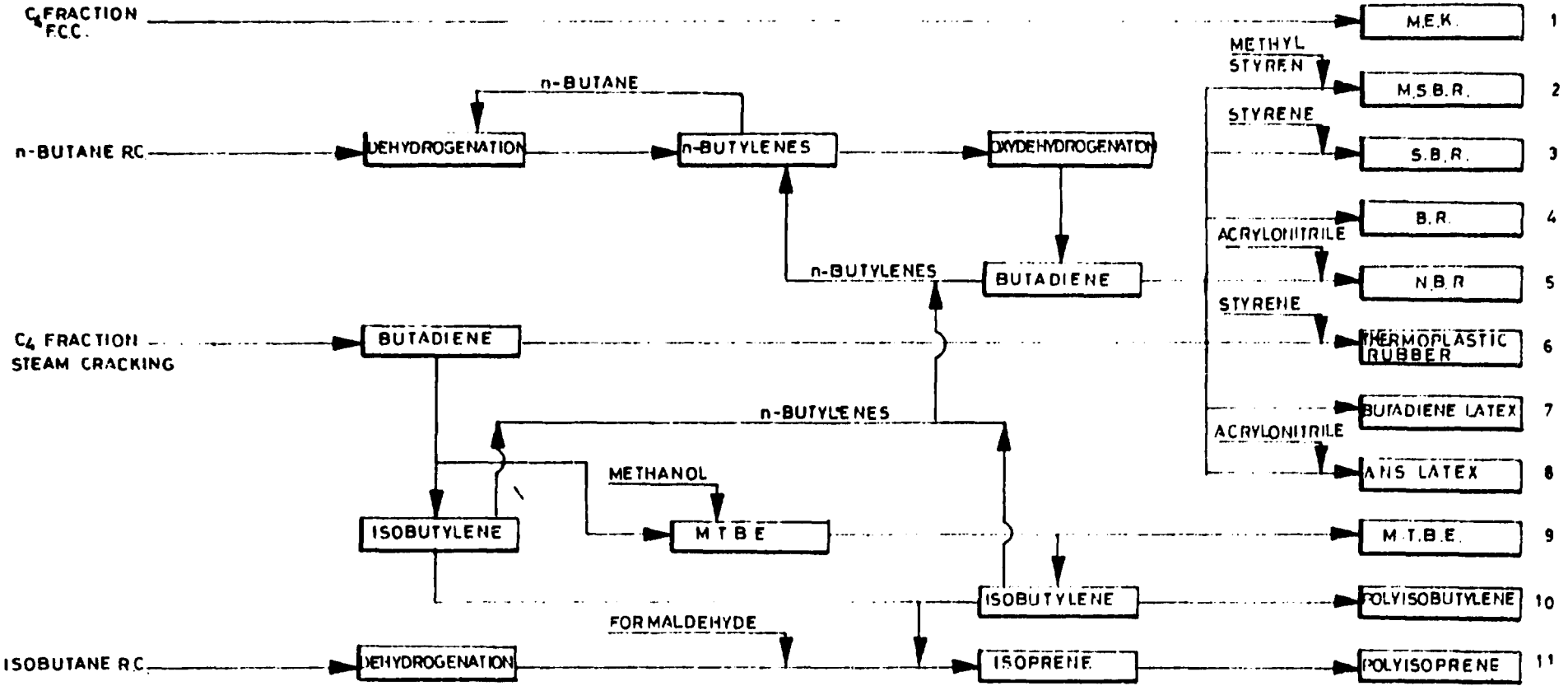
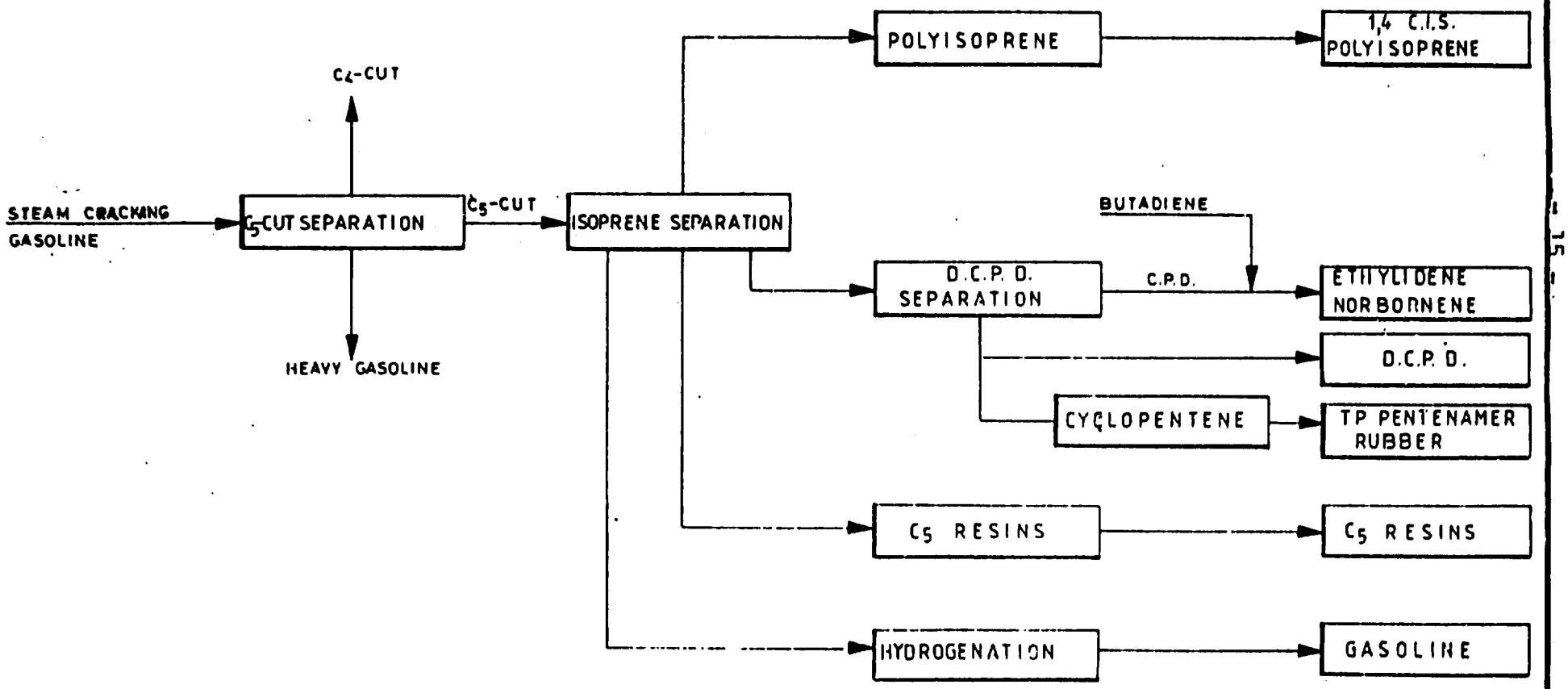


Fig.3 C5 FRACTION UTILIZATION



3.5. Tyres manufacturing

Because synthetic rubber belogs to the basic petrochemical products already discussed under 3.4., above the tyre manufacturing units have to be analysed.

In Iran there are five units for the production of tyres, as follows:

		t/y
1.	Dena Tire Co.	32,000
2.	Iran Tire Manufacturing	24,000
3.	Kian Tire Co.	20,500
4.	Pars Tire Co.	18,000
5.	Barez Tire Co.	14,000
	Total production	**118,500**

One of the most representative units (see Annex 6.3.) visited are Iran Tire Manufacturing Co., because of the tradition in the field and the accumulated experience.

For the tire industry, all raw materials are now imported, like: S.B.R., P.B., N.R., B.R. except the reinforced filler - carbon black which is provided by AHVAZ CARBON BLACK Co from Iran.

The reinforced cord, Nylon 6, is imported from Turkey and good progress is now being made by research to replace Nylon 6 with polyester cord fibres and with metallic cord.

The main products of the tire manufacturing companies are: passenger tire, light truck tire, heavy truck tire, bus/track tire, tube, flap and other type of tires.

The main preoccupations of the sector are to increase the quality of the tires, to extend the life from 55.000 km up to 80.000 km, developing new types of tires, cost reduction, penetration on the international market and environment protection.

3.6. Fertilizers

In 1964, by operation of small fertilizer complex, the Iranian fertilizers industry was born.

Within N.P.C., there are two fertilizers complexes in operation: Shiraz and Razi, and there is another unit in Khorassan, under construction.

The total capacities installed for fertilizers are as follows (see Annex 6.1.):

	tons/year
Ammonia	1,412.000
Ureea	1,763.000
Ammonium Nitrate	254,000
Sodium Tripolyphosphate	30,000
Sodium Carbonate	146,000
Sodium Bicarbonate	20,000
Diammonium Phosphate	470.000
Total	**4,095,000**

Fig. 4. shows the flow diagram for the more sophisticated fertilizers production, as it was already realized in the countries having tradition in the fertilizers production.

There is a lot of room during the next period for the petrochemical producers and the Ministry of Agriculture to analyse the opportunity to diversify the production of fertilizers, taking into account the nature of the soil and type of the main crops: wheat, barley, rice, maize, potatoes, a.s.o.

3.7. Organic Chemical Synthesis

In Bandar Imam Petrochemical Complex, there is a production of caustic soda, chlorine, benzene, xylenes, hydrochloric acid, and in Shiraz Petrochemical Complex, methanol.

The program of development of petrochemical industry in the second five years: 1994-1998 includes new units for organic chemical synthesis.

Fig. 5, 6, 7, 8 give the flow diagrams for more sophisticated chemical synthesis, as it was already realized in the countries having tradition in the field.

Fig.4. FLOW DIAGRAM FOR CHEMICAL FERTILIZERS PRODUCTION

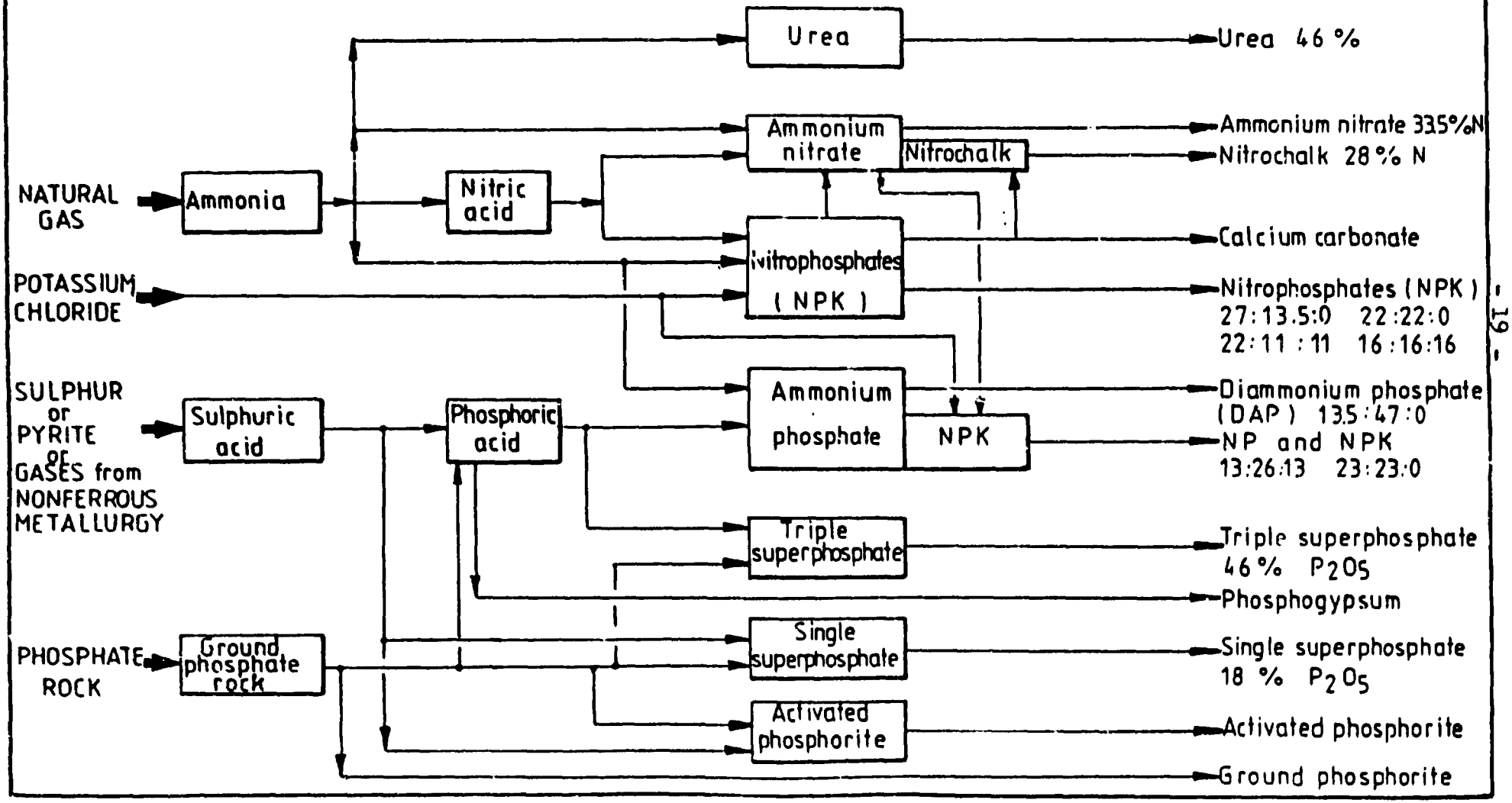


Fig. 5. CHLORINATED PRODUCTS

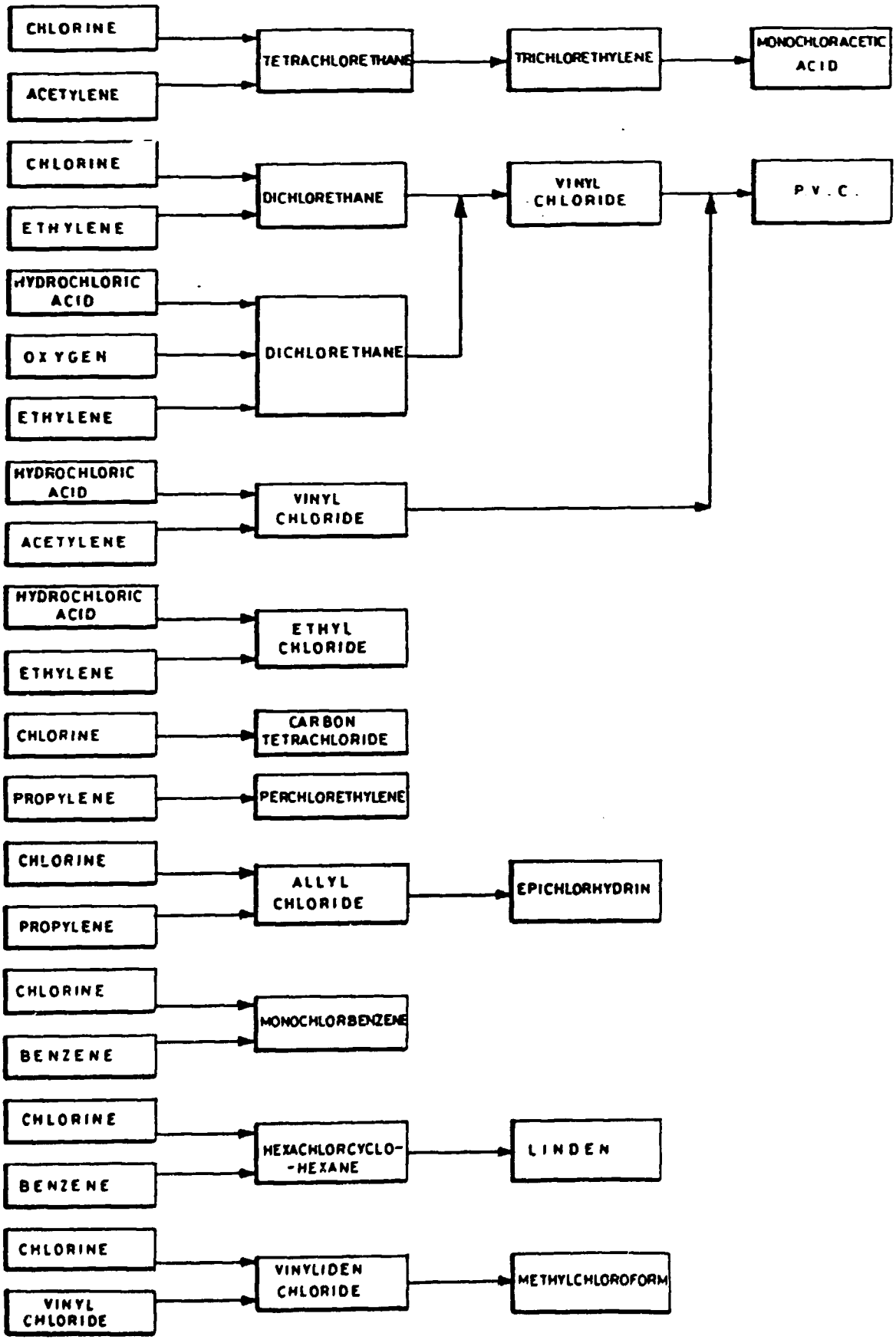


Fig. 6. DETERGENTS AND INTERMEDIARY SYNTHESES

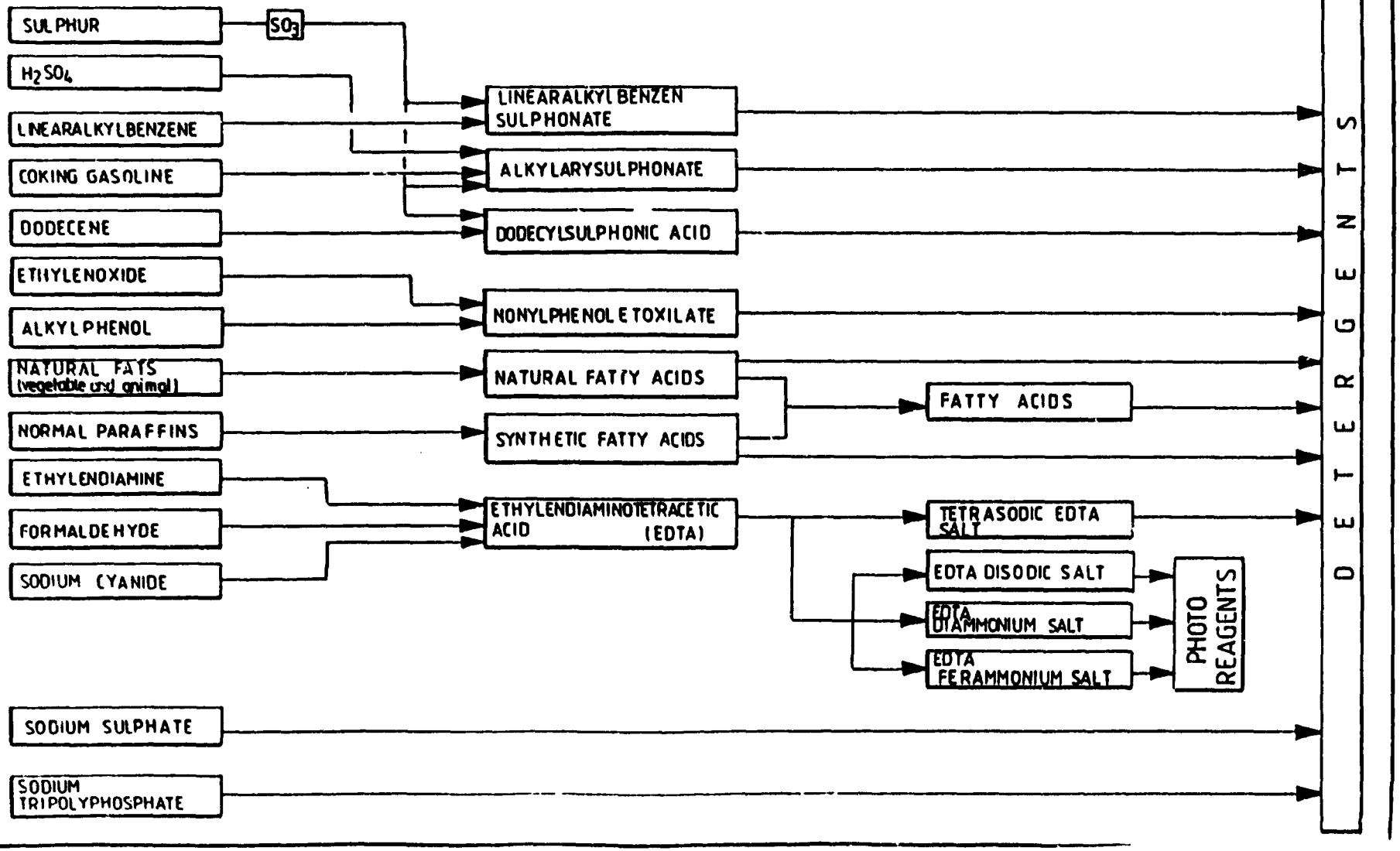


Fig. 7. PLASTIFIERS SYNTHESIS

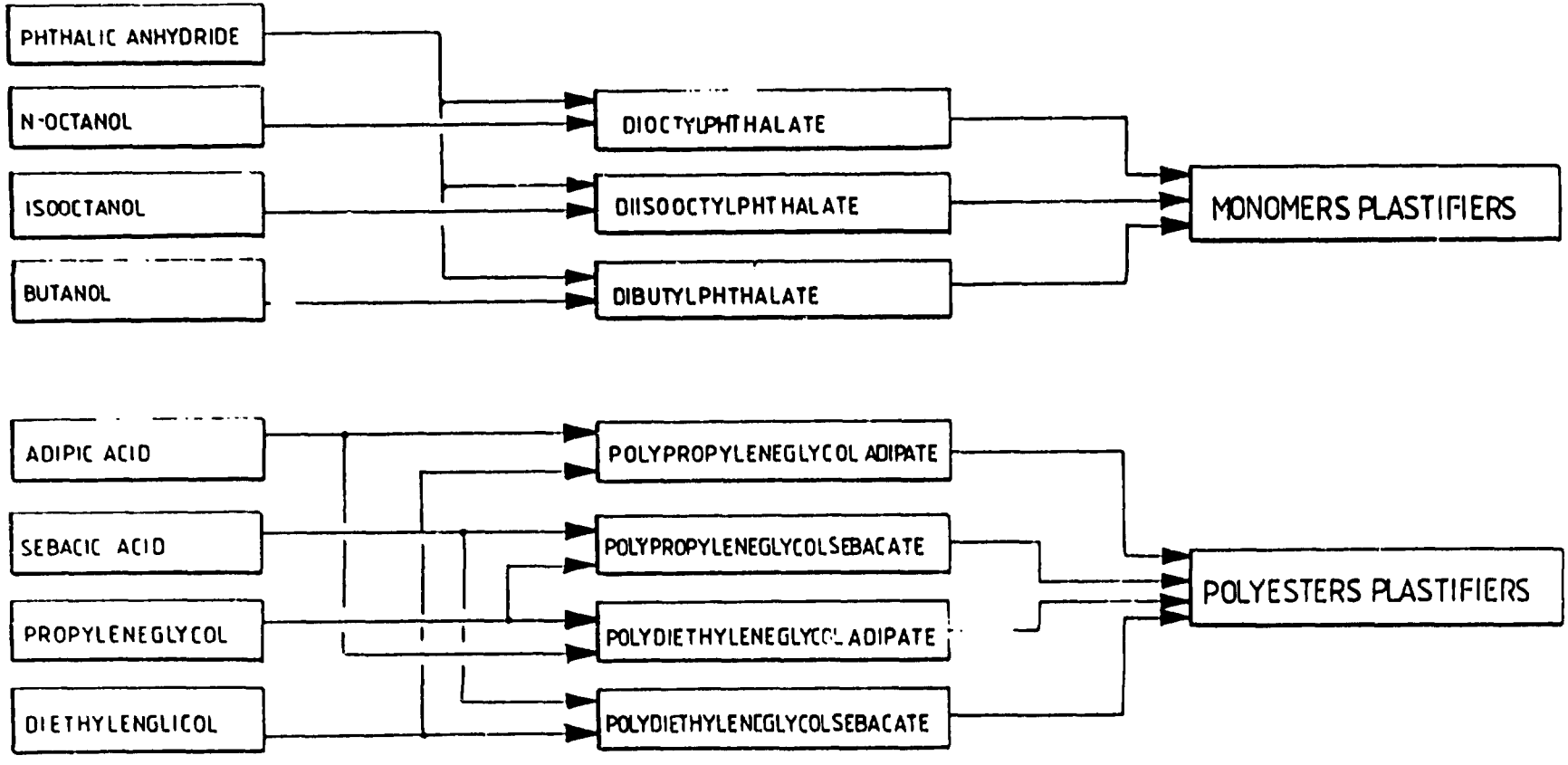
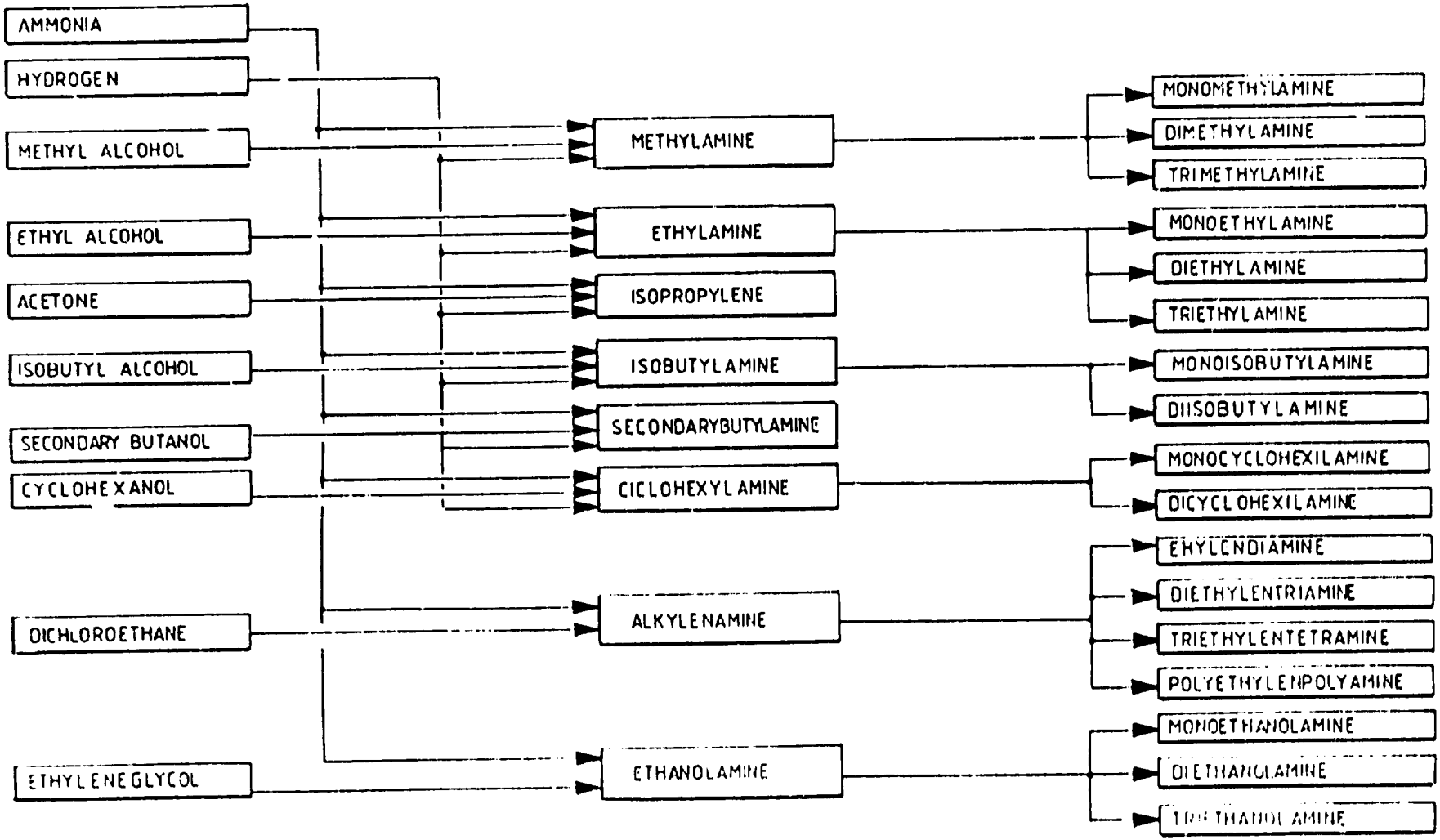


Fig. 8. AMINE SYNTHESES



3.8. Electrical energy supply

Electric Power Research Center, a subsidiary company of the Ministry of Energy, is actively engaged in applied research activities needed by electric power industry.

It is obvious the strong connection between energy supplying department and petrochemical units, like a major consumer of electricity.

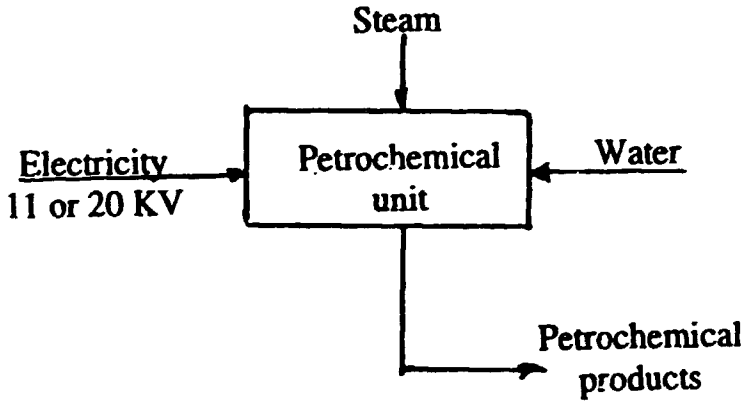
The electrical energy network lines distributions in Iran are as follows:

a. Transmission lines at 230 and 400 KV

b. Sub-transmission lines at 63 and 132 KV

c. Distribution stations at 11 and 20 KV

If we consider a petrochemical unit as abox consumer, we have:



This means that Ministry of Energy has to supply to the petrochemical units only electricity, as a second source, and petrochemical units must take care of themselves to produce different parameters of preassure steam, water and electricity from their own sources.

The new conception in this field is to make simultaneous co-generation of electricity and steam, and such a system has to be

analized if it is also opportune in the case of Iran, for the near petrochemistry developments.

3.9. Environment protection

The Center for Coordination of Environmental Studies was founded in 1973, following the United Nation's Conference on Human Settlement which was held in Stockholm. Its views and objectives were:

a. The protection and restoration of the man-made natural environment.
b. To promote research on environmental issues.
c. To increase public awareness and enhance the general knowledge of the people in the society.
d. The protection and restoration of cultural and ecological heritage.

During the last ten years, the center has gained some valuable experience and made achievements in the environmental field. The luck of an adequate number of experts in the field, as well as the growing need for their services, forced the center to reconsider its goals and objectives.

Consequently, the general policy of the center was revised and educational activities at postgraduate levels were added to the previous goals.

So that in March 1989 the name of the center was changed to "Institute for Environmental Studies", belonging to the University of Tehran.

Thus, there are regulations on plant pollution control such as:

- Air pollution standards;
- Water pollution standards;
- Earth pollution standards.

Annex 7 gives plant pollution regulations received from Arak Petrochemical Complex. The standard has to be revised, because the allowed concentrations of some pollutants like: sulphur dioxide, carbon monoxide and particles, are not in the range of international standards.

4. RESEARCH AND DEVELOPMENT ACTIVITIES

4.1. General remarks.

As there is a lot of opinions regarding the objectives of the research and development activites, it would be better to try to explain, from the very beginning, the real ways and aims of such activities.

The real aim of the research activities is:

a. - Elaboration of new product s;

b. - Improvement of the qualities of the products to be on line with the international standards and norms;

c. - Development of the new technological processes in accordance with the real necessity of the country in the given socio-economic conditions;

d. - Up-dating of the existing technologies in the fields of crude oil processing, petrochemistry, chemistry, down-stream, petrochemical products or in any other field of related industrial activities;

e. - Elaboration of the technological analyses of the existing plants, solving bottlenecks of some area of the units, to reach the design capacity of the plants;

f. - Energy saving analyses by using: thermodynamic methods, heat

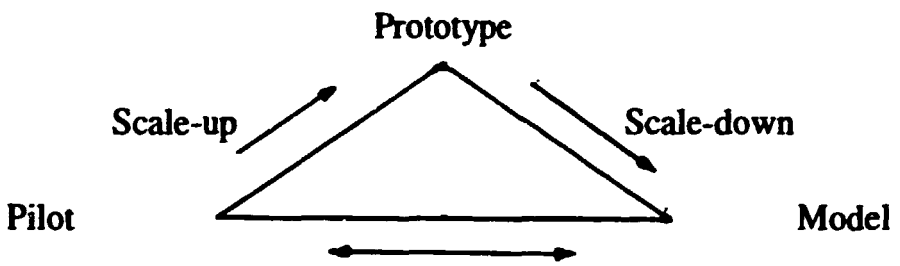
ballances, heat-pump technology, a.s.o.;

g. - Risk assessement and environmental protection studies;

h. - Experimental determination of physical and chemical properties of the gases, liquids and solid components to improve existing Data Bank through their own research or from the literature.

Research has to be performed to a minimum pilot scale (capacity of production) to permit later-on confident exploration of the experimental data for the engineering companies, to the industrial scale (prototype).

Usually, the relationship between the pilot, model and prototype (commercial plant) recommends a scale-up ratio 1 : 20 + 25.



In this respect, pilot experimentation cannot be avoided if there are not similar industrial units. All necessary data to design a realiable industrial unit have to be collected from the pilot experiments.

If some few data are missing, a model to a small scale has to be realized in order to obtain such data.

Minimum experimental data for a reliable extrapolation to the industrial unit are as follows:

- Flow diagram of the process;

- Flow shets of the process;
    - Conversion, selectivities and yields for each reaction step or phase of the processes;
    - Overall material balance and for each main equipment;
    - Overall heat balance and for each main equipment;
    - Raw materials qualities and specific consumptions;
    - Auxiliary materials qualities and specific consumptions;
    - Main utilities and energies qualities and specific consumptions (water, steam, electricity, fuel oil);
    - Sizes of the main equipment;
    - Process and instrument flow diagram (P + I), including: temperature, pressure, residence time, a.s.o.;
    - Process description based on P + I flow-sheets;
    - End-products qualities and quantities;
    - By-products qualities and quantities;
    - Recommendations on corrosion protection of the equipment;
    - Residual effluents: gases, liquid and solid wastes;
    - Environment protection;
    - Operation manual for: start-up, normal operation, emergency shut-down, normal shut-down;
    - Patents, licences, a.s.o.

Good results can be obtained in case the terms of references for the new technological unit have been discussed between production people, research and engineering development.

To speed-up the transfer of the technologies from the research stage into the commercial scale, the following have to be taken into

account:

Research have to be involved in the elaboration of the indigenous technolgies, but also for the implementation of the imported technologies.

In the case of imported technologies, which is now the main case for Iran, the research people can be involved by the petrochemical units in a lot of activities, such as:

- elaboration of terms of reference, tenders specifications or simple inquiries for offers;
- selection of the technologies based on the offers received (see fig. 9 based on expert experience);
- technical assistance to the petrochemical units in the contracting period;
- elaboration of the detailed engineering documentations based on the know-how received from licencers;
- technical assitance for the implementation of the new technologies on site, start-up and follow-up after the start-up to reach the design capacity.

In the case of domestic technologies, in addition to those mentioned above research centers have to elaborate: new technologies or up-dating existing technologies, based on terms of reference made in close cooperation with the petrochemical units.

4.2. Industrial research institutions overlook

In the Islamic Republic of Iran a chain of research centers belonging to different categories has been established:

1. - Research and development companies and engineering services of

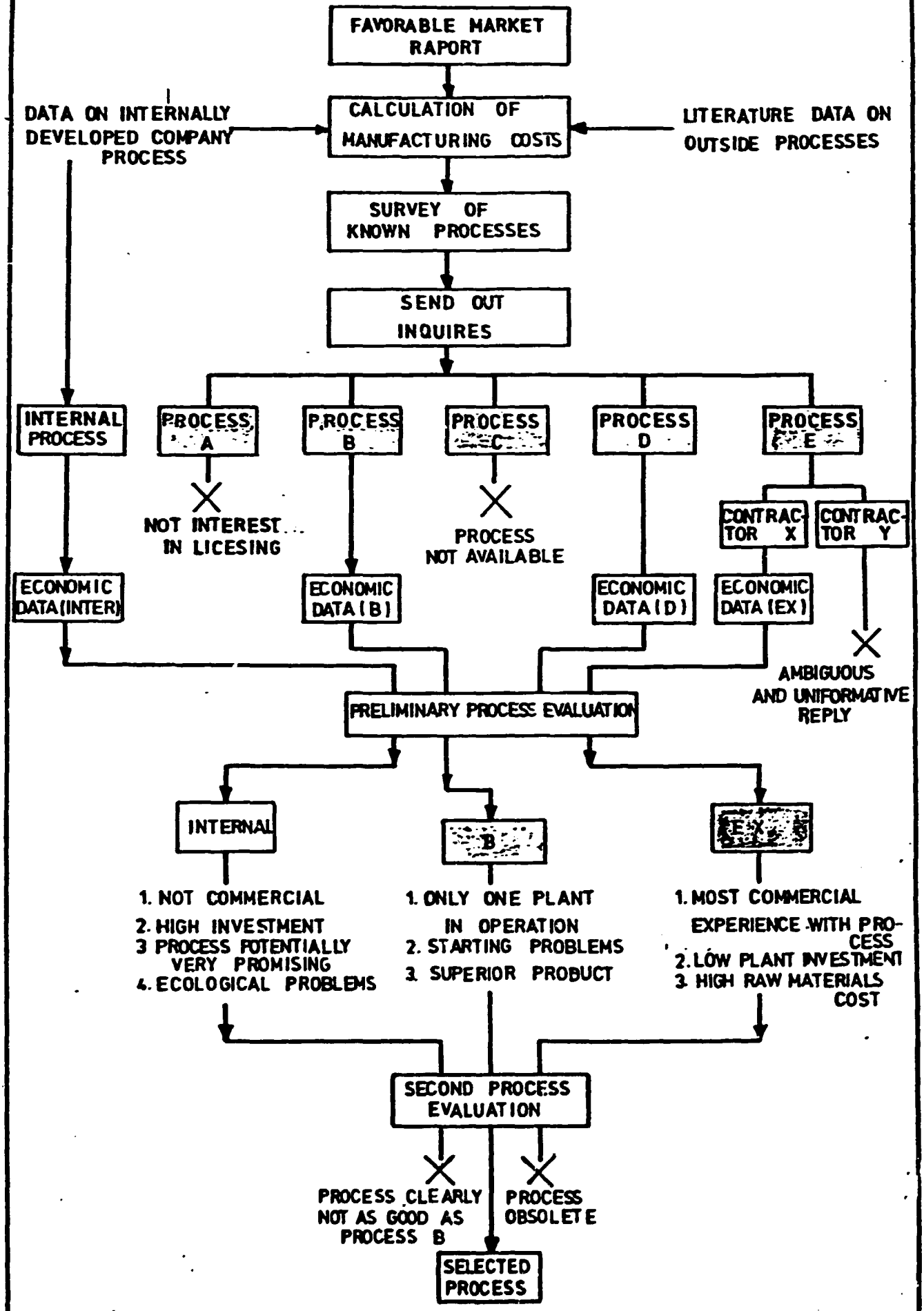


FIG. 9 TYPICAL STEPS IN EVALUATING COMPETITIVE LICENSED PROCESSES

homogeneous industries. There are 15 homogeneous research Institutes (see Annex 9) of the homogeneous industries which have been established with the investment of relevant factories;

2. - Research and development units in the factories;

3. - Non-governmental Industrial Research Centers, in private sector. Research and development companies in private sector in the field of petrochemistry can be seen in Annex 8.

There are 64 non-governmental-engineering-research centers which have the licence from Ministry of Industries to offer engineering and research services.

The expert, during his mission, has visited counterpart governmental, research and development companies and engineering services of hemogeneous petrochemical industry, research and development units in petrochemical factories and research and development companies in private sector.

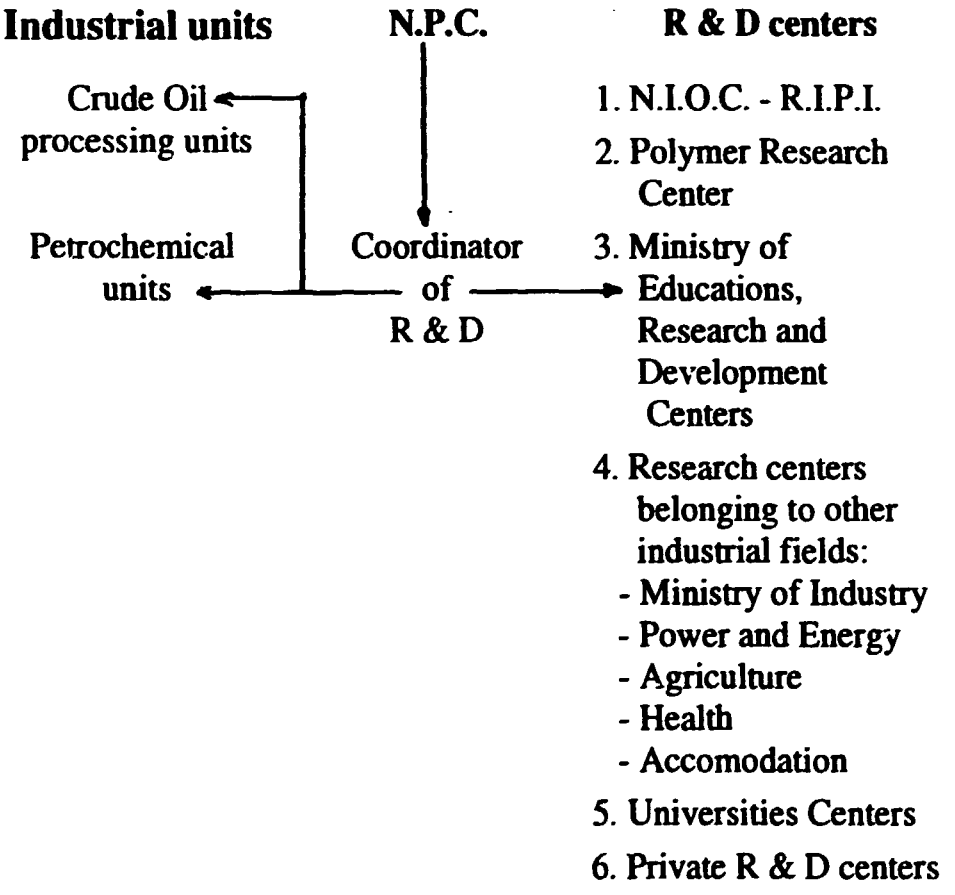
During his mission, the expert also visited the production sector of the petrochemical units.

The list of visited centers is given in Annex 4; after visiting each unit of the plant, a brief summary was made (see Annex 6).

In each visited center or petrochemical unit, the expert experienced kindness and hospitality. The discussions which were provided with the staff of the units were fruitful. The remarks, ideas and some recommendations given are described in Annex 6.1.

National Petrochemical Company has a Service-Coordinator of research, development and engineering activities belonging to the Department of Operation, as shown in Annex 6.1.

The network connections between coordinator R + D, petrochemical units and research and development centers, can be seen below:



N.P.C. has also connections with two foreign institutes: Indian Petroleum Company Ltd and Brazilian Process and Engineering Consult Company.

Coordinator group has to take care of all connections between petrochemical units and research and development centers of homogeneous industries, factories or non-governmental centers.

Annex 6.1. gives the working procedures of this coordinator group,

from the preliminary analyses up to the implementation of the projects.

The main objectives of the coordinator group of R + D activities are as follows:

1. Existing processes improving;

2. Prevent mechanical failures and corrosions;

3. Energy saving;

4. Environment protection.

Much more attention was paid to the improvements of the existing petrochemical processes compared with the elaboration of the new technological processes, based on domestic research activities, as there are some difficulties in the cooperation with the domestic research centers, such as:

- Technological processes provided by the Iranian research institutes are more academic but do not contain all necessary elements required by the engineering companies to scale-up from the pilot plant to the industrial unit;

- Some fundamental data necessary for the correct evaluation of processes (selectivity of chemical reactions, specific consumptions, economic evaluation, a.s.o.) are missing;

- Research centers do not show enough flexibility to answer the real problems which confront petrochemical units.

In conclusion, the lack of confidence in the capabilities of the domestic research centers to solve the major problems of the petrochemical production has led to the present situation: factories are oriented to import the petrochemical technology, even small industrial improvement.

Between the 15 hemogeneous research institutes, state-owned,

there are three centers active for the petrochemistry, such as: N.I.O.C. - R.I.P.I., Polymer Technology and Chemistry and Chemical Engineering Center.

By far the most important for the Iranian petrochemistry development is the Research Institute for Petroleum Industry which belongs to the National Iranian Oil Company.

As it can be seen in the Annex 6.2., there are five main fields in which this institute is active.

Its main fields of activity are as follows:

- drilling oil;
- refinery and petrochemistry;
- polymers;
- environment protection;
- engineering and development.

The scientific and technical staff has a lot of experience in the field they are working. The research laboratories are medium level equipped with scientific and research apparata and technical information.

Already developed technologies and new projects for the future expansion of the petrochemistry are illustrated by Annex 6.2.

To speed-up the transfer of the new technologies to the petrochemical units, there are some coercions like:

- procurement of the new testing equipment in the fields: exploring hydrocarbons reserves, testing the performace of the catalysts, synthesis and applications of polymers, additives, inhibitors and environment protection, estimated costs in the range of 4 millions UD dollars;

- by the other hand, there are complaints about inefficient utilization of the existing facilities for research and testing due to the bad understanding of the staff;
- selection of the emplyees has to be improved (existing staff: 800 emplyees of which 400 are graduated);
- there are no incentives for the skilled staff because the salaries are not directly related to the scientific results;
- there is no competition to find out orders from the petrochemical units, because the salaries and all expences for the research institutes are supported from the state budget;
- there are no more incentives in the fields of patent rights for the staffworking in research and development centers.

In the tire manufacturing field there is a lot of preoccupation for the improvement of the existing technologies, such as:

- extension of the active life of the tires, from 55.000 km up to 80.000 km, by improving the qualities of the tires, like: abrasion resistence, heat building-up capacity, stretch resistence and sheet separations;
- development of a new compound for the side wall of the tires;
- new technology for the tubless tires;
- development of a new type of tire, steel belts 145/13 for the industrual users.

The research activities in the rubber field: synthesis and tire production has to be much more connected in the future, after the assimilation in production of the synthetic rubber in Iran, in the near future.

Besides, there is a lot of common testing methods and laboratory equipment used in both production, synthetic rubber and tire manufacturing.

In the research field there are some constraints which have to be eliminated in the near future:

1. Training of the Iranian engineers and technicians to improve their knowledge in the rubber and tires rubber production;
2. Tire testing facilities are very expensive, such as: high speed analyses for which in Iran does not exist experience to order such new instruments.

For the training of the engineers and technicians there are two possibilities:

- to bring, through UNIDO undertake, two or three skilled experts to make the training in Iran of the selected personnel for the optimisation of the compounds for the new receptures,

or

- to send two or three specialists from Iran to be trained in the proper units in foreign countries.

4.3. Private research and development units.

The policies of the Ministry of Industry for the advancement of the targets of the first economic, social and cultural plan to lay the foundation for industrial research system and dissimination of the research in the private sector, could be also beneficial to strengthening the relations between the researchers and the industrialists in solving their problems and thus leading to self-sufficiency.

Taking into consideration the global experience and reviewing

industrial research activities in order to organise industrial research system, it is essential to establish a chain of research units and to take advantage of the expertise and the finances of the non-governmental sector.

The Society of Centers for Scientific and Industrial Research in Iran, follows-up its activities with 150 members in the following fields:

- Crude oil processing;
- Petrochemical industry;
- Pharmaceutical field;
- Pollution control;
- Electric and electronics;
- Metal industries;
- Medical engineering, and
- Miscellaneous related industries.

5. RECOMMENDATIONS

The suggestions given below, classified into:

- General recommendations and
- Sectorial recommendations,

are the result of investigations and findings derived from visits organized and selected on the basis of national priorities by the Iranian counterpart and also based on the world wide practice in the field of petrochemistry.

The "General Recommendations" are supposed to be valid for the

whole crude oil processing, petrochemistry and chemistry, while the "Sectorial Recommendations" are related to the different sectors of the petrochemical production.

5.1. General recommendations.

5.1.1. Subsidies.

Petrochemical production is supported/subsidized only in some developing countries which have their big crude oil and gases resources, and Iran is not an exemption.

In all other developed countries, as well in the excommunist East European countries, petrochemical production is no more subsidized.

To reach the internartional level of quality and to penetrate into the international market, a revision of the policy and the system of subsidies is recommended for Iranian petrochemical production.

Prices kept at low level can be an obstacle for future development, in many respects:

- no incentives for the petrochemical process to reduce specific consumptions of raw materials and energy, by-products and waste materials;

- no incentives for producers to improve the quality and no real basis for competition or market functions.

The above consideration are based on the invididual expert experience in the case of petroleum industry, the owneraship of the exploitation and production is a highly sophisticated social-political question and needs consideration, exceeding the aims of the present

mission.

5.1.2. Privatization.

The beneficial effects of the privatization are proven all over the world and can be noticed even during a short stay in Iran.

However, some constraints - due to the transformation of the social/political system and even more to the recent period of war - are still in force in Iran.

But taking into consideration the big investments required, considerably risk of production and environment protection, a careful but deliberate continuation of the privatization movement is recommended.

In accordance with the newly realized policy of privatization of the industry in Iran, N.P.C. has already issued several licences to private sector (Annex 6.1).

However, the opportunity of the following petrochemical units to be transfered to the private sector for implementation has to be analysed due to the high risk of the production and/or complexity of the technological processes: Acrylonitryle, Polypropylene, Caprolactam and Butyl rubber.

The privatization of such petrochemical units would be recommended in joint-venture companies with wellknown foreign licensors or suppliers.

5.1.3. Flow of Information.

The flow of information between R + D centers and petrochemical units is assured by the Coordinating Group belonging to N.P.C., as it is shown in the report. The Coordinating Group has a professional team of

engineers which take care to assure good connections between N.P.C., petrochemical units and R + D centers.

The places visited are suffering of limited access to printed publication, especially books and periodicals from abroad.

A separated budget in foreign currency for state-owned enterprises is proposed to be assigned at the disposal of users, in order to enhance up-dated information with priority to those industries and R + D institutions, which are oriented towards export activities. Estimated figures for such separate budget for petrochemical industry could be in the range of 100.000 - 160.000 US $/year.

5.1.4. Central Service unit for experimental equipments.

There is a need expressed by all visited units for regular maintenance, spare parts, specific laboratory equipment, construction and information on recent new applications in the petrochemical field.

A central unit interested to take care of any experimental instrumentation and cope with the demand of the users should be installed.

5.1.5. R + D integration in the industrial activities.

Some measures have to be taken in order to speed up the transfer of the technologies from the research to the commercial scale:

- collecting data about present capabilities of the existing research and development institutions and current research activities;
- future possibilities and needs of the research and development centers;
- find out information for the next five years for main sectors of the economy.

Information is power, and it is indispensable not only in the selection of the proper technology and of the right partner but also as a permanent tool for development programme.

For this purpose it is required:

- information on the market;

- information on the: technology, materials used or applied, quality of the products and their application, activities of the outside competitors;

- any research or development or changes that could indicate alternative products applications.

Basically all of the four important elements of the technology should be subjected to permanent development: process, equipment, product and the application of the product.

All those data can be performed by each sector of the economy, and based on these information have to decide if would be opportune to establish a Center for Technical Assistance or a Ministry of Research and Development for the whole economy of Iran.

A comparison between the existing organisation and the new proposal, fallows:

Existing Organisation

High Council
for
Research and Development

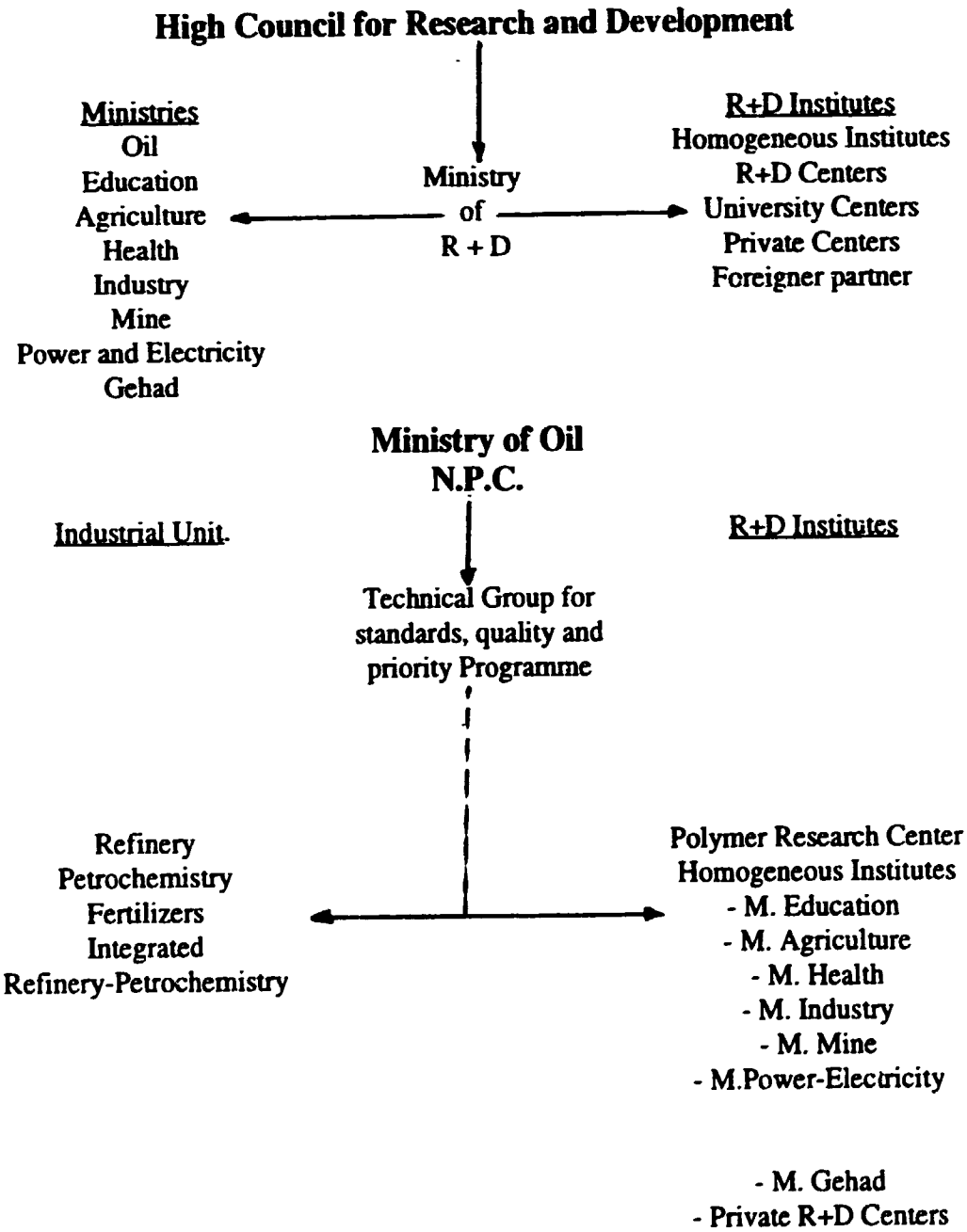
1	2	3	4	5
		Coordinator Committees		

M.O. M.E. M.A. M.H. M.I. M.P.E. .... M.G.

Ministry of Oil
N.P.C.

Industrial Units		R + D Institutes
Refinery		R.I.P.I.-N.I.O.C.
Petrochemistry		Polimer Research Center
	Coordinating Group	Homogeneous Institutes:
Fertilizers	← for →	- M. Education
	R+D activities	- M. Agriculture
		- M. Health
Chemistry		- M. Industry
		- M. Mine
		- M. Power-Electricity
Integrated Refinery-Petrochemistry		
		- M. Gehad
		- Private R+D Centers

New Proposal



New Proposal

Advantages:

1. Direct connection between R + D Institutes and industrial units.
2. New task for existing Coordinating Group:

   - Quality control supervision;
   - Standardisation of the products and Services;
   - Priority National Programme implementation.

3. Direct involving of the R + D Institutes to obatain orders.
4. Preliminary preparation step for the privatization of R + D activities.
5. Incentives fo the research people.
6. Improvement of the products qualities, standard and environment protection.

Constraints.

1. Double subordonation of the R + D Institutes: Ministry of Research and Development and other ministers.
2. Skilled personnel migration to the better paid sectors of the economy.

Fig. 10. gives the Ministry of Research and Development's organisation chart.

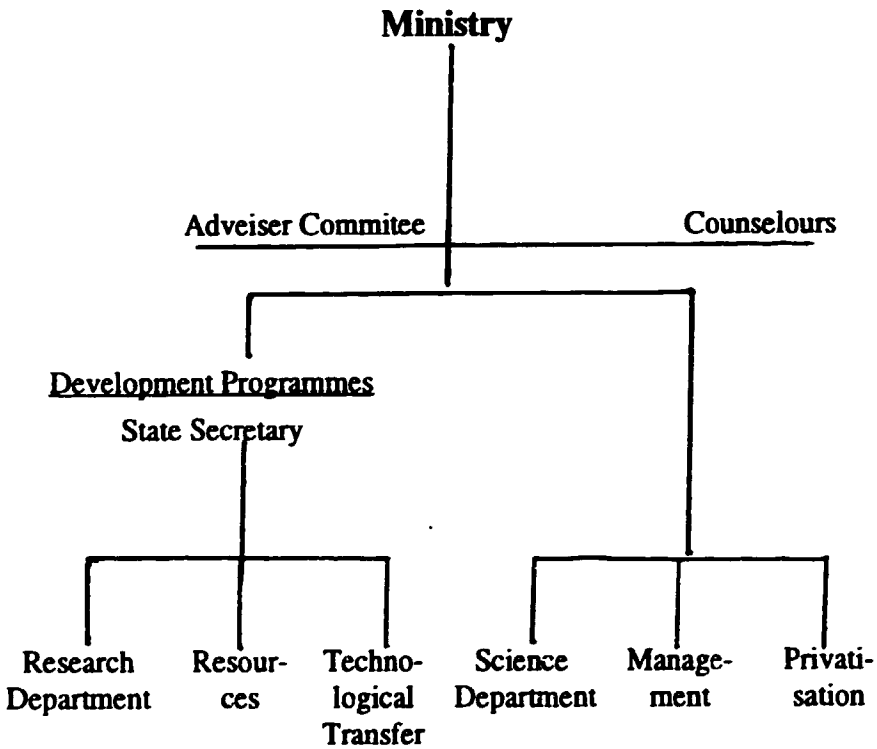


Fig. 10. Organization chart of the Ministry of Research and Development

5.2. Sectorial recommendations.

There are few R + D centers in Iran, active in the field of petrochemical industry, which could provide new products and know-how, thus contributing to the development of the Iranian petrochemistry.

After some field experience concerning the real needs of the petrochemical units, some practical recommendations were given during the visits at: Arak Petrochemical Complex, Iran Tire Manufacturing, National Petrochemical Company, research and development centers.

Steam cracking unit, from Arak Petochemical Complex, based on KTI technology is now confrounted with some difficulties in the area of cracking furnaces. To avoid premature cocking of the tubes discussions have to be carried with the licensor to accept some suggestions like: suphur components injection into the feed, modification of the steam/hydrocarbons ratio, heat thermal profile along the tubes have to be adjusted to the new conditions.

An outline of recommendations can be seen in the report, some of them being presented below:

a. Monomer productions.

1. Complete separation of the valuable components existing in C_4 cuts, as it is shown in Fig. 2. of the report.
2. Complete separation of the valuable components in C_5 cuts from the pyrolyses gasoline, as it is snwon in Fig. 3. of the report.
3. Utilization of the separated components as feedstock for the production of resins, new types of rubber, copolymers, etc. (see fig. 5, 6, 7, 8).

b. Solvents.

Assimilation into the domestic production for: n-hexane, n-pentane, n-octane, as solvents for existing and future development of the polymers production.

c. New Petrochemical products.

1. M.T.B.E. - methyl-tertiary-butyl-ether production, to improve the quality of the Mogas (motor gasoline) by replacing the lead.
2. Development of the new technologies to produce "composite materials" based on polymers and fillers for many purposes: cars components, items for planes, sportive items, building materials, a.s.o.

d. Fertilizers.

Better use of the domestic raw materials for the production of the N.P.K. fertilizers, as it is shown in Fig. 4. of the report, to assist agriculture's needs.

e. Tyre rubber production.

Assimilation into the domestic production of the new type of tyre based on metallic and polyesthers cord.

Assimilation into the production of the tubless type tire, in the near future period.

f. Auxilliary chemicals.

Assimilation into the production of the following chemicals: antioxidant, catalyst components, additives, a.s.o., already mentioned in the Annex 6.7.

g. Equipments.

For the existing petrochemical units, more than 85% of the total equipment was imported and paid in open market currency. To avoid the same situation in the next petrochemical development period, one has to analyse the opportunity to assimilate in the Iranian production of the static equipment such as: columns, heat exchanger, vessels, reboilers, pipes, control instruments, a.s.o., by the equipment manufacturing sector of Iran.

h. Emphasis on multipurpose pilot plant on multi-disciplinary R + D with some bias towards physics and biology, rather than pure chemistry. Proliferation of multiple and competing technologies, particularly for the manufacture of intermediates.

5.3. Recommended mechanism to link the research and development activities in the Iranian Industry.

1. Priority programmes at national level for the R + D activities in the fields of: crude oil processing, petrochemistry, down-stream petrochemistry and related industries, and corresponding budget for the programmes.

2. Encouragement of state-owned research and development institutes privatization not over night, but in due time to enter into the competitive market of the engineering services.

   Before the privatization of the Homogeneous Institutes, it is recommended to install "Private Incubators" inside of some units for specific field of activity as a first step for further privatization of the whole unit.

3. In the transition period one can grant subsidies to the R + D centers, taking as a basis 0.5% of the total turnover of the petrochemical industry or 8% of the net benefit.

   The following data are relevant to the question of financing research and development in a country with industrial tradition:

   Austria - supports from the public founds, about 50% of the necessary costs for R + D.

   Denmark - financial support of R + D from industrial sectors is achieved by co-financing up to 50% from funds requirement, the remainder being secured by financed companies.

   France - the state subsides 52% of the R + D cost.

   U.S.A. - in 1990, 145 billion US $ was alotted from public-funds, accounting for 49% of the funds necessary for R + D, of which 10% is meant for fundamental research.

- in order to back up R + D, a part from direct intervantion, the United States promote various financial mechanism, among which: tax reduction on R + D, by 25% for research cost, accelerated paying off and reduction of investment tax.

Italy - Italy promotes complex measures in order to get the economical development of the south closer to that of the industrialized North.

The research centers set up in the South can benefit of a nonreimbursable contribution of up to 50% for the purchase of equipment and loans under easy terms: 15 years plus a three times lower interest than the curently practiced one.

Spain - Integration of Spain into the Economic European Community raised several complex problems to the economy. The cost of R + D in 1993 accounted for 0.49% of the Gross Industrial Product, of which 80% is secured from public funds.

Romania - For the support of R + D, 1% shall be granted out of the industrial production value covering about 60% of the total necessary cost.

4. Dissimination of the small R + D centers in all petrochemical centers, doing applied research: new products, improvement quality, technical assistance, a.s.o.

The research and development efforts can be divided into four categories as defined below:

1. Basic research
2. Process know-how
3. Product know-how
4. Technical improvements.

Often, research which is applied to the equipment and other facilities or on product application or improvements after the technology has been deployed is called generically "Applied Research".

Basic research which has often been called pure or fundamental research, studies mainly the nature of chemicals, and their reactivity, the properties of elements, chemical processes and the hybrid compounds that can be induced. This research is usually carried out in universities and technical institutes or in specialized research laboratories.

Many companies do not consider it expedient to spend resources on pure research because of insecure or low returns on invested capital. However, recently, it has become evident that the technologies used are in many instances outmoded energy wasting, environmentally polluting and not sufficiently quality concious.

In fact, it has become a necessity, to create a R + D competitive edge in basic research to support other R + D functions.

Applied research, is a major R + D activity of chemical and petrochemical companies which concentrate their efforts on designing new and better processes with significantly lower costs

and improved quality of products.

A good exemple of this are British Petroleum and UNIPOL polyethylene and polypropylene processes based on fluidized-bed reactor technology.

In many end product applications, the process itself does not necessarily play the most important role, but competitiveness depends rather on factors such as product formulation and product system based on a particular technology or raw materials composition.

A good exemple of such a product system is the creation of "Composite materials", as a combination between polymers and fillers (organic or inorganic), resulting a new product with different properties and utilisations in the fields like: aeronautic industry, cars construction, building materials, sport items, a.s.o.

Technical improvements are widdy used in the process industries as routine tools to improve the process to make it safer, to control emissions, to reduce the costs, to improve catalyst systems, separation facilities, a.s.o.

The area of technical improvements can be considered as an important part of technology with immediate relevance to operating petrochemical complexes.

5. Up-dating the Patent and Brevet Law of Iran, in accordance with the international regulation in the field, to give some incentives to the research people.

6. In Iran there is the obligation for the students to spend each year a limited probation period to learn and accustomeded themselves with their future profession.

It is necessary to elaborate for students practical training programmes designed by the petrochemical units by cooperation with the heads of the engineering schools and the effective pursuit of the implementation of such programmes during the training period of the students.

According to practice, training programmes of petrochemical students should cover the following fields:

- maintenance and repair of dynamic and static equipment;
- operation and maintenance of instruments;
- supervision of processes according to operation manuals;
- systems to supply utilities, primary and secondary energy necessary for the good operation of petrochemical units;
- systems to prevent and fight fires;
- environmental protection;
- labour safety, quick solutions in case of emergency, poisoning etc;
- analytical methods for raw materials, products and intermediate products;
- up-to-date managing procedures, financial analysis, cash-flow, risk assessment;
- risk management in petrochemical units.

7. Facilities to set-up R + D centers for technical assistance to the customers of the petrochemical products, on site. not only in the research centers: equipment procurement, facilities, credits, taxes exempt, a.s.o.

5.4. Speed-up the transfer of technologies from the research to the commercial stage.

1. Installing powerful marketing, licence and patent services into the Homogeneous Research Institutes to find out the real necessities of the domestic and foreign market.

2. Homogeneous Institutes have to be a combination between powerful research and enginnering activities, not only research.

   In such case, R + D centers can offer complete package documentation: licence, know-how, basic-design and detailed engineering.

3. Promoting a powerful network of Business Centers to facilitate the market information between the producers and the buyers, research and development centers and industrial units, domestic and foreign partners.

4. Promoting a powerful network of Small and Medium-Size Development Centers - SMSDC - in the country, which have to act as consultancy centers for the privatization in the field of down-stream petrochemical products and related fields.

5.5. Present capabilities of R + D centers and new research fields recommended.

Present capabilities of the R + D institutions are acceptable such as N.I.O.C. - R.I.P.I. and in some fields, at the international level, such as: Polymer Research Center, Tire Rubber Manufacturing Center, Electric Power Research Center.

Recommended future researches:

1. Integrated petrochemical complex studies for the future development of the Iranian Petrochemistry and crude oil processing as it is now Arak Petrochemical Complex (see Annex 6.7).

2. New types of synthetic rubber assimilation: butyl rubber, isoprene rubber for domestic needs or export in the regional area. Such a task calls for a better use of C_4-cuts, C_5-cuts and other valuable components.

3. "Composite Materials" development, based on advanced research in the field, provided by Polymer Research Center, or other R + D centers, for many purposes: cars, plane, sport, coating, building, electronics, radar technic, aero-space industry, a.s.o.

   Composite materials are based on the controlled distribution of one or more reinforcement materials in a continuous matrix phase. Composites differ fundamentally from conventional engineering materials in that a second material is added to produce performance characteristics not available from the first unmodified material.

   The second phase may be added to provide strenght and stiffness,

as carbon fibers or other reinforcement materials: ceramic, inorganic powder, organic fiber, glass fiber.

The continuous phase, matrix can be: polyesther, epoxy resins, polybutadiene, ethylene-propylene rubber, polyolefins, natural rubber, a.s.o.

Composites materials are widely used in engineering practice because of their unique mechanical properties, which are determined by the visco-elastic nature of the elastomer.

Most composites materials are designed and produced for the automative industry, to carry a considerable static load, dynamic excitation, dynamic stiffening, high damping elastomers bearings for protection of the buildings against earthquake damages a.s.o.

Substantial research work has to be done for polymers and fillers destinated to the composite materials fabrication.

4. Environmental protection research devoted to the air purification, liquid and solid waste management, in accordance with the existing prescription in Iran and trying to reach the international level in the field (see report).

5. Electricity-steam co-generation for the new petrochemical units, by co-operation in the field between Ministry of Energy and Ministry of Oil.

6. New type of fertilizers and pesticides to meet the requirement of the Ministry of Agriculture in the field.

7. Alternative raw materials for petrochemical industry using renewable resources like: biomasse, vegetable by-products or heavy residue from the crude oil processing.

8. Silicones.

Polymeric compounds containing chrains of silicon atoms alternating with oxygen atoms, with the silicon atoms linked to organic groups. A variety of silicone materials exists, including oils, waxes and rubbers. They tend to be more resistent to temperature and chemical atack than their carbon analogues.

Silane is produced by reduction of silicon tetrachloride using lithium tetrahydroaluminate or by the reaction of magnesium silicide (MgSi) with acids.

Silane (SiH_4) itself is stable in the absence of air but is spontaneously flammable, even at low temperature.

Taking into account /that in Iran there are big resources of raw materials of high concentration, it is recommended to develop silicones industry.

5.6. Methods to involve Iranian research in the definition of the development strategies.

1. Risk assesment studies in the following fields:

- industrial
- social
- finance

Installing "Safety Centers" in the industrial units for preventive maintenance of equipments.

2. Elaboration of a strategic research programme at the international level, regarding:
   - better utilization of the crude oil and natural gases reserves to prevent the exhaustion of such reserves in non-profitable chemical processes or utilizations;
   - marketing studies for regional and international area to penetrate for the Iranian products.

6. LIST OF ANNEXES

Annex 1. Job. description.

Annex 2. List of senior counterparts.

Annex 3. List of people met.

Annex 4. List of petrochemical units and research and development centers, visited.

Annex 5. Ministry of Oil.

Annex 6. Reports on the petrochemical units and research and development centers, visited.

6.1. Ministry of Oil-National Petrochemical Company.

6.2. National Iranian Oil Company - Research Institute for Petroleum Industry.

6.3. Iran Tire Manufacturing company.

6.4. Behran Oil Company.

6.5. Electric Power Research Center.

6.6. National Petrochemical Company - second visit.

6.7. Arak Petrochemical Complex.

6.8. Arak Engineering Company.

6.9. Polymer Research Center.

6.10. Ministry of Agriculture.

6.11. Private Research Center - Petrocarbon Research. Co.

6.12. National Petrochemical Company - 3rd visit.

Annex 7. Plant pollution regulations.

Annex 8. Organisation in research private sector.

Annex 9. List of Homogeneous Research Institutes.

Annex 10. List of Complete research projects.

ANNEX 1

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION

DP/IRA/87/013/11-54

Post title	Expert in research, development activities related to the petrochemical industry
Duration	1.0 month
Date required	as soon as possible
Duty station	Tehran, Iran
Purpose of mission	To provide advice and assistance to the government of the Islamic Republic of Iran in assessing the present capabilities of research institutions to assist national petrochemical industry on its development plans.

Duties

The expert is expected to perform the following activities in cooperation with the national counterpart:

1. Evaluation of present capabilities of the reseacrh and development ir stitutions to assist the national petrochemical industry, both in public and private sectors on its development, utilizing the locally available indigenous raw materials. Indication of those activities which require improvement.

2. Possibilities of research institutions to contribute to the development of the petrochemical industry and production of different derivatives, indicating the specific activities to be performed. Advice on the procedures to be followed. Estimated costs and contributions of the parties involved. Possibilities of better industrial utilization of locally available raw materials for energy production. Personnel requirements, equipment and infrastructure for the implementation of the recommendations.

3. Aspects related to the treatment of effluent and environmental protection. Specific recommendation

for the improvement of the existing treatment systems.

4. Interrelations of the mentioned sector with other industrial activities in the country. Research on the utilization of by-products. Market investigations for export of locally produced products.

5. Demand of the selected products both in local and international markets.

6. Estimated costs for performance of research works and future industrial production. Availability of qualified personnel for the performance of research and development works as well as their industrial applications. Requirements of additional qualification.

7. The expert should present the typed mission report including findings, conclusions and recommendations.

Qualifications

Language English

Background information:

The MOI intends to implement a national plan within the overall gamut of the first five-year Plan to establish a linkage between the programmes of the research institutions and the existing industries to upgrade ageing technology and ensure improved production and commercialization of the research findings. This, it is envisaged, will also increase export and encourage the private sector entrepreneurs to invest in industries.

Through the project, the Ministry of Industry of Iran will receive concrete advise on the utilization of existing research and development institutions in the field of chemical research in order to orient these institutions to the planning, organization and execution of their plan of activities addressing them to the development of the chemical industrial sector and improvement of its efficiency. Fulfillment of the project objective will entail an investigation of the means and ways for stronger direct working contacts as well as active promotion of closer working association amoung different instututions and industry.

The project will allow to define the surplus capacities of the research institutions, high level educational centers, engineering designs and development organization which could be made available for the development of the industrial potential in the country.

ANNEX 2

LIST OF SENIOR COUNTEPARTS

NAME	TITLE	AFFILATION	ADRESS
Dr. Ali.A. Tofigh	Deputy minister	M.O. Industry	No, 10, Kabkanian Lane, Keshavarz-Blvd Valey- e- asre sq.
Dr. Mohammad Ali Mirmohammadi	Head of the Department of Mining Eng.	M.O. Higher Education	TEHRAN University
Dr. Manoochehr Oliazadeh	Professor, of Mineral processing	M.O. H. Education	TEHRAN University
Nader . Niktabe	Organizing manager	M.O.I.	R&D Department

ANNEX 3

LIST OF PEOPLE MET

DATE	NAME OF INSTITUTES	PEOPLE MET.
7.05.1994	Ministry of Oil-NPC	1. E. Karimzadegan (Ph.D.) Deputy Director of Planning 2. Dr. M.S. Parvizi Head of Coordinating Group for R+D
8.05.1994	N.I.O.C. - R.I.P.I.	3. G.Ali Beheshtian Deputy of Planning and Production 4. N.Nourbaklish (Ph.D.) Engineering and Development Department
9.05.1994	Iran Tire Manufacturing Company	5. J.Karimi Plant Manager 6. A.R. Jafari Assistent Managing Director in Expansion of the factory and Materials Research
10.05.1994	Behram Oil Company	7. S.A. Hosseini Rad. Head of Production 8. M.I. Amane Head of Marketing and Development

DATE	NAME OF INSTITUTES	PEOPLE MET
11.05.1994	Electric Power Research Center	9. A.K.Sedigh Manager 10. Dr. Saheil Shoroshi School of Management 11. Daryoosh Azarm M.Sc. Mechanical Department 12. Mohamed Ali Kassai Electrical Engineer
14.05.1994	N.P.C. - 2 nd visit	13. Saro S. Shazarian Head of Technical Service 14. Dr. B.Rajabalitabar Technical Consultant 15. Dr. M.S. Broujem Technical Consultant
15.05.1994	Arak Petrochemical Complex	16. I. Namazy Exploatation Deputy Manager 17. H. Beigy Assistant Technical Manager 18. I. Meshkat Process Engineer 19. I. Mostajab Engineering Department
16.05.1994	Arak Enginnering Company	20. Dr. M.S. Parvizi 21. I. Meshkat

DATE	NAME OF INSTITUTES	PEOPLE MET.
18.05.1994	Polymer Research Center	22. Dr. S.A. Hashemi Deputy Director in Research and Head of Composite Section 23. Dr. M. Nekoomanesh Deputy of Plan and Designing
18.05.1994	Ministry of Agriculture	24. N.H. Shrarifi Jazdi Deputy Managing Director of Fertilizer Distribution and Pesticide Production Company
24.05.1994	Private Research Center Petrocarbon Research Co.	25. A. Ghaemi Managing Director 26. M.F. Alavi Energy Consultant 27. M.B. Ghanizadeh Energy Consultant
25.05.1994	National Petrochemical Company	28. E. Karimzadegan (Ph.D.) Deputy Director of Planning 29. Dr. M.S.Parvizi Head of Coordinating Group for R+D

ANNEX 4

LIST OF PETROCHEMICAL UNITS AND RESEARCH AND DEVELOPMENT CENTERS VISITED

1. Ministry of Oil - National Petrochemical Company

2. National Iranian Oil Company - Research Institute of Petroleum Industry - RIPI - first visit

3. Iran Tire Manufacturing Company

4. Behran Oil Company

5. Electrical Power Research Center

6. National Iranian Oil Company - Research Institute of Petroleum Industry - RIPI - second visit

7. Arak - Petrochemical Complex

8. Arak - Engineering Company

9. Polymer Research Center

10. Ministry of Agriculture

11. Private Research Center - Petrocarbon Research Co.

12. National Petrochemical Company - 3rd visit.

ANNEX 5

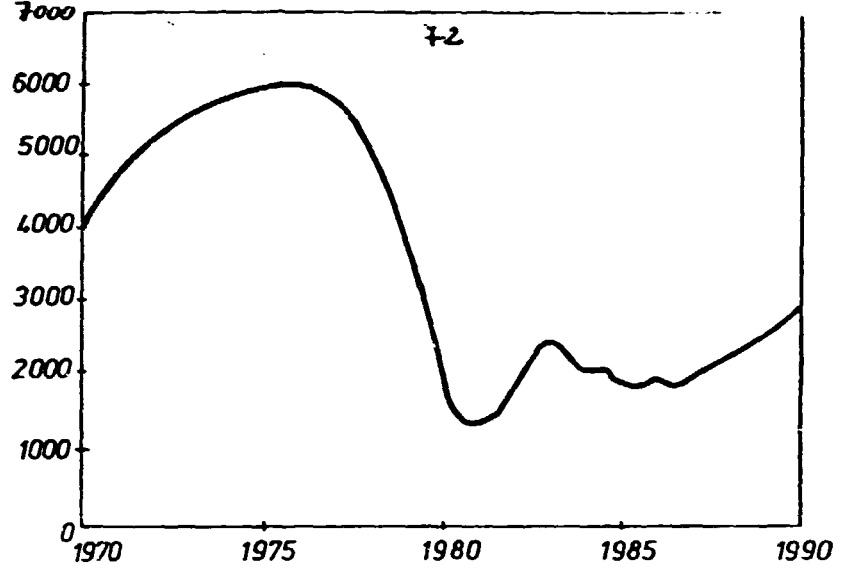
OIL INDUSTRY

Iran is a country situated in the Middle East, almost at the center of Asia, and it is the sixteenth largest country in the world, encompassing 1.648.000 square km in area. From the total teritory of Iran, more than 50% is of mountains terrain, 25% is desert or wildness and the rest fertile plain. The population of Iran had the following evolution:

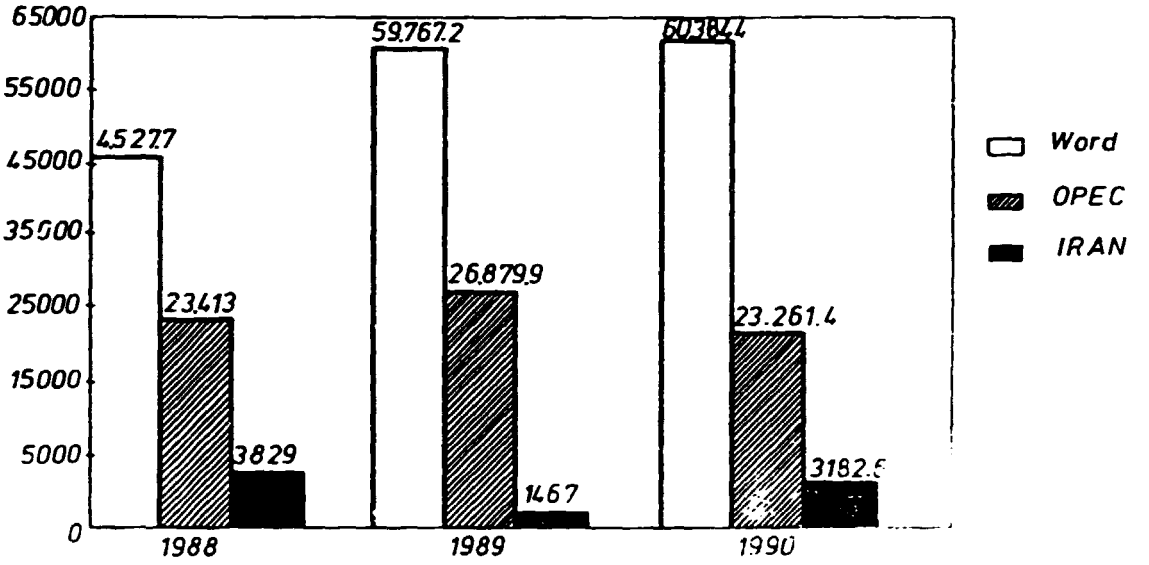
	1956	1966	1976	1985	1991	2000
Million people	18.9	25.7	33.7	49.4	58.1	78
Density people/Sq km	11.5			30.37		47.3

Evolution of crude oil production in Iran, in OPEC countries and in the world can be seen in the attached figure. In determining Iran's G.N.P. oil is regarded as an important resource, meeting the country's financial and industrial needs. There are 493 industrial units active in the field with the total number of employees: 52.746 and they constitute 11.4% of the overall labor force used in all industries. The annual value of the production by these units in 1990, was 976 million us dollars.

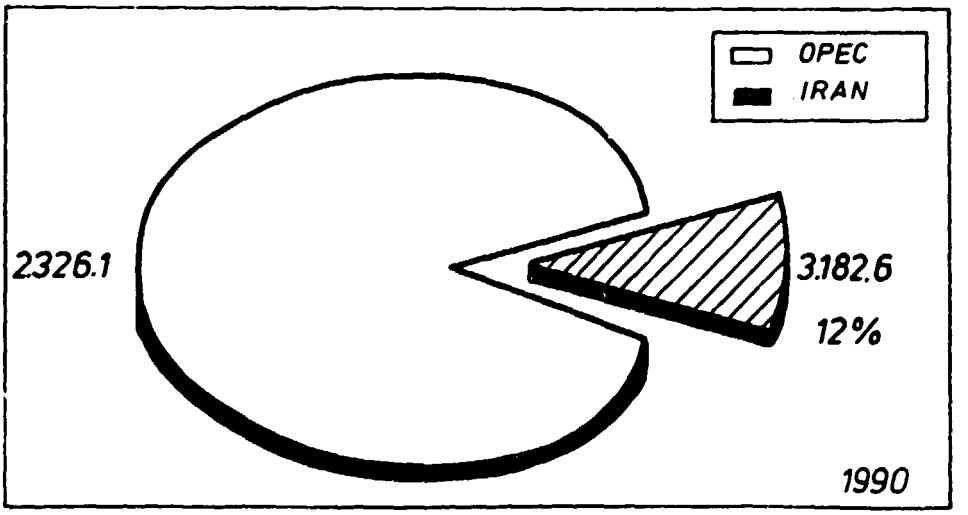
The Oil Ministry was formed after the revolution in 1981, to supervise the oil industry and to co-ordinate the various activities. M.of.Oi has 11 departments and three affiliate companies: NIOC-National Iranian



Evolution of crude oil production
1000 Barrels / day in IRAN
Source: OPEC Annual Statistical Bulletin



Word crude oil production
1000 Barrels/ day



Crude oil production in OPEC Member Countries
1000 Barrels day and %
Source: OPEC Annual Statistical Bulletin

Oil Company, NIGC-National Iranian Gas Company and NPC-National Petrochemicals Company.

Crude oil extraction in the 10 year plan - 1989-1999. In the first 5 year - 387.500 t/day, and the average annual growth of the crude oil production is forecast to reach 3.7%.

The crude oil used as feedstock for Iranian refineries will increase from 92.875 t/day in 1989 to more than 162.500 t/day in 1994, with an annual grow the rate of 15%.

This is planned to be attained by completion and commissioning of the Bandar Abbas refinery: 28.125 t/day Arak refinery phase I: 16.875 t/day, reconstruction of the Abadan refinery in two stages: 162.500 t/day and 325.000 t/day in the subsequent year, commissioning of Bandar Taheri refinery in 1992, expansion of Arak refinery in 1993 and raising of active capacity of existent refineris.

N.I.O.C. is in charge of all operation related to the exploration, production, transport, refinery processing, sale and distribution of oil and gas in Iran.

Refineries production profile:

Arak refinery

Crude oil: 32.750 t/day

Products:

L.P.G.:1.878 m^3/day

Petrol: 6.664 m^3/day

Kerosen: 6.148 m^3/day

Gas oil: 12.668 m^3/day

Bandar Abbas refinery

Crude Oil: 28.125 t/day

Products:

L.P.G: 2.237 m^3/day

Petrol: 8.917 m^3/day

Kerosen: 6.723 m^3/day

Gas oil: 9.982 m^3/day

Fuel oil: 10.938 m^3/day	Fuel oil: 7.289 m^3/day
	Engine oil: 656 m^3/day
	Tar : 795 m3/day

Bandar Tehari refinery	**Abadan refinery**
Crude oil: 8.750 t/day	Crude oil: 16.250 t/day
Products:	Products:
L.P.G.: 410 m^3/day	L.P.G.: 700 m^3/day
Petrol: 2.781 m^3/day	Petrol: 2.687 m^3/day
Kerosen: 1.758 m^3/day	Kerosen: 3.514 m^3/day
Gas oil: 737 m^3/day	Gas oil: 3.721 m^3/day
Fuel oil: 183 m^3/day	Fuel oil: 9.612 m^3/day

Gases:

NIGC - has the task of separation supplying, distribution and selling natural gases and L.P.G.

Natural gases Installations (million cubic meters)

1986 - 117,133

1987 - 127,625

1988 - 156,463

1989 - 186,165

1990 - 200,825

Proven natural gases rezerves:

World: $140 \cdot 10^6$ Million cubic meters

OPEC: $60 \cdot 10^6$ Million cubic meters

Iran : $17 \cdot 10^6$ Million cubic meters

ANNEX 6

REPORTS ON THE PETROCHEMICAL UNITS AND RESEARCH DEVELOPMENT CENTERS VISITED

6.1. Ministry of Oil - National Petrochemical Company

6.2. National Iranian Oil Company
Research Institute of Petroleum Industry - first visit

6.3. Iran Tire Manufacturing Co.

6.4. Behran Oil Co.

6.5. Electric Power Research Center.

6.6. National Petrochemical Company - 2-nd visit

6.7. Arak - Petrochemical Complex.

6.8. Arak - Engineering Company.

6.9. Polymer - Research Center.

6.10. Ministry of Agriculture.

6.11. Private Research Center - Petrocarbon Research. Co.

6.12. National Petrochemical Company - 3-rd visit.

ANNEX 6.1.

7.05.1994

Visit to

MINISTRY OF OIL

NATIONAL PETROCHEMICAL COMPANY

(N.P.C.)

Collocutors:

Deputy Director of Planning - **E. Karimzadegan** (Ph.D.)

Head of Coordinativy Group for R+D - **Dr. M-S. Parvizi**

The Iranian Petrochemical Industry was born in 1964, by operation of a small fertilizers complex, and now there are eight manufacturing companies, as shown in table 1., mously producing fertilizers. During the current Five Years Development Plan: 1989-1994, of the country, several units are under implementation as shown in table 2, of which, three have already come on stream . At present, petrochemical production is 5.5 million tons per year, but after the fully implementation of the first Five Years Plan, the production capacity of petrochemicals will reach 9 million tons per year.

The programme of Development of Petrochemistry in the second 5 years development plan: 1994-1999, which is currently under review, includes a new olefin complex with basic petrochemical products such as: polyolefins, polystyrene and copolymers.The plan in addition includes production of: Methanol, MTBE, TPA, PET, Acetic Acid, Methyl Methacrylates, Polycarbonate and Epoxi resins, as shown in the table 3.

Table 1.

Existing complexes & plants - units : 1000 tons/year

SHIRAZ PETROCHEMICAL COMPLEX		KHARG CHEMICAL COMPLEX	
Ammonia	432	Sulphur	198
Urea	543	Propane	66
Nitric Acid	386	Butane	55
Ammonium Nitrate	254	Pentane	112
L.Sodium Carbonate	80	**ABADAN PETROCHEMICAL COMPLEX**	
D. Sodium Carbonate	66	EDC	89
Sodium Bicarbonate	20	VCM	64
Sodium Tripoly Phos.	30	PVC	60
DAP	20	DDB	10
Methanol*	84	Caustic Soda	30
		Chlorine	26

RAZI CHEMICAL COMPLEX		ESPHAHAN AROMATICS***	
Ammonia	660	Benzene	75
Urea	720	Toluene	20
Sulphur	500	*o*-Xylene	22
Sulphuric Acid	1060	*p*-Xylene	44
Phosphoric Acid	255		
DAP**	450		

FARABI PETROCHEMICAL		IRAN CARBON BLACK	
		Carbon Black	23
DOP	40	PAZARGAD CHEMICALS ABADAN & SHIRAZ UNITS	
		Caustic Soda	27.5
Phathalic Andydride	5.5	Chlorine	24.5

* - *Operating Since 1990*

** - *240 Thousand tons new capacity since 1991*

*** - *Operating since 1992*

TABLE 2.

Projects under construction - Unit : 1000 tons/year

BANDAR IMAN PETRO. COMPLEX		TABRIZ PETROCHEMICAL COMPLEX	
LPG	1900*	LLDPE/HDPE/Butene 1	100
L.D.Polyethylene	100	Polystyrene	80
H.D.Polyethylene	60	Phenol	30
SBR	40	SBR	20
Caustic Soda	258	Styrene	10
Chlorine	240	Propylene	34
Benzene	260	Acetone	18
EDC/VCM	150		
Mixed xylenes	210		
EDC	300		
Hydrochloric Acid	60		

ARAK PETROCHEMICAL COMPLEX	
Phase 1	
H.D. Polyetylene	60
LLD. Polyethylene	60
Acetic Acid	30
Vinyl Acetate	30
Poly Butadiene	25
Pyrolysis Gasoline	106
Butene-1	7
Phase 2	
2-Ethyl-Hexanol	45
Ethylene Glycol	105
Ethanol Amines	30
Ethylene Oxide	110

HERBICIDES	
Alachlor	0.5
Butachlor	2.5
Monochloro Acetic Acid	10.5
Chloro Acetyl Chloride	1.5
Diethyl Aniline	2.5
CARBON BLACK (EXPANSION)	
Carbon (diff. grades)	21
KHORASAN PETROCHEMICAL COMPLEX	
Ammonia	330
Urea	500
Sulphur Coated Urea	90

** - Of two NF trains one already operating*

Table 3.

Second Five Year Development Projects of Petrochemical Industry - unit : 1000 tons/year

6th Olefin Complex. BANDAR IMAM		**ENG. Polymers Complex**	
LLDPE/HDPE	150		
Polystyren GP	50	Polycarbonate	25
Polystyren EPS	40	Epoxy Resins	10
Polystyren HI	60		
KHARK CHEMICAL Expansion		**Xylene Separation**	
Methanol	660	Paraxylene	140
Acetic Acid	100	Orthoxylene	40
MTBE Complex. BANDAR IMAM		**TPA, PET, Complex**	
MTBE	600	TPA	50
Methyl Methacrylates	60	PET	30

This, development plan emphasizes on export orientation, profit maximization and privatization. It is also to be mentioned that in accordance with the newly realized policy of privatization of industry in Iran, the National Petrochemical Company has already issued several licenses to private sector investors to execute petrochemical units, as shown in table 4.

New downstreams petrochemical projects have been selected for implementation by the private sector as shown in table 5.

Table 4.

Projects Licensed to Private Sector for Implementation

- units : 1000 tons/year -

No	Project	Capacity
1.	Petroleum Resins	3 x 10
2.	Dioctyl Phtatate	40
3.	Melamine Crystal	10
4.	PVC	70
5.	Ethyl Amines	5
6.	ABS, SAN	15
7.	Aniline	30
8.	Polypropylene	50
9.	Acrylonitrile	50
10.	Methyl Methacrylates	17
11.	Caprolactam	60
12.	MTBE	2 x 50

To promote these projects and to attract private investors, N.P.C. will provide necessary feedstock at 20% below the Persian Golf F.O.B. exist prices.

Table 5.

Projects to be implemented by Private Sector Within Second 5 Year Development Scheme - unit : 1000 tons/year

No	Project	Capacity
1.	Ion Exchange Resins	10
2.	Polyacetal	10
3.	Ethoxylates	20
4.	Methyl Amines	5
5.	Maleic Anhydride	20
6.	Linear Alkylbenzen (LAB)	50
7.	Methyl Ethyl Keton (MEK)	25
8.	Adipic Acid/HMD	*
9.	Polyisobutylene	*
10.	Butyl Rubber	*
11.	Isopropyl Alcohol	*
12.	Chlorinated Solvents	*
13.	Benzoic Acid/Sodium Benzoate	*
14.	Chloro Methanes	*
15.	Polyvinyl Acetate	*

* - *Capacities to be decided*

Figure 1 shows the organization chart of the Ministry of Oil in the area of crude oil processing and petrochemistry .

Working procedures of Research, Development and Engineering activities can be seen in figure 2.

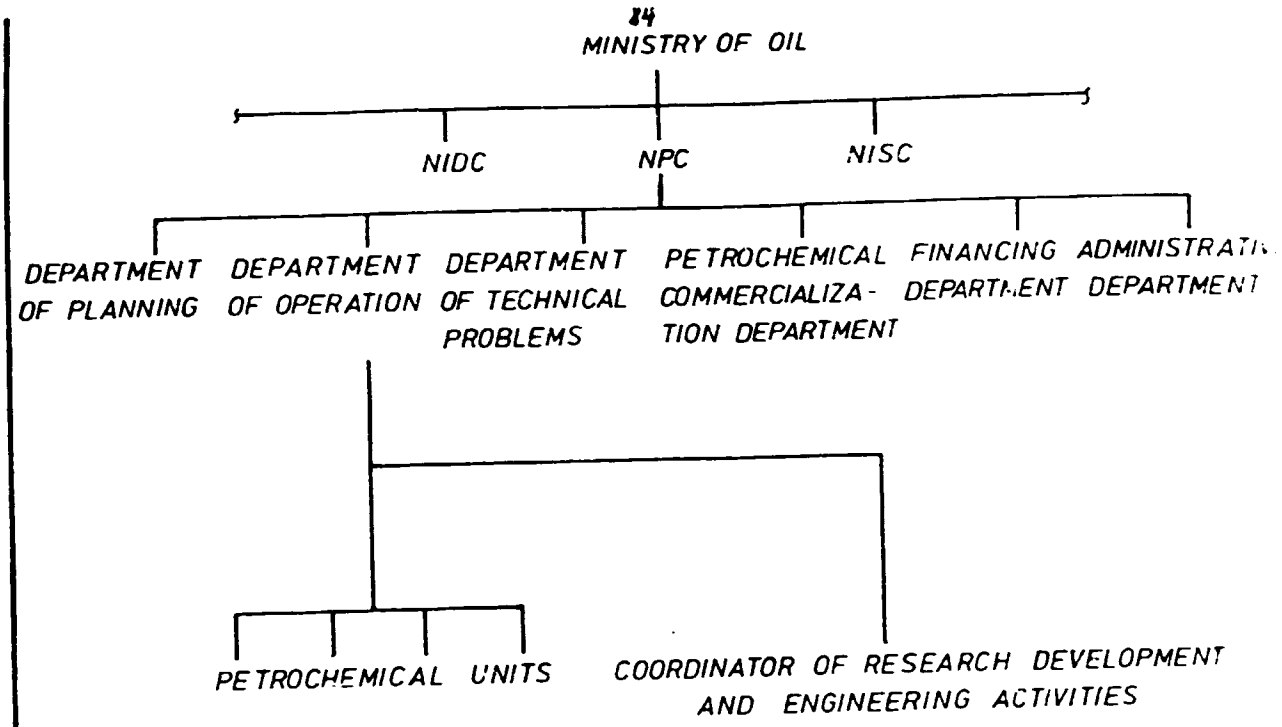


Fig.6 Organisation Chart of the Ministry of Oil

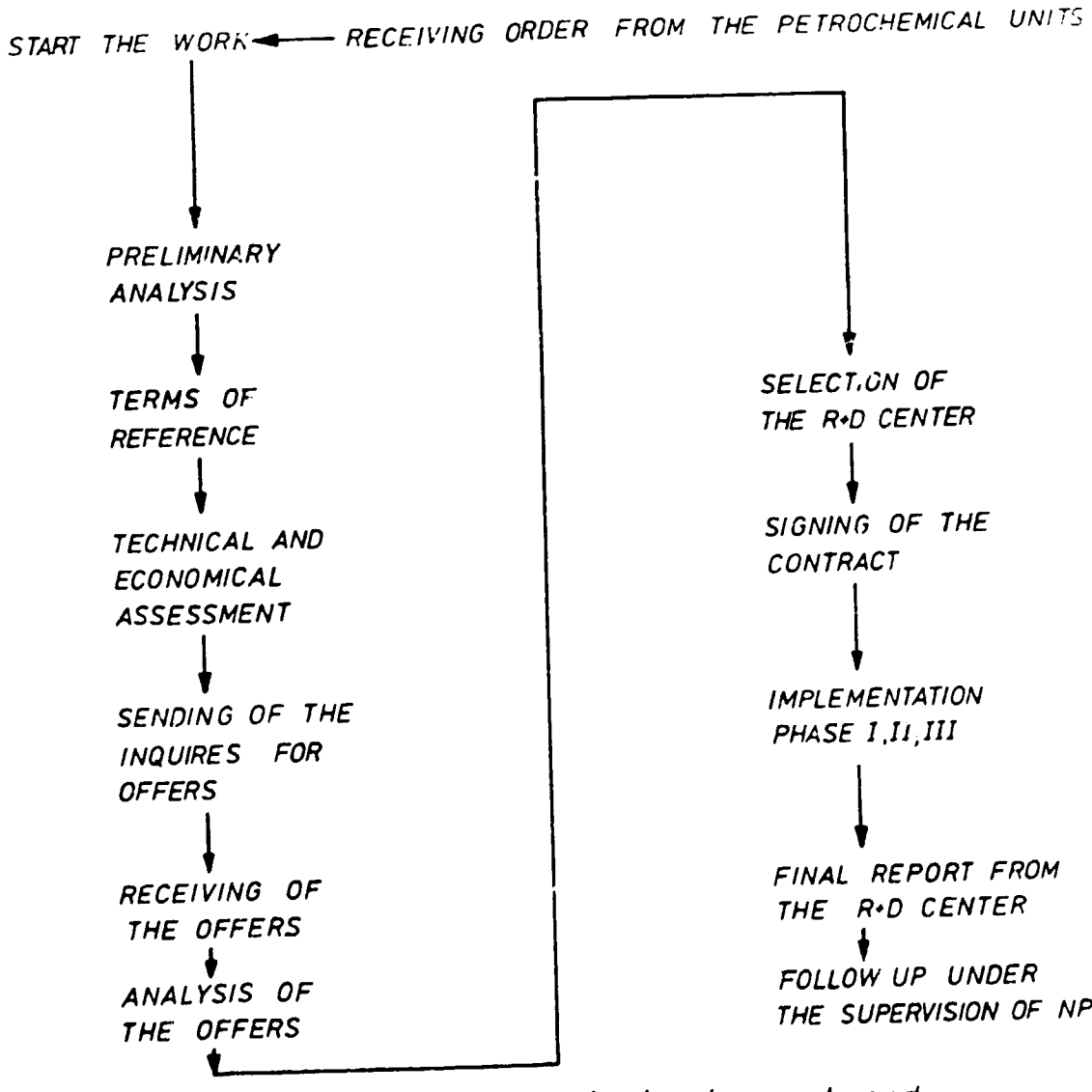


Fig.7 Working procedures of research development and engineering activities

For the future development, of the research activities, N.P.C. recommends to provide small research and development centers inside of the petrochemicals units to solve some local specific development requirements.

Development of the research has to have some main objectives like:

a. Process improvements;

b. Prevent mechanical failure and corrosion;

c. Energy saving;

d. Environment protection.

There are some difficulties in the cooperation activites with research and development units which belong to M.O.I. or other departments, such as:

1. Technological processes provided by the research units are, let say more academic but they do not contain all necessary elements to scale up from the pilot plant to the industrial production.
2. Some time there are missing fundamental data to make a correct evaluation of the offers (selectivity of the process, specific consumptions, economic evaluations, a.s.o.)
3. Not so much flexibility to answer to the real problems which confront petrochemical units.

ANNEX 6.2.

8.05.1994

Visit to

N.I.O.C. - R.I.P.I.
NATIONAL IRANIAN OIL COMPANY
RESEARCH INSTITUTE OF PETROLEUM INDUSTRY

Collocutors:

Deputy Director of
Planning and Production - **G. ALI BEHESHTIAN**

Engineering and Development
Department - **N. NOURBAKHSH** (Ph.D.)

The Research Institute of Petroluem Industry - NIOC, began its activities in 1958 with limited staff and facilities, when The Iranian Oil Industry employed many foreign specialists and consultants from multi-national oil corporations and referred its specific research requirements to international research centers. There was little opportunity for RIPI to develop the basic and applied industrial research.

Following the Islamic Revolution in 1979, various services provided by foreign companies in Iran were terminated and consequently it was developed a national strategy for research in the field.

The research institute organization chart is:

Director of R.I.P.I.

Deputy Director for Production and Planning			**Deputy Director for Research Services**	
Drilling Oil Engineering	Refinery and Petrochemistry	Polymers	Environment Protection	Engineering and Development
800 employees of which			400 employess are graduated	

Development technology in the field:

1. Lube oil additives produced in 4 batch pilot plants with a capacity of 300-500 t/y additives.
2. Rail way greases produced in one batch pilot plant with a capacity of 200 t/y.
3. Gas sweetening for sulphur removal on an original catalyst.
4. Bitumen for coating gas pipe lines.
5. Testing of the refinery catalysts for processes like: hydrotreating, hydrocracking, ammonia, monocomponent reforming catalyst for refineries cuts.
6. Crude oil analysis, as an evaluation catalogue necessary for engineering activities to design equipments for refineries.
7. One step dehydro-izomerisation of C_4 cut for making iC_4' (n-butane to izo-butene in one step).

New projects:

1. Methyl tertiorybutylether (MTBE) catalytic process for an industrial plant with a capacity of 50.000 t/y.

2. Ethanol-amines, non-catalytic process for an industriai plant with a capacity of 40.000 t/y.
3. Sulphur as fertilizers component.
4. Additives for gas-oil reducing pollutont emissions.
5. Lube oil additives for improvement of the Viscosity Index.
6. Lube oils specialities for gear boxes, compresors.
7. Coating bitumen for specific purposes.
8. Fundamental research on C_1 chemistry to obtain synthesis gas: $CO + H_2$, based on methane gas or LPG as raw materials.

For the transfer of the technology from the research stage into the commercial activities. then are some coercions like:

- Procurement of the new testing equipment in fields like: exploring hydrocarbon resources, testing of the catalysts performances (Chemosorption properties, zeolite activity, a.s.o.), synthesis and application of polymers, additives inhibitors and environment protection.
- Inefficient utilization of the existing facilities for research and testing due to the bad understanding of the staff.
- Selection of the employees has to be improved.
- There are no incentives for the skilled staff, because the salaries are not directly related to the efficiency of the work.
- There is no competition to find out orders from the petrochemical complexes, because the expenses for the research institute are supported from the state budget.

- Petrochemical units has no confidence in the working ability of the domestic research institutes, preferring to buy technology from well known foreign companies in the field.
- There are no more incentives in the field of patent rights for the staff working in research and development.

ANNEX 6.3.

9.05.1994

Visit to

IRAN TIRE MANUFACTURING CO.

Collocutors:
Plant Manager - **Y. KARIMI**

Assistant Managing Director in Expansion of Factory and Materials Research - **A.R. JAFARI**

In Iran there are 5 units for the production of tires:

1. Dena Tire Co.	- 32.000 tons/y
2. Iran Tire Manufacturing	- 24.000 tons/y
3. Kian Tire Co.	- 20.500 tons/y
4. Pars Tire Co.	- 18.000 tons/y
5. Barez Tire Co.	- 14.000 tons/y
Total productions	**- 118.500 tons/y**

One of the most representative units is Iran Tire Manufacturing Co., because of its tradition in the field and the accumulated experience.

Iran Tire Manufacturing Company was founded in 1963, by Sabet PASAL Group, as initial shareholders, with a capacity of 4.000 tons/year (1.000 tires/day).

Now, the status of the company is as follows:

- 64% of shares belongs to the Banyade Mostazafan
- 20% of shares belongs to the Shere Owner Ship Development Organization
- 10% of shares belongs to the Fiscal Organization
- 6% of shares belongs to the Workers of the factory

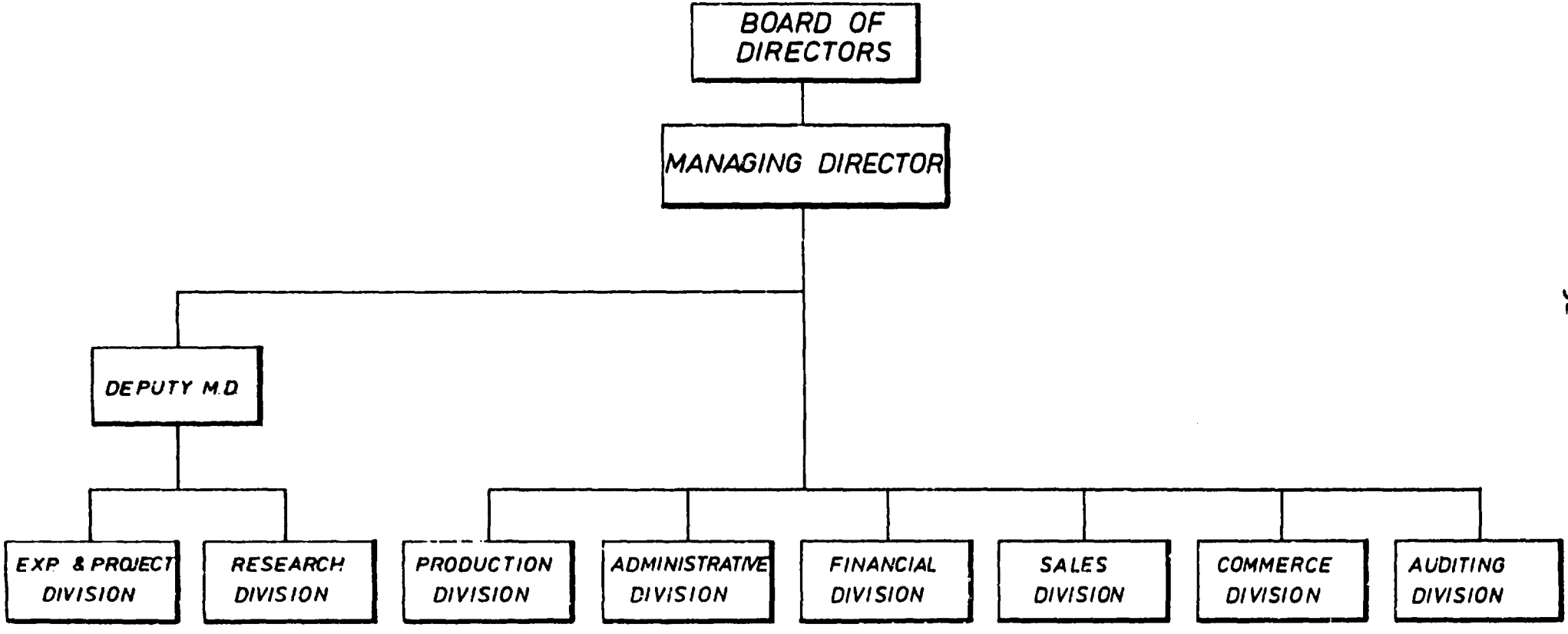
Design capacity of the factory is 28.000 t/y but the running capacity is about 24.000 t/year: 512 for tractors, 700/16 for minibuss, 165/65/13 for passenger cars.

The main products of the factory are: passenger tire, light truck tire, heavy truck tire, buss/track tire, tube, flap and others type of tires.

In the appendix it can be seen the organization chart, for a total employees: 800 persons.

All raw materials are now imported, i.e. : S.B.R., P.B., N.R., B.R., except carbon black, which is provided by AHVAZ CARBON Black. Co. from IRAN. The reinforced cord is imported from Turky (Nylon 6), and there is under development a research programme to replace Nylon 6 with polyester cord fibers and with metallic cord.

Some other chemicals are also produced in IRAN like sulphur and ZnO.



ORGANIZATION CHART OF IRAN TIRE MANUFACTURING CO.

Future programme development:

1. Improving the existing quality of the tires, to extend the life from 55.000 km upto 80.000 km, by improving abrasion resistence, heat building-up, stretch resistence and sheet separations.
2. Costs reductions, by replacing an antioxidant for ozone activity with a lower price product from foreign countries: 200 t/year consumption, with an existing selling price of 6-7 $/kg.
3. Development of a new compound for the side wall of the tires.
4. Development of a new technology for the tubeless tires in the future.
5. Development of a new skin compound for the tube, to reduce the cost of the production.
6. Development of a new product, steel belts, 145/13, for the industrial users.

For the **R + D activities**, there are some constraints, like:

1. Training of the engineers and technicians, for which there are some alternative possibilities:
   - to bring through UNIDO help two or three skilled specialists from the western countries to make the training in IRAN of the selected personnel, for the optimisation of the compounds fort the new receptures;
   - to send two or three specialists from IRAN to be trained in proper units in foreign countries;
2. Tire testing facilities are very expensive, like those for high speed analysis and in IRAN there is not any experience to order such new instruments. It would be necessary to cooperate with other R&D

centers, especially from the University, to order such equipment or with the Polymer Research Center from IRAN.

ANNEX 6.4.

10.05.1994

Visit to

BEHRAN OIL. CO.

Collocutors:

Head of Production - **S.A. HOSSEINI RAD.**

Head Marketing and

Development: R & D - **M.J. AMANE**

The main products of these units are lube oils and waxes. It is private company and the shareholders are:

Bonyad-e-mos Taza-fan Fondation - 67%

Private: staff, workers, a.s.o. - 33%

The initial unit was built in 1967 by ESSO, like a blending unit of components, but later on, a new refinery unit and base oil unit were added.

The raw materials are vacuum distillation cuts, received from the near-by refinery, 200.000 tons/year yielding 100.000 t/y basic oil, 30.000 paraffin waxes, and the ballance representing heavy residue, aromatic hydrocarbon, a.s.o.

The principal plants are:

- aromatic separation in a furfurol extraction unit;
- paraffins separation in a filtration unit with methyl-ethyl-cetone and toluene;

- hydrofinishing unit - for removing unsaturated hydrocarbons by hydrogenation process.

Main products are lube oil for engine, industrial oils, waxes like paraffins, antifreezing components, a.s.o.

The aromatic fractions contain: benzene, toluene and mixtures of *o* + *p*-xylenes and there of are used by the petrochemical units, as raw materials for the production of basic petrochemicals monomers and polymers. The heavy residue represents a very good raw material for carbon black units in IRAN.

The quality of the lube oils meets the international prescription, based on initial receptures received from ESSO, being subsequently improved by the R + D specialists of Behran Oil Co.

Working time - 250 h or 12.000 km. per charge.

Main consumers are in the domestic market, but Behran Oil Co. exported also lube oil and paraffins into Turky, Italy, Romania, in small quantities.

For the time being all refineries in IRAN benefit by important subsidies for the prices of crude oil and energies. For example:

- from 8 liters of vacuum distillation cut which cost about 0.8 US $, it has to be obtained 4 liters of lube oil, which are selling for 0.8 US $.

- Utilities, cost is:

Electrical Energy	- 0.7 C/kwh
Steam	- 40 C/ton
Water	- 13 C/m^3
Fuel Oil	- 0.7 C/kwh

Than to cover the salaries of the employes, back payment of the investment, energies consumption, and all others expenses one can consider only the turning to better account the by-products, like a difference between raw materials and lube oils.

The price of electricity cannot be the same as the price of fuel oil, unless subsidizing the electricity cost.

Research and Development Center

Behran Oil Co. has a real good team of engineers in the Marketing, research and Development department:

- Modern research equipment for testing raw materials, end products specific equipment for the improvment of lube oil receptures and waxes.
- Intensive concern for the accumulation of technical papers, books, magazines in the crude oil processing and related fields.
- Incentive programme for the future research and development activities like:quality improvment of the lube oil and wax, better use of the by-products, assimilation of the most newly imported additives for a better recepture for lube oil and waxes, a.s.o.

There are also a lot of constraints, such as:

- Wrong understanding of the research and development activities by a lot of people going from one extreme to another: to start everything from the beginning or to import evrething or to assimilate the new technique and after that to develop original processes.
- There is no priority, programme for the research activities in the country, in different areas of activities, for example, there are not

any specific companies which are doing laboratory equipment, so that a lot of improvisations take place to make researchs.

- Absence of technical information regarding other R + D activities from IRAN, and especialy from advanced countries in the industrial fields.
- There is not enough preocupation for the government to coach the technocrats to the industrial development, especially in the State - Owned Companies.

ANNEX 6.5.

Visit to

ELECTRIC POWER RESEARCH CENTER
(E.P.R.C.)

Collocutors:

Quality Control Manager	- **MOHAMED ALI KASSAI**
Communication Department Manager	- **A.K. SEDIGH**
Mechanical Department	- **DARYOOSH AZARM** (M.Sc)
School of Management	- **Dr. SAHEIL GHOROSHI**

Electric Power Research Center, a subsidiary company of the Ministry of Energy, is actively engaged in applied research activities needed by electric power industry. The visit had to be done because of strong connections between energy supplying department and petrochemical units, like a major consumer of electricity.

E.P.R.C. has also, among many others, a chemistry Engineering Division, for:

- research projects related tc chemical aspects of power plant
- design water treatment systems
- corrosion analysis and metallic surface protection

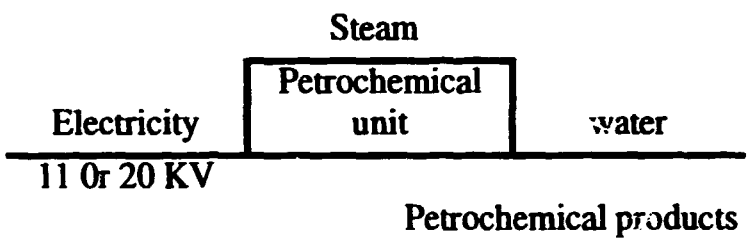
The network lines distributions in IRAN are as follows:

a. Transmission lines at 230 and 400 KV

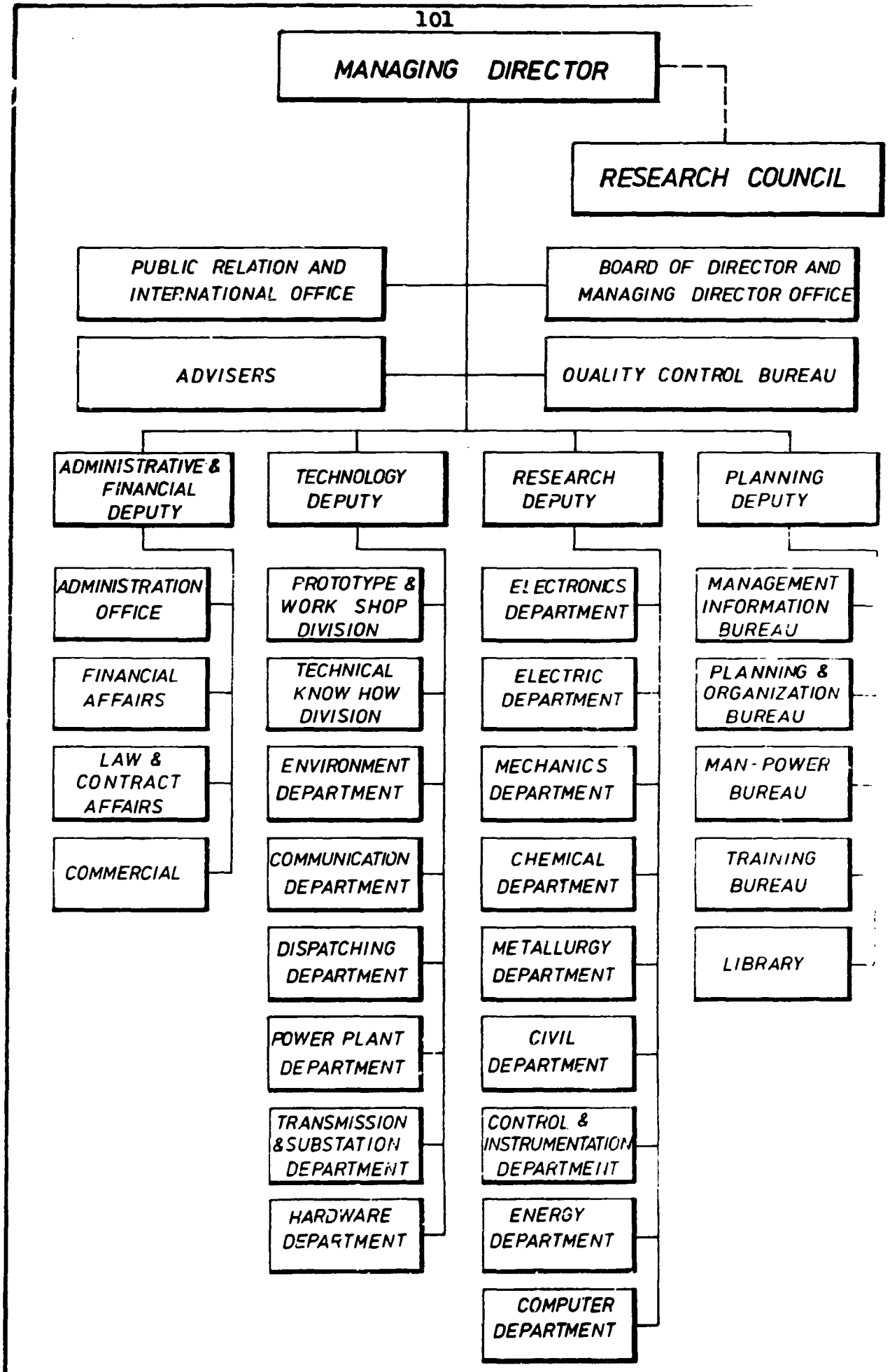
b. Sub-transmission lines at 63 KV and 132 KV

c. Distribution stations at 11 and 20 KV

If we consider a petrochemical unit as a box consumer, than we have:



Which means that Ministry of Energy has to supply to the petrochemical units only Electricity, while these unit have to take care themselves to produce steam and provide water. There is not a co-generation system already installed between electricity supplier and petrochemical unit.



ELECTRIC POWER RESEARCH CENTER
EFFECTIVE MANAGEMENT CHART

ANNEX 6.6.

14.05.1994

Visit to

MINISTRY OF OIL - N.P.C.

(2nd visit)

Collocutors:

Dr. M.S. PARVISI	- Head of Coordinating Group R + D
SARO S. SHAZARIAN	- Head of Technical Service
Dr. B. RAJABALITABAR	- Technical Consultant
Dr. M.-S. BRONJENI	- Technical Consultant

Main points discussed:

a. Maintenance metods used in petrochemical units:

- planning maintenance;
- emergency maintenance;
- preventive maintenance.

b. Safety Management Center for preventive maintenance and risk management.

c. Environmental protection metods.

Iranian collocutors are interested in getting more information on the above mentioned points, from countries with experience in the petrochemical fields.

ANNEX 6.7.

15.05.1994

Visit to

ARAK PETROCHEMICAL COMPLEX

Collocutors:

Mr. NAMAZY - exploitation

Mr. H. BEIGY - Assistant Technical Manager

Mr. MESHKAT - Process Engineer Manager

Mr. MOSTAJAB - Engineering Design Manager

The main feed used in the Complex is light and heavy naphtha from the Arak refinery.

One of the exceptional characteristics of the Arak Petrochemical Complex is the selection of the most updated technology, like:

1. Olefins plant - KTI - Netherlands
2. Pyrolysis gasoline, Hydrogenation unit - IFP - France
3. L.L.D.P.E. - B.P. Chemicals - SUA
4. HDPE - Hoechst - Uhde - Germany
5. Polypropylene - Hi-Mont - Tecnimont - Italy
6. Vinylacetale - Bayer - Uhde - Germany
7. Butadiene - Nippon Zeon - Japan
8. Polybutadiene - Nippon Zeon - Japan
9. Ethylene-oxide - Scientific-Design - SUA
10. Oxo-alchools - Davy Mc Kee - England

The annex gives some other data regarding ARAK PETROCHEMICAL COMPLEX.

HISTORY OF ARAK PETROCHEMICAL COMPLEX

The main idea for implementation of this project is to realize a complete petrochemical complex for production of the polymeric products through available hydrocarbons derived from crude oil (naphtha) and supply of basic materials for the domestic industries and furthermore export of the surplus products to foreign countries.

Petrochemical industry plays a distinctive role among other industries mainly for its almost unlimited abilities for the production of thousands of products with high added value used in many different areas of the industries.

Nowadays in the developed countries investiment in this area is the basis for the economical and strategical policy of the export which in turn causes a great development in their economy, industry and social affairs.

Having a good source of raw materials and considerable industrial, agricultural and educational potential, gives Iran a good opportunity for use of petrochemical products and for further development in this industry.

Preliminary studies started in 1983 and in 1984 it was approved by the High Committee of Economy. In 1985 first letter of credit for design, engineering and procurement services of the Olefin plant was opened and from 1988, construction and erection activities started. In 1987 as the engineering for the different units were on the progress, Arak Petrochemical Company as a legal institution was established, and took over the responsibility of the whole project.

In the end of 1992 with support of both National petrochemical Company and Bank Melli, together with hard work of ARPC personnel, water treatment, power and steam generation units came into operation and subsequently other utilities as well as Olefin and Polyolefin plants have been commissioned and made ready for start up and operation.

Arak Petrochemical Complex is located at about 22 km from Arak town on the Arak-Broojerd Road, next to Seventh Refinery, with elevation of 1888 m above sea level. The area allocated for the process, utilities and the off-site units is around 523 hectares and further 215 hectares in the west side of the Complex is under negotiation for future expansion and access to the main road for unloading and loading of feeds and products. The major consideration for site selection was the accessibility to the roads, main gas pipeline and the Seventh Refinery which is the source of the feed for Complex.

FEED, PRODUCTS AND MAIN CONSUMPTION

The Main feed used in the Complex is light and heavy nahptha from Arak Refinery. At the early stages of the operation, this feed will be supplied from the Isfahan Refinery.

The feed supplied to the Complex will be stored in dedicated storage tanks and will be fed to Olefin plant through a distibution system. For the feed supplied from Isfahan, truck unloading facilities has been considered.

The other feed used in the Complex is Natural Gas supplied from the principal pipeline passing from the proximity of the Complex which will be distributed by a special system to the consumption unit

Furthermore about 6000 MTPY Ammonia and 124,000 MTPY Oxygen is required in the Complex. Ammonia will be imported from Shiraz Petrochemical Complex and Oxygen foressen to be produced in the Air separation unit in the Complex.

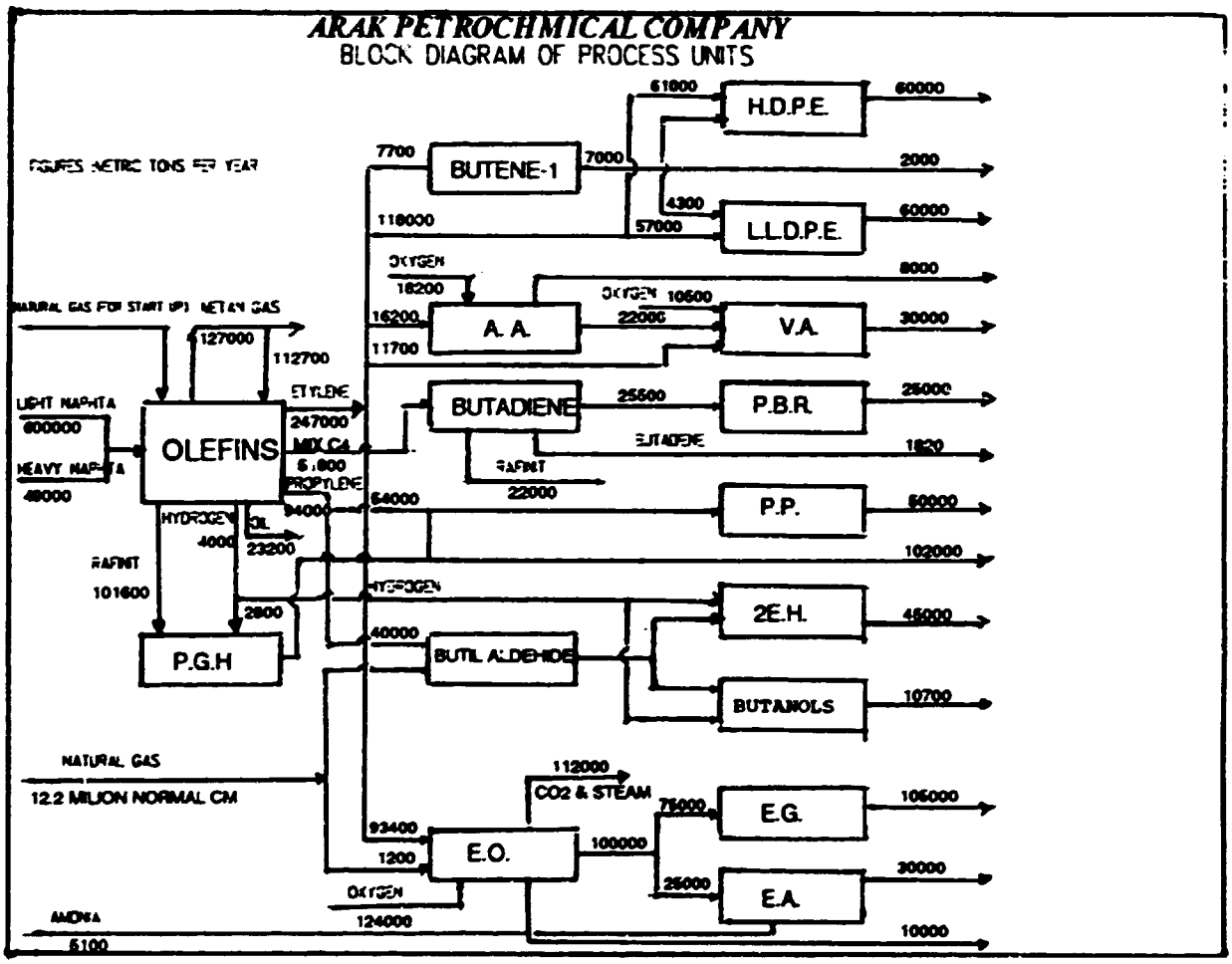
The number of the products produced in the Complex exceeds 14 products some with different grades. Some by-products will be produced in the plants also.

TECHNOLOGY AND STAGES OF PROJECT EXECUTION

One of the characteristics of the Arak petrochemical project is the selction of the most updated technology and international contractors for the engineering and supply of the equipment carried out by the Iranian experts during the imposed war and economic sanction. More than 12 most recent licences for process units and 6 more for the utilities have been selected.

In selection of the technology, great attention has been paid to conformity of processes, with local climatic conditions and culture and on optimum use of raw materials and utilities. Fifteen international contractors mainly from Italy, France, England, Holland, Germany, Belgium and Jpan are involved in supply of license, engineering and equipment. The work started in 1985, and till now engineering, supply and delivery of the equipment for the 1st phase of the Complex have been completed and is ready for start up.

Two Iranian contractors are also engaged in construction works partially. In addition more than 250 Iranian contractors are also involved in common facility works. For coordination, supervision, planning and control of the Complex works in off-shore and on-shore an Italian


ARAK PETROCHMICAL COMPANY
BLOCK DIAGRAM OF PROCESS UNITS
FIGURES METRIC TONS PER YEAR
NATURAL GAS FOR START UP) METAN GAS
127000
112700
LIGHT NAPHTA
600000
HEAVY NAPHTA
48000
OLEFINS
ETYLENE
247000
MIX C4
5,800
PROPYLENE
94000
HYDROGEN
4000
OIL
23200
RAFINT
101600
2800
P.G.H
7700
BUTENE-1
7000
118000
61000
H.D.P.E.
60000
2000
4300
57000
L.L.D.P.E.
60000
OXYGEN
18200
16200
A. A.
11700
8000
OXYGEN 10600
22000
V.A.
30000
BUTADIENE
25500
P.B.R.
25000
BUTADIENE
1820
RAFINT
22000
54000
P.P.
60000
102000
HYDROGEN
40000
BUTIL ALDEHIDE
2E.H.
45000
BUTANOLS
10700
NATURAL GAS
12.2 MILION NORMAL CM
112000
CO2 & STEAM
93400
1200
E.O.
100000
75000
E.G.
105000
25000
E.A.
30000
OXYGEN
124000
AMONIA
6100
10000

contractor has been assigned as Managing Contractor. In all contracts, emphasis has been given for transfer of technology and know how, and in this respect the project engineers and experts have gained a good experience.

FINANCE AND BUDGET STATUS

Total investment necessary for realization of the Complex, based on the recent rate of currency is estimated 1500 Billion Rials, with 70% in foreign currency. Up to now more than 1090 Billion Rials is incurred in the project out of which the equivalent amount of 2000 milion US dollars in Rls, is spent in foreign currency and the remainder in Rials. From this amount about 70 Billion Rls has been expended in house making project.

Source of financing:

Cash	: 300 Billion Rls
Credit given by Bank Melii	: 350 Billion Rls
International credit through NPC	: 740 Billion Rls
Balance	: 110 Billion Rls

In order to support the project financing background and facilitating participation of the public Investments in production activities, ARPC was established with partnership of National Petrochemical Company and Bank Melli in 1987. The Bank participation is a good criteria for the public cooperation in constructive projects after the Islamic Revolution of Iran.

DESCRIPTION OF DIFFERENT PROCESSES.

The main operation activity performed in the Complex is converting light and heavy naphtha to olefins in the Olefin plant and in the next step producing intermediate and final products through the Olefins. In a different section, natural gas which is used as main fuel in the Complex is used as raw material in the production of Butyraldehydes from which 2-Ethylhexanol and Butanols will be derived as final products. For the diversity of the products produced in the Complex, different processes have been utilized which will be represented herebelow:

OLEFIN PLANT: In the Olefin plant which is the heart of the Complex, naphtha is cracked thermally and converts to smaller molecules. The gaseous mixture after condensation, purification, demethanazing and separation of C_2 compounds at low and high temperatures, will be converted to Ethylene, Propylene and a mixture of C_4 products. Pyrolysis gasoline and hydrogen will be produced as valuable by-products in this process.

The license and design of the plant has been supplied by the Italian Company TPL. The relevant process for the hot section which is inclusive of the cracking furnaces, belongs to KTI of Netherlands.

PYROLYSIS GASOLINE HYDROGENATION UNIT: The raw pyrolysis gasoline produced in the Olefin plant at the first step converts to diolefins and styrenic molecules and in order to prevent formation of tarry materials, it is hydrogenated and separated to C_5, C_6 (mainly benzene), C_7+

and heavy ends. Among these materials C_5 and C_7^+ which have high octane number, are mixed with some refinery products with low

octane number such as C_5 and naphtha and sold as super gasoline for use as automobile fuels. The C_6 product is sent to Tabriz Petrochemical Complex for the production of benzene and the heavy ends are recycled back to the Olefin plant. This process has been licensed by the French IFP company and the whole work implemented by Italian company TPL.

LINEAR LOW DENSITY POLYETHYLENE PLANT (LLDPE): In this plant Ethylene at 30 atm. pressure and a temperature lower than 100°C is polymerized in the presence of catalyst to polyethylene in the gaseous phase. The product is supplied in different grades in the form of pellets.

The process license of this plant belongs to BP Chemical Co. and has been supplied by TPL.

HIGH DENSITY POLYETHYLENE PLANT (HDPE): High density polyethylene is produced by the direct polymerization of ethylene at 10 atm pressure and a temperature between 75 to 90°C in the reactor. The reaction is performed in the gaseous phase and in the presence of catalyst. The final product is supplied to the market in different grades in the form of pellets suitable for different consumptions. The process of Hoechst has been selected for this plant which has been presented by the German company UHDE.

POLYPROPYLENE PLANT: Polypropylene is produced by the polymerization of propylene at 60-70°C temperature and 30-35 bar pressure in the presence of catalyst in the slurry phase. In this process, both homogeneous and non homogeneous polymer (with ethylene) are produced in different grades having extensive consumption in downstream

industries. The Hi-mont process has been selected for this plant presented by Tecnimont of Italy.

ACETIC ACID PLANT: In this plant acetaldehyde is produced as intermediate product by oxidation of ethylene in the presence of catalyst. Acetic acid is produced by catalytic oxidation of acetaldehyde in the liquid phase having a purity more than 99.5%. The process utilized in this plant belongs to Bayer of Germany presented to ARPC by UHDE company.

VINYL ACETATE PLANT (VA): In the Arak VA plant, vinylacetate is produced by oxidation of acetic acid and ethylene in the presence of catalyst in a fixed bed reactor. The reaction will be performed at low temperature in the gaseous phase. The purity of the product is 99.9%. The selected process is from Bayer presented to ARPC by UHDE.

BUTADIENE PLANT: Extraction of butadiene from C_4 cut by a solvent is one of the most usual ways for the production of butadiene. The process selected for this plant belongs to Nippon Zeon of Japan and presented to ARPC by MES company. The process consists of four steps of primary extractive distillation, secondary extractive distillation, direct distillation and purification of solvent.

POLYBUTADIENE PLANT: In this plant the monomer of 1,3-butadiene from butadiene separation plant will be polymerised in the presence of catalyst, and PBR is produced as an artificial rubber.

The process of Nippon Zeon has also been selected for this plant presented to ARPC by MES company.

The polymerization will be performed in a solvent in the presence of catalyst. Catalyst has a very important role in this process and diminishes the formation of the butadiens isomers to a great extent.

ETHYLENE OXIDE PLANT: In the process selected for this plant, ethylene oxide is produced by the reaction of ethylene and pure oxygen in the presence of catalyst. License of this plant has been granted by Scientific Design (SD) while design, engineering and construction up to production stage have been performed by Tecnimont on a turn key basis.

ETHYLENEGLYCOL PLANT: Ethyleneglycol is produced by the addition of ethylene oxide to water in an exothermic reaction (hydration process). The glycols (mono-di and tri) are separated in distillation columns under vacuum. The total work of this plant from design and engineering to the construction and start up is at Techninont care on a turn key basis.

2-ETHYLHEXANOL PLANT: The process for the production of 2-ethylhexanol and butanols is comprised of three production sections namely synthetic gas production, 2-ethylhexanol, normal and isobutanols sections. In the first stage, natural gas Converts to Synthesis gas ($Co + H_2$) in an endothermic reaction. In the second stage propylene and synthesis gas react in an hydroformylation reaction in the presence of rhodium complex as catalyst in aqueous phase. The reaction is exothermic and a mixture of normal and izobutyraldehyde is produced. Normal butyraldehyde will be converted to 2-ethylhexanol in the aldolisation unit and this aldehyde is converted to the final 2-ethylhexanol after hydrogenation.

A mixture of normal and isobutyraldehyde after hydrogenation will be converted to normal and isobutanol. For this plant the Oxo process of Davy Mc kee has been selected and the design and engineering have been performed by Abay Company.

ANNEX 6.8.

16.05.1994

Visit to

ARAK ENGINEERING COMPANY

Collocutors: **Dr. M.-S. PARVIZI**

Main problems discussed:

1. Engineering experience of the company.
2. Possible cooperation through UNIDO for technical assistance in petrochemical fields: solvent production,catalysts, analysis, laboratory equipment, a.s.o.
3. Possible cooperation with some developed countries in the field of research and engineering activities.
4. Equipment production assimilation in Iran for static and dynamic technological items.
5. Exchange of information between research and engineering sectors, to speed-up the transfer of the technlogies from the research to the commercial scale.
6. Environmental protection in petrochemical units.

ANNEX 6.9.

Visit to

POLYMER RESEARCH CENTER OF IRAN

Collocutors:

1. **Dr. S.A. HASHEMI** - Deputy Director in Research and Head of Composite Section

2. **Dr. M. NEKOOMANESH** - Deputy of Plan and Designing

In 1986, an independent polymer research center known as, the Polymer Research Center of Iran was established in Teheran. It is euipped with the most sophisticated laboratory equipment.

Short term goals:

- Assisting in the education and the training of the skilled manpower required by the industry;
- carrying out basic research project in the field of polymers;
- acquiring the know-how for the mass production of polymers.

Long term goals:

- acquising the necessary know-how in the production processes of engineering plastics;
- monitoring the commercialisation of new plastic products, with emphasis in their applications;
- development for composites materials: plastics, rubber and fillers.

There are some specific laborators, like: cromatography, thermal analysis, spectrum analysis. microscope section, physical and mechanical properties, rheology laboratory, elastomer workshop, plastics workshop, composite workshop, pilot plant workshop, computer services and library.

ANNEX 6.10.

18.05.1994

Visit to

MINISTRY OF AGRICULTURE

Colïocutors:

M.H. SHARIFI YAZDI - Deputy Managing Director of Fertilizer Distibution and Pesticide Production Company

The objectives of this company are: fertilizer distribution and pesticide production in IRAN.

Annual consumption of fertilizers in Iran:

1. Urea	- 1.200.000 tons
2. D.A.P.	- 1.000.000 tons
3. Ammonium Sulphate	- 100.000 tons
4. Ammonium Nitrate	- 100.000 tons
5. Potassium Sulphate	- 100.000 tons
Total	**= 2.500.000 tons**

Domestic supply:

90% Urea, 50% D.A.P. and the difference has to be imported.

Up to the present, Iran does not make use of NPK fertilizers but it is expected to also use NPK fertilizers and plastics for land amelioration in the future.

The Ministry of Agriculture intends to promote research works in the field of plastic product assimilation to keep the water in the land.

The distribution of the fertizers and pesticide production does not make the object of this report.

Annal Consumption of Fertilizer in IRAN (1372)

1.	Diammonium Phosphate	1,000,000 (tons)
2.	Urea	1,200,000 (tons)
3.	Ammonium Sulphate	100,000 (tons)
4.	Ammonium Nitrate	100,000 (tons)
5.	Potassium Sulphate	100,000 (tons)
	Total	2,500,000 (tons)

ANNEX 6.11.

Visit to

PRIVATE RESEARCH CENTER:
TEHRAN ENERGY CONSULTANTS

Collocutors:

A. SHAEMI	- Managing Director
M.F. ALAVI	- Energy Consultant
M.B. SHAMZADEH	- Energy Consultant

Petrocarbon Research Co., founded in 1992.

Company Profile: Research and development on petroleum and petrochemical industries and oil and gas resources engineering.

Machinery design for above mentioned activities and engineering design, economical analysis and utilization of oil and gas.

Tehran Energy Consultants, founded in 1992.

The prime objective, of the company is to provide technical advice and assistance to the oil industry in the area of reservoir management and well technology.

To open a private society in Iran is relatively easy, because the fees are: 100 us $ and in about 2 months, all inscription formalities can be fulfilled.

The main constraints are:

- private companies are not usually involved in industrial development programme by the state - owned companies;
- the payment of the service already done take long time, after the conclusion of the contracts;
- there are not logistic supports for the private companies: houses, computers, access to technical information as it is for the state-ownead homogeneous research institutes;
- no access to the advanced specialied laboratory in the field.

In spite of the fact, employee's high level knowledge, private companies are not enough involved in the Iranian industrie development.

ARAK PETROCHEMICAL COMPLEX

PLANT POLLUTION REGULATIONS

1 AIR POLLUTION STANDARDS

1.1 PLANT LIMITATIONS

1.1.1 AS GENERAL

POLLUTANT	STANDARD	NOT ALLOWED MORE THAN
Sulfur dioxide	0.03 ppm Annual Average 0.14 ppm daily Average 0.50 ppm 3-Hour Average	2 ppm
Hydrogen Sulfide		0.01 ppm
Carbon monoxide	9 ppm 8-Hour Average 35 ppm Hourly Average	
Particles	75 mg/m^3 Annual Average 260 mg/m^3 Daily Average	
Hydrocarbons & Nitrogen oxide	0.24 ppm 3-Hour Average 0.05 ppm Annual Average 0.01 ppm Hourly Average	20%

1.1.2 Regarding Equipments

1.1.2.1 Volatile Organics Storaging

Storage tanks with a capacity of more that 60000 liters are permitted to be in service, if:

ARAK PETROCHEMICAL COMPLEX

1.1.2.1.1 It handles enough high pressure and is equipped with a " double deck pontoon" or "internal floating cover" and their auxiliaries. This is only for the organics with a vapor pressure less than 568.85 mm Hg (as actual condition in the tank).

1.1.2.1.2 The tank sample point should be covered except during sampling intervals.

1.1.2.1.3 The tank should be equipped with vapors recycle facilities. If other vapor control facility is used it should be approved by " Sazeman Mohyt Zist".

1.1.2.1.4 Any volatile organic storage tank with a capacity of more than 2000 liters should be equipped with special loading pipe. The pipe should go down to the tank bottom.

1.1.2.2 Volatile organics loading in any storage vessel is prohibited, unless it is equipped with gases and vapors collector or an equivalent equipment. The loading pipe connection to the storage should be sealed.
The pipe is also to be drained safely after any loading operation. The loading valve should automatically be closed when the tank is filled up.
Collected gases and vapors, if not sent out to burner, should be compressed and recycled to the main storage.
If any other facility which has at least an efficiency of 90% is to be used, should be approved by "Sazeman Mohyt Zist".
This is permitted for loading capacities of less than 90000 liters per day.

1.1.2.3 Pumps and compressors which handle volatile organics. They should be well-sealed and their gas and vapors corresponding control facility should be approved by " Sazeman Mohyt Zist".

ARAK PETROCHEMICAL COMPLEX

1.1.2.4 Vent Gases:

1.1.2.4.1 Venting gases from the plant is prohibited, unless it is burned at least 0.3 sec. in a high temperature at 700 C (in a furnace or a catalytic incinerator with a termpera-ture indicator on its outlet.

1.1.2.4.2 No purging or blow-down without mentioned facilities is permitted.

1.1.2.5 Separators: each single stage or multistage separator which has a capacity of 800 liters/day or more, and its feed is a pure or mixture of oil-oriented products, should be equipped with the same facilities as mentioned in items 1.1.2.1.1 and 1.1.2.1.2 or 1.1.2.1.1

1.1.2.6 Working with Organic Solvents

1.1.2.6.1 Venting more than 7 kg/day or 1.5 kg/hr through any machinery or equipment, which organics in presence of oxygen are heated in that, is prohibited, unless it is purified from its hydrocarbons by 85%.

1.1.2.6.2 Outlet products or by-products is permitted to be flowed, if mentioned venting from corresponding machinery or equipment was performed.

1.1.2.6.3 Venting more than 20 kg/day or 4 kg/hr organics through any machinery or equipment which handles other organics than mentioned, especially if they are active photochemical fluids, is prohibited, unless before venting to atmosphere it is purified from hydrocarbons by 95%.

1.1.2.6.4 Sending out the air coming from an air or heating drier during the first 12-hour operation since start-up , is also regulated by the same standards mentioned above.

1.1.2.6.5 Venting more than 1500 kg or more than 225 kg/hr organics through any machinery or equipment which a non-photochemical organics is flowing through it, is prohibited; unless it is purified from hydrocarbons by 85%.

1.1.2.6.6 Any solution produced is also permitted to flow if its corresponding machinery or equipment could be vented according mentioned regulations.

1.1.2.6.7 Solvents which are used for cleaning purposes, also should be treated as mentioned in 1.1.2.6 .

1.1.2.6.8 The drainage or excess organic vapors should be treated by one of the following ways:

1.1.2.6.8.1 Burning: so that at least 90% organic carbon is converted to carbon dioxide.

1.1.2.6.8.2 Absorption.

1.1.2.6.8.3 Any other way which is approved by "Sazeman Mohyt Zist".

1.1.2.6.9 The burner or equivalent equipment should be equipped with necessary instrumentation which is suggested by "Sazeman Mohyt" for pollution control purposes.

1.1.2.6.10 Any process which includes venting more than 6 lit/day of active photochemical solvent should not be used.

ARAK PETROCHEMICAL COMPLEX

1.1.2.6.11 Active photochemical solvents are those with more than 20% by volume of the solvent contents the following:

1.1.2.6.11.1 Hydrocarbons , Alcohols, Aldehyds, Esters, Ketones with an unsaturated Olefines or cyclic structures.

1.1.2.6.11.2 Aromatics molecules (with eight carbon atoms) except ethylbenzene.

1.1.2.6.11.3 Ethylbenzene, some ketons, tricolor-ethylene or toluene 20%.

1.2 Working area limitations:

The following standards are based on eight hours per day and fourty hours per week or working durations:

Pollutant	8-hour Average ppm	15-minutes Average ppm
Sulfur dioxide	2	-
Nitrogen dioxide	3	5
Hydrogen sulfide	10	15
Methyl mercaptan	0.5	-
Ethyl mercaptan	0.5	-
Buthyl mercaptan	0.5	-

It should never happen to receive more than four times the 15-minute average limits, during any 8-hour working period; and the happening intervals should not be less than 60 minutes.

ARAK PETROCHEMICAL COMPLEX

1.3 Living Area Limitations:

Pollutant	Concentration
Methyl mercaptan	$9x10$ mg/m^3 for 20 minutes
Propylene	1.5 ppm for 24 hours
Ethylene	0.1
	0.5 ppm for one hour

ANNEX 8

RESEARCH ORGANIZATION IN PRIVATE SECTOR

The policies of the Ministry of Industries for the advancement of the targets of the first economic social, and cultural plan to lay the foundation for industrial research system and dissemination of the research in the private sector could be also benefic to strengthening the relations between the researchs and the industrialits in solving their problems and thus leading to self-sufficiency.

Taking into consideration the global experience and reviewnig industrial research activities shows that in order to organize industrial research system it is essential to establish a draw of research units and to take advantage of the expertise and the finaces of the non-goveramental sector (see-appendix).

The society of the Centers for scientific and industrial researchs of IRAN follows up its activities with 150 members in the following fields: crude oil processing, chemical and petrochemical industries, pharmarceuticals, pollution control of the environment, electric and electronics, metal industries, foodstuffs, nou-ferrous minerals, medical engineering and miscellaneous industries.

RESEARCH ORGANIZATION FOR PETROCHEMICAL INDUSTRY IN PRIVATE SECTOR

No	Nome	Field of activity
1.	Tehran Hydrocarbon Co. 22. 2st. Dashtestan St. Pasdaran Ave. Tehran Tel. 243520-242882	Research on hydrocarbon synthesis, polymers, process design for chemical, petrochemical and refineries industry.
2.	Rubber Industries Engineering-Research. Co. 62 West Bagherkhan Ave. Tehran, PO Box 158-5981 Tel. 920225 - 920965	Development of rubber and type industries: consulting, research and training.
3.	Petroleum, Gas and Petrochemical Research Center Tehran, PO Box 19395 - 4918 Fax : 6005819 Tel. 918238	Research and industrial projects for chemical, petroleum, gas and petrochemical industries
4.	Petrocarbon Research. Co. Apl. 16, N° 17, North Saba Ave. Tehran Tel. 6405749	R & D on petroleum and petrochemical industries and oil and gas resources
5.	Process Research Center N° 255 Gh. Gahmanpoar Alley, South Kamranyeh St. Farmanyeh Av. Tehran, PO Box 19395/4341 Tel. 2582674	Chemical Industries process design
6.	Khodpash Services Institute N° 10-2n floor N 164 Bldy Keshavans Blvd. Palestine Ave. Tehran, Tel. 918241	Machines design for chemical processes
7.	Chemical Industries Research Group. N° 10,,4th Alley, Azita Sf. Mirdamad Blvd. Tehran, Tel. 2224652 Fax : 266059	Applied research in Chemical industries
8.	Petrokimya Research Center N: 2/23 Jalali Shofar Alley Jamaizadeh Ave. Tehran, Tel. 936915	Applied research on new processes in petroleum technologies.

ANNEX 9

LIST
OF THE COMPLETED RESEARCH PROJECTS

1. Technology of alcoholic fuel and the possiblity of implementing the relevant project in the country.
2. Application of short fibres in the rubber continuous phase.
3. Design of the nitrile and chloroprene latex compound for production of industrial gloves.
4. Preparation of compound of special elastomers.
5. Replacement of polypropylene film by solofan in foodstuff packages.
6. Production of resins with petroleum base on pilot plant scale.
7. Preparation of siliconic resins for dyes to be resistent against heat.
8. Survey on hard PVC formulation and the mode of application thereof in the industries of extrusion basis.

ANNEX 10

HOMOGENEOUS RESEARCH INSTITUTE

1. (ISIRI) Standard Institution (m.o.Industry).
2. Material & Energy Application & Research center (m.o.E).
3. IROST: IRANIAN Research orga. (for science & technology)
4. Pasteur Institute (m.o.Health).
5. Power research center (m.o.power).
6. Polymer technology R&D center.
7. Atomic Energy Research center.
8. Chemistry & chemical Engineering Research center.
9. Genetic Engineering research center.
10. Communication Research center.
11. Past & disease control .orga.
12. Agricultural Engineering Research center.
13. Iranian food Industry Research center.
14. NIOC R&D Center.
15. Environmental Research center.