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"MASTER PLAN FOR DEVELOPMENT OF THE CHEMICAL INDUSTRY IN ISLAMIC REPUBLIC OF IRAN

DP/IRA/86/007/21-01/

Technical report: Implementation of the computer Decision Support System MIDA-UN1 and application of MIDA methodology to programming development of the chemical industry in Iran.

Final Report

Prepared for the Government of Islamic Republic of Iran by the United Nations Industrial Development Organization acting as executing agency for the United Nations Development Programme

Based on the work of
JSRD: Joint Systems Research Department
of the Academy of Mining and Metallurgy, Cracow, and
of the Industrial Chemistry Research Institute, Warsaw, Poland

United Nations Industrial Development Organization
Vienna

ABSTRACT

This report summarizes results of the work done by Joint Systems Research Department of the Institute for Control and Systems Engineering in the Academy of Mining and Metallurgy, Cracow, Poland and of the Industrial Chemistry Research Institute, Warsaw, Poland for the
Master Plan for Development of the Chemical Industry in Iran within the UNIDO Project DP/IRA/86/007.

The activity at the Development Projects of the Chemical Industry (DPCI), the Ministry of Industry in Teheran, began on June 7th, 1987, and terminated on July, 15th, 1987.

The major task of the JSRD mission in the project for the Master Plan was implementation of a decision support system (Multiobjective Interactive Decision Aid - MIDA) and supply of a relevant methodology (MIDA methodology) for programming development of the chemical industry. This was done by installation of the computer system which was functionally modified for specific requirements of the user (MIDA - UN1) and by three case studies worked out for representative technological networks called *Production Distribution Areas - PDA*. Two of the PDA were selected for the organic chemistry (one called Petrocomplex , the other called High Tonnage Organics - HTO) and the third PDA comprised selected plants of the inorganic chemistry. The transfer of know-how was performed both by lectures and seminars as well as by consultations and training ("learning by doing") organized for DPCI personnel and invited quests.

Following the output of the mission it is recommended to continue the work done by application of MIDA to other branches of the chemical industry. To fulfill these tasks a continuous improvement of knowledge of the systems analysis methods (especially mathematical modelling and linear programming techniques) as well as of computer skills are indispensible.

CONTENTS

I. INTRODUCTION

The activity and output of the mission of Joint Systems Research Department of the Institute for Control and Systems Engineering in the Academy of Mining and Metallurgy, Cracow, Poland and of the Industrial Chemistry Research Institute, Warsaw, Poland contracted within the *UNIDO Project DP/IRA/86/007* is a contribution to the
Master Plan for Development of the Chemical Industry in Iran.

The mission took place at the Development Projects of the Chemical Industry (DPCI) which is a counterpart organization related to the Ministry of Industry in Teheran. It began on June 7th, 1987, and terminated on July, 18th, 1987. According to the schedule assumed, two team members, namely Prof. H.Gorecki (senior scientific advisor of JSRD) and Mr. J.Wojtania (senior industrial advisor) left earlier after completion of their mission three and four weeks correspondingly.

The report on the project outputs in organized in the following way:

- a concise presentation of the methodology applied that introduces key ideas and terminology used in the further chapters is given in Section II (preliminary section),

- major activities performed within the project with references to corresponding pieces of the documentation are reported in Section III; this comprises an overview of the scope of the work and its particular components as education and training, implementation of the MIDA-UN1 system, installation of chemical technologies database (SRI profiles) and description of the case studies concerning three selected branches of the chemical industry (this part together with Sections IV and V constitute a body of the report),

- performance and technical properties of the computer equipment on which MIDA-UN1 system is installed in DPCI are assesed, and their implications for the present and future implementation of the system are described in Section IV,

- the list of the documentation delivered to DPCI with a brief description of the contents of consequtive volumes is put to Section V,

- final conclusions and recommendations are included into Section 6.

The report is therefore constructed as a reference to all the results of the JSRD mission and as such it is a guide through the material concerning MIDA-UN1 installation and application for the project. This material has been delivered to DPCI and is available upon request. It falls into the following volumes:

1. Guide to Programming Development of the Chemical Industry.

2. MIDA-UN1, Multiobjective Interactive Decision Aid, User's Manual.

3. MIDA-UN1, Computer System, Installation Manual,

4. Database for SRI Technological Profiles, User's Manual,

5. Application of MIDA to High Tonnage Organics (HTO) PDA and Inorganics (INO) PDA Cases.

Moreover, according to the briefing document being an integral part of the terms of reference, the following documents were references for the mission:

a) Contract NO. 87/9,

b) Terms of Reference of May 1987, including the briefing note of the backstopping officer J.A. Kopytowski,

c) Intermediate report of consultant 11-51,

d) Final report of consultant 11-52,

e) Chemical origin and market-SRI,

f) Chemical conversion factors and yields-SRI,

g) Working paper on UNIDO Technical Assistance to "Integrated Chemical Industry Development".

Following the outputs of the project, it is recommended to continue the work done by application of MIDA to enhance the scope of the analysis both by introducing new branches of the industry into the analysis as well as by defining new scenarios relevant to changing conditions and goals of the development. As the first step, the results of work on the two case studies (HTO and INO) perhaps with some further evaluation and refinement, should become an integral part of the Master Plan. It is also suggested that DPCI would work out country-specific methodological procedures to integrate MIDA type of the analysis with methods used by the Government of the Islamic Republic of Iran. This can also include selected UNIDO methods for evaluation of industrial projects.

II. METHODOLOGY

To accomplish the major tasks of the project, the computer Decision Support System (DSS) called *MIDA-UN1: Multiobjective Interactive Decision Aid* was implemented and installed in DPCI office. The system is devised to support decision makers who deal with the analysis for *Integrated Development Programming* of various branches of the chemical industry. MIDA-UN1 can guide and assist the decision maker in the following steps of the analysis:

* characterizing strategies of technological development,

* specifying goals of development,

* determining impacts of development strategies (in terms of resources and indicators assumed for the analysis),

* indicating strategies best suited to the goals.

To support the analysis, the system is integrating the information to analyze alternative strategies. Therefore the system incorporates a database that organizes and stores all information necessary for Integrated Development Programming (as it is described in the *Guide to Programming Development of the Chemical Industry* and *Working Paper on UNIDO Technical Assistance to Integrated Chemical* Industry Development").

In order to deal effectively with such a complex problem area, a disciplined system approach has been applied that combines comprehensive identification of the technological and economic reality with tools and relevant methodology based on mathematical programming techniques and computer DSS.

The MIDA approach to the problem uses a concept of a *PDA - Production Distribution Area* network as a model of the inflows and outflows of the basic resources involved in production, distribution and development processes. This model of the chemical industry provides the planner and decision maker with basic information on the industry in terms of products, intermediate products, raw materials, production levels and capacities, prices, foreign exchange, investment required for the new plants etc.

The decomposition of the whole industrial structure into PDAs (tightly connected industrial networks) is necessary for efficient analysis of large-scale production systems. Each PDA model transforms a technological and market conditions into economic indicators and criteria that evaluate whole industrial structures or their selected components (technologies) being considered for development. The evaluation process covers both processing and distribution of chemicals. Only by joint analysis of these two factors one can undertake an approach of the integrated development programming.

By incorporating the technological knowledge into the PDA model(s), MIDA methodology fills the gap between the corporate- and macro economy levels. Unlike the both levels of the analysis, this one particularly takes into account the technological context of the development and therefore it is helpful in analysis of long-lasting consequences of the technology choice.

In general, the PDA model organizes data that comprise:

- the processing and flows of chemicals within the PDA,

- the flows of chemicals into and out of other areas or industries representing the marketing or business activity of the PDA,

- the flow of investment, revenue and other resources such as energy, manpower etc,

- economic conditions of the PDA activity such as prices, taxes and other policy measures.

The PDA model provides a basis for formulating decision problems concerned with the *generation of efficient development alternatives* for a Production- Distribution Area . A variety of alternatives to be analysed comes as an effect of possible *substitution* among raw materials, production goals and technologies.

This key feature of the chemical industry opens way to selection of the production structure best suited to the existing constraints and possibilities. This is done by formulation of objectives (preferences) and constraints (limitations of the development) constructed within the framework of the model and structured into a so called *development thesis* (assumptions for the development program).

Starting with the *development thesis* MIDA supports analysis of impacts both on technological and economic side. Particularly, for assumed objective(s) and constraints, the system generates the most efficient (optimal) technological structure of a PDA. It means that it selects a coherent network of technologies that best suit the assumed conditions and therefore assure integrated development of the industry considered within the PDA.

MIDA UNI allows for doing analysis for a set of decision criteria that are representative for development programming and selected by the decision maker as the best one for the case in question. The user can use either single linear criteria (e.g. net profit), fractional criteria that are the efficiency measures (e.g. simple rate of return on capital) or combination of criteria applied simultaneously (multiobjective optimization).

The PDA model is designed to be applied interactively. Each run of the model yields guidance for new data development and new issues to address by expanding (or diminishing) the structure of the model. Thus, the model provides a framework to effectively answer 'what if' questions concerning development strategies. In this sense, the user performs the analysis by doing *simulation experiments* with the model by means of the computer system.

MIDA-UN1 computer system is a tool devised to support the user with computer programs to apply the development programming method called MIDA methodology.

The system has been designed as a *menu-driven, screen oriented* and *user-friendly* DSS. Consequently, it means that everybody who operates the system is guided with a hierarchically organized collection of menus that contain all functional options that the system offers. Therefore no direct calls to the computer operating system are required and the software incorporated to the system is transparent to the user.

It means that *no* computer knowledge is necessary for an appropriate use of the system, except the system installation.

III. JSRD ACTIVITY IN THE PROJECT AREA

The contracted work covered all the project targets, namely:

1) Implementation of the software system defined in the terms of reference and the contract (MIDA-UN1 version of MIDA computer system),

2) Computer implementation and analysis of three selected technological networks or PDAs to assess industrial development alternatives that satisfy the desired production goals with an efficient consumption and appropriate allocation of critical resources such as investment, energy and manpower,

3) Design and implementation of database for SRI technological profiles (as acquired from Process Economics Program of SRI, 1986, and other issues),

4) Training and teaching of the counterpart staff on seminars and during "learning by doing" exercises.

Before the computer equipment was sent and installed in the DPCI office, it had been thoroughly tested by the JSRD specialists at the supplier's premises. As certain discrepancies between the purchase order and parameters of the hardware and software delivered occurred ("Report on the testing of the computer system", DP/IRA 36/007/41-00), a supplementary delivery was done. At DPCI the computer system was installed by JSRD team that comprised all the work necessary to make the computers operational in the network configuration before the MIDA-UN1 system could be implemented. It was necessary because of a lack of technical service provided by the supplier while DPCI personnel is not qualified to deal with such a task.

The selection of the technological profiles to be analysed was a result of the joint work of both teams. The knowledge of the DPCI personnel concerning chemical technologies and their inventive attitude towards the problems connected with development are to be highly appreciated. This created a very good atmosphere for the collaboration and is opening hopeful prospects for the future application of the method and the computer tools.

In parallel to the preparatory work for the analysis, a number of lectures and seminars were given to the DPCI personnel and invited specialists. They were mainly focused on the methodology to be applied but also were intended to give a more broad view on the mathematical programming methods with emphasis on linear programming and multiobjective optimization.

The two case studies assumed in the framework of the contract were enhanced by a third one that was prepared as a preliminary example called "Petrocomplex PDA case study". The Petrocomplex PDA comprised 43 technologies rooted in ethylene, propylene and benzene as basic feedstocks. A series of experiments was performed according to a procedure that illustrates basic steps of analysis for development taking into account specific conditions of Iranian petrochemical industry. Some simplifications were intentionally introduced in order to maintain educational character of the case. The procedure proposed, however, is recommended to be applied to other cases of organic chemical industry, and as such the analysis was incorporated to the *Guide for Programming Development of the Chemical Industry* which was prepared by JSRD and delivered to DPCI for the project implementation. As a result, DPCI was provided not only with an educational case study, but also with a useful operational PDA model which can be used in the future work in the Master Plan.

The two major case studies comprised analysis done for the so-called High Tonnage Organics PDA (HTO) and Inorganics PDA (INO). In the first one, a network consisting of 97 installations was assembled and analysed, of which [illegible] plants are actually in operation and some are suspended while the majority can be foreseen for implementation. The number of chemicals and other media used for the production is about 220. The basic source information for new plants was derived from SRI International PEP Yearbook, 1986. For a big number of technologies taken for a preliminary selection according to the assumed wide range of final products, a major effort was invested in the assembling of the PDA network together with appropriate evaluation of economic conditions of the development. Because of the large size of the tightly connected network, the generation of consistent development alternatives and their precise and comprehensive evaluation were performed owing to the highly efficient and multifunctional MIDA-UN1 computer system. The whole case study was described in the separate volume (see the volume on *HTO and INO PDA Case Studies*.

The second case, although of a smaller size, required an extensive preparatory work because of the unique character of the technological profiles. All the parameters had to be revised and recalculated, if necessary, in order to meet the standard of input data for MIDA-UN1 system. The production system including 63 processes run on [illegible] installations was put together and investigated (about [illegible] chemicals and other media were of concern). The description of the study is also enclosed separately (see the volume on *HTO and INO PDA Case Studies*). In both cases all the input data as well as scenarios for the analysis were prepared jointly with the DPCI representatives. As a reference for scenario definition the Technical Report of UNIDO No

DP/IRA/86/007/11 52/Rev.1/J 1202 as well as other materials being at the disposal of DPCI were used.

For the case-specific optimization experiments it was necessary to implement some new functional options of MIDA-UN1 system on request of the user. Especially the set of optimization criteria was altered and a set of global values that can be constrained were added. To enable convenient and reliable transmission of the data stored in SRI database to the MIDA-UN1 database where PDAs for further analysis are defined, special procedures were designed and installed.

Unfortunately, the computer work was affected by power cuts that made it burdensome and caused a risk of permanent damage of the software and the equipment. For these reasons it is strongly recommended to install the electric generator already purchased by UNDP as soon as possible.

Concluding, all project targets were reached. The additional work was done to facilitate the user's future work both with a theoretical background as well the computer tools.

A. Education and Training

The educational program of the JSRD work for DPCI comprised a two-fold activity: theoretical courses of applied systems analysis oriented on development programming of the chemical industry and practical training with MIDA computer system. Particularly, the main points of the program were as follows:

- two seminars on MIDA methodology for Integrated Development Programming given to DPCI personnel as well as to invited guests from Ministry of Plan & Budget, Ministry of Oil & Gas Industry and Minstry of Industry in Iran, National Petroleum Company and National Oil Company. Also some representants of the industry were present. The seminars were led by Dr. Maciej Zebrowski, head of JSRD.

- courses on fundamentals of systems analysis and mathematical programming given by Prof. Dr. Henryk Gorecki, scientific advisor of JSRD, during his three week stay with DPCI. This also comprised individual consulations for the permanent staff and invited persons.

- two lectures in the Ministry of Plan and Budget entitled: "Development of of Complex Systems" by Prof. Henryk Gorecki and "Integrated Development Programming related to Macroeconomic Planning" by Dr. Maciej Zebrowski.

- two lectures in the Ministry of Oil and Gas entitled: "Multiobjective Decision Making - Review of Multiobjective Optimization Methods" by Prof. Henryk Gorecki and "MIDA Methodology in the Integrated Development Programming for Gas, Oil and Chemical Sector with Emphasis on Energy Analysis" by Dr. M.Zebrowski.

As a continuation of the first two lectures, a discussion in DPCI was arranged on request of the Ministry of Plan and Budget representatives. Especially, a group from the Regional Planning Bureau of the Ministry participated in the meeting.

To provide the participants of the lectures with concise information about MIDA approach and the computer system, a leaflet was prepared on request. Moreover, as a support and reference materials *Guide for Development Programming of the Chemical Industry* and handouts of the lecture and courses by Prof. Gorecki (250 pages) were delivered. The materials are available in the DPCI library. To support training with the computer system the *MIDA User's Manual* was provided. The practical training of the DPCI personnel was individually adjusted to responsibilities and skills of the staff.

B. Implementation of MIDA-UN1 System

MIDA-UN1 is the version of MIDA computer system tailored for specific application of MIDA methodology for programming development of the chemical industry in Iran. For the locally unique tasks and conditions of the development, several requirements for the system's functional modification has been taken into account as a result of cooperation with DPCI. All the functions offered by the system are described in the *MIDA-UN1 User's Manual* and therefore here only those options that are case-specific are briefly reported. The proposals for *new* or *modified* functions of the system and their implementation after discussion with DPCI concerned:

* a set of objectives and constraints corresponding to the goals and circumstances of the development,

* a set of indicators corresponding to evaluation measures used by decision makers responsible for the development of the industry in Iran,

* a mode of the system's operation as best suited to the needs of the user and subject to limited capabilities of the computer equipment (see *MIDA-UN1 Installation Manual* and Chapter IV of this report).

In particular, three types of optimization (i.e. single linear objective-, single fractional objective- and multiobjective-optimization) were implemented with respect to the following criteria:

1. PDA Net Income (NI),
2. PDA Manufacturing Value Added (MVA),
3. Fixed Capital Investment (FCI),
4. Energy Consumption (EC).

On the basis of the above criteria it is possible to define derivative criteria as e.g. NI/FCI, MVA/FCI as well as multicriteria sets to show a compromise and trade-offs between output an input resources (gains and costs).

As a representative set of case-specific constraints the following values were agreed and implemented:

- global investment cost, i.e. an assumed upper limit of the investment value, that are to be allocated into the development program,

- global imports value, i.e an upper limit of foreign expenditure both on purchase of final products and raw materials and semiproducts.

These constraints are necessary to reflect the situation that building up the Master Plan is restricted by comparatively scarce funds in foreign exchange. Besides the global constriants, the user can impose particular limitations (bounds) on production or availability of selected items.

It has been discussed with DPCI, the development programs expressed in terms of selected production structure of the industry are globally evaluated by means of the following indicators:

- PDA Net Income - NI,
  - FCI,
  - NI/FCI,
  - PDA Import,
  - Manufact. Value Added - MVA,
  - MVA/FCI,
- Production Profit :
  - Simple Rate of Return :
  - Production Import :
  - Manufact. Value Added MVA
  - MVA/FCI :
  - MVA/Value of Production
- Export,
- Domestic Purchase,
- Domestic Sale,
- Energy Consumption,
- Direct Labour.

As can be observed, the above indicators are classified into two categories that correspond to the PDA as a whole and to the production system itself. This was done to explicate evaluation of development program from two various viewpoints. The indicators are calculated after an experiment for an assumed scenario representing a development program is run. Some of the aggregates give criterion value(s), the other are simple performance indicators. The program is corrected for the recalculated investment costs corresponding to the full capacities assumed for the plants (the calculated production levels as corresponding to the optimal solution can be a portion of the maximum capacity assumed). In specific, this comprises the corrected value of FCI and other indicators that use this value as a component.

Moreover, to support a preanalysis of the PDA, a single plant evaluation procedure was worked out. This concerns a *separate plant (installation)* analysis based on the information stored in the database. The factors that are retrieved and calculated comprise:

Capacity,

Fixed Capital Investment - FCI,

Product Value - PV,

Total Manufacturing Cost,

Profit,

Simple Rate of Return,

Pay-back Period,

Manufacturing Value Added - MVA,

MVA/FCI,

MVA/PV,

PV/FCI,

Energy Consumption.

The mode of the system installation and operation has to be enhanced by the functions to make its operation possible and efficient despite the limitations of the hardware and software delivered. In particular, the following features had to be implemented:

1. the special structure of the optimization module (OPTIMIST) to make it a stand-alone tool (see the references above). This required an additional, user-friendly interface to support input/output operations beyond the MIDA-UN1 system,

2. two versions of OPTIMIST to increase efficiency of calculations by adjusting the version to a size of the problem.

In addition to the software work, in order to facilitate operation of the system for the users not familiar with the linear programming technique and computers, easily written but comprehensive documentation was adopted.

C. The Database of SRI Technological Profiles

The Database of SRI Technological Profiles stands for a computer, relational database designed and implemented for storing information on chemical technologies descibed by Stanford Research Institute (SRI). This information is at the disposal of DPCI. The database was implemented as an additional software to MIDA-UN1 but it can be used as an independent unit.

The database fulfills the same standard as the MIDA database and follows the pattern of the MIDA database as much as possible. This concerns the similar structures of the databases and the same operation rules to enter, store, manipulate and retrieve information organized into database. Therefore all instructions of the data handling contained in the *MIDA-UN1 User's Manual* hold for the SRI Database with exception of the calling and quitting commands (appended to the *MIDA-UN1*Operation/Installation since the database in not an integral part of MIDA but a stand-alone computer tool.

Because the MIDA system is to use some substantial information from the SRI database, a link between the two databases was foreseen and implemented. It allows for automatic transmission of data concerning selected technological profiles from SRI to MIDA database that is of special importance while assembling a new PDA for the analysis or modifying an existing one (the data retrieval procedure is described in *Database for SRI Technological Profiles*.

Besides the role that SRI database plays in connection with the MIDA system, it can be used as an independent data bank useful for other customers. It provides all the facilities of relational databases, i.e. convenient and powerful functions responsible for data entry and retrieval. All these mechanisms are described in detail in the *MIDA User's Manual*. Similarly to the MIDA database the user is provided with the forms that are input vehicles of the data into the SRI database. These forms are different from the MIDA forms, but they are similar to the pattern of original SRI description of the technologies, that makes them self-explanatory.

D. The Petrocomplex case study

This case study concerns programming development of a PDA of organic chemistry called Petrocomplex. The set of the technologies being analysed originated from the DPCI concept to show an application of MIDA methodology related to a production-reality of the Iranian chemical industry.

Keeping in mind a real applicability of the analysis it was intended, however, to maintain an educational style of the study which inevitably caused some simplifications and limitations. Even though, for the sake of comparative analysis as well as to convey a wider range of development scenarios, the network of Petrocomplex comprising about 20 technologies selected by DPCI had been complemented with more than 20 installations. Owing to the extensions introduced, the case study is a representative example of the MIDA-methodology for an organic chemistry PDA.

The technological network considered in the case study comprises of chemical profiles rooted in ethylene, propylene and benzene as basic feedstocks.The set of profiles selected for the analysis included those provided by DPCI as well as alternative additional technologies derived from semi or by-products that occur in the network.

A main idea of selection of the profiles can be summarized along the following main points:

1. the analysis concentrates on main processing chains selected with respect to well defined production lines,

2. only those chains that have technological units of economic scale are of concern,

3. technological repertoire consists of possibly integrated processing complexes in order to avoid situation where PDA produces outputs that are substantially troublesome, useless or difficult to sell (possible utilization or further processing should be foreseen).

4. very sophisticated or risky technologies are considered with reservation.

The supplementary technologies are complementary to the initial structure of the PDA and, on the other hand, they aim at fulfillment of the production goal determined in the UNIDO report Nr. DP/IRA/86/007/11 52/Rev.1/J [illegible] (based on the work of E. Zawada). The set of the additional technologies corresponds to the following main directions:

1. production of ethylene, propylene, pyrolisis gasoline and C4 fraction from naphta,

2. processing of C4 fraction from the ethylene cracking, i.e.:

   - buthadiene extraction,
   - buthadiene processing (PB, SBR, BS, ABS),
   - utilization of C4 fraction from the buthadiene extraction, i.e. MTBE production and/or acetic acid and formic acid,

3. processing of pyrolytic gasoline to aromatics, basically to benzene, and consequently production of:

   - caprolactam,
   - adypic acid,
   - hexamethyldiamine,
   - phenol

   as a feedstock for production of polyamide fibers,

4. extension of the basic network as well as of the directions 1, 2:

   - methanol production for its further processing to: acetic acid, MTBE, methylmetacrylate,
   - hydrogen production for hydro-dealkylation pyrolysis gasoline to benzene,
   - LLDPE production,
   - perchloroethylene production,
   - methylmetacrylate production (to utilize of hydrogencyanide from acrylonitrile production),
   - production of acetic acid from methanol

Concluding, the above extensions aim at development of the chemical industry towards production of:

a. synthetic rubbers and elastomers; PB, SBR, BS,

b. polyamide fibers based on caprolactam (nylon 6), adypic acid and HMDA (nylon 66),

c. phenol for resins, dyes, paints, medicines and pesticides,

d. MTBE as addititives to gasoline,

e. other plastics; MM, ABS.

A goal of the development strategy for Petrocomplex can be expressed as a profitable fulfillment of the estimated demand for products. The investment must be efficient as much as possible and lead to foreign exchange savings. It leads to a selection of the ratio *profit vs. investment* to be maximized as a objective for the development. There is a strong preference to minimize purchase which in this case is equivalent to lowering of import expenditure. The data were available for one market only and it was assumed that in general the purchase represents imports while sales are equivalent to export but can be also considered as a domestic sale.

For technical reasons some additional constraints are assumed, that means the purchase of nontransportable intermediates is prohibited. This forces the own production within Petrocomplex if such a production is indispensible due to the case considered. No specific constraints are imposed on availability of raw materials and intermediates except of the only constraint on a purchase of nontransportable media such as hydrogen, chlorine, syngas etc.

Having the problem formulated, a sequence of experiments was run by means of MIDA system. They were selected and sequenced following a basic procedure appropriate for the analysis of such a class of cases. The procedure falls into two steps. In Step 1 a preliminary evaluation of the PDA is performed. The calculations aimed at estimation of the minimal investment cost necessary for fulfillment of the production goal regardless its profitability. A series of experiments shows a relationship between the minimal value of the investment and import volume concerning both purchase of some raw materials, semi-products or final products. Therefore, they illustrate the impact of substitution of import by investment located into development of the domestic production.

In Step 2 a profitability analysis follows. The scenario comprises of a goal which is the profit maximization subject to constraints imposed on investment and demand for final products (both upper bounded). Under the above assumptions, again a series of experiments was performed. The results indicate on the most profitable production structures corresponding to various levels of investment. A certain flexibility of fulfilling the production goal was allowed by imposing upper bounds on the final production. Obviously, for a given investment, the maximum profit corresponds to the best value of simple rate of return on investment. Finally, we can observe that maximum of the efficiency ratio i.e. profit vs. investment is fulfilled.

The relationships between the maximum profit values and investment levels as well as MVA values corresponding to optimal profits were investigated. Correspondingly, relationships between efficiency ratios and investment are calculated.

The results of the Petrocomplex case study are reported in detail in the *Guide of Development Programming of the Chemical Industry*.

E. High Tonnage Organics (HTO) PDA Case Study

This case study concerned the organic chemicals PDA selected together with the specialists from DPCI. Selection of the technological profiles to be taken into account is motivated by the main goal of the Master Plan that is to rise production of plastics, rubbers, fibers and heavy tonnage organics on the base of rich natural resources of the country (natural gas and crude oil) and basing on the existing industry.

It was impossible and meaningless to jointly analyse all sectors of the chemical industry as they were listed in the Table 3 of the UNIDO Report DP/IRA/86/007/11-52/Rev.1/J 1202 based of the work of E. Zawada. Let us comment the last statement in brief.

Application of the PDA model requires careful preparation of assumptions concerning a general strategy of development as well as precise development lines for particular industries. It should lead to a preliminary selection of technologies to be candidates for the development in order to get a well defined, consistent and important PDA with respect to the goals of MP.

It should be realized that basically, any PDA model transforms a technological knowledge into economic parameters that evaluate industrial structures being considered for development. In a case of complex models a number of factors that are likely to influence the optimal solution can be too big for analysis of important relationships within the model by means of backwards reasoning (i.e. from the output economic parameters to the particular determinants of the solution). Therefore, a general strategy in MIDA methodology is to select tightly connected industrial networks and then to analyse them separately and coordinate programs derived for various branches. Such an approach allows for better consideration of different nature of branches and for case-specific analysis.

Having the above in mind, however, the HTO PDA that was selected for the analysis represents a large scale network. It covers about 50% (by weight) chemical products excluding fertilizers and inorganic chemicals. The set of plants comprises technological profiles that produce derivatives of optional petrochemical raw materials such as gas oil, naphta, LPG and natural gas. The production can be split into six groups of main petrochemical products and heavy tonnage organics as e.g.:

- basic petrochemicals (olefines and BTX),

- auxiliary intermediates (methanol, phenol, chlorine etc.),
- plastics,
- rubber;
- fibers,
- some auxiliary intermediates for production of paints and other branches of the industry.

In the network, the existing, currently being implemented and new (potentially to be built) plants were of concern. Below the lists concerning all three categories of plants are included.

1. Exiting Plants

name of installation	capacity
NYLON 6 MELT - PARSILON COMP.	16000.00
NYLON 6 MELT - ALYAF COMP.	10000.00
POLYETYLENE THEREFTALATE POLYACRYL COMP.	55000.00
DI-OCTYL PHTALATE - IRAN - NIPPON	40000.00
PHTALIC ANHYDRIDE IRAN NIPPON	22000.00

2. Plants under implementation

name of process	capacity
ACRYLONITRILE ARAK	33000.00
VINYL CHLORIDE FROM ETHYLENE ARAK	150000.00
PVC ARAK	150000.00
VINYLACETATE ARAK	30000.00
ACETIC ACID ARAK	30000.00
PE HD ARAK	60000.00
CHLORINE ARAK	100000.00
PE LLD ARAK	60000.00
POLYPROPYLENE ARAK	5[illegible]000.00
BUTADIENE ARAK	26000.00
POLYBUTADIENE ARAK	25000.00
ETHYLENE ARAK	240000.00
DMT ISFEHAN	65000.00
BTX ISFEHAN	85000.00
P-XYLEN ISFEHAN	44000.00

3. New Plants (planned for a potential implementation)

name of installation

ETHYLENE FROM GAS OIL
ELTHYLENE FROM ETHANE-PROPANE MIXTURE

ETHYLENE FROM WIDE RANGE NAPHTA MS
ETHYLENE FROM WIDE RANGE NAPHTA HS
BENZENE FROM PYROLYSIS GASOLINE
MIXED XYLENES FROM NAPHTENIC FEED
MIXED XYLENES FROM PARAFFINIC FEED
BENZENE FROM TOLUENE
P-XYLENE RECOVERY CRISTALIZATION
P-XYLENE (PAREX)
P-XYLENE RECOVERY (ADSORPTION)
BUTADIENE FROM C4 EXTRACTION
METHYL METHACRYLATE CYANOHYDRIN PROCESS
ISOBUTYLENE BY ACID EXTRACTION (CFR)
MTBE FROM MIXED BUTENES
D-ETHYLHEXANOL (OXO PROCESS)
PROPYLENE OXIDE BY ETHYLBENZENE PROCESS
PROPYLENE OXIDE BY CHLOROHIDRINE PROCESS
POLYOL TRIFUNCTIONAL POLYETHER
BUTENE-1 FROM MTBE RAFFINATE
ISOPROPANOL BY CATION EXCHANGE RESIN
DI-OCTYLPHTALATE FROM PHTALIC ANHYDRIDE
PHTHALIC ANHYDRIDE AIR OX. OF O-XYLENE
METHYL ETHYL KETONE FROM MTBE RAFFINATE
METHYL ETHYL KETONE FROM ISOBUTYLENE RAF
TRIETHANOLAMINE FROM EO END NH3
POLYMETHYLMETHACRYLATE
PERCHLOROETHYLENE FROM PROPANE
PERCHLOROETHYLENE FROM EDC
HYDROGEN FROM NATURAL GAS
PHENOL (CUMENE)
CHLORINE (MEMBRANE PROCESS)
METHANOL FROM NATURAL GAS
POLYETHYLENE LD (AUTOCLAVE REACTOR)
POLYETHYLENE LD (TUBULAR REACTOR)
POLYETHYLENE LLD (UCC)
POLYETHYLENE LLD (DUPONT)
POLYPROPYLENE (AMOCO)
POLYVINYLCHLORIDE BY SUSPENSION POLYMER.
POLYVINYL CHLORIDE BY EMULSION POLIMER.
VINYL CHLORIDE BY OXYCHLORINATION
VINYL CHLORIDE FROM EDC
VINYL ACETATE FROM ETHYLENE
ACETIC ACID FROM ETHYLENE
ACETIC ACID FROM METHANOL
POLYSTYRENE EXPANDABLE
POLYSTYRENE HIGH IMPACT
ABS BY EMULSION/MASS POLYMERIZATION
STYRENE BY BENZENE ALKYLATION
ETHYLBENZENE LIQUID PHASE
ETHYLENE DICHLORIDE BY CHLORINATION
ETHYLENE DICHLORIDE BY OXYCHLORINATION
POLYETHYLENE HD (UCC)
POLYETHYLENE HD (PHILIPS)
STYRENE-BUTADIENE LATEX
STYRENE-BUTADIENE RUBBER BY EMUL.POLYM.

STYRENE-BUTADIENE RUB. BY SOL.POLYMER.
POLYBUTADIENE
BUTYL RUBBER
POLYISOBUTYLENE
NYLON 6 MELT
CAPROLACTAM FROM CYCLOHEXANE
CAPROLACTAM FROM TOLUENE
CAPROLACTAM FROM PHENOL
CYCLOHEXANE BY HYDROGENATION OF BENZENE
POLYETHYLENE TEREPHTALATE MELT FROM DMT
POLYETHYLENE TEREPHTALATE MELT FROM TA
TEREPHTHALIC ACID FROM P-XYLENE
DMT FROM P-XYLENE
ETHYLENE GLYCOL AND ETHYLENE OXIDE
ACRYLONITRILE BY PROPYLENE AMMOOXIDATION
SYNTGAS (2:1) FROM NATURAL GAS
SYNTGAS (3:1) FROM NATURAL GAS
CARBON MONOOXIDE FROM SYNTGAS
OXYGEN BY AIR FRACTIONATION

The destroyed or suspended plants were not included to the analysis except those of Iran - Japan Company being damaged less than 30%. The above installations were of concern in one of the experiments while changing the demand vector.

The technological repertoire to be analysed was judged to be rich enough (75 plants) to consider all reasonable alternatives of the development. Each plant was characterized by:

1. capacity in tons/year as related to a main product,

2. raw materials consumption/ton of the main product,

3. by-products production/ton of the main product,

4. utilities consumption/ton of the main product,

5. investment costs for battery limits, offsites and total,

6. operating labor.

For each plant three different production capacities were considered. As far as existing plants were of concern, the data were supplied by DPCI. New plants were characterized be the data acquired from Process Economics Program of SRI, 1986, except of 3 plants that were described according to SRI Report, 1978, and other 4 ones described in Chemical Process Economics, CHEM SYSTEMS International Ltd, Second Edition, 1980.

The potential capabilities of the network were confronted with the production goal which corresponds to the demand vector assumed. The potential capabilities of the network were confronted with the production derived from the UNIDO report as mentioned above. The demand vector was differentiated up to two time-periods:

a) 1987 - 1992; the reconstruction phase,

b) 1993 - 2000: the development phase.

For the demand vectors, a series of optimization experiments was performed. As a result of the calculations and adjacent analysis, feasible tradeoffs between investment levels and imports values were determined provided that the demand is fulfilled and that each development program assures maximization of PDA Net Income over Investment (the optimization criterion).

For comparison, a series of calculations was done to generate development programs that maximize Production Profit, regardless fulfilling the demand but taking into account a feasible level of the domestic market consumption.

All the calculations were done provided that the Arak and Isfehan complexes will run on the full capacities.

The essential problem that was encountered during the analysis was that the demand vector is generally not balanced with the capacities of the existing or currently implemented Arak and Isfehan complexes. On the other hand, the assumed range of the demand as determined in the report based on the work of E.Zawada, does not correspond to economically feasible capacities of new plants (that are supposed to produce the same products as Arak and Isfehan).

Therefore, the following alternative strategies of the development have been suggested and consequently a number of analyses was performed. In the first variant the investment program would aim at building plants of economic capacities although their potential would exceed the production level determined by the demand. The excessive production would be exported in the first period and then consumed by domestic market on the level forecasted for year 2000. To make the development program realistic, upper bounds on production were imposed according to sell ability of the products on the foreign market. In the second variant, the installations having small capacities as fitted to the current (1992) demand vector would be rejected from the investment program. To fulfill the demand, missing amounts of the products would be imported.

Both programs as above can be recommended as they are economically feasible on the contrary to a solution that assumes small-scale production. If the latter assumption had to be maintained for some reasons, it would be recommended to search for an unconventional technologies that could not be incorporated into the analysis of HTO PDA.

The detailed results of the analysis are appended to the volume that reports the case study.

F. Inorganic Chemistry PDA Case Study

This case study concerns analysis of inorganic chemical industry technologies assembled into a complex production-distribution system called INO PDA. A preliminary selection of the technologies was done by DPCI and personnally by P. Rozwadowski (UNIDO expert) and A.A. Jafari (DPCI specialist of inorganic chemistry). The selection was motivated by a main target of the Master Plan that is integrated and efficient development of the inorganic chemical industry indispensible for other branches of the industry and the market. On the other hand, it was adjusted to natural resources of the country.

The INO PDA comprises both a low-tonnage technologies as well as mass production of e.g. soda ash, sodium glaze, precipitated calcium carbonate, sodium water glass, sodium metasilicate etc. that altogether amounts to 63 processes run on 58 installations. Only the new (those that are potentially to be developed) technologies were taken into account in the analysis. All processes of concern are listed as follows:

process name	capacity
ANTIMONY TRIOXIDE	2000.00
ALUMINUM SULPHATE	30000.00
ARGON	750000.00
BARIUM CHLORIDE	2000.00
BARIUM CARBONATE	3000.00
LITHOPONE 30%	10000.00
LITHOPONE 60%	10000.00
BARIUM HYDROXIDE	1500.00
SODIUM TETRABORATE (BORAX)	5000.00
BORIC ACID	8000.00
SODIUM PERBORATE	20000.00
PRECIPITATED CALCIUM CARBONATE	10000.00
PRECIPITATED CALCIUM CARBONATE(TOOTH P.)	1000.00
CALCIUM CARBIDE	60000.00
CALCIUM HYPOCHLORITE	5000.00
CALCIUM CHLORIDE	10000.00
AMMONIUM CHLORIDE	4000.00
SODIUM BICHROMATE	3000.00
SODIUM CHROMATE	1000.00
POTASSIUM BICHROMATE	1000.00
ANHYDROUS CHROMIC ACID	1000.00
CHROMOSAL - BASIC CHROMIUM SULPHATE	2000.00
COPPER OXIDE (BLACK)	40.00
COPPER OXIDE (RED)	100.00
COPPER SULPHATE	2000.00
CRYOLITE - ALUMINUM SODIUM FLUORIDE	4200.00
ALUMINUM FLUORIDE	2200.00
HYDROGEN FLUORIDE	1000.00
IRON OXIDE (RED)	2000.00

FERROFERRIC OXIDES (BLACK)	1000.00
FERROUS SULPHATE	1000.00
LEAD OXIDE (RED)	2000.00
MAGNESIUM OXIDE	50000.00
MANGANESE DIOXIDE	2000.00
MOLYBDENUM TRIOXIDE	140.00
NICKEL SULFATE	500.00
SODIUM TRIPOLYPHOSPHATE	50000.00
SODIUM HEXAMETAPHOSPHATE	1000.00
SODIUM PYROPHOSPHATE (DIBASIC)	300.00
TRICALCIUM PHOSPHATE	7500.00
DICALCIUM PHOSPHATE	40000.00
POTASSIUM CARBONATE	1000.00
POTASSIUM CHLORATE	1000.00
POTASSIUM NITRATE	2000.00
SODIUM GLAZE	25000.00
SODIUM WATER GLASS	60000.00
SILICA GEL (MACRO)	1500.00
SILICA GEL (MICRO)	1500.00
SODIUM METASILICATE	10000.00
SODIUM THIOSULPHATE	1000.00
SODIUM HYDROGEN SULFITE	4000.00
SODIUM SULFITE	2000.00
SODIUM HYDROSULFITE	2000.00
SODIUM CHLORIDE (MEDICAL)	1500.00
SODIUM NITRATE	8000.00
TITANIUM DIOXIDE	20000.00
ZINC SULFATE	1000.00
ZINC CHLORIDE	4700.00
MOLECURAL SIEVE-ZEOLITES (cl. 3A)	500.00
MOLECULAR SIEVE - ZEOLITES (cl. 4A)	500.00
MOLECURAL SIEVE - ZEOLITES (cl. 5A)	500.00
MOLECURAL SIEVE - ZEOLITES (cl. 13X)	500.00
SODA ASH	100000.00

For each of the technologies, the single plant evaluation was performed. This comprised calculation of the performance indicators as described in the Section B of the report (e.g. PV, IMC, MVA, Profit and Simple Rate of Return). After the evaluation had been done, the technologies that were estimated as economically infeasible for their low capacities, were again investigated with re-scaled capacities.

In the next step, the analysis was performed for the whole INO PDA, it means that all technological connections between the installation were taken into account. For the sake of the analysis, a series of computer experiments was run to generate efficient development programms according to maximum production profit subject to assumed investment levels. Detailed results of the analysis for various investment values (changing in 50 Mill. $ intervals up to the level of full implementation of the whole set of technologies) are given in the seperate volume: *Application of MIDA to HTO FDA and INO FDA Case Studies.*

The results of the analysis were submitted to P.Rozwadowski and A.A.Jafari to support the ultimate expertise of the development program by repeated rescalling of some plants and elimination of some technologies. In addition, the results of the single plant evaluation and the production goal (demand) for the year 2000 were taken into account. The list of finally selected installations with their capacities is given below.

process name	capacity
ANTIMONY TRIOXIDE	3000.00
ALUMINUM SULPHATE	35000.00
SODIUM TETRABORATE (BORAX)	15000.00
BORIC ACID	12000.00
SODIUM PERBORATE	50000.00
PRECIPITATED CALCIUM CARBONATE	100000.00
PRECIPITATED CALCIUM CARBONATE(TOOTH P.)	4000.00
CALCIUM CARBIDE	60000.00
CALCIUM HYPOCHLORITE	7000.00
AMMONIUM CHLORIDE	1000.00
SODIUM CHROMATE	1500.00
POTASSIUM BICHROMATE	2000.00
ANHYDROUS CHROMIC ACID	1500.00
COPPER OXIDE (BLACK)	40.00
COPPER OXIDE (RED)	400.00
COPPER SULPHATE	2000.00
CRYOLITE - ALUMINUM SODIUM FLUORIDE	2700.00
ALUMINUM FLUORIDE	2700.00
IRON OXIDE (RED)	7000.00
FERROFERRIC OXIDES (BLACK)	5000.00
FERROUS SULPHATE	3500.00
LEAD OXIDE (RED)	4000.00
MANGANESE DIOXIDE	11000.00
MOLYBDENUM TRIOXIDE	2500.00
NICKEL SULFATE	300.00
SODIUM TRIPOLYPHOSPHATE	70000.00
SODIUM HEXAMETAPHOSPHATE	1000.00
TRISODIUM PHOSPHATE	7500.00
DICALCIUM PHOSPHATE	40000.00
POTASSIUM CARBONATE	3000.00
POTASSIUM CHLORATE	4000.00
POTASSIUM NITRATE	6000.00
SODIUM GLAZE	32000.00
SODIUM WATER GLASS	80000.00
MOLECURAL SIEVE-ZEOLITES (cl. 3A)	1000.00
SODIUM METASILICATE	80000.00
SODIUM THIOSULPHATE	1000.00
SODIUM HYDROGEN SULFITE	8000.00
SODIUM SULFITE	12000.00
SODIUM HYDROSULFITE	9000.00

SODIUM CHLORIDE (MEDICAL)	2500.00
SODIUM NITRATE	12000.00
TITANIUM DIOXIDE	50000.00
ZINC CHLORIDE	6500.00
SODA ASH	150000.00

All particular results of the analysis is appended to the volume reporting the case study.

IV. ASSESSMENT OF THE COMPUTRR EQUIPMENT

For the implementation of the MIDA-UNI system at [illegible], the below specified computer equipment was delivered:

1. one IBM AT microcomputer in the following configuration:

   - processor 80286, 6 MHz,
   - co-processor 80287,
   - RAM 640 kB,
   - Color Graphic Monitor and CGA Card
   - one RS232 serial port,
   - one Parallel Centronix port,
   - 20 MB Hard Drive,
   - 1,2 MB Floppy Drive,
   - 2 x 20 MB IOMEGA Bernoulli Box with interface,
   - IBM PC-Net Card,
   - Epson Printer LQ 1000 with a tractor and cut-sheet feeder,
   - 1.5 MB Exp. Memory.

2. two IBM XT microcomputers, each in the following configuration:

   - processor 8088, 4.77 MHz,
   - co-processor 8087,
   - RAM 640 kB,
   - Graphics Monochrome Monitor and Hercules Card,
   - one Parallel Centronix port,
   - 2 x 360 kB Floppy Drives,
   - IBM PC-Net Card.

3. Additional equipment and supplies:

- PC-Net Basis Multiplexer,
- 3 cables (25, 100 250 ft),
- 40 floppy disks,
- 4 Bernoulli removable cartridges,
- one Bernoulli cleaning set,
- paper for the printer (3 boxes of 10" and 2 of 15")
- ink ribbon for the printer (10 ea)

Moreover, the following software was purchased:

a) IBM DOS 3.2 Operating System,

b) XENIX V 2.0 Operating System,

c) Manx Aztec C [illegible] Package ver.3.4 (DOS),

d) MS Fortran ver.4.0 (DOS),

e) MS Word Text Processing System (DOS),

f) MINOS/GAMS LP Package (DOS),

g) INFORMIX-SQL DOS ver.2.0 (single user)

h) INFORMIX-ESQL DOS ver.2.0 (single user); the library of programs for the Microsoft C compiler ver.3.0,

i) PC-Net Program ver.1.10 (DOS),

j) diagnostic software (AT, XT).

The hardware and software delivered is sufficient to organize a computer network running under MS-DOS. The IBM AT is a "host" or "server" computer while both IBM XT play a role of the "receivers". Thus, the network system is a multiuser one, because it is possible to get access to the mass storage of the server from the receivers (but of course the simultaneous access to different files only is allowed).

The implemented configuration is advantageous for the office work (reservation systems, text processing etc.), but unfortunately it cannot efficiently support MIDA-UN1 system which belongs to the class of the engineering or scientific computer applications. This is mainly caused by a low speed of the computers as well as by a substantial "losses" of RAM resources to be used by MIDA-UN1 software because the network programs require 300 kB of RAM on the server, and 100 kB of RAM on the each of the receivers. On the other hand, the core module of MIDA-UN1, i.e. the optimization package has to use 500 kB of RAM which of course excludes a possibility of running it on the AT computer as far as it is used as a server. In this situation the package can be installed on the XT computer but in this case it runs very slowly (because of low frequency of the processor).

Moreover, it has to be explained that the sofware delivered (as on the list above) does not fit to the network system. One example is the version of the Infornix Database System which was cannot use the network facilities. Therefore, it is impossible to access the same database from two or three computers at the same time.

As opposed to the above configuration, it is possible to work without the network. This solution naturally, "unburdens" the AT computer, making, however, the two XTs practically useless for the MIDA-UN1 system. Moreover, it reduces a reliability of the system (especially if a failure of the AT happened).

Besides the configuration of the whole system, the hardware delivered also causes bottlenecks of the system's performance. Particularly, parameters of the Bernoulli mass storage as applied to such a system can be questioned. The disks are much slower than Winchester drives which in addition causes fatal transmission errors during the work of the network. The IBM AT computer can run under XENIX system installed on a part of the hard drive. Due to a lack of RS232C serial ports on the XT computers, however, it is impossible to take a crucial advantage of XENIX that is the powerful *multiuser* operating system (and therefore the equipment is limiting the usage of XENIX for one user only). An additional shortcoming of the hadware is the "expanded memory" that cannot be accessed by XENIX. To avoid this difficulty, the card should be reconfigured as a "extended memory", otherwise a substantial resource of RAM is useless. The reconfiguration can be done by a qualified service. Another limitation of the system's performance under XENIX is connected with the Bernoulli drives that cannot be accessed by XENIX.

The above remarks can be concluded in a constructive way as a proposal on improvement of the system, especially to rise the MIDA-UN1 efficiency. The following changes in the system's structure are strongly recommended:

- replacement of the network and Bernoulli Box with additional Winchester drives for AT and both XT computers. In addition, a purchase of a "tape streamer" with the interface, is suggested,

- installation of RS232 serial ports, one on each XT computer, and the missing port(s) on the AT computer,

- reconfiguration of the "expanded memory" into the "extended memory".

The modifications would result in having three independent, efficient systems running under DOS and alternatively a real multiuser system running under XENIX. To impiement the suggested configuration, the following equipment should be purchased:

a) two Winchester drives, each 20 MB capacity, (two disks with controllers for the XT computers),

b) two RS232 serial ports for XT computers,

c) two cables for RS232,

d) one RS232 serial port for AT computer.

V. MIDA-UN1 DOCUMENTATION

The documentation delivered concerns both the MIDA methodology as well as operation of the MIDA computer system. It falls into five volumes:

1. Guide for the Programming Development of the Chemical Industry,

2. MIDA-UN1, Multiobjective Interactive Decision Aid, User's Manual,

3. MIDA-UN1 Computer System, Installation Manual,

4. Database for SRI Technological Profiles, User's Manual,

5. Application of MIDA to High Tonnage Organics (HTO) PDA and Inorganics PDA Case Studies.

Guide for the Programming Development of the Chemical Industry, offers a methodology capable of proposing possible restructuring and/or structuring of various sectors of the chemical industry. The systems analysis approach proposed takes into account a variety of interrelated and alternative production processes (either in use or under development), compares their efficiency, their consumption of different resources etc. and finds the combination of technologies that best meets particular needs while staying within the limits imposed by the availability of resources and environmental constraints.

The guide is directed toward those who are already acquainted with the chemical industry or, at least, have experience in its selected branches and subsectors. It concerns specifically planners, industrial economists, technologists, chemical engineers and other experts. Decision makers especially those responsible for development are most important in this game. They are assumed to be not only experienced in the field but willing to absorb the approach presented and open to rethinking their views as well. The experience is to be combined with the methodology propo[illegible]

The material comprised in the guide is assumed to accompany the regular, case study based course of the "learning by doing" type. Even though it has been prepared as an assistance for such extensive course it offers a self-contained knowledge on the subject and can be used independently from the course. In such case, however, at least basic knowledge of the programming development is to be assumed.

The guide represents the knowledge and expertise of JSRD for which we take full responsibility for the know how offered.

MIDA-UN1, Multiobjective Interactive Decision Aid, User's Manual cont : all information which is necessary and sufficient for a ppropriate operation of the MIDA computer system. The system is a tool devised to support the user with computer programs to apply MIDA methodology for programming development. The manual was substantially extended and enhanced during the mission to facilitate the users who have a limited background in computer science.

The manual falls into two parts. The first one provides the user with a general description of the system to make him familiar with the system's structure and to help him to associate particular functions with the system's architecture. In the second part all particular functions are described in the order as they are implemented on the consecutive levels of the system's menus. All additional information that can be useful for performing advanced functions of the system is enclosed in the appendices.

MIDA-UN1 Computer System Installation Manual is a concise reference booklet of the system's installation and maintenance as well as a "lifeboat" instruction if some failures or damages of the system occur.

Database for SRI Technological Profiles contains the inf ation on the format and contents of the database designed and implemented to store the data concerning technological description of chemical technologies according to Process Economics Program of SRI. It refers to the MIDA-UN1 User's Manual as the database operation mechanism is unified with the MIDA-UN1 database. Additional information concerns the data transmission procedure to the MIDA-UN1 database.

Application of MIDA to High Tonnage Organics (HTO) PDA and Inorganics (INO) PDA Case Studies" The volume contains all results of the two major case studies performed with application of MIDA methodology as referred to in the Section III, Chapters E and F.

VI. CONCLUSIONS

The results of JSRD work on the Master Plan for Development of the Chemical Industry in Iran can be summarized as follows.

The scope of the work done covered the tasks contracted. The additional work was done, however, to facilitate retrieval of data from SRI database to MIDA database, to improve efficiency of the computer equipment and reduce effects of frequent power failures. Some extra effort was also invested in preparation materials about MIDA on request of the participants of the seminars and lectures.

Generally, MIDA methodology and the computer system proved their usefulness for the customers from DPCI. Nevertheless, further augmentation of the technological and computer knowledge of the users of the system are indispensible. It is recommended to perform this task by trainig DPCI own staff and recruitment of specialists familiar with computers and linear programming techniques. While a comprehensive knowledge of the chemical technology of the DPCI staff should be highly awarded, their collaboration with senior industrial experts should be maintained and even developed.

The case studies done with the contribution of DPCI are representative examples of MIDA methodology and what's more important they were assessed to be meaningful for the Master Plan. It should be a good starting point for further and permanent analysis for development of other areas of the chemical industry. The HTO case study should be continued with special emphasis on "policy measures exercises" (e.g. with respect to rate of interest, depreciation, exchange rate) as well as analysis of impacts of other decisive factors as prices of raw materials, value of location factor etc. Especially market analysis should be carried out to evaluate the export potential with respect to various products. A special attention must be put to local prices adjustment. In such a kind of analysis MIDA system will prove its usefulness; first through evaluation of the exchange rate - the official one versus the shadow value, second through evaluation of MVA both with respect to social and industrial profitability. The latter type of the analysis must be preceded by local prices adjustment.

All the analyses should provide decision makers with important hints for establishing long range economic policy. The Petrocomplex PDA could be developed with assistance of NPC to support evaluation of existing and foreseen projects (such as Arak and Isfehan complexes). Specific recommendations are included in the volume on the case studies.

The Master Plan must be performed as a per[illegible] activity; next cases are expected to cover downstream processing towards resins, paints etc. It is suggested that a Master Plan will cover the 10 years time horizon, while a longer time span up to 15 years will be used for forecasts.

As an ultimate goal of the MIDA application it has been proved that using MIDA substantially limits the amount of work on pre-feasibility and feasibility studies since it allows to do numerous prefeasibility analyses for evaluation of complex industrial networks in a convenient and efficient way (*simulation experiments*). As it can lead to reduction of the alternatives to be a subject of further investigation, the system also saves effort in the stage of feasibility study.

M I D A - UN1
Multiobjective Interactive Decision Aid

Application to
High Tonnage Organics PDA and Inorganics PDA
Case Studies

July, 1987
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CONTENTS

1. Introduction

This volume reports on results of the two case studies concerning High Tonnage Organics PDA and Inorganic Chemistry PDA prepared for the
Master Plan for Development of the Chemical Industry in Iran
within the UNIDO Project DP/IRA/86/007.

Both cases were carefully selected as a part of the DPCI main task it is the work for the Master Plan (MP). At the same time it was decided that the analysis of the cases will be done with MIDA methodology using MIDA-UN1 Decision Support System. The methodology and the sytem supplied by JSRD are, as it is explained in the Final Report, a practical tool for preparation of the MP, this is what is understood by the term of Integrated Development Programming (see *Working Paper on UNIDO Technical Assistance to Integrated Chemical* Industry Development" MIDA-UN1 is a special version of MIDA system which was developed to fit needs and requirements of DPCI.

This volume consists of two parts. Part one covers the introduction and the first two chapters, namely 2 and 3. Chapter 2 explains the problem of the development of the chemical industry in Iran. It identifies structural dependencies in the Iranian economy in a broader global context of other countries; both developed and developing ones. The results of this overview point out a development delay of the chemical industry both with respect to other developing countries and to the Iranian economy. As a result, there is a gap between a relatively well developed consumer market-oriented branches of the chemical industry and heavy feedstock producing branches that utilize domestic resources. This situation led to a growing dependency on imports which slows down the whole economy. Due to the damages caused by war the situation is even more grave despite the great effort of the country expressed in allocation of the highest investment to the chemical industry in the decade of 70-ties.

From the thorough analysis done by the experts E.Sawada and P.Rozwadowski and jointly by DPCI and JSRD as synthesized in Chapter 2, the development thesis for the MP thus also for the HTO and INO PDAs is as follows:

* Master Plan must be based on the approach called Integrated Development Programming.

* Development of the chemical industry is to be considered as a vehicle of the economic development of the country, and if the development is to be directed towards decreasing dependency on import, a basic priority would be exploitation of natural organic and inorganic resources.

* Two areas namely HTO and INO are selected as a special case studies of the development of the chemical industry.

* Investment must be directed towards lowering imports both by HTO and INO as well as to related industries.

* Investment must be at the same time allocated with possibly maximum attainable rate of return on investment.

In elaboration of the material, a very valuable contribution of NPCI and especially of Dr. E.Karimzadegan with respect to Chapter 2 are to be greatly acknowledged. The contribution of J.Sajadi to Chapter 3 on HTO and of A.A.Jafari and P.Rozwadowski to Chapter 4 on INO is to be appreciated.

The results of the analysis proved that the High Tonnage Organics PDA constitutes a key domain in development of the chemical industry. The PDA includes production of five groups of products and intermediates:

- basic petrochemicals (olefines and BTX),

- auxiliary intermediates (methanol, phenol, chlorine etc.)

- plastics,

- rubbers and fibers,

- some auxiliary intermediates for production of paints and other products. As is shown in Chapter 2, 60% of the chemical import (2-2.2 Bill. $ in 1983) was allocated into the petrochemicals, of which about 1.2 Bill. $ into the HTO.

The second case that of Inorganic Industry or INO which does not play a very significant role at present, deals with a new opportunity for Iran since the country is very rich in raw materials for the inorganic industry. This branch was examined very carefully by UNIDO expert (see report ....) during his mission which is a part of the Master Plan. In fact, CSRD closely collaborated in the case of INO PDA with P. Rozwadowski and A.A. Jafari who completed the second part of the above report. Owing to this coincidence both studies are complementary and can be treated as a mutual references.

The analysis based on MIDA methodology was done for HTO and INO; the results are reported in Chapters 4 and 5 correspondingly with specific conclusions and recommendations.

2. Master Plan for the Development of the Chemical Industry in Iran and HTO, INO PDAs Cases.

2.1 Global Comparison - a Background

A base for the Master Plan of the Industrial Development is provided by national goals and strategies for development defined for the long term. In the case of Iran, the national goals of the development have not been formulated in a way which would provide indications and goals for Master Plan of Development of the Chemical Industry. This situation calls for strictly pragmatic sectoral industry-oriented approach to elaboration of the Master Plan of the Chemical Industry.

In this approach an identification of demand for final and intermediate products provides production goals which for chemical branches in question represent a strategic assumption about the development of branches and industries being consumers of these products. This is especially so since the chemical industry due to its role of feedstock supplier to other industries is to be considred as a main driving force for the industrial development. This is specifically a case of Iran which is rich in natural resources being a feedstock of the chemical industry.

The demand or Demand Product Vector (DPV) has been identified and systematised and on the results of the analysis by P.Rozwadowski and A.A.Jafari as well as other numerous sources, DPV was further evaluated by D[illegible] and [illegible] and used in this study.

To the above background an important illustrative factor may be provided with some statistical data. This will be done from the global point of view down to the sectoral and branch level within the chemical industry. Table I shows the ratio of Industrial Production Value to GNP Value for developing and developed countries. With the proportion as 1 to 2 in a favour of developed economies, it shows that the ratio is relatively stable in the developed economies even with a tendency to decrease (data available up to 1978) due to a growing role of non-industrial economic activities. While in the developing economies this ratio shows a steady growth since it is far from the saturation. As we turn our attention to Table 2, we find that the ratio of Total Value of Chemical Production vs. Total Industrial Production is again stable in the developed economies (on the average level of about 20%, from 1960-1978). Developing countries show quite clear growing trend. What is even more important it shows that the rate of development of the chemical industry exceeds distincly the rest of the industries as a whole.

Unfortunately, in the case of the Iranian economy, the data available for the period of 1973-198[illegible] indicate that the average growth of the chemical industry in the terms of the ratio from the Table 2, went from 11.5% to 13.6% . As it will be shown below, this relatively slow growth of share of the chemical industry in the total industrial production was accompanied by a structural development of the chemical industry which led to a growing dependency of the whole economy and this industry in particular on imports. Further insight can be gained from Table 3 which shows an average share of the Manufacturing Value added of the basic branches of the chemical industries of developed and developing countries for the period of 1970-1979. The Table shows that main portion of MVA in developed economies has been generated by utilizing natural resources of the developing countries. Since developing countries import large quantities of intermediates and final products , the process is continuously deteriorating their situation even in the case of having natural resources. Again in the case of Iran it is very much the situation with a high level of the crude oil export.

Table 4 illustrates for the case of Iran a pattern of change of MVA in the chemical industry as compared to selected sectors of the Iranian industry. It can be seen that the increase of the MVA in the Chemical Industry during the period 1973-1982 was considerably smaller than an average of the whole industry.

Additionally, Table 5 shows an average ratio of MVA to Product Value in the chemical industry and related industrial sectors. This is locating the chemical industry in a relatively good position.

Finally, in Table 6 we find an average share of Raw Material Value in the Product Value and the its dependency upon imports of raw materials. This is given by the ratio of the Imported Raw Materials Value to the Total Value of Raw Materials.

Summarising the observations so far it can be stated that:

* the chemical industry in Iran did not achieve the position it has in other countries with respect to the level and complexity of the development of its national economy. It means that the chemical industry is not developing proportionally to the other industries.

* the dependency of the chemical industry on the imports is growing rapidly which is a result of slow pace and structural path of the development of the chemical industry.

TABLE 1 Share of Value of Industrial Production in GNP for Developed and Developing Countries. (Fixed Prices)

Years	Developing Countries (%)	Developed Countries (%)
1960	10.3	28.6
1970	12.8	28.8
1978	13.7	25.8

REF :

1) Handbook of Industrial Statistics UN. Newyork, 1982.
2) Yearbook on Industrial Statistics UN. Newyork, 198[illegible].

TABLE 2 Share of Value of Chemical Production in the Total Industrial Production for Developed and Developing Countries.(Fixed Prices)

Years	Developing Countries (%)	Developed Countries (%)
1963	11.1	21.1
1970	13.6	19.2
1978	15.8	20.4

REF :

See table 1

TABLE 3 Average Share of Value Added for the Basic Branches of Chemical Industry in Developed, Developing Countries and Centrally Planned Economies in the Period 1970 - 1979.(Fixed Prices)

Industrial Branch	Developing Countries (%)	Developed Countries (%)	Centrally Planned Economies(%)
Industrial Chemicals (351)*	7	66	27
Other Industrial Chemicals (352)	18	43	39
Refineries (353)	35	49	16

* The Branches are identified According to ISIC

REF :
See Table 1

TABLE 4 Pattern of Change in Value Added in the Chemical Industry as Compared to Basic Sectors of Industries in Iran. (1973 & 1983) (Current Prices).

Industrial Sectors*	1973 Value	1973 Share (%)	1982 Value	1982 Share (%)	Average Growth 1973-82 (%)
Total MVA	122		770		23
Non-Metallic Minerals(36)	11	9	113	14.7	30
Textiles (Wearing apparel)(32)	23	19	292.8	25	26
Machinary & Equipment (38)	25	20	182	23	25
Chemicals (35) (Excluding Refineries)	18	15	81	10.5	18.2
Food, Beverage & Tobbaco(31)	32	27	126	16.4	16.3

* According to ISIC.

REF :
Evaluation of Past and Present Situation of Chemical Industry In Iran. DPCI Report No.24 , March 1986.(in Farsi). Based on Data by Central Bank & Statistical Center of Islamic Republic of Iran.

TABLE 5 Average Ratio of Value Added to Product Value in the Chemical Industry and Selected Industrial Sectors in Iran (Average of the Years 1979 - 82). (Current Prices)

Industrial Sector*	Average Ratio (%)
Total Manufacturing (300)	46
Food , Beverage & Tobbaco (31)	38
Textile & Wearing apparel (32)	50
Non-Metalic Minerals (36)	68
Basic Metals (37)	32
Machinary & Equipment (38)	44
Miscellaneous Industries (39)	55

* According to ISIC.

REF : See Table 4

TABLE 6 Average Share of Raw Material in Product Value of Basic Industrial Branches and their Dependence on Import (in the Years 1979 to 1982). (Current Prices)

Industrial Sector*	Value of Raw Materials / Value of Product (%)	Value of Imported Raw Materials / Total Value of Raw Materials (%)
Food , Baverage & Tobbaco (31)	50	49
Machinary & Equipment (38)	63	23
Basic Metals (37)	57	62
Chemical Industry (35)	40	55
Non-Metalic Minerals (36)	23	21

* According to ISIC.

REF : See Table 4

TABLE 7 Value of Import for Selected years

In chemicals , Metals and Machinary & Equipment

Item.	1977		1981		1982		1983	
	10^9 \$	% of Total	10^9 \$	% of Total	10^9 \$	% of Total	10^9 \$	% of Total
CHEM & CHEM Prods. (35)*	1,577	12.2	3.36	26.9	2.406	19.24	3.72	18.8
Basic Metals (37)	2,885	16.9	2.204	16.3	2.42	19.36	3.38	17.1
Machinary & Equipment (38)	4,279	33.1	2.63	19.5	2.42	19.39	4.66	23.5
		62 %		62.8 %		58 %		59.7 %

* According to ISIC

REF : Foreign Trade Statistics, Iran Customs Administration.

* the chemical industry is itself more and more dependent on imports despite the fact that the country is rich in natural resources,

The investment in the period of 1973-1982 was the highest of all industrial branches with a major portion of this allocated to the petrochemical industry and all that effort could substantially improve the situation , but unfortunately a decisive share of it became unoperational. On the other hand, investment in the downstream market-oriented branches such as: plastics processing, rubber an tires manufacturing, synthetic fibers, resins, paints, detergents etc. was relatively successful. This created well supplied final goods market increasing the social demand. This in turn due to a gap caused by the situation in the petrochemical industry gave way to skyrocketing imports of intermediates which normally could be supplied by the petrochemical industry. The market-oriented development should be considered as an asset since it opens potential for improving living standards. In order to trace more closely the nature of the above phenomena we should take a closer look at the imports of two chemical branches, namely High Tonnage Organics (HTO) and Inorganic Chemicals (INO). Almost 60% of the industrial Product Value is dependent on imports of raw materials, machinery and spare parts. With regard to chemicals and chemical products as well as metal industry they together comprise 40% of annual value of imports in this country.

Table 7 summarizes the imports of major items in 1981, 1982 and 1983 as presented at the First Seminar of the Polymer Science and Technology (June 1986). It shows the scale of the above import. It is significant that 60% of the chemical import are petrochemicals and polymers. For 1983 this equals to 2-2,2 Bill. $. If we take HTO alone, this would comprise a level of imports being 60% of the above, which is about 1,2 Bill. $. Another estimation accounted for the country's annual demand for synthetic fibers (242 000 Ton), high tonnage plastics (700 000 Ton), resins (50 000 Ton) and rubbers (65 000 Ton) gives total of about 1 Million Ton. With the average cost of 1 Kg 1.5 - 2 $, this amounts to 1.5 to 2 Billion $. Locally only 60 000 T is produced annually which accounts only for 5% of the demand, showing the gap but also an opportunity for the future. Both on the Goverment and Economic Council level, there exist a deep understanding of the situation which results in assigning of special priority to the development of the petrochemical industry in which HTO plays a decisive role.

Fig.1 presents a structure of the imports of all chemicals in the period 1976-1977 and 1982-1983.

The above considerations identify the past and present situation as it was developing in the course of time. In order to arrive at the forecasted demand, the analysis reported in this volume focused on Petrochemicals as the one from which the HTO has been extracted.

Table 8 (which is quoted from the report of E.Zawada) shows the growth of demand for selected petrochemical products (in % per annum) in the whole world, industrialized and developing countries from mid 70-ties up to 1990. Table 9 (elaborated from the same source) provides a forecast of the Demand Growth Rate for Plastics, Fibers and Rubbers in various regions and countries having both developed and developing economies. The data give some indication for a comparison with the demand projection as estimated by DPCI (and NPC).

In Chapter 3 (Section 3.1) particular demand figures (for products and intermediates) assumed for HTO are displayed (see Chapter 3). A main observation to be made at this stage is that it is to be difficult for Iran to attain the rate of growth of petrochemical production that would enable this country to catch up with the rest of the world. A very deep evaluation of development alternatives has to be done so as to make it possible.

With regard to the inorganic industry (INO), the situation is even more obvious, however the imports burden (see Table 8) is proportionally smaller.

The share of total import of inorganic intermediates is in average of 6-8%; 8% in 1973, 7% in 1977, 6% in 1982. An average increase over the above period (as related to current prices) was 17% as compared to 16% of the total import of the country and 20% of the chemical import (basing on "Foreign Trade Statistics, Custom and Administration of Iran for respective periods 1973-1982). The importance of INO products for many industrial sectors cannot be overestimated. Iran is very rich in minerals being a natural basis of the development of INO. This branch was carefully reviewed and results of its potential development are reported in UNIDO reports resulted from the mission of P.Rozwadowski. Since the second mission of P.Rozwadowski is to be completed concurently with the JSRD mission, it is assumed that with respect to Inorganics Industry his report will provide up-to-date justification for the selection of INO PDA for further evaluation as was recommended by DPCI.

The above considerations led to the formulation of the following development thesis which is proposed to become one of the key assumptions for the Master Plan of the Development of the Chemical Industry in Iran:

* Master Plan must be based on the approach called Integrated Development Programming.

Fig. 1 : Structure of Import of Chemicals (Percent Distribution) for Period 1976-7 & 1982-3

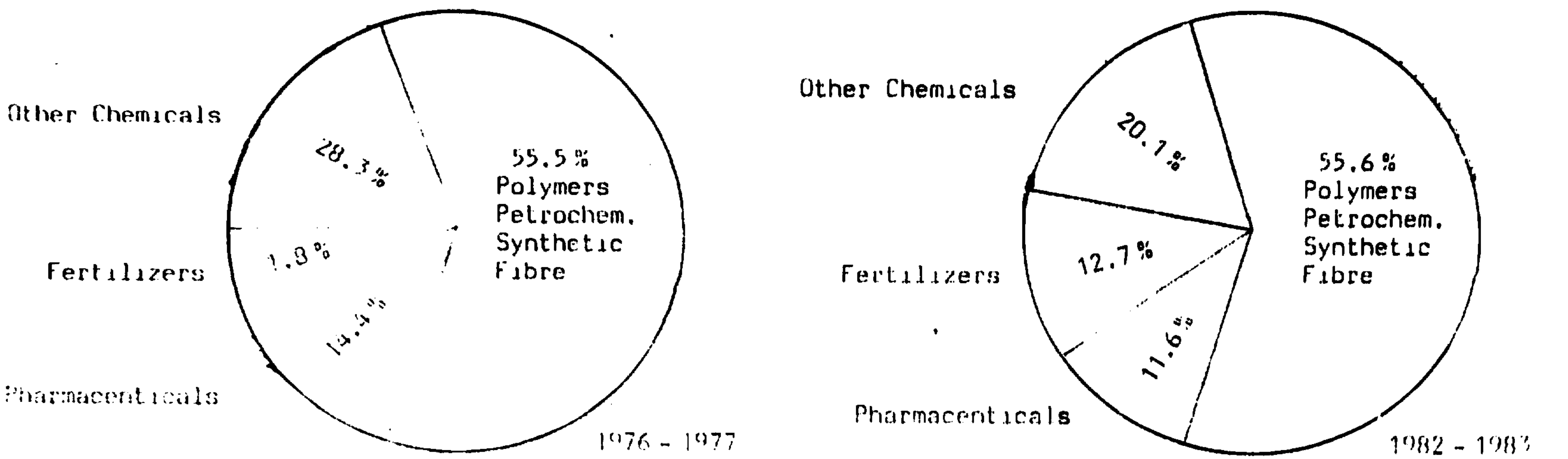

Table 8 **Growth of demand for selected petrochemical products (per cent per annum)**

Petrochemical Product	World Total			Industrialized Countries			Developing Countries		
	1975-1979	1979-1984	1984-1990	1975-1979	1979-1984	1984-1990	1975-1979	1979-1984	1984-1990
Thermoplastics									
LDPE	10.3	5.1	5.6	11.3	3.6	3.9	19.1	11.1	10.8
HDPE	17.9	6.5	6.1	16.9	5.5	4.9	24.4	11.4	11.2
PP	20.4	8.5	8.6	19.0	7.7	7.6	28.7	12.3	12.2
PVC	11.4	6.2	6.3	10.6	4.6	4.6	16.1	12.7	11.0
PS	11.9	5.4	5.9	11.2	4.7	4.9	18.1	10.2	10.6
AVERAGE	13.6	6.1	6.4	12.6	4.8	5.0	19.6	11.7	11.1
Synthetic Fibers									
Acrylic Fibers	10.3	2.8	3.6	9.4	2.1	4.0	14.1	7.1	6.6
Nylon Fibers	7.2	2.8	2.4	6.6	2.8	1.3	8.2	6.3	5.5
Polyester Fibers	9.9	5.1	3.7	8.7	4.1	2.3	13.0	7.6	6.9
AVERAGE	9.0	4.1	3.5	8.1	3.0	3.2	11.9	7.4	6.4
Synthetic Rubber									
SBR	7.2	4.2	3.7	6.6	3.5	3.2	14.3	8.3	6.0
Polybutadiene	7.8	6.3	3.2	7.0	5.6	2.8	13.7	16.7	5.8
AVERAGE	7.5	5.8	3.6	6.6	3.9	3.1	14.1	8.7	5.9

Source : Second world-wide study on the Petrochemical Industry UNIDO, ID/W.G.336/3

Table 9

Demand Growth rate for Plastics, Fibers and Rubbers

Region/country	1985-1990			1990-2000		
	Plastic %	Fibers %	Rubbers %	Plastics %	Fiber %	Rubber %
Japan	3.7	1.7	1.9	4.1	2.3	2.4
Western Europe	3.1	-4.0	1.3	4.1	3.3	2.3
North America	2.3	4.4	1	4.1	2.3	2.4
European	3.7	3.5	3	4.1	2.8	2.7
Others	5.9	-	-	4.1	-	-
Average(industrialized countries)	3.1	1.7	1.9	4.1	2.6	2.5
M.east,N.A, W Asia	14.9	-	-	7.1	22.3	-
Rest of Asia	4.9	6.7	8.4	3.6	5.3	5.2
Asian CPES	3.7	6.9	14.9	6.9	4.6	7.1
Latin America	8.2	8.4	3.1	5.0	4.5	4.6
Average (developing countries)	7.6	7.0	5.9	5.4	9.3	5.2

Source : Reworked from the Petrochemical Industry in Developing Countries, Prospects and Strategies, UNIDO/IS.572 .

* Development of the chemical industry is to be considered as a vehicle of the economic development of the country, and if the development is to be directed towards decreasing dependency on import, a basic priority would be expoitation of natural organic and inorganic resources.

* Two areas namely HTO and INO are selected as a special case studies of the development of the chemical industry.

* Investment must be directed towards lowering imports both by HTO and INO as well as related through their products industries.

* Investment must be at the same time allocated with possibly maximum attainable rate of return on investment.

2.2. Basic Assumptions and Methodological Guidelines

From the analysis summarized in the previous chapter that resulted in a general development thesis for the Master Plan and assumptions for the analysis, the two high priority areas for Integrated Development Programming namely HTO and INO PDAs were selected.

Below more specific assumptions and guidelines following from the analysis are formulated:

* The case studies are an integral part of the Master Plan.

* The time horizon of the analysis covers time-span up to the year 2000.

* The Demand Product Vector (DPV) are derived from the UNIDO reports based on the work of E. Zawada (HTO) and P. Boguadowski (INO) with collaboration of DPCI.

* Other case studies will follow in order to assure coherence and provide feedback to already completed studies.

The analysis will be based on MIDA methcdology adjusted to the cases in question and taking advantage of MIDA-UN1 system implementation.

Following are the recommendations from the report of E. Zawada which are directly applicable to the cases considered:

1. Within the assumed long term (up to year 2000), Development program of the chemical industry in Iran for which the Master Plan is being prepared the

following two planning periods are assumed:

- **Phase I (up to year 1992)** during which the rehabilitation of existing capacities and already initiated projects is to be executed.

- **Phase II (up to year 2000)** aimed at the further expansion of the chemical industry and implementation of new larger projects feasible for the MP.

2. At the Phase I, a review of existing and accepted projects (e.g. the letter of intent), projects stopped by the war or destroyed should be reinvestigated on their compatibility with the actual priorities within the strategic objectives of the national economy.

3. Basing on the consumption forecast included into the report, the capacities (one of which should be the basic capacity) for individual products and intermediates should be identified and included into the databank of the technological profiles for further investigation. Since the consumption forecast prepared by DFCI was made for international market only, the export component should be considered.

4. Investment cost of individual capacities should be recalculated by multiplying the US Gulf Coast or West European capital costs with an appropriate location factor. It is recommended to adopt the location factor of 1.2 for the seaside and 1.4 - 1.6 for interior locations (or an average value of 1.3) basing on 1.0 for US Gulf Coast.

5. Investment and production costs or values should be calculated in US $ to give a possibility for internal comparisons. However, parallel adoption of shadow price in Rials should be also considered.

The above recommendations were adopted for the HTO-PDA and INO PDA analysis and reflected in experiments.

Methodological implications for MIDA-UN1 implementation.

MIDA-UN1 is a version of MIDA computer system that is functionally modified to fit the needs of the Master Plan.

The point of departure for the analysis is the *development thesis* which expresses the goal of the development **aimed at the best fulfilment of the demand with reduction of imports and provided that the investment would be allocated in the most profitable way.**

This evidently shows that a basic trade off to be analysed is *investment vs. import*. All other types of the analysis can be also applied but they have to be related to the main line.

The following criteria, global constraints and performance indicators are implemented in MIDA-UN1 system:

- PDA Net Income (NI),
- PDA Manufacturing Value Added (MVA),
- Fixed Capital Investment (FCI),
- Domestic Investment,
- PDA Import,
- MVA/FCI,
- NI/FCI,
- Energy Consumed in PDA (EC),
- Production Profit,
- Simple Rate of Return,
- Production Import,
- MVA/Production Value,
- Export,
- Domestic Purchase,
- Domestic Sale,
- Direct Labour.

According to the above assumptions and as it was agreed with DPCI, all calculations were done in US $. Since the system is prepared for doing calculations both in foriegn and local currency (lc), the exchange rate has been assumed as equal to 1.

Now let us briefly discuss on the reasoning of MIDA methodology based on PDA concept and MIDA-UN1 implementation tailored for this project. It covers both production and distribution as opposed to the purely industrial production viewpoint. It shows advantages that MIDA can offer to the National Economy level of planning such as it is the one responsible for the Master Plan. This is how MIDA supports a so-called intermediate economy evaluation (see *Guide for Development Programming of the Chemical Industry*).

The analysis assumes that the demand for the chemical production is to be fulfilled since as it has been already stated, it represents the higher level strategy of the economic development. It means that if the demand cannot be satisfied with the own production (from PDA), then the import has to supplement it up to the desired level. It should be noted that a Net Income calculated for PDA equals to the value of yearly sales decreased by Total Manufacturing Cost of all plants active in the PDA and additionally reduced by a value of the supplementary import. It means that the optimal solution takes into account also the import minimization. Since it was assumed in the development thesis that the investment should be as much profitable as possible, two main lines are considered in the analysis.

Generating Efficient Development Alternatives for Fulfillment of the Demand.

The first assumption is again a necessity of the demand fulfillment which means that Demand Product Vector (DPV) should be fixed or defined within a range. The second way of defining DPV is more practical since it provides a certain flexibility to the optimization by less constrained area of feasible solutions and also prohibits unrealistic level of production of chemicals that could not be sold above certain amount.

For a given DPV, analysis can show what is the social cost of its fulfillment subject to different levels of restrictions imposed on imports. In each case for the criterion

$$\frac{\text{PDA NI}}{\text{FCI}} \longrightarrow \max$$

and assumed level of import the corresponding ratio for the Production Profit also achieves a maximum value but it can become greater if the demand fulfillment had been complemented with import (we can say that the two experiments are concordant but not equivalent). This kind of exercise can be repeated for a given demand and different restrictions on import yielding a fundamental trade-off between import and investment. Such trade-offs can obviously be obtained for different DPV providing a family of trade-off characteristics.

For a parallel analysis (for better reference), instead of the profit MVA can be considered. This can be especially valuable since it can show an impact of the coutry's policy measures such as interest rate, exchange rate, depreciation etc. as related to local conditions (such as e.g. expressed by the location factor).

Generating Efficient Development Alternatives Without the DPV Fulfillment

This is related to the situation when not all products included in DPV can be supplied at the assumed level due to restrictions on import and investment. The analysis would be based on maximization of the ratio NI/FCI for different levels of investment. This strategy seeks for a most profitable development of the industry and imported will be only those goods that are not attractive for the industry or indispensable as raw materials for a profitable production. In such a case upper bounds are to be imposed on the most profitable products in order to keep their production on a realistic level. Moreover, selected (strategic products) can be assumed to be produced in the country (therefore these would be the only range-bounded items in DPV). In such a case the FDA NI is concordant with the Production Profit and what is more both values are equal.

Accordingly, the same type of the analysis can be done with respect to FDA MVA as a criterion.

In the above considerations other possible modes of the analysis are not discussed since they are general and not so specific for MIDA-UNI. This concerns the energy-oriented analysis or multiobjective evaluation based on feasible combinations of objectives provided by the system.

MIDA-UNI implementation supports calculation of all factors and indicators which allow evaluation of development alternatives that assure a balance between the industrial and social profitability controlled by the policy measures.

3. The Case of High Tonnage Organics PDA

3.1 The Demand Evaluation and Profile Selection

As has been mentioned already, HTO PDA constitutes a key domain in the development of the chemical industry in Iran.

It covers about 50% (by weight) chemical products excluding fertilizers and inorganic chemicals. The set of plants comprises technological profiles that produce derivatives of optional petrochemical raw materials such as gas oil, naphta, LPG and natural gas. The production can be split into six groups of main petrochemical products and heavy tonnage organics as e.g.:

- basic petrochemicals (olefines and BTX),
- auxiliary intermediates (methanol, phenol, chlorine etc.),
- plastics,
- rubbers
- fibers,
- some auxiliary intermediates for other production.

In this section the content of HTO PDA is characterized in terms of technological profiles selected for the new investment as well the existing plants already chosen through other studies. The starting point for the selection was provided by the forecast of the demand or Demand Product Vector (DPV) elaborated in the report of E.Zawada. The relevant part of the original DPV, namely the demand for Plastics, Rubbers and Fibers was then selected as the one for HTO (see Table 10).

The demand evaluation in the case of HTO, according to the properties of PDA model (as part of MIDA methodology), was done only with respect to the demand from outside of the HTO. All the internal consumption is calculated and balanced automatically by the system. Some alterations of the demand vector were introduced according to suggestions of DPCI. Moreover, due to the computing capabilities of the of MIDA-UN1, a number of alternatives (in demand as proposed in the E.Zawada report) could be reduced without elimination any one of them The result is shown in Table 11, where in addition to the groups of products, values concerning some intermediates were appended. When evaluating DPV with respect to these intermediates, their forecasted consumption by other branches (resins, paints, detergents and other) was also taken into account.

Table 10

Thousand Tons

No.	Product	potential consumption or demand in 1987 thousand tons	Consumption estimation 1992: case at annual growth rate	Consumption estimation 1992: thousand tons	Consumption estimation 2000: case at annual growth rate	Consumption estimation 2000: thousand tons	Remarks
	PLASTICS						
1	Polyethylene, HD	I 163 II 240	I 0 II 0	160 240	I 4 II 6 III 8	220-330 225-380 295-440	
2	Polyethylene LD	I 119 II 180	I 0 II 0	120 180	I 4 II 6 III 8	162-245 190-290 220-330	including LLDPE
3	Polyvinyl-chloride (PVC)	I 146 II 170	I 0 II 0	145 170	I 4 II 6 III 8	200-230 230-270 270-315	
4	Polypropylene (PP)	I 48 II 62	I 0 II 0	50 60	I 4 II 6 III 8	65-85 75-100 90-115	
5	Polystyrene	I 44-46 II 54	0	50	I 4 II 6	70 80	including ABS. SAN, PS expandable
6	Polyvinyl Acetate	25	0	25	I 6 II 8	40 45	
7	Polyurethane	74	0	77	8	125	
	FIBRES						
8	Polyamide	42	I 0 II arbitr. II arbitr.	42 50 63	I arbitr II " III "	71 89 67	Projection in 2000 for apparel fibres at 4,6,8 per cent. Other end-uses arbitrary

Cont. Table 10

Thousand Tons

No.	Product	potential consumption or demand in 1987 thousand tons	Consumption estimation 1992: case at annual growth rate	1992: thousand tons	2000: case at annual growth rate	2000: thousand tons	Remarks
9	Polyester	50	I 4 II 6	60 67	I 4 II 6	82 106	
10	Polyacrylic	82	I arbitr. II	50 82	I 4 II 4	80 112	
11	Polypropylene	15 33	I 4 II 6	15 35		21 42	
12	Cellulose Acetate	6	arbitr.	8-10	arbitr.	8-10	
	ELASTOMERS, RUBBER PRODUCTS						
13	Styrene-Butadiene Rubber (SBR)	45-50	I II	45-50 70	I II	80 110	
14	Polybutadiene Rubber (SBR)		I II	10.5 18	I II	[illegible] 30	
15	Butyl Rubber	4.8	I II	5 10	I II	8 16	
16	Nitryl Rubber	2.8		3		4	
17	Tires and Tubes	120	I II	120 200	I 4 II 5	190 420	[illegible]

Table 11

Consumption Projection of High Tonage Organics (HTO)

unit : Thousand ton

Chemical products or intermediates	Consumption estimation		Remarks
	Year 1992	Year 2000	
PLASTICS			
Polyethylene HD	160-240	240-330	
Polyethylene LD	150-180	200-250	Including LLDPE
Polyvinylchloride (PVC):			
- Emulsion	20	30	
- Suspension	160	220-260	
Polypropylene	62	85	
Polystyrene	50	70-80	
ELASTOMERS AND RUBBERS			
Styrene - Butadiene Rubber	50	80	
Styrene - Butadiene Latex	15	25	
Polybutadiene	10.5	18-30	
Butyl Rubber	5	10	
FIBER			
Polyamide (Nylon 6)	42-50	50-70	
Polyester (Pet)	60	82-106	
Polyacrylic	50-80	85-100	
OTHER PRODUCTS AND INTERMEDIATES			
Acetic Acid	8-16	12-24	
Acetone	5.9	8.5	
ABS	10	15	

Cont. Table 11

Chemical products or intermediates	Consumption estimation		Remarks
	Year 1992	Year 2000	
Benzene	55-60	62-80	
Butadiene	–	–	
Butene - 1	–	–	
Butene - 2	–	–	
Butyl Alcohol	5-15	15-22.5	
Butyl Rubber	5	10	
Caprolactam	–	–	
Chloroethanes & Methane :			
- Perchloroethylene	8	12	
- Trichloroethylene	5	7.5	
- Carbon Tetrachloride	1.4-7	7-11	
Cyclohexane	–	–	
Dioctylphtalate	48-60	65-75	
Dimethyl Terphtalate	–	–	
Ethylbenzene	–	–	
Ethylene		[illegible]	
Ethylene Dichloride (EDC)	–	–	
Ethylene Oxide	15	22.5	
2-Ethylhexyl Alcohol(Plasticizer Alcohols)	–		
Ethanolamines :			
- Monoethanol Amine (MEA)	0.9	.5	
- Diethanol Amine (DEA)	0.4	0.6	
- Triethanol Amine(TEA)	8-10	10-18	

Cont. Table 11

Chemical products or intermediates	Consumption estimation		Remarks
	Year 1992	Year 2000	
Hydrogen Cyanide	–	–	
Isobutylene	–	–	
Isobutyl Alcohol	1.8	2.6	
Isopropanol	1	2	
Methanol	47	70-75	
Methyl Ethyl Ketone (MEK)	4.6	7	
Methyl Tertiary Butyl Ether (MTBE)	No limits	No limits	
Methylmethacrylate	2	3	
Monoethylene Glycol	15	20	
Phenol	8-10	15-20	
Phtalic Anhydride	10	15	
Polyether Polyol	38	65	
Polyisobutylene	0-5	5-10	
Polymethylmetacrylate	1.5-3	6	
Propylene Oxide	–	–	
Styrene	2-10	10-15	
Synthesis Gas (H_2 + Co)	–	–	
Toluene	40	60	

Cont. Table 11

Chemical Products or intermediates	Consumption estimation		Remarks
	Year 1992	Year 2000	
Vinylacetate	25-30	42-48	
Vinylchloride Monomer (VCM)	–	–	
O-Xylene	–	–	
P-Xylene	–	–	

For the DPV defined, the selection of technological profiles was performed. It was agreed with DPCI that the existing plants would be included to the HTO model, together with plants selected previously as a result of other studies. The latter category was assumed to be treated as plants under implementation (i.e. that investment for their development had been decided). As will be shown in Section 3.3. an alternative status of such plants was also considered but this line of the analysis was not fully followed and it is recommended to be continued. Evertually, to the list of selected profiles all three categories of plants were included:

1. Exiting Plants

name of installation	capacity
NYLON 6 MELT - PARSILON COMP.	16000.00
NYLON 6 MELT - ALYAF COMP.	10000.00
POLYETYLENE THEREFTALATE POLYACRYL COMP.	55000.00
DI-OCTYL PHTALATE - IRAN - NIPPON	40000.00
PHTALIC ANHYDRIDE - IRAN NIPPON	22000.00

2. Plants under implementation

name of process	capacity
ACRYLONITRILE ARAK	33000.00
VINYL CHLORIDE FROM ETHYLENE ARAK	150000.00
PVC ARAK	150000.00
VINYL ACETATE ARAK	30000.00
ACETIC ACID ARAK	30000.00
PE HD ARAK	60000.00
CHLORINE ARAK	100000.00
PE LLD ARAK	60000.00
POLYPROPYLENE ARAK	50000.00
BUTADIENE ARAK	26000.00
POLYBUTADIENE ARAK	25000.00
ETHYLENE ARAK	240000.00
DMT ISFEHAN	65000.00
BTX ISFEHAN	85000.00
P-XYLEN ISFEHAN	44000.00

3. New Plants (planned for a potential implementation)

name of installation

ETHYLENE FROM GAS OIL
ELTHYLENE FROM ETHANE-PROPANE MIXTURE
ETHYLENE FROM WIDE RANGE NAPHTA MS
ETHYLENE FROM WIDE RANGE NAPHTA HS
BENZENE FROM PYROLYSIS GASOLINE
MIXED XYLENES FROM NAPHTENIC FEED

MIXED XYLENES FROM PARAFFINIC FEED
BENZENE FROM TOLUENE
P-XYLENE RECOVERY CRISTALIZATION
P-XYLENE (PAREX)
P-XYLENE RECOVERY (ADSORPTION)
BUTADIENE FROM C4 EXTRACTION
METHYL METHACRYLATE CYANOHYDRIN PROCESS
ISOBUTYLENE BY ACID EXTRACTION (CFR)
MTBE FROM MIXED BUTENES
D-ETHYLHEXANOL (OXO PROCESS)
PROPYLENE OXIDE BY ETHYLBENZENE PROCESS
PROPYLENE OXIDE BY CHLOROHIDRINE PROCESS
POLYOL TRIFUNCTIONAL POLYETHER
BUTENE-1 FROM MTBE RAFFINATE
ISOPROPANOL BY CATION EXCHANGE RESIN
DI-OCTYLPHTALATE FROM PHTALIC ANHYDRIDE
PHTHALIC ANHYDRIDE AIR OX. OF O-XYLENE
METHYL ETHYL KETONE FROM MTBE RAFFINATE
METHYL ETHYL KETONE FROM ISOBUTYLENE RAF
TRIETHANOLAMINE FROM EO END NH3
POLYMETHYLMETHACRYLATE
PERCHLOROETHYLENE FROM PROPANE
PERCHLOROETHYLENE FROM EDC
HYDROGEN FROM NATURAL GAS
PHENOL (CUMENE)
CHLORINE (MEMBRANE PROCESS)
METHANOL FROM NATURAL GAS
POLYETHYLENE LD (AUTOCLAVE REACTOR)
POLYETHYLENE LD (TUBULAR REACTOR)
POLYETHYLENE LLD (UCC)
POLYETHYLENE LLD (DUPONT)
POLYPROPYLENE (AMOCO)
POLYVINYLCHLORIDE BY SUSPENSION POLYMER.
POLYVINYL CHLORIDE BY EMULSION POLIMER.
VINYL CHLORIDE BY OXYCHLORINATION
VINYL CHLORIDE FROM EDC
VINYL ACETATE FROM ETHYLENE
ACETIC ACID FROM ETHYLENE
ACETIC ACID FROM METHANOL
POLYSTYRENE EXPANDABLE
POLYSTYRENE HIGH IMPACT
ABS BY EMULSION/MASS POLYMERIZATION
STYRENE BY BENZENE ALKYLATION
ETHYLBENZENE LIQUID PHASE
ETHYLENE DICHLORIDE BY CHLORINATION
ETHYLENE DICHLORIDE BY OXYCHLORINATION
POLYETHYLENE HD (UCC)
POLYETHYLENE HD (PHILIPS)
STYRENE-BUTADIENE LATEX
STYRENE-BUTADIENE RUBBER BY EMUL. POLYM
STYRENE-BUTADIENE RUB. BY SOL. POLYMER.
POLYBUTADIENE
BUTYL RUBBER
POLYISOBUTYLENE

NYLON 6 MELT
CAPROLACTAM FROM CYCLOHEXANE
CAPROLACTAM FROM TOLUENE
CAPROLACTAM FROM PHENOL
CYCLOHEXANE BY HYDROGENATION OF BENZENE
POLYETHYLENE TEREPHTALATE MELT FROM DMT
POLYETHYLENE TEREPHTALATE MELT FROM TA
TEREPHTHATIC ACID FROM P-XYLENE
DMT FROM P-XYLENE
ETHYLENE GLYCOL AND ETHYLENE OXIDE
ACRYLONITRILE BY PROPYLENE AMMOOXIDATION
SYNTGAS (2:1) FROM NATURAL GAS
SYNTGAS (3:1) FROM NATURAL GAS
CARBON MONOXIDE FROM SYNTGAS
OXYGEN BY AIR FRACTIONATION

The destroyed or suspended plants were not included to the analysis except those of Iran - Japan Company and Abadan Petrocomplex being damaged less than 30%. The above installations were of concern in one of the experiments while changing the demand vector.

3.2 Data Preparation

Main Parameters

The following values of Main Parameters (see MIDA-UN1 User's Manual) were assumed for the calculations according to MIDA methodology cost calculation scheme (see Guide to Programming Development of the Chemical Industry):

local factor	1.3
labor wages	3600.0
exchange rate	1.0
supervision wages	0.0
bloc depreciation	10.0
laboratory wages	0.0
offsites depreciation	5.0
laboratory materials	0.0
debt/equity ratio	0.0
operation supply cost	0.75
interest on debt	10.0
direct overhead	60.0
working capital	15.0
maintenance cost	5.0
interest on work. cap.	10.0
administration	15.0
insurance	1.0
sale & marketing	10.0
property tax & rent	2.0
R & D	3.0

The values were agreed with DPCI for this stage of the analysis. It is expected that a special study on policy measures specific for local conditions will be undertaken by DPCI after evaluation of results obtained so far.

Preparation of Technological Profiles

HTO covers the part of the industry which NPC is responsible for. It was agreed between DPCI and NPC that to assure a comparison with other studies, SRI Technological Profiles will be used as a standard in this study.

Despite the statement in the foreword to PEP 1986 that technological profiles prepared by SRI are to be used as a computer data, some refinements had to be done to make them applicable for such a tool. Specifically the following refinements were performed:

* Different fuel gases such as natural gas, fuel gas, CO rich gas, tail gas etc. are calculated in SRI in heating units "T-cal" and have the same unit prices. In some cases, e.g. for steam cracking plants they either feed the plant (natural gas in utilities) or are by-products (tail gas). A summation of the fuel gas for individual plants was done to avoid a multiple calculation.

* For hydrogen different units (Nm3, kG) and different prices were introduced in SRI. To avoid ambiguity these data were unified (Nm3 and one typical price).

* Some auxiliary substances such as catalysts, miscallenous chemicals, additives, antioxidants etc., do not have precise denomination and some also do not have unit prices. For the sake of uniformity, they were divided into two groups: "Catalysts and Chemicals" and "Chemicals" and their consumption shares were determined in US $ per 1 ton of the main products.

* Most often, SRI profiles give the consumption figures in tonnes per 1 ton of the main product but unit prices are given in c/kG. For uniformity, all prices were transformed into US $/1 ton.

* In those cases where the main product is not one substance but a mixture like e.g. "Ethanoloamines", the profiles were recalculated for one main product e.g. Triethanoloamine and the other producs like Di- or Monoethanoloamine were treated as by-products.

* The SRI description of the profiles goes deeply into detailes, so often very low consumption figures of different chemicals and auxiliary chemicals with negligible effect on production costs are included in preparation of the database for the development of the

chemical industry, a reasonable compromise must be achieved in order not to be overfloaded with information of minor importance and not to loose important factors on the other hand.

Market Data.

Raw materials, products and chemicals were divided into two groups:

- those acquired from and send to local market such as basic raw materials. For this group the proces were taken from SRI source,

- products and chemicals that were assumed to be imported as inputs to the production, such as catalysts, special chemicals etc., and products that should be imported for a lack of the domestic production. For this group the SRI prices (international market FOB prices) were transformed CiF prices adding:

  - 100 $ per 1 ton of gases,

  - 50 $ per 1 ton of liquids,

  - 25 $ per 1 ton of solids.

CiF prices were multiplied by 1.25 to cover duties, insurance etc.

A separate category are prices of utilities. These were determined for local conditions:

cooling water	0.0251	$/M3
process water	0.1	$/M3
steam	7.32	$/T
electricity	0.05	$/kWh

The price of labour was assumed 3600 $/year (see Main Parameters) Technological parameters of the above utilities are in conformity with SRI standards.

On request of DPCI (see Sec. 2.2), all calculations were done in US $. Since the system is prepared for calculations both in local currency (lc) and in foreign currency, any currency system can be used through using the exchange rate value. From that followed that in the Main Parameters of MILA, the rate of exchange was assumed to be equal to 1.

3.3 Results of experiments.

About one hundred experiments was performed to cover the assumed scope of analysis. Forty of them were stored in subdirectory \USR\WOJBAZA\RESULTS on the Bernoulli volume labelled MIDA_F (which is the property of DPCI).

The procedure was as follows. First a simple plant evaluation was performed in order to check correctness and consistency of technological data. The options 1.2.6 and 1.2.7 (see chapter 1.2 of MIDA-UN1 User´s Manual) are very useful for such an analysis. The printout is attached as Appendix A1.

As result of this step, the full printout obtained from the option 1.2.8 was attached to the volume. It can be seen that many HTO technological profiles have not only negative profit but negative MVA as well. It results from price relations between prices on imported chemicals (see section 3.1 above) and those taken from SRI directly. The negative value of profit arises as an effect of assumed local conditions especially a high value of the location factor taken equal to 1.3 with respect to SRI data. Following were experiments carried out along the methodological guidelines assumed (Section 2.2). The selected printouts from these experiments are put to Appendix A2. Below a discussion on the experiments is given.

Generating Efficient Alternatives for Fulfilment of the Demand.

As was suggested in section 2.2 a series of experiments was performed in order to find a trade off between investment and import under conditions that demand will be fulfilled and maximum of PDA net income over investment will be assured.

Results were obtained for two DPV corresponding to the forecasted demands up to years 1992 and 2000. Detailed results were stored under the codes N0 to N6 and P0 to P9, respectively. The full printout of these experiments would take more than a hundred pages, for the sake of illustration detailed printouts for N0 and P0 experiments were attached. They were selected since the value of criterion, namely the ratio of profit over investment, is maximum with unconstrained investment.

Summary of all experiments is shown below on Fig and 7 - 11 for 1992 and 2000.

Year 1992

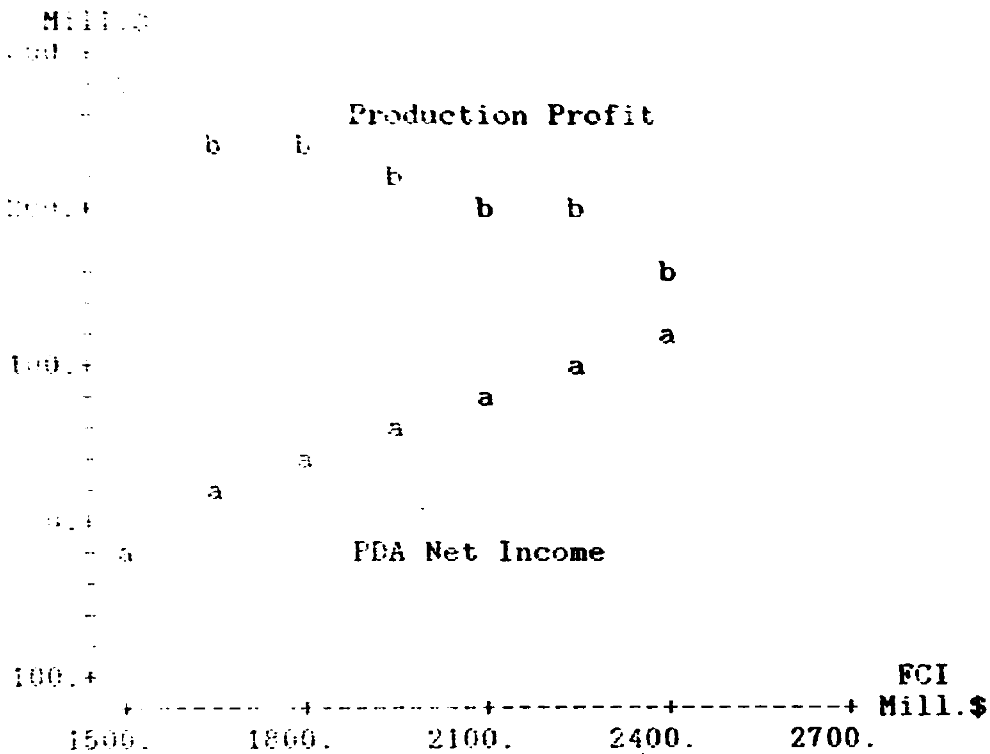

Fig. 2.

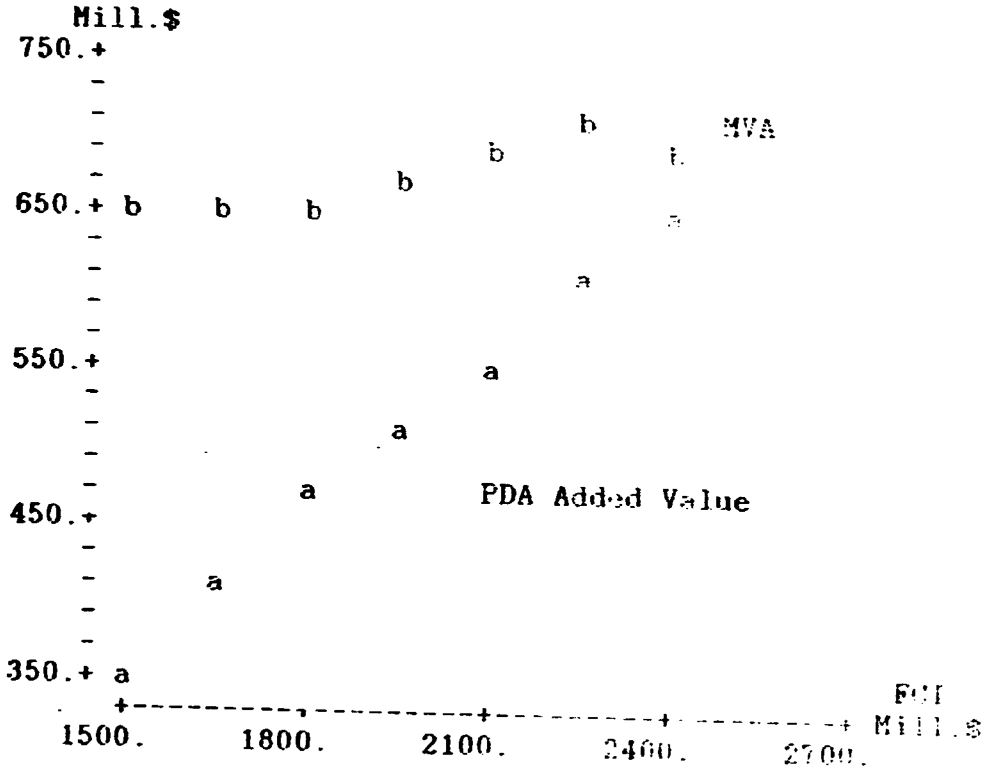
Mill.$
750.
650.
550.
450.
350.
MVA
PDA Added Value
1500.
1800.
2100.
2400.
2700.
Mill.$

Fig. 3.

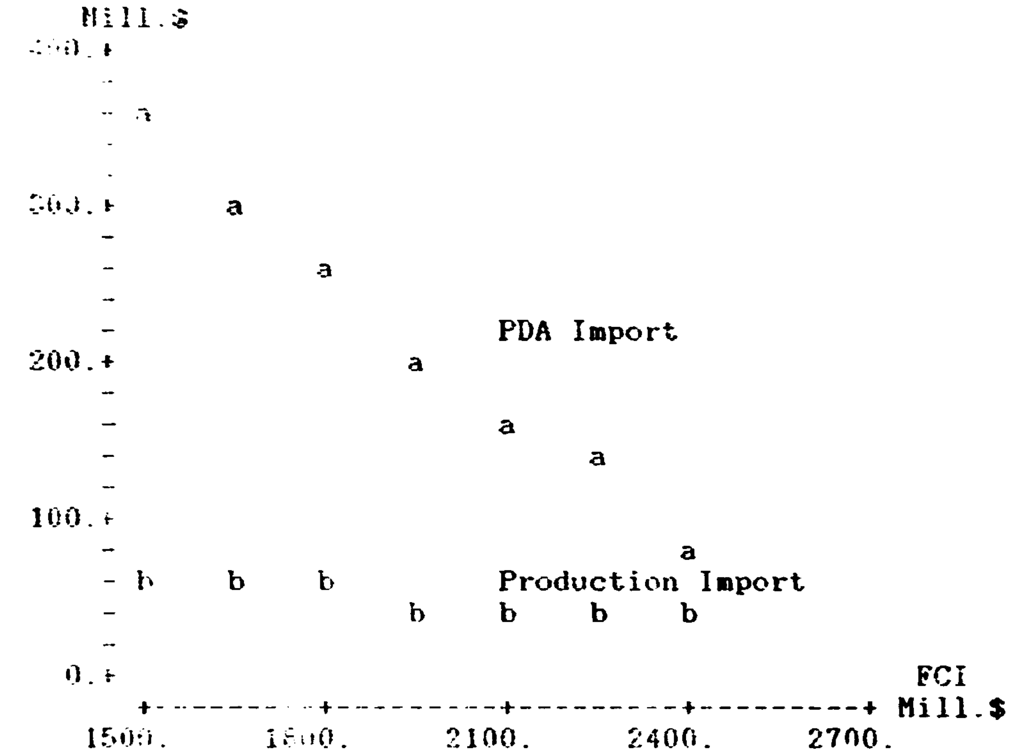
Mill.$
PDA Import
200.
100.
Production Import
0.
FCI
Mill.$
2100.
2400.
2700.

Fig. 4.

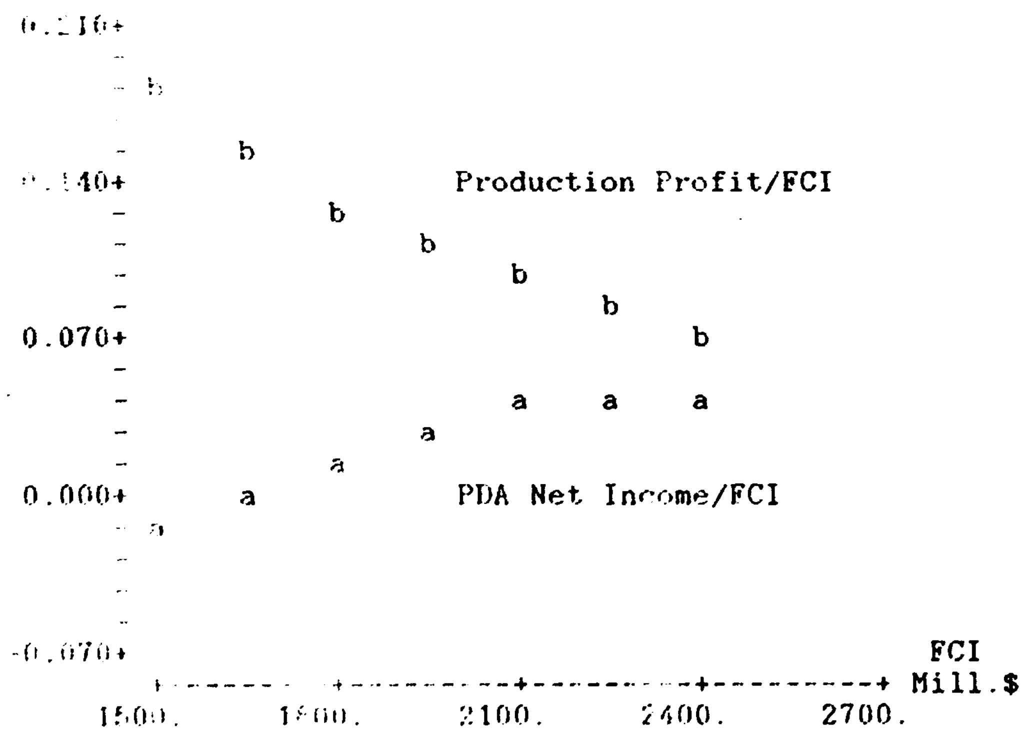
Production Profit/FCI
0.070+
0.000+
PDA Net Income/FCI
FCI
Mill.$
2100.
2400.
2700.

Fig. 5.

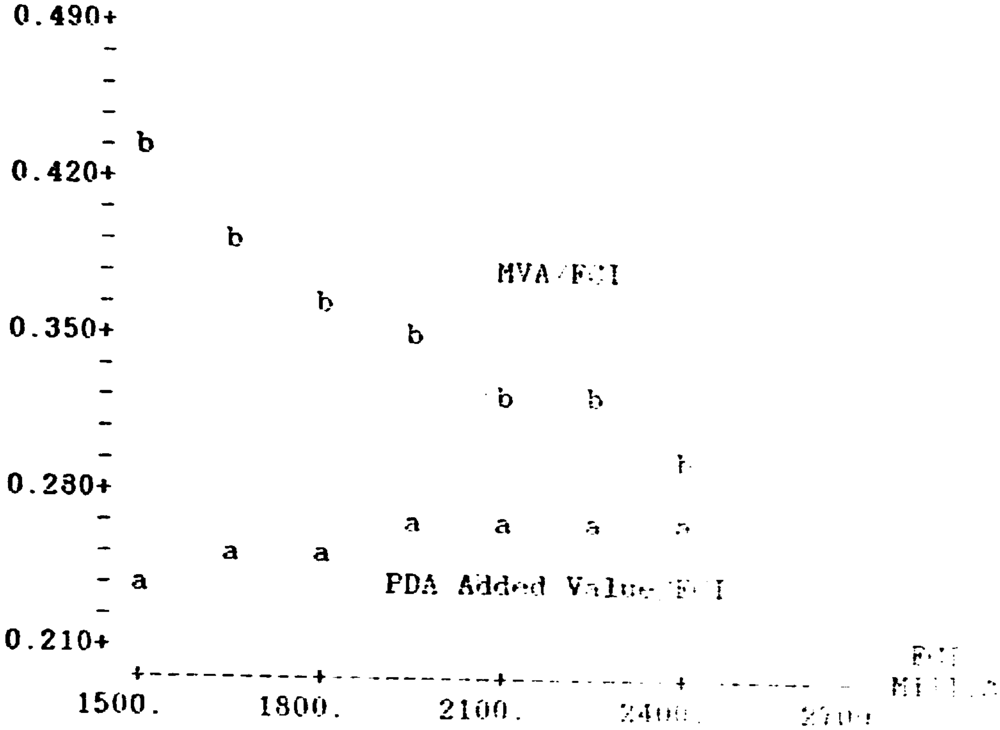

Fig. 6.

Year 2000

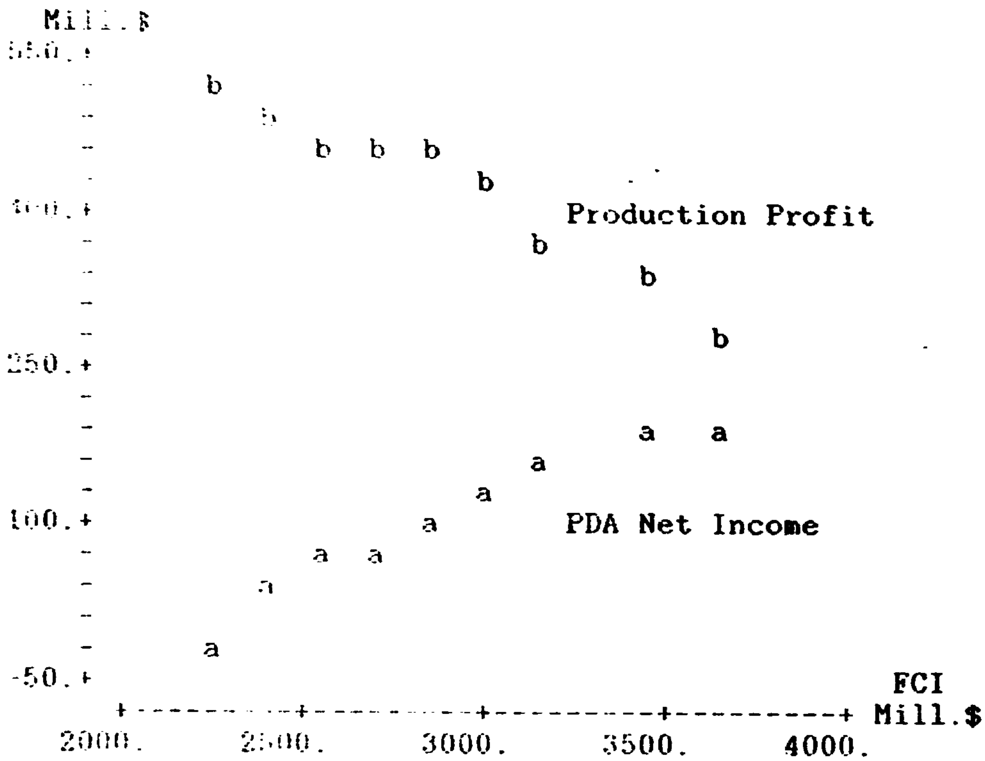

Fig. 7.

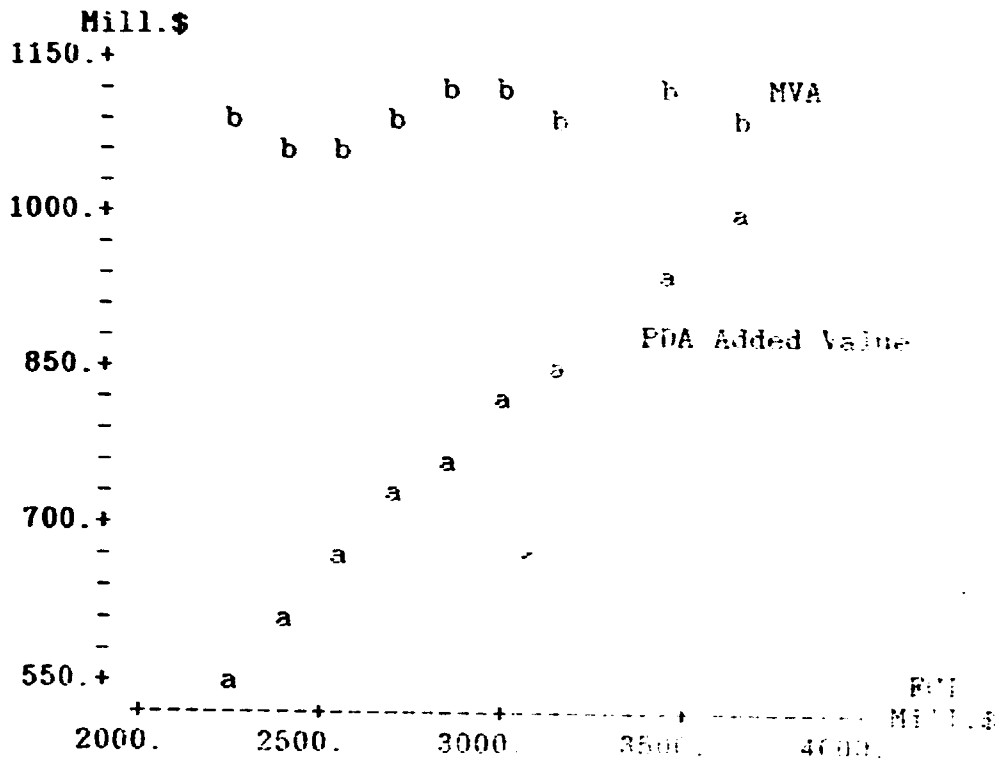
Mill.$
1150.
1000.
850.
700.
550.
MVA
PDA Added Value
2000.
2500.
3000.
3500.
4000.

Fig. 8.

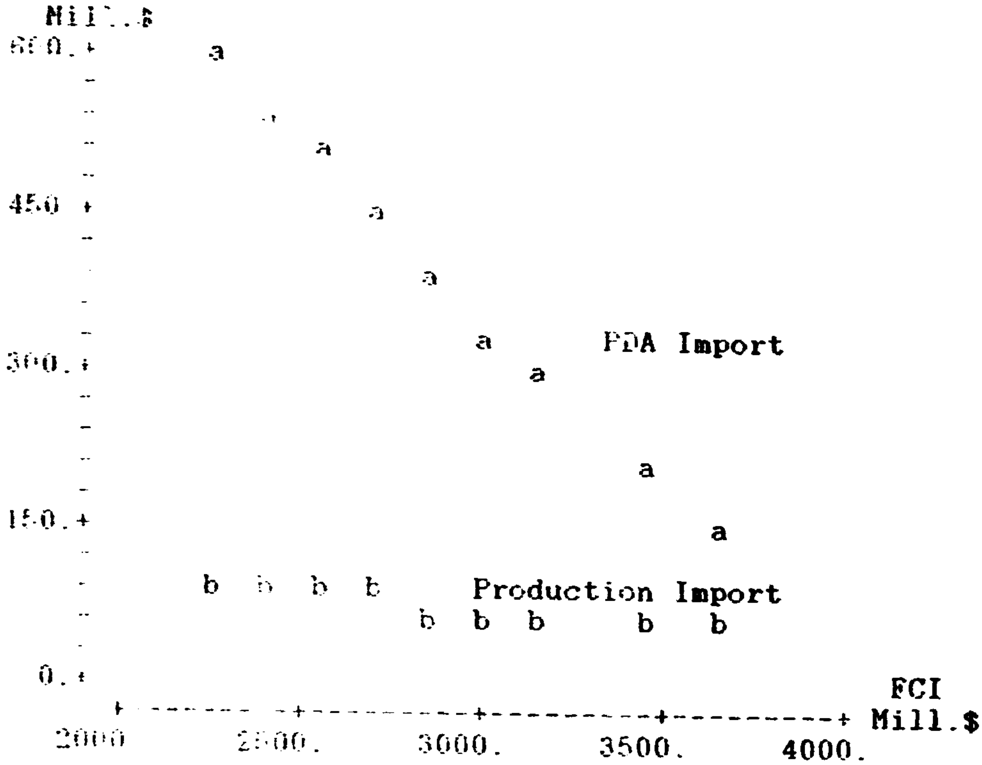
Mill.$
450
150.
0.
PDA Import
Production Import
FCI
Mill.$
3000.
3500.
4000.

Fig. 9.

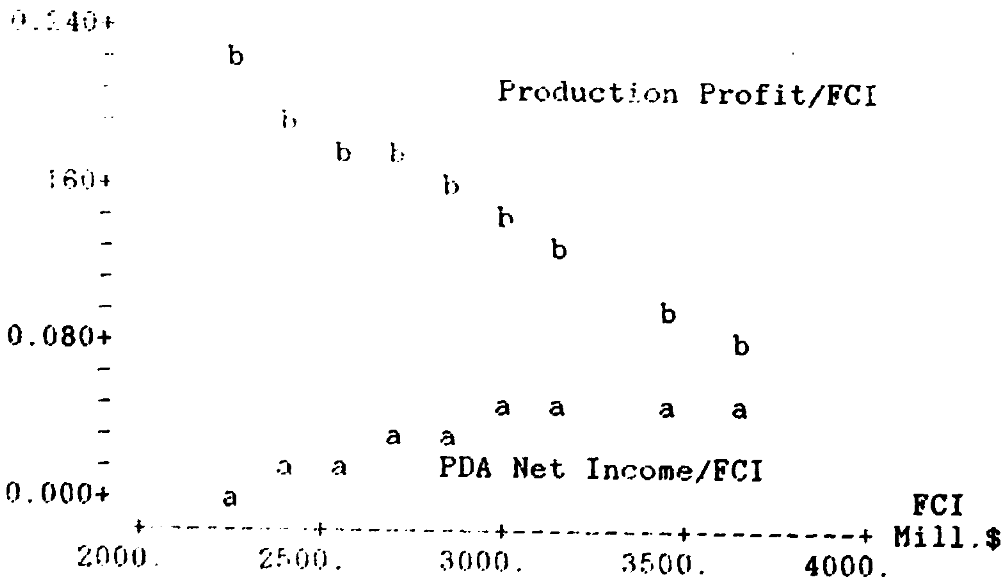
0.080+
0.000+
Production Profit/FCI
PDA Net Income/FCI
FCI
Mill.$
2000.
3000.
3500.
4000.

Fig. 10.

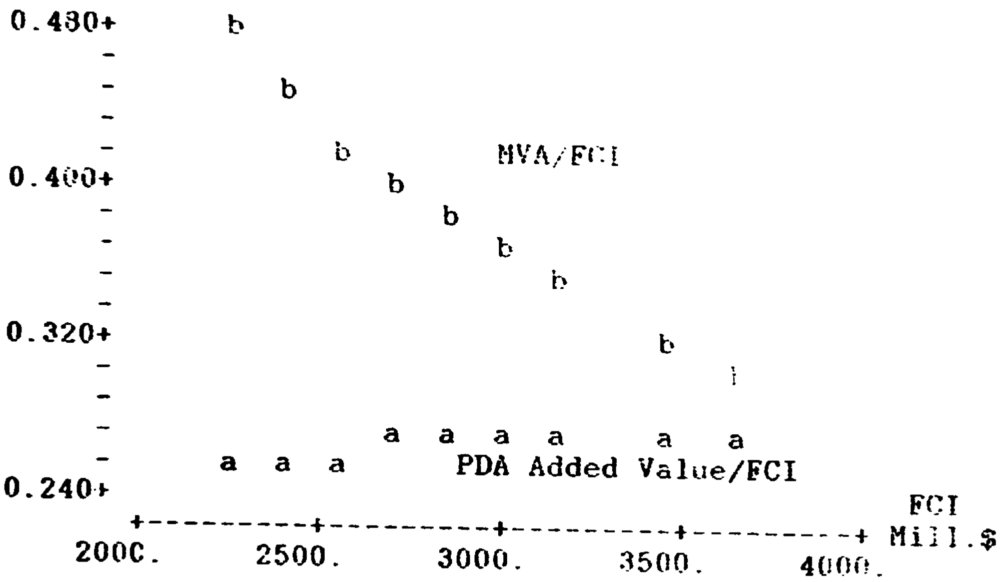

Fig. 11.

Generating Efficient Alternatives without fulfilment of DPV.

Again, following methodological guidelines, a series of experiments was performed. It was aimed at finding the optimal investment for industrial development from the producers point of view provided that DPV cannot be fulfilled exactly along its structure and therefore is to be used more as an indication than as a strictly defined production goal.

Following the above the ratio of profit over investment was maximized for different levels of investment under assumption that only upper limits of DPV were imposed that represent realistic sell ability or consumption. In such a case only the raw materials import may take place to supply the most profitable production. Then PDA net income is equal to Production Profit.

These experiments were coded A0 to A[illegible] and B[illegible] to B[illegible] for 1992 and 2000 respectively and stored in directory \USR\WOJBAZA\RESULTS (see above).

Figures 12-13 illustrate dependencies for 1992 while Figures 14-15 show results for 2000.

Year 1992

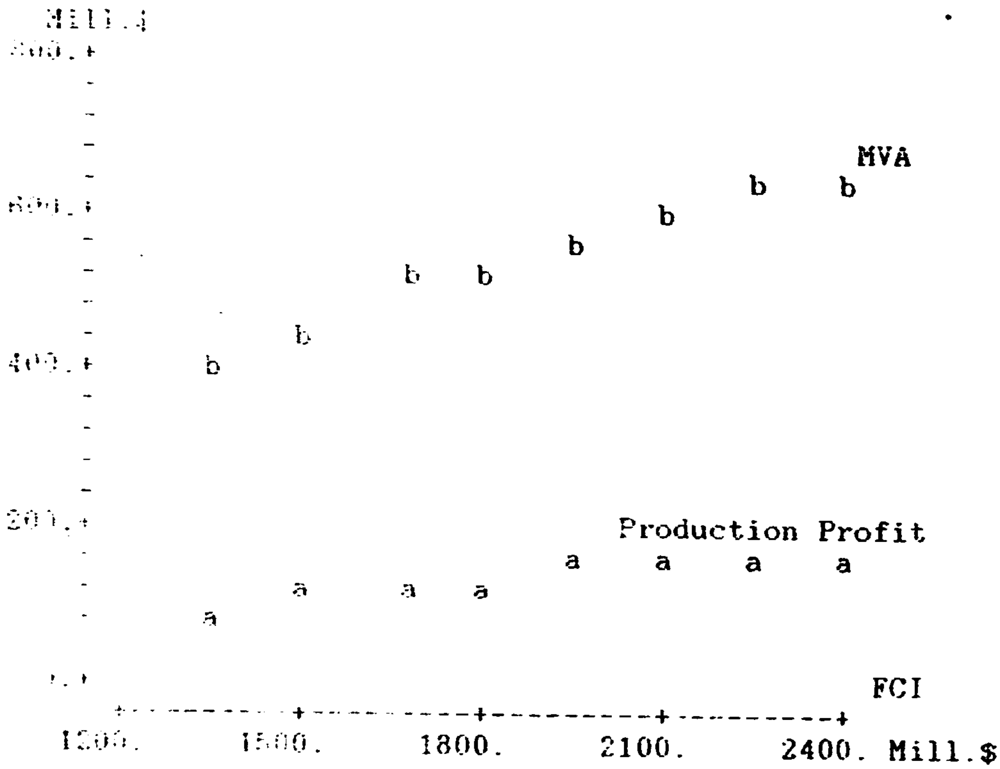

Fig. 12.

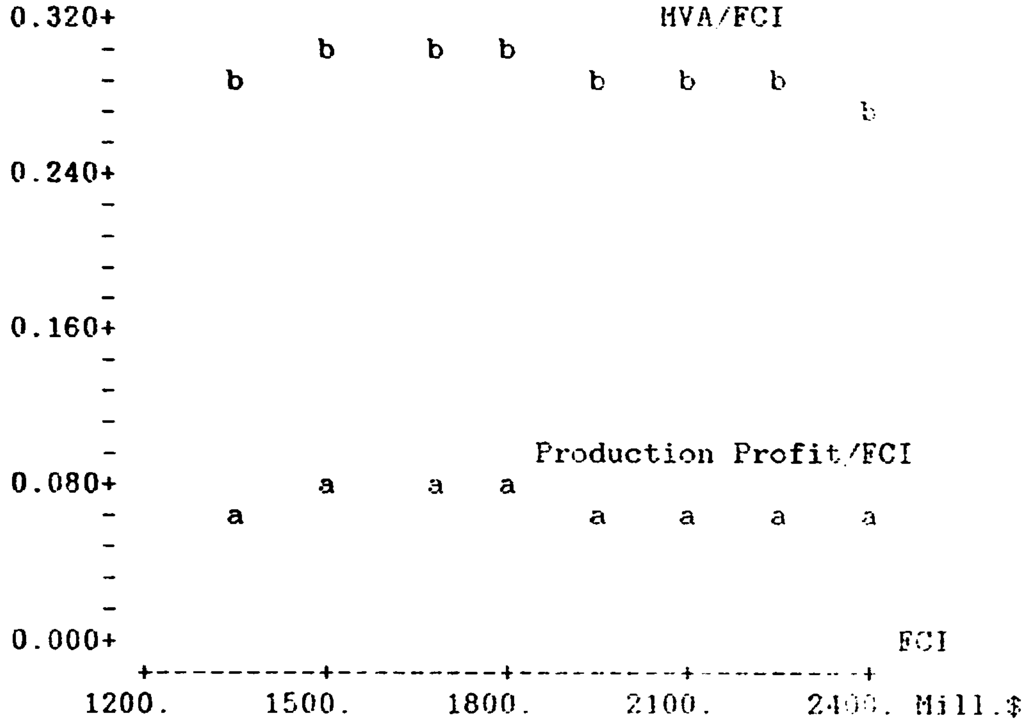
0.320+
HVA/FCI
0.240+
0.160+
Production Profit/FCI
0.080+
0.000+
FCI
1200.
1500.
1800.
2100.
Mill.$

Fig. 13.

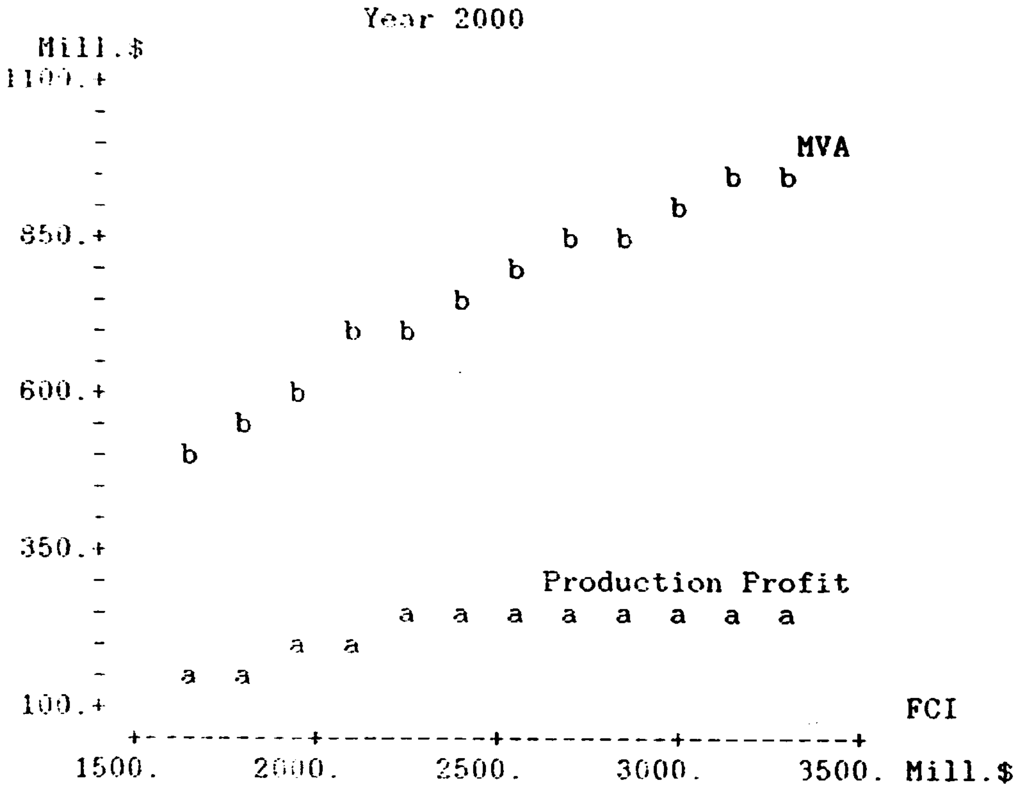
Year 2000
Mill.$
1100.
850.
600.
350.
100.
MVA
Production Profit
FCI
1500.
2000.
2500.
3000.
3500.
Mill.$

Fig. 14.

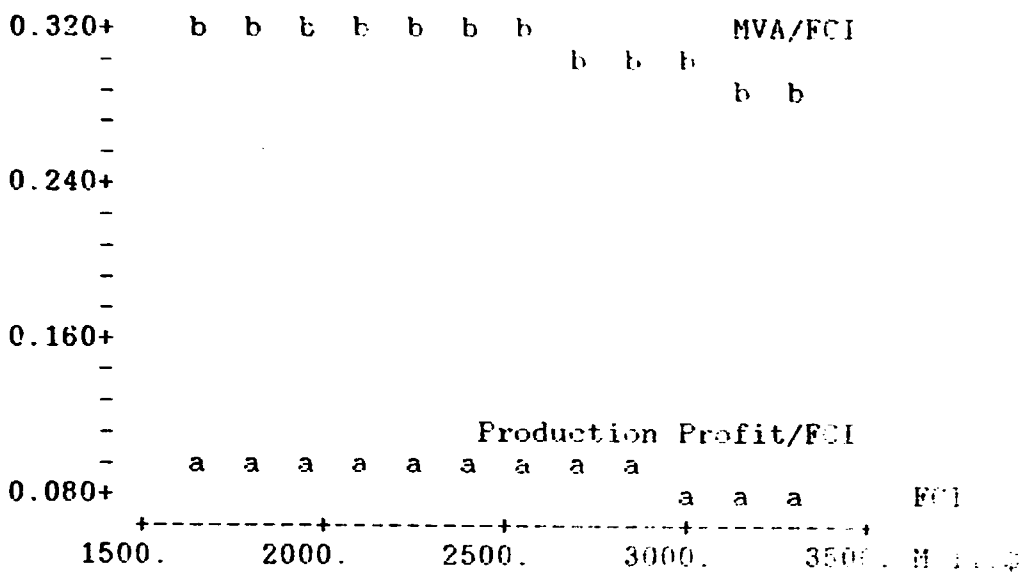

Fig. 15.

All the calculations were done provided that the Arak and Isfehan complexes will run on the full capacities.

The essential problem that was encountered during the analysis was that the demand vector is generally not balanced with the capacities of the existing or currently implemented Arak and Isfehan complexes. On the other hand, the assumed range of the demand as determined in the report based on the work of E.Zawada, does not correspond to economically feasible capacities of new plants (that are supposed to produce the same products as Arak and Isfehan). For example, the capacity assumed for PVC Arak plant is 150000 tons/year is the demand for PVC is estimated on the level of 160000 tons/year for 1992. This discrepancy, due to assumption that PVC Arak plant was to remain intact, forced 10000 tons/year additional capacity to be developed. A similar situation arised in the case of polypropylene where the capacity assumed equals to 50000 t/y while the demand is 62000 t/y. This discrepancy could be easily dealt with by a simple adjustment of respective Arak plants. Unfortunately, Arak complex is so carefully balanced for ethylene and propylene production that such a simple operation would lead to a proportional decrease of the other production due to a lack of the raw materials.

Therefore, the following alternative strategies of the development have been suggested and consequently a number of experiments was performed. In the first variant the investment program would aim at building plants of economic capacities although their potential would exceed the production level determined by the demand. The excessive production would be exported in the first period and then consumed by domestic market on the level forecasted for year 2000. To make the development program realistic, upper bounds on production were imposed according to sell ability of the products on the foreign market. Results of the relevant experiments namely K2 illustrate the case. It was done for DPV upper bounded on the level of year 2000 and lower bounded on the level of 1992 with unconstrained investment. In the second variant, the installations having small capacities as fitted to the current (1992) demand vector would be rejected from the investment program. This took place due to the above situation regarding Arak comples but also due to the low demand for some products. This concerns for example isobutyl alcohol, isopropanol, phenol, aceton, perchloroethylene, trichloroethylene etc. To fulfil the demand, missing amounts of the products have to be imported. This is illustrated by the experiment KM1. In addition, on request of of DPCI in this experiment DPV was modified. The modification was aimed to reflect production of those capacities that were damaged less than 30% (Iran - Japan complex) and thus can be considered for reconstruction. The DPV correction had to be applied since data for respective profiles that could be incorporated into HTO PDA were not available.

The following units with the extent of damages assumed to be lower than 30% were considered as those to be reconstructed in the future (with the exception of SBR - 50% of damage - which was also included. Nevertheless, the final decision on reconstruction of abandoning these projects (including those that were not considered in the analysis must be made prior to the conclusion on the Master Plan:

IRAN - JAPAN PETRO COMPLEX

Polypropylene	50000 T/Y
PEHD	60000 T/Y
PELD	10000 T/Y
SBR	40000 T/Y

ABADAN PETRO COMPLEX

PVC	40000 T/Y

Both alternatives (experiments K2 and KM1) can be recommended as they are economically feasible on the contrary to a solution that assumes small-scale production. If the latter assumption had to be maintained for some reasons, it would be recommended to search for an unconventional technologies that could not be incorporated into the analysis of HTO PDA.

3.4 Conclusions and Recommendations

HTO case study can be summarized as follows. The first fundamental stage in the Integrated Development Programming of industry covered by HTO was completed.

This coverd the following steps:

* identification of HTO case with respect to national economy in the broad context of the industry and the chemical one in particular. This was based on international comparison (world-wide, regional and with respect to the developed and developing economies). The analysis fully confirmed the choice of HTO for the purpose assumed in the project.

* formulation of development thesis for the Master Plan for Development of the Chemical Industry and the one for HTO,

* selection of HTO boundaries with respect to whole petrochemical industry, its other branches and downstream processing (97 technological profiles and [illegible] chemicals),

* preparation and refinement of the data.

Based on the above, the following was accomplished:

* according to MIDA methodology starting from the development thesis and MIDA-UNI implementation, specific methodological steps were devised for the analysis,

* along such lines, analysis was performed with MIDA-UN1 Decision Support System. Out of more than one hundred of the experiments, forty were selected as representative results of Integrated Development Programming of the HTO. The experiments selected provide a very useful background and should be used for a reference both as the material for the Master Plan and for continuation of the study by DPCI. Specifically, for the demand vectors, a series of optimization experiments was performed. As a result of the calculations and adjacent analysis, the feasible trade offs of investment levels and import volumes were determined provided that the demand is fulfilled and that each development program assures maximization of PDA Net Income over Investment (the optimization criterion). For comparison, a series of calculations was done to generate development programs that maximixe Production Profit, regardless fulfilling the demand but taking into account a feasible level of the domestic market consumption.

* the HTO case study should be continued with special emphasis on "policy measures exercises" (e.g. with respect to rate of interest, depreciation, exchange rate) as well as analysis of impacts of other decisive factors as prices of raw materials, value of location factor etc.

* market analysis should be carried out to evaluate the export potential with respect to various products.

* a special attention must be put to local prices adjustment. in such a kind of analysis MIDA system will prove its usefulness: first through evaluation of the exchange rate - the official one versus the shadow value, second through evaluation of MVA both with respect to social and industrial profitability. The latter type of the analysis must be preceded by local prices adjustment.

It is strongly recommended that DPV forecast would be studied in the context of Arak and Isfehan complexes in order to avoid discrepancies between DPV and capacities assumed. The following strategies are recommended for such an evaluation and decision:

- export-oriented or investment-intensive; this would base on selection of larger capacities excessing the country's demand for 1992. The additional production would be exported. Then year 2000 opens an alternative of either fulfilling the country's forecasted demand or continuing export and investment.

- import-balanced or investment-saving; this assumes that low capacities selected for 1992 DPV are to be rejected from the development program while the missing amounts of the products would be imported,

It is understood that for each alternative strategy, a feasibility of implementation of selected plants with the capacities divided into parallel technological lines would be extensively evaluated. Such a technically obvious procedure would open a possibility for investment scheduling providing capacities that would better fit the forecasted DPV and other constraints.

It has to be recalled from the results of identification and the demand analysis, which had been confirmed by the experiments with MIDA-UN1, that meeting production goals especially for 1992, will be difficult despite assuming some development rates lower than these of other developing countries. In addition to the above considerations, the evaluation and decision on reconstruction of selected Iran-Japan and Abadan plants is to be made with respect to the both strategies.

If for some reasons it was decided that low capacities are to be preserved in the Master Plan, an intensive study should be undertaken in order to find appropriate technological profiles. Generally offered technologies (e.g. SRI or CHEM SYSTEM profiles) do not support such low capacities.

4. The Case of Inorganics PDA

4.1 INO PDA Description

This case study concerns analysis of inorganic chemical industry technologies assembled into a Production-Distribution Area called INO PDA. A preliminary selection of the technologies was done by DPCI and personally by P. Bo[illegible]ski (UNIDO expert) and A.A. Jafari (DPCI specialist of inorganic chemistry). The selection was motivated by a main target of the Master Plan that is integrated and efficient development of the inorganic chemical industry indispensible for other branches of the industry and the market. On the other hand, it was adjusted to natural resources of the country.

The INO PDA comprises both a low-tonnage technologies as well as mass production of e.g. soda ash, sodium glaze, precipitated calcium carbonate, sodium water glass, sodium metasilicate etc. that altogether amounts to 63 processes run on 58 installations. Only new (those that are potentially to be developed) technologies were taken into account in the analysis. All processes of concern are listed as follows:

process name	capacity
ANTIMONY TRIOXIDE	2000.00
ALUMINUM SULPHATE	30000.00
ARGON	750000.00
BARIUM CHLORIDE	2000.00
BARIUM CARBONATE	3000.00
LITHOPONE 30%	10000.00
LITHOPONE 60%	10000.00
BARIUM HYDROXIDE	1500.00
SODIUM TETRABORATE (BORAX)	5000.00
BORIC ACID	8000.00
SODIUM PERBORATE	20000.00
PRECIPITATED CALCIUM CARBONATE	10000.00
PRECIPITATED CALCIUM CARBONATE(TOOTH P.)	1000.00
CALCIUM CARBIDE	60000.00
CALCIUM HYPOCHLORITE	5000.00
CALCIUM CHLORIDE	10000.00
AMMONIUM CHLORIDE	4000.00
SODIUM BICHROMATE	3000.00
SODIUM CHROMATE	1000.00
POTASSIUM BICHROMATE	1000.00
ANHYDROUS CHROMIC ACID	1000.00
CHROMOGAL - BASIC CHROMIUM SULPHATE	2000.00
COPPER OXIDE (BLACK)	40.00
COPPER OXIDE (RED)	100.00
COPPER SULPHATE	2000.00
CRYOLITE - ALUMINUM SODIUM FLUORIDE	4200.00
ALUMINUM FLUORIDE	2200.00

HYDROGEN FLUORIDE	1000.00
IRON OXIDE (RED)	2000.00
FERROFERRIC OXIDES (BLACK)	1000.00
FERROUS SULPHATE	1000.00
LEAD OXIDE (RED)	2000.00
MAGNESIUM OXIDE	50000.00
MANGANESE DIOXIDE	2000.00
MOLYBDENUM TRIOXIDE	140.00
NICKEL SULFATE	500.00
SODIUM TRIPOLYPHOSPHATE	50000.00
SODIUM HEXAMETAPHOSPHATE	1000.00
SODIUM PYROPHOSPHATE (DIBASIC)	300.00
TRISODIUM PHOSPHATE	7500.00
DICALCIUM PHOSPHATE	40000.00
POTASSIUM CARBONATE	1000.00
POTASSIUM CHLORATE	1000.00
POTASSIUM NITRATE	2000.00
SODIUM GLAZE	25000.00
SODIUM WATER GLASS	60000.00
SILICA GEL (MACRO)	1500.00
SILICA GEL (MICRO)	1500.00
SODIUM METASILICATE	10000.00
SODIUM THIOSULPHATE	1000.00
SODIUM HYDROGEN SULFITE	4000.00
SODIUM SULFITE	2000.00
SODIUM HYDROSULFITE	2000.00
SODIUM CHLORIDE (MEDICAL)	1500.00
SODIUM NITRATE	8000.00
TITANIUM DIOXIDE	20000.00
ZINC SULFATE	1000.00
ZINC CHLORIDE	4700.00
MOLECULAR SIEVE-ZEOLITES (cl. 3A)	500.00
MOLECULAR SIEVE - ZEOLITES (cl. 4A)	500.00
MOLECULAR SIEVE - ZEOLITES (cl. 5A)	500.00
MOLECULAR SIEVE - ZEOLITES (cl. 13X)	500.00
SODA ASH	100000.00

The set of technological profiles taken into account as agreed with DPCI and discussed with P. Rozwadowski covered only new technologies i.e. those potentially to be developed. Corrections that concern existing plants were introduced and this is elaborated in the report of P. Rozwadowski. These plants could not be described herewith for a lack of data on consumptions coefficients. The technological profiles as listed above were prepared in the form required by MIDA database and stored in the directory \USR\ROZBAZA installed on the Bernoulli disk labeled MIDA F. In the Appendix B1 detailed data on inputs and outputs of consecutive processes were attached.

Beyond the technological data, all necessary information on prices and major economic parameters were prepared with contribution of A.A. Jafari and P. Rozwadowski. The prices were prepared basing on Market Reporter, 1988 and in some cases (mostly for mineral resources) adjusted to local conditions. Similarly, the prices of utilities were introduced according to domestic level. The full list of prices is given in Appendix B2. The following main parameters were assumed for the analysis:

local factor	1.0
labour wages	2400.0
exchange rate	1.0
supervision wages	4800.0
bldg depreciation	6.6
laboratory wages	3600.0
offsites depreciation	5.0
laboratory materials	0.0
debt/equity ratio	0.0
operation supply cost	0.75
interest on debt	10.0
direct overhead	60.0
working capital	12.0
maintenance cost	4.5
interest on work. cap.	10.0
administration	15.0
insurance	0.6
sale & marketing	6.0
property tax & rent	1.5
R & D	1.5

4.2 Results of Experiments

The analysis was initiated with the single plant evaluation performed for each technology. This comprised calculation of the performance indicators as described in the Section B of the report (e.g. PV, TMC, MVA, Profit and Simple Rate of Return). The results are illustrated in Appendix B4. After the evaluation had been done, the technologies that were estimated as economically infeasible for their low capacities, were again investigated with re-scaled capacities. The list of the latter plants containing their capacities and FCI values is attached as Appendix B3.

In the next step, the analysis was performed for the whole INO PDA, it means that all technological connections between the installation were taken into account. For the sake of the analysis, a series of computer experiments was run to generate efficient development programms according to maximum production profit subject to assumed investment levels. Detailed results of the analysis for various investment values (changing in 50 Mill. $ intervals up to the level of full implementation of the whole set of technologies) are given in the Appendix B5. As the set of technologies was changing with assumed levels of investment, as for each investment value the most profitable plants would be accepted to the development program, the table below illustrates a priority of development up to the assumed investment thresholds. In the table, "+" denotes those plants that would be introduced to the program at full capacities, "e" - with capacities higher than determined as minimally economic (according to the report of F.Kowalewski and A.A.Jafari), "l" - with capacties less than economically recommended and "-" for those rejected from the program. All results of calculations performed for the whole range of investment with 25 Mill.$ intervals, are stored on the Bernoulli volume MIDA_F in the directory \USER\ROZIAZA\RESULTS under the names IN25-IN384. The resulting dependencies are summarized as depicted below:

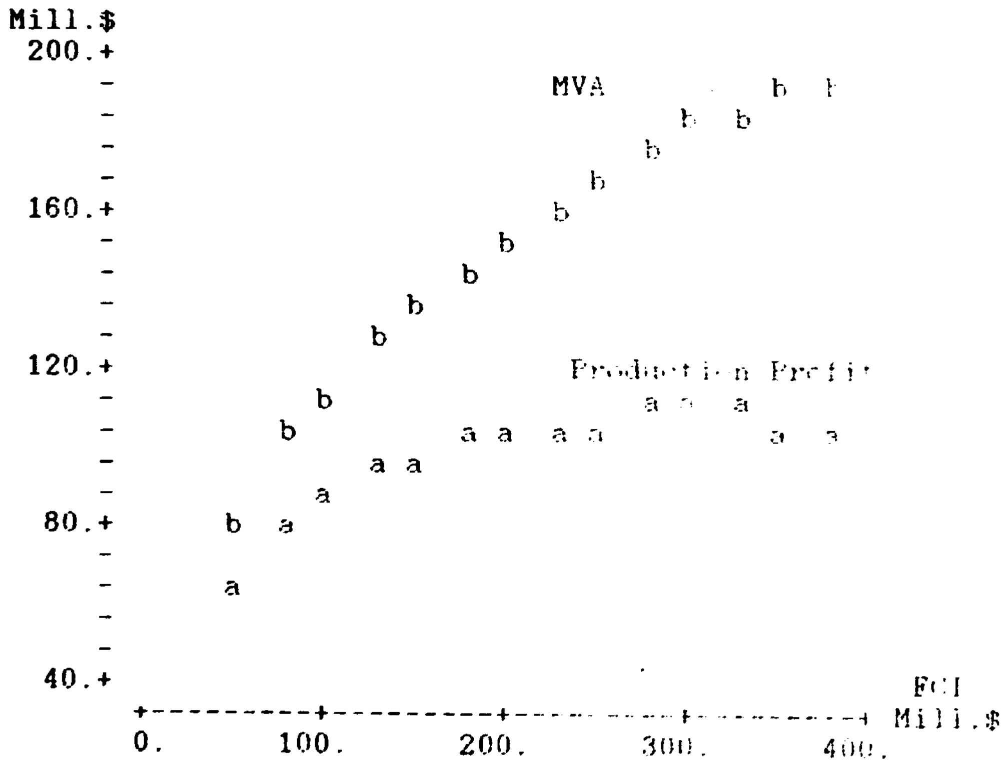

Fig. 16.

Process Name	Investment in Mill. $						
	50	100	150	200	250	300	350
ANTIMONY TRIOXIDE	-	+	+	+	+	+	+
ALUMINUM SULPHATE	-	e	+	+	+	+	+
ARGON	-	-	-	-	-	-	-
BARIUM CHLORIDE	-	-	-	-	-	-	-
BARIUM CARBONATE	-	-	-	-	-	-	+
LITHOPONE 30%	-	-	-	-	-	+	+
LITHOPONE 60%	-	-	-	-	-	-	-
BARIUM HYDROXIDE	-	-	-	-	-	-	-
SODIUM TETRABORATE (BORAX)	-	+	+	+	+	+	+
BORIC ACID	-	-	-	-	-	1	+
SODIUM PERBORATE	+	+	+	+	+	+	+
PRECIP. CALCIUM CARBONATE	-	+	+	+	+	+	+
PRECIP.CALC.CARBO.(TOOTH P.)	-	-	-	-	-	+	+
CALCIUM CARBIDE	I	+	+	+	+	+	+
CALCIUM HYPOCHLORITE	+	+	+	+	+	+	+
CALCIUM CHLORIDE	-	-	-	-	-	+	+
AMMONIUM CHLORIDE	-	-	-	+	+	+	+
SODIUM BICHROMATE	-	-	!	+	+	+	+
SODIUM CHROMATE	-	-	-	+	+	+	+
POTASSIUM BICHROMATE	-	-	-	-	-	-	+
ANHYDROUS CHROMIC ACID	+	+	+	+	+	+	+
CHROMOSAL	-	-	[illegible]	+	+	+	+
COPPER OXIDE (BLACK)	-	-	-	-	-	+	+
COPPER OXIDE (RED)	-	-		-	-	+	+
COPPER SULPHATE	-	+	+	+	+	+	+
CRYOLITE - ALUM. SOD. FLUOR.	-	-	-	-	-	+	+
ALUMINUM FLUORIDE	-	+	+	+	+	+	+
HYDROGEN FLUORIDE	-	-	-	-	-	+	+
IRON OXIDE (RED)	+	+	+	+	+	+	+
FERROFERRIC OXIDES (BLACK)	-	-	-	+	+	+	+
FERROUS SULPHATE	-	-	-	-	-	-	-
LEAD OXIDE (RED)	-	+	+	+	+	+	+
MAGNESIUM OXIDE	+	+	+	+	+	+	+
MANGANESE DIOXIDE	-	+	+	+	+	+	+
MOLYBDENUM TRIOXIDE	-	+	+	+	+	+	+
NICKEL SULFATE	-	-	-	+	+	+	+
SODIUM TRIPOLYPHOSPHATE	-	-	+	+	+	+	+
SODIUM HEXAMETAPHOSPHATE	-	+	+	+	+	+	+
SODIUM PYROPHOSPHATE	-	-	-	-	-	-	-
TRISODIUM PHOSPHATE	+	+	+	+	+	+	+
DICALCIUM PHOSPHATE	+	+	+	+	+	+	+
POTASSIUM CARBONATE	-	-	-	-	-	-	-
POTASSIUM CHLORATE	-	-	-	-	-	-	+
POTASSIUM NITRATE	-	-	-	-	-	-	+
SODIUM GLAZE	1	1	1	1	1	1	+
SODIUM WATER GLASS	1	1	1	1	1	1	+

Process Name	Investment in Mill. $						
	50	100	150	200	250	300	350
MOLEC. SIEVE-ZEOLITES(cl.3A)	-	-	-	-	-	-	-
SILICA GEL (MACRO)	-	-	-	-	-	+	+
SILICA GEL (MICRO)	-	-	-		-	-	-
SODIUM METASILICATE	-	-	-	+	+	+	+
SODIUM THIOSULPHATE	-	-	-	+	+	+	+
SODIUM HYDROGEN SULFITE	-	-	+	+	+	+	+
SODIUM SULFITE	-	-	-	-	-	+	+
SODIUM HYDROSULFITE	-	-	+	+	+	+	+
SODIUM CHLORIDE (MEDICAL)	-	-	-	+	+	+	+
SODIUM NITRATE	-	-	-	-	-	-	i
TITANIUM DIOXIDE	-	-	-	I	e	+	+
ZINC SULFATE	-	-	-	-	-	-	-
ZINC CHLORIDE	-	-	-	+	+	+	+
MOLEC. SIEVE-ZEOLITES(cl.4A)	-	-	-	+	+	+	+
MOLEC. SIEVE-ZEOLITES(cl.5A)	-	-	-	-	-	-	-
MOLEC. SIEVE-ZEOLITES(cl.13X)	-	-	-	-	-	-	-
SODA ASH	1	1	1	1	!	]	..

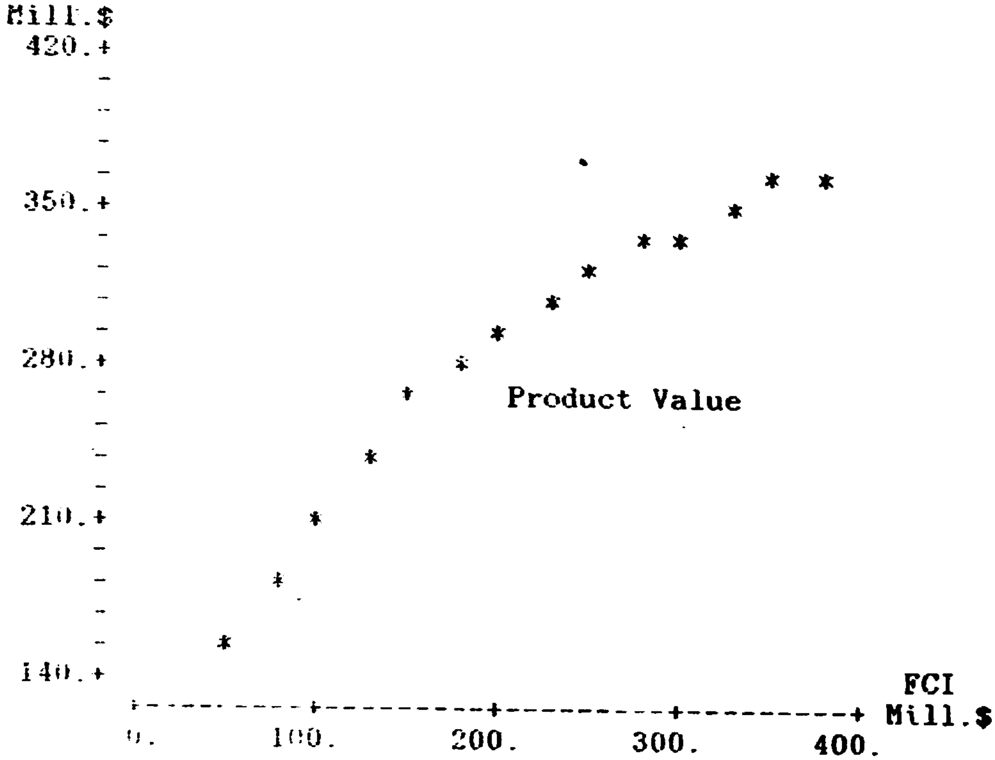
Mill.$
420.
350.
280.
210.
140.
Product Value
FCI
Mill.$
0.
100.
200.
300.
400.

Fig. 17.

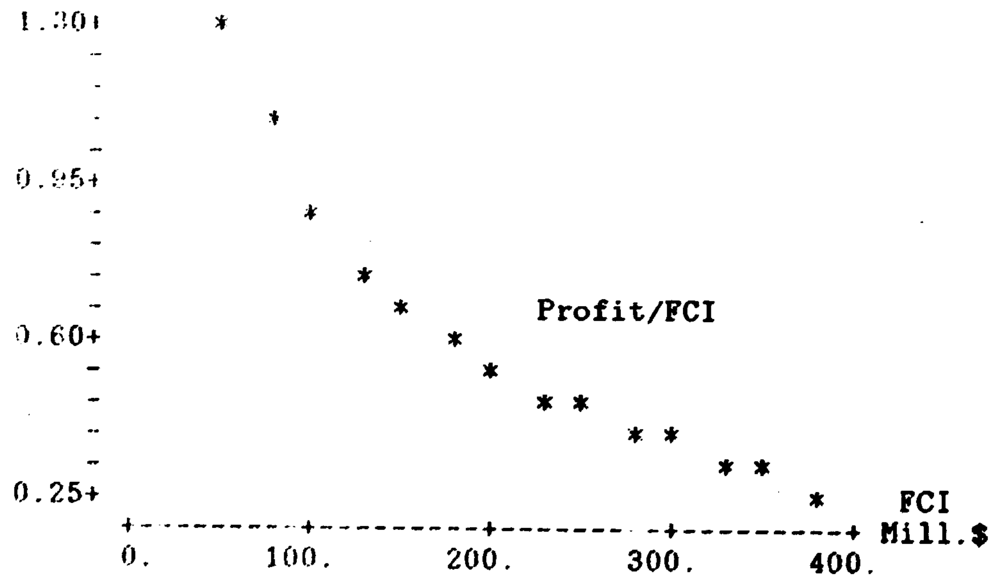
1.30
0.95
0.60
0.25
Profit/FCI
FCI
Mill.$
0.
100.
200.
300.
400.

Fig. 18.

The results of the analysis were submitted to P.Rozwadowski and A.A.Jafari to support the ultimate expertise of the development program by a repeated rescalling of some plants and elimination of some technologies. In addition, the results of the single plant evaluation and the production goal (demand) for the year 2000 were taken into account. The list of finally selected installations with their capacities is given below.

process name	capacity
ANTIMONY TRIOXIDE	3000.00
ALUMINUM SULPHATE	35000.00
SODIUM TETRABORATE (BORAX)	15000.00
BORIC ACID	12000.00
SODIUM PERBORATE	50000.00
PRECIPITATED CALCIUM CARBONATE	100000.00
PRECIPITATED CALCIUM CARBONATE(TOOTH P.)	4000.00
CALCIUM CARBIDE	60000.00
CALCIUM HYPOCHLORITE	7000.00
AMMONIUM CHLORIDE	1000.00
SODIUM CHROMATE	1500.00
POTASSIUM BICHROMATE	2000.00
ANHYDROUS CHROMIC ACID	1500.00
COPPER OXIDE (BLACK)	40.00
COPPER OXIDE (RED)	400.00
COPPER SULPHATE	2000.00
CRYOLITE - ALUMINUM SODIUM FLUORIDE	2700.00
ALUMINUM FLUORIDE	2700.00
IRON OXIDE (RED)	7000.00
FERROFERRIC OXIDES (BLACK)	5000.00
FERROUS SULPHATE	3500.00
LEAD OXIDE (RED)	4000.00
MANGANESE DIOXIDE	11000.00
MOLYBDENUM TRIOXIDE	2500.00
NICKEL SULFATE	300.00
SODIUM TRIPOLYPHOSPHATE	6000.00
SODIUM HEXAMETAPHOSPHATE	1000.00
TRISODIUM PHOSPHATE	7500.00
DICALCIUM PHOSPHATE	40000.00
POTASSIUM CARBONATE	3000.00
POTASSIUM CHLORATE	4000.00
POTASSIUM NITRATE	6000.00
SODIUM GLAZE	32000.00
SODIUM WATER GLASS	30000.00
MOLECURAL SIEVE-ZEOLITES (cl. 3A)	1000.00
SODIUM METASILICATE	30000.00
SODIUM THIOSULPHATE	1000.00
SODIUM HYDROGEN SULFITE	8000.00
SODIUM SULFITE	12000.00
SODIUM HYDROSULFITE	9000.00
SODIUM CHLORIDE (MEDICAL)	2500.00
SODIUM NITRATE	12000.00
TITANIUM DIOXIDE	50000.00

ZINC CHLORIDE	6500.00
SODA ASH	150000.00

The above data (stored on the MIDA_F volume in the directory \USR\INO2000R were used as an input information for futher analysis. It comprised the single plant evaluation and complex optimization analysis for the whole PDA. The sequence of experiments was performed for various objectives as maximization of MVA, max Profit, max Profit/Energy Consumption and one experiment for multiobjective optimization (max Profit and max MVA, min FCI and min Energy Consumption). All the results are attached in Appendix B6.

4.3 Conclusions

The preliminary selection of techologies to be developed in the IHO PDA resulted from the expertise on raw material base, forecasted demand on chemical products and conditions of the technologies availability. In the analysis only new plants were of concern. This, however, was the correct assumptions taking into account that the existing capacities were excluded from the production demand (see report of P. Rozwadowski and A.A. Jafari). Nevertheless, it is recommended to investigate a program including the existing potential.

The volume of products specified within the demand vector combined with a limited export possibility, determine low capacities of some technologies (that cannot be recommended from the economic point of view). For the above reason, a number of plants was excluded from the development program by A.A.Jafari and P.Rozwadowski (see details in their reports).

5. Summary

The case studies done with the contribution of DPCI are representative examples of MIDA methodology and what is more important they were assessed to be meaningful for the Master Plan. The results provide a good platform for elaboration of the Master Plan. It provides a sufficient background and a framework for futher and permanent analysis for development also for other areas of the chemical industry. The analysis so far should provide the decision makers with important hints for establishing long-range economic policy. The expertise gained by DPCI staff in the course of implementation of the case studies provides sufficient ground for their self-reliance in the Intergated Development Programming.

Appendix : A 1. Single plant evaluation

Process : 1 ETHYLENE FROM GAS OIL

Capacity :	225000
Fixed Capital Investment - FCI :	378.451 mln.
Product Value - PV :	158.517 mln.
Total Manufacturing Cost :	301.741 mln.
Profit :	-143.224 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	-47.061 mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	0.419
Energy Consumption :	-6122.984 TJ

Process : 2 ELTHYLENE FROM ETHANE-PROPANE MIXTURE

Capacity :	225000
Fixed Capital Investment - FCI :	253.080 mln.
Product Value - PV :	94.661 mln.
Total Manufacturing Cost :	104.825 mln.
Profit :	-10.165 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	43.707 mln.
MVA/FCI :	0.173
MVA/PV :	0.462
PV/FCI :	0.374
Energy Consumption :	-832.985 TJ

Process : 3 ETHYLENE FROM WIDE RANGE NAPHTA MS

Capacity :	225000
Fixed Capital Investment - FCI :	354.705 mln.
Product Value - PV :	171.720 mln.
Total Manufacturing Cost :	167.701 mln.
Profit :	4.019 mln.
Simple Rate of Return :	0.011
Back-pay Period :	88.265 years
Manufacturing Value Added - MVA :	80.762 mln.
MVA/FCI :	0.228
MVA/PV :	0.470
PV/FCI :	0.484
Energy Consumption :	-2180.083 TJ

Process : 4 ETHYLENE FROM WIDE RANGE NAPHTA HS

Capacity :	225000
Fixed Capital Investment - FCI :	343.626 mln.
Product Value - PV :	144.896 mln.
Total Manufacturing Cost :	150.064 mln.
Profit :	-5.168 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	67.915 mln.
MVA/FCI :	0.198
MVA/PV :	0.469
PV/FCI :	0.422
Energy Consumption :	-2765.623 TJ

Process : 5 BENZENE FROM PYROLYSIS GASOLINE

Capacity :	69500
Fixed Capital Investment - FCI :	27.810 mln.
Product Value - PV :	27.588 mln.
Total Manufacturing Cost :	33.554 mln.
Profit :	-5.966 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	2.279 mln.
MVA/FCI :	0.082
MVA/PV :	0.083
PV/FCI :	0.992
Energy Consumption :	482.539 TJ

Process : 6 MIXED XYLENES FROM NAPHTENIC FEED

Capacity :	92000
Fixed Capital Investment - FCI :	63.836 mln.
Product Value - PV :	73.132 mln.
Total Manufacturing Cost :	63.544 mln.
Profit :	9.588 mln.
Simple Rate of Return :	0.150
Back-pay Period :	6.658 years
Manufacturing Value Added - MVA :	27.172 mln.
MVA/FCI :	0.426
MVA/PV :	0.372
PV/FCI :	1.146
Energy Consumption :	-2195.801 TJ

Process : 7 MIXED XYLENES FROM PARAFFINIC FEED

Capacity :	86400
Fixed Capital Investment - FCI :	61.209 mln.
Product Value - PV :	62.201 mln.
Total Manufacturing Cost :	60.186 mln.
Profit :	2.014 mln.
Simple Rate of Return :	0.033
Back-pay Period :	30.388 years
Manufacturing Value Added - MVA :	18.831 mln.
MVA/FCI :	0.308
MVA/PV :	0.303
PV/FCI :	1.016
Energy Consumption :	-3152.287 TJ

Process : 8 BENZENE FROM TOLUENE

Capacity :	40000
Fixed Capital Investment - FCI :	15.691 mln.
Product Value - PV :	10.355 mln.
Total Manufacturing Cost :	21.469 mln.
Profit :	-11.114 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	-6.035 mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	0.660
Energy Consumption :	-347.616 TJ

Process : 9 P-XYLENE RECOVERY CRISTALIZATION

Capacity :	80000
Fixed Capital Investment - FCI :	77.013 mln.
Product Value - PV :	38.275 mln.
Total Manufacturing Cost :	55.595 mln.
Profit :	-17.321 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	1.697 mln.
MVA/FCI :	0.022
MVA/PV :	0.044
PV/FCI :	0.497
Energy Consumption :	1294.592 TJ

Process : 10 **P-XYLENE (PAREX)**

Capacity :	67500
Fixed Capital Investment - FCI :	37.118 mln.
Product Value - PV :	36.762 mln.
Total Manufacturing Cost :	39.510 mln.
Profit :	-2.748 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	7.700 mln.
MVA/FCI :	0.207
MVA/PV :	0.209
PV/FCI :	0.990
Energy Consumption :	1703.295 TJ

Process : 11 **P-XYLENE RECOVERY (ADSORPTION)**

Capacity :	40000
Fixed Capital Investment - FCI :	52.608 mln.
Product Value - PV :	23.309 mln.
Total Manufacturing Cost :	31.844 mln.
Profit :	-8.535 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	3.921 mln.
MVA/FCI :	0.075
MVA/PV :	0.168
PV/FCI :	0.443
Energy Consumption :	619.440 TJ

Process : 12 **BUTADIENE FROM C4 EXTRACTION**

Capacity :	50000
Fixed Capital Investment - FCI :	17.342 mln.
Product Value - PV :	22.594 mln.
Total Manufacturing Cost :	27.222 mln.
Profit :	-4.628 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	1.371 mln.
MVA/FCI :	0.079
MVA/PV :	0.061
PV/FCI :	1.303
Energy Consumption :	380.570 TJ

Process : 13 **METHYL METHACRYLATE CYANOHYDRIN PROCESS**

Capacity :	45000

Product Value - PV :	60.581 mln.
Total Manufacturing Cost :	48.394 mln.
Profit :	12.188 mln.
Simple Rate of Return :	0.166
Back-pay Period :	6.035 years
Manufacturing Value Added - MVA :	29.955 mln.
MVA/FCI :	0.407
MVA/PV :	0.494
PV/FCI :	0.824
Energy Consumption :	299.061 TJ

Process : 14 ISOBUTYLENE BY ACID EXTRACTION (CFR)

Capacity :	35000
Fixed Capital Investment - FCI :	22.210 mln.
Product Value - PV :	33.519 mln.
Total Manufacturing Cost :	15.987 mln.
Profit :	17.532 mln.
Simple Rate of Return :	0.789
Back-pay Period :	1.267 years
Manufacturing Value Added - MVA :	22.815 mln.
MVA/FCI :	1.027
MVA/PV :	0.681
PV/FCI :	1.509
Energy Consumption :	200.291 TJ

Process : 15 MTBE FROM MIXED BUTENES

Capacity :	47500
Fixed Capital Investment - FCI :	12.343 mln.
Product Value - PV :	16.110 mln.
Total Manufacturing Cost :	14.988 mln.
Profit :	1.122 mln.
Simple Rate of Return :	0.091
Back-pay Period :	11.003 years
Manufacturing Value Added - MVA :	4.793 mln.
MVA/FCI :	0.388
MVA/PV :	0.297
PV/FCI :	1.305
Energy Consumption :	80.693 TJ

Process : 16 D-ETHYLHEXANOL (OXO PROCESS)

Capacity :	50000
Fixed Capital Investment - FCI :	62.026 mln.
Product Value - PV :	35.647 mln.
Total Manufacturing Cost :	36.792 mln.
Profit :	-1.145 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	13.331 mln.
MVA/FCI :	0.215
MVA/PV :	0.374
PV/FCI :	0.575
Energy Consumption :	-378.440 TJ

Process : 17 PROPYLENE OXIDE BY ETHYLBENZENE PROCESS

Capacity :	90000
Fixed Capital Investment - FCI :	168.067 mln.
Product Value - PV :	153.5[illegible]8 mln.
Total Manufacturing Cost :	[illegible]

Profit :	-4.060 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	40.679 mln.
MVA/FCI :	0.242
MVA/PV :	0.265
PV/FCI :	0.914
Energy Consumption :	3016.764 TJ

Process : 18 PROPYLENE OXIDE BY CHLOROHIDRINE PROCESS

Capacity :	90000
Fixed Capital Investment - FCI :	67.470 mln.
Product Value - PV :	82.505 mln.
Total Manufacturing Cost :	67.080 mln.
Profit :	15.425 mln.
Simple Rate of Return :	0.229
Back-pay Period :	4.374 years
Manufacturing Value Added - MVA :	34.172 mln.
MVA/FCI :	0.506
MVA/PV :	0.414
PV/FCI :	1.223
Energy Consumption :	1439.532 TJ

Process : 19 POLYOL TRIFUNCTIONAL POLYETHER

Capacity :	40000
Fixed Capital Investment - FCI :	14.520 mln.
Product Value - PV :	44.143 mln.
Total Manufacturing Cost :	36.800 mln.
Profit :	7.343 mln.
Simple Rate of Return :	0.506
Back-pay Period :	1.977 years
Manufacturing Value Added - MVA :	13.959 mln.
MVA/FCI :	0.961
MVA/PV :	0.316
PV/FCI :	3.040
Energy Consumption :	41.460 TJ

Process : 20 BUTENE-1 FROM MTBE RAFFINATE

Capacity :	20000
Fixed Capital Investment - FCI :	20.176 mln.
Product Value - PV :	9.700 mln.
Total Manufacturing Cost :	9.330 mln.
Profit :	0.370 mln.
Simple Rate of Return :	0.018
Back-pay Period :	54.534 years
Manufacturing Value Added - MVA :	4.569 mln.
MVA/FCI :	0.226
MVA/PV :	0.471
PV/FCI :	0.481
Energy Consumption :	308.684 TJ

Process : 21 ISOPROPANOL BY CATION EXCHANGE RESIN

Capacity :	65000
Fixed Capital Investment - FCI :	38.025 mln.
Product Value - PV :	49.075 mln.
Total Manufacturing Cost :	25.000 mln.
Profit :	24.095 mln.

Back-pay Period :	1.578 years
Manufacturing Value Added - MVA :	32.885 mln.
MVA/FCI :	0.865
MVA/PV :	0.670
PV/FCI :	1.291
Energy Consumption :	492.895 TJ

Process : 22 DI-OCTYLPHTALATE FROM PHTALIC ANHYDRIDE

Capacity :	35000
Fixed Capital Investment - FCI :	11.271 mln.
Product Value - PV :	35.000 mln.
Total Manufacturing Cost :	29.447 mln.
Profit :	5.553 mln.
Simple Rate of Return :	0.493
Back-pay Period :	2.030 years
Manufacturing Value Added - MVA :	10.789 mln.
MVA/FCI :	0.957
MVA/PV :	0.308
PV/FCI :	3.105
Energy Consumption :	41.783 TJ

Process : 23 PHTHALIC ANHYDRIDE AIR OX. OF O-XYLENE

Capacity :	15000
Fixed Capital Investment - FCI :	20.475 mln.
Product Value - PV :	7.981 mln.
Total Manufacturing Cost :	9.041 mln.
Profit :	-1.060 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	3.357 mln.
MVA/FCI :	0.164
MVA/PV :	0.421
PV/FCI :	0.390
Energy Consumption :	-111.009 TJ

Process : 24 METHYL ETHYL KETONE FROM MTBE RAFFINATE

Capacity :	15000
Fixed Capital Investment - FCI :	20.335 mln.
Product Value - PV :	7.490 mln.
Total Manufacturing Cost :	10.458 mln.
Profit :	-2.968 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	1.555 mln.
MVA/FCI :	0.076
MVA/PV :	0.208
PV/FCI :	0.368
Energy Consumption :	234.570 TJ

Process : 25 METHYL ETHYL KETONE FROM ISOBUTYLENE RAF

Capacity :	15000
Fixed Capital Investment - FCI :	21.927 mln.
Product Value - PV :	7.259 mln.
Total Manufacturing Cost :	10.539 mln.
Profit :	-3.279 mln.
Simple Rate of Return :	
Back-pay Period :	

MVA/FCI :	0.067
MVA/PV :	0.202
PV/FCI :	0.331
Energy Consumption :	274.155 TJ

Process : 26 TRIETHANOL AMINE FROM EO END NH3

Capacity :	45000
Fixed Capital Investment - FCI :	25.051 mln.
Product Value - PV :	95.131 mln.
Total Manufacturing Cost :	46.976 mln.
Profit :	43.155 mln.
Simple Rate of Return :	1.922
Back-pay Period :	0.520 years
Manufacturing Value Added - MVA :	57.475 mln.
MVA/FCI :	2.294
MVA/PV :	0.604
PV/FCI :	3.798
Energy Consumption :	971.398 TJ

Process : 27 POLYMETHYLMETHACRYLATE

Capacity :	15000
Fixed Capital Investment - FCI :	50.375 mln.
Product Value - PV :	30.000 mln.
Total Manufacturing Cost :	36.214 mln.
Profit :	-6.214 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	6.562 mln.
MVA/FCI :	0.130
MVA/PV :	0.219
PV/FCI :	0.596
Energy Consumption :	50.412 TJ

Process : 28 PERCHLOROETHYLENE FROM PROPANE

Capacity :	20000
Fixed Capital Investment - FCI :	16.617 mln.
Product Value - PV :	14.126 mln.
Total Manufacturing Cost :	11.714 mln.
Profit :	2.413 mln.
Simple Rate of Return :	0.145
Back-pay Period :	6.837 years
Manufacturing Value Added - MVA :	6.461 mln.
MVA/FCI :	0.389
MVA/PV :	0.457
PV/FCI :	0.850
Energy Consumption :	63.168 TJ

Process : 29 PERCHLOROETHYLENE FROM EDC

Capacity :	12000
Fixed Capital Investment - FCI :	14.425 mln.
Product Value - PV :	12.171 mln.
Total Manufacturing Cost :	8.117 mln.
Profit :	4.054 mln.
Simple Rate of Return :	0.281
Back-pay Period :	3.558 years
Manufacturing Value Added - MVA :	7.408 mln.
MVA/FCI :	0.514
MVA/PV :	[illegible]

PV/FCI :	0.844
Energy Consumption :	37.260 TJ

Process : 30 HYDROGEN FROM NATURAL GAS

Capacity :	506000000
Fixed Capital Investment - FCI :	56.814 mln.
Product Value - PV :	49.284 mln.
Total Manufacturing Cost :	50.375 mln.
Prorit :	-1.091 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	14.146 mln.
MVA/FCI :	0.249
MVA/PV :	0.287
PV/FCI :	0.867
Energy Consumption :	8461.332 TJ

Process : 31 PHENOL (CUMENE)

Capacity :	45000
Fixed Capital Investment - FCI :	79.599 mln.
Product Value - PV :	25.983 mln.
Total Manufacturing Cost :	43.087 mln.
Profit :	-17.104 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	0.795 mln.
MVA/FCI :	0.010
MVA/PV :	0.031
PV/FCI :	0.326
Energy Consumption :	667.764 TJ

Process : 32 CHLORINE (MEMBRANE PROCESS)

Capacity :	180000
Fixed Capital Investment - FCI :	168.252 mln.
Product Value - PV :	58.279 mln.
Total Manufacturing Cost :	77.076 mln.
Profit :	-18.798 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	17.246 mln.
MVA/FCI :	0.103
MVA/PV :	0.296
PV/FCI :	0.346
Energy Consumption :	1155.051 TJ

Process : 33 METHANOL FROM NATURAL GAS

Capacity :	410000
Fixed Capital Investment - FCI :	176.319 mln.
Product Value - PV :	41.410 mln.
Total Manufacturing Cost :	103.379 mln.
Profit :	-61.969 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	-20.935 mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	0.235

Process : 34 POLYETHYLENE LD (AUTOCLAVE REACTOR)

Capacity :	50000
Fixed Capital Investment - FCI :	55.984 mln.
Product Value - PV :	24.595 mln.
Total Manufacturing Cost :	38.454 mln.
Profit :	-13.860 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	-0.001 mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	0.439
Energy Consumption :	175.490 TJ

Process : 35 POLYETHYLENE LD (TUBULAR REACTOR)

Capacity :	50000
Fixed Capital Investment - FCI :	56.456 mln.
Product Value - PV :	24.661 mln.
Total Manufacturing Cost :	38.568 mln.
Profit :	-13.907 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	0.090 mln.
MVA/FCI :	0.002
MVA/PV :	0.004
PV/FCI :	0.437
Energy Consumption :	150.030 TJ

Process : 36 POLYETHYLENE LLD (UCC)

Capacity :	160000
Fixed Capital Investment - FCI :	53.352 mln.
Product Value - PV :	112.480 mln.
Total Manufacturing Cost :	89.772 mln.
Profit :	22.708 mln.
Simple Rate of Return :	0.426
Back-pay Period :	2.350 years
Manufacturing Value Added - MVA :	41.815 mln.
MVA/FCI :	0.784
MVA/PV :	0.372
PV/FCI :	2.108
Energy Consumption :	219.456 TJ

Process : 37 POLYETHYLENE LLD (DUPONT)

Capacity :	50000
Fixed Capital Investment - FCI :	30.139 mln.
Product Value - PV :	35.183 mln.
Total Manufacturing Cost :	30.972 mln.
Profit :	4.211 mln.
Simple Rate of Return :	0.140
Back-pay Period :	7.157 years
Manufacturing Value Added - MVA :	12.766 mln.
MVA/FCI :	0.424
MVA/PV :	0.363
PV/FCI :	1.167
Energy Consumption :	54.392 TJ

Process : 38 POLYPROPYLENE (AMOCO)

Capacity :	37500
Fixed Capital Investment - FCI :	28.046 mln.
Product Value - PV :	24.271 mln.
Total Manufacturing Cost :	20.116 mln.
Profit :	4.155 mln.
Simple Rate of Return :	0.148
Back-pay Period :	6.750 years
Manufacturing Value Added - MVA :	11.127 mln.
MVA/FCI :	0.397
MVA/PV :	0.458
PV/FCI :	0.865
Energy Consumption :	105.928 TJ

Process : 39 POLYVINYLCHLORIDE BY SUSPENSION POLYMER.

Capacity :	90000
Fixed Capital Investment - FCI :	68.546 mln.
Product Value - PV :	55.710 mln.
Total Manufacturing Cost :	71.802 mln.
Profit :	-16.092 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	3.140 mln.
MVA/FCI :	0.046
MVA/PV :	0.056
PV/FCI :	0.813
Energy Consumption :	487.116 TJ

Process : 40 POLYVINYL CHLORIDE BY EMULSION POLIMER.

Capacity :	23000
Fixed Capital Investment - FCI :	38.415 mln.
Product Value - PV :	23.500 mln.
Total Manufacturing Cost :	24.845 mln.
Profit :	-1.345 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	7.833 mln.
MVA/FCI :	0.204
MVA/PV :	0.333
PV/FCI :	0.612
Energy Consumption :	222.300 TJ

Process : 41 VINYL CHLORIDE BY OXYCHLORINATION

Capacity :	250000
Fixed Capital Investment - FCI :	104.252 mln.
Product Value - PV :	123.750 mln.
Total Manufacturing Cost :	105.922 mln.
Profit :	17.828 mln.
Simple Rate of Return :	0.171
Back-pay Period :	5.848 years
Manufacturing Value Added - MVA :	46.056 mln.
MVA/FCI :	0.442
MVA/PV :	0.372
PV/FCI :	1.187
Energy Consumption :	2225.500 TJ

Process : 42 VINYL CHLORIDE FROM EDC

Capacity :	125000
Fixed Capital Investment - FCI :	47.715 mln.
Product Value - PV :	74.792 mln.
Total Manufacturing Cost :	70.628 mln.
Profit :	4.164 mln.
Simple Rate of Return :	0.087
Back-pay Period :	11.459 years
Manufacturing Value Added - MVA :	19.249 mln.
MVA/FCI :	0.403
MVA/PV :	0.257
PV/FCI :	1.567
Energy Consumption :	1240.725 TJ

Process : 43 **VINYL ACETATE FROM ETHYLENE**

Capacity :	67500
Fixed Capital Investment - FCI :	63.702 mln.
Product Value - PV :	51.097 mln.
Total Manufacturing Cost :	78.133 mln.
Profit :	-27.036 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	-7.036 mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	0.801
Energy Consumption :	[illegible] TJ

Process : 44 **ACETIC ACID FROM ETHYLENE**

Capacity :	[illegible]
Fixed Capital Investment - FCI :	[illegible] mln.
Product Value - PV :	[illegible] mln.
Total Manufacturing Cost :	[illegible] mln.
Profit :	-1.675 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	14.215 mln.
MVA/FCI :	[illegible]
MVA/PV :	0.341
PV/FCI :	0.605
Energy Consumption :	[illegible] TJ

Process : 45 **ACETIC ACID FROM METHANOL**

Capacity :	67500
Fixed Capital Investment - FCI :	60.857 mln.
Product Value - PV :	40.567 mln.
Total Manufacturing Cost :	29.411 mln.
Profit :	11.156 mln.
Simple Rate of Return :	0.183
Back-pay Period :	5.455 years
Manufacturing Value Added - MVA :	24.200 mln.
MVA/FCI :	0.398
MVA/PV :	0.597
PV/FCI :	0.667
Energy Consumption :	322.326 TJ

Process : 46 **POLYSTYRENE EXPANDABLE**

Capacity :	7500

Product Value - PV :	7.395 mln.
Total Manufacturing Cost :	7.309 mln.
Profit :	0.086 mln.
Simple Rate of Return :	0.007
Back-pay Period :	137.766 years
Manufacturing Value Added - MVA :	2.928 mln.
MVA/FCI :	0.247
MVA/PV :	0.396
PV/FCI :	0.625
Energy Consumption :	6.622 TJ

Process : 47 POLYSTYRENE HIGH IMPACT

Capacity :	60000
Fixed Capital Investment - FCI :	22.815 mln.
Product Value - PV :	52.260 mln.
Total Manufacturing Cost :	42.690 mln.
Profit :	9.570 mln.
Simple Rate of Return :	0.419
Back-pay Period :	2.384 years
Manufacturing Value Added - MVA :	18.377 mln.
MVA/FCI :	0.805
MVA/PV :	0.352
PV/FCI :	2.291
Energy Consumption :	77.022 TJ

Process : 48 ABS BY EMULSION/MASS POLYMERIZATION

Capacity :	25000
Fixed Capital Investment - FCI :	39.043 mln.
Product Value - PV :	48.750 mln.
Total Manufacturing Cost :	27.236 mln.
Profit :	21.514 mln.
Simple Rate of Return :	0.551
Back-pay Period :	1.815 years
Manufacturing Value Added - MVA :	31.177 mln.
MVA/FCI :	0.799
MVA/PV :	0.640
PV/FCI :	1.249
Energy Consumption :	41.437 TJ

Process : 49 STYRENE BY BENZENE ALKYLATION

Capacity :	225000
Fixed Capital Investment - FCI :	106.190 mln.
Product Value - PV :	83.929 mln.
Total Manufacturing Cost :	132.893 mln.
Profit :	-48.964 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	-16.516 mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	0.790
Energy Consumption :	2369.160 TJ

Process : 50 ETHYLBENZENE LIQUID PHASE

Capacity :	250000
Fixed Capital Investment - FCI :	41.787 mln.
Product Value - PV :	74.686 mln.

Profit :	-36.872 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	-17.343 mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	1.787
Energy Consumption :	100.870 TJ

Process : 51 ETHYLENE DICHLORIDE BY CHLORINATION

Capacity :	180000
Fixed Capital Investment - FCI :	11.661 mln.
Product Value - PV :	42.550 mln.
Total Manufacturing Cost :	42.939 mln.
Profit :	-0.390 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	6.320 mln.
MVA/FCI :	0.542
MVA/PV :	0.149
PV/FCI :	3.649
Energy Consumption :	-27.090 TJ

Process : 52 ETHYLENE DICHLORIDE BY OXYCHLORINATION

Capacity :	180000
Fixed Capital Investment - FCI :	37.794 mln.
Product Value - PV :	42.516 mln.
Total Manufacturing Cost :	87.193 mln.
Profit :	-44.678 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	-28.541 mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	1.125
Energy Consumption :	84.582 TJ

Process : 53 POLYETHYLENE HD (UCC)

Capacity :	160000
Fixed Capital Investment - FCI :	60.268 mln.
Product Value - PV :	91.680 mln.
Total Manufacturing Cost :	88.225 mln.
Profit :	3.455 mln.
Simple Rate of Return :	0.057
Back-pay Period :	17.443 years
Manufacturing Value Added - MVA :	23.497 mln.
MVA/FCI :	0.390
MVA/PV :	0.256
PV/FCI :	1.521
Energy Consumption :	219.456 TJ

Process : 54 POLYETHYLENE HD (PHILIPS)

Capacity :	50000
Fixed Capital Investment - FCI :	32.131 mln.
Product Value - PV :	28.650 mln.
Total Manufacturing Cost :	31.964 mln.
Profit :	-3.314 mln.
Simple Rate of Return :	

Back-pay Period :	
Manufacturing Value Added - MVA :	5.734 mln.
MVA/FCI :	0.178
MVA/PV :	0.200
PV/FCI :	0.892
Energy Consumption :	69.767 TJ

Process : 55 STYRENE-BUTADIENE LATEX

Capacity :	35000
Fixed Capital Investment - FCI :	69.283 mln.
Product Value - PV :	37.695 mln.
Total Manufacturing Cost :	36.956 mln.
Profit :	0.739 mln.
Simple Rate of Return :	0.011
Back-pay Period :	93.702 years
Manufacturing Value Added - MVA :	16.328 mln.
MVA/FCI :	0.236
MVA/PV :	0.433
PV/FCI :	0.544
Energy Consumption :	164.766 TJ

Process : 56 STYRENE-BUTADIENE RUBBER BY EMUL.POLYM.

Capacity :	35000
Fixed Capital Investment - FCI :	69.283 mln.
Product Value - PV :	34.090 mln.
Total Manufacturing Cost :	36.759 mln.
Profit :	-2.669 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	12.897 mln.
MVA/FCI :	0.186
MVA/PV :	0.378
PV/FCI :	0.492
Energy Consumption :	164.766 TJ

Process : 57 STYRENE-BUTADIENE RUB. BY SOL.POLYMER.

Capacity :	35000
Fixed Capital Investment - FCI :	73.464 mln.
Product Value - PV :	34.090 mln.
Total Manufacturing Cost :	37.053 mln.
Profit :	-2.963 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	13.254 mln.
MVA/FCI :	0.180
MVA/PV :	0.389
PV/FCI :	0.464
Energy Consumption :	407.260 TJ

Process : 58 POLYBUTADIENE

Capacity :	45000
Fixed Capital Investment - FCI :	110.301 mln.
Product Value - PV :	77.400 mln.
Total Manufacturing Cost :	52.129 mln.
Profit :	25.271 mln.
Simple Rate of Return :	0.229
Back-pay Period :	4.365 years

MVA/FCI :	0.445
MVA/PV :	0.634
PV/FCI :	0.702
Energy Consumption :	952.795 TJ

Process : 59 BUTYL RUBBER

Capacity :	5000
Fixed Capital Investment - FCI :	21.570 mln.
Product Value - PV :	6.000 mln.
Total Manufacturing Cost :	11.391 mln.
Profit :	-5.391 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	-0.205 mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	0.278
Energy Consumption :	165.00? TJ

Process : 60 POLYISOBUTYLENE

Capacity :	5000
Fixed Capital Investment - FCI :	[illegible] mln.
Product Value - PV :	4.000 mln.
Total Manufacturing Cost :	[illegible] mln.
Profit :	[illegible] mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	[illegible] mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	0.3?5
Energy Consumption :	[illegible] TJ

Process : 61 NYLON 6 MELT

Capacity :	[illegible]
Fixed Capital Investment - FCI :	[illegible] mln.
Product Value - PV :	27.9?0 mln.
Total Manufacturing Cost :	[illegible] mln.
Profit :	[illegible] mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	[illegible] mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	2.270
Energy Consumption :	[illegible] TJ

Process : 62 CAPROLACTAM FROM CYCLOHEXANE

Capacity :	35000
Fixed Capital Investment - FCI :	131.716 mln.
Product Value - PV :	74.911 mln.
Total Manufacturing Cost :	76.473 mln.
Profit :	-1.562 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	29.205 mln.
MVA/FCI :	[illegible]

PV/FCI :	0.569
Energy Consumption :	1060.444 TJ

Process : 63 CAPROLACTAM FROM TOLUENE

Capacity :	35000
Fixed Capital Investment - FCI :	212.901 mln.
Product Value - PV :	78.941 mln.
Total Manufacturing Cost :	96.946 mln.
Profit :	-18.005 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	27.653 mln.
MVA/FCI :	0.130
MVA/PV :	0.350
PV/FCI :	0.371
Energy Consumption :	1290.520 TJ

Process : 64 CAPROLACTAM FROM PHENOL

Capacity :	35000
Fixed Capital Investment - FCI :	111.207 mln.
Product Value - PV :	79.403 mln.
Total Manufacturing Cost :	74.225 mln.
Profit :	5.183 mln.
Simple Rate of Return :	0.047
Back-pay Period :	21.456 years
Manufacturing Value Added - MVA :	32.380 mln.
MVA/FCI :	0.291
MVA/PV :	0.408
PV/FCI :	0.714
Energy Consumption :	706.598 TJ

Process : 65 CYCLOHEXANE BY HYDROGENATION OF BENZENE

Capacity :	50000
Fixed Capital Investment - FCI :	8.923 mln.
Product Value - PV :	21.374 mln.
Total Manufacturing Cost :	24.893 mln.
Profit :	-3.519 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	0.874 mln.
MVA/FCI :	0.098
MVA/PV :	0.041
PV/FCI :	2.395
Energy Consumption :	-182.640 TJ

Process : 66 POLYETHYLENE TEREPHTALATE MELT FROM DMT

Capacity :	25000
Fixed Capital Investment - FCI :	42.653 mln.
Product Value - PV :	45.852 mln.
Total Manufacturing Cost :	38.775 mln.
Profit :	7.077 mln.
Simple Rate of Return :	0.166
Back-pay Period :	6.027 years
Manufacturing Value Added - MVA :	18.424 mln.
MVA/FCI :	0.432
MVA/PV :	0.402
PV/FCI :	1.075
Energy Consumption :	194.470 TJ

Process : 67 POLYETHYLENE TEREPHTALATE MELT FROM T?

Capacity :	25000
Fixed Capital Investment - FCI :	41.683 mln.
Product Value - PV :	45.000 mln.
Total Manufacturing Cost :	36.216 mln.
Profit :	8.784 mln.
Simple Rate of Return :	0.211
Back-pay Period :	4.746 years
Manufacturing Value Added - MVA :	19.705 mln.
MVA/FCI :	0.473
MVA/PV :	0.438
PV/FCI :	1.080
Energy Consumption :	237.175 TJ

Process : 68 TEREPHTHATIC ACID FROM P-XYLENE

Capacity :	75000
Fixed Capital Investment - FCI :	97.378 mln.
Product Value - PV :	60.225 mln.
Total Manufacturing Cost :	61.516 mln.
Profit :	-1.291 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	22.002 mln.
MVA/FCI :	0.226
MVA/PV :	0.365
PV/FCI :	0.618
Energy Consumption :	681.660 TJ

Process : 69 DMT FROM P-XYLENE

Capacity :	75000
Fixed Capital Investment - FCI :	1[illegible]1.794 mln.
Product Value - PV :	44.700 mln.
Total Manufacturing Cost :	66.221 mln.
Profit :	-21.521 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	7.942 mln.
MVA/FCI :	0.060
MVA/PV :	0.178
PV/FCI :	0.339
Energy Consumption :	826.965 TJ

Process : 70 ETHYLENE GLYCOL AND ETHYLENE OXIDE

Capacity :	90000
Fixed Capital Investment - FCI :	171.517 mln.
Product Value - PV :	115.202 mln.
Total Manufacturing Cost :	126.521 mln.
Profit :	-11.319 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	31.071 mln.
MVA/FCI :	0.181
MVA/PV :	0.270
PV/FCI :	0.672
Energy Consumption :	509.364 TJ

Process : 71 ACRYLONITRILE BY PROPYLENE AMMOXIDATION

Capacity :	90000
Fixed Capital Investment - FCI :	163.371 mln.
Product Value - PV :	95.763 mln.
Total Manufacturing Cost :	71.700 mln.
Profit :	24.063 mln.
Simple Rate of Return :	0.147
Back-pay Period :	6.789 years
Manufacturing Value Added - MVA :	59.089 mln.
MVA/FCI :	0.362
MVA/PV :	0.617
PV/FCI :	0.586
Energy Consumption :	114.516 TJ

Process : 72 SYNTGAS (2:1) FROM NATURAL GAS

Capacity :	384000000
Fixed Capital Investment - FCI :	94.813 mln.
Product Value - PV :	72.930 mln.
Total Manufacturing Cost :	90.717 mln.
Profit :	-17.787 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	7.823 mln.
MVA/FCI :	0.083
MVA/PV :	0.107
PV/FCI :	0.769
Energy Consumption :	15874.341 TJ

Process : 73 SYNTGAS (3:1) FROM NATURAL GAS

Capacity :	834000000
Fixed Capital Investment - FCI :	77.459 mln.
Product Value - PV :	81.063 mln.
Total Manufacturing Cost :	82.876 mln.
Profit :	-1.813 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	20.642 mln.
MVA/FCI :	0.266
MVA/PV :	0.255
PV/FCI :	1.047
Energy Consumption :	14935.003 TJ

Process : 74 CARBON MONOOXIDE FROM SYNTGAS

Capacity :	27300000
Fixed Capital Investment - FCI :	4.933 mln.
Product Value - PV :	12.652 mln.
Total Manufacturing Cost :	13.516 mln.
Profit :	-0.864 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	1.586 mln.
MVA/FCI :	0.322
MVA/PV :	0.125
PV/FCI :	2.565
Energy Consumption :	13.677 TJ

Process : 75 OXYGEN BY AIR FRACTIONATION

Capacity :	40000
Fixed Capital Investment - FCI :	19.074 mln.
Product Value - PV :	5.840 mln.
Total Manufacturing Cost :	6.259 mln.
Profit :	-0.419 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	3.519 mln.
MVA/FCI :	0.184
MVA/PV :	0.603
PV/FCI :	0.306
Energy Consumption :	109.440 TJ

Process : 76 **NYLON 6 MELT PARSILON COMP.**

Capacity :	16000
Fixed Capital Investment - FCI :	12.823 mln.
Product Value - PV :	29.760 mln.
Total Manufacturing Cost :	42.079 mln.
Profit :	-12.319 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	-5.245 mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	2.321
Energy Consumption :	76.405 TJ

Process : 77 **NYLON 6 MELT ALYAF COMP.**

Capacity :	10000
Fixed Capital Investment - FCI :	9.216 mln.
Product Value - PV :	18.600 mln.
Total Manufacturing Cost :	26.683 mln.
Profit :	-8.083 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	-3.378 mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	2.018
Energy Consumption :	47.753 TJ

Process : 78 **POLYETYLENE THEREFTALATE POLYACRYL COMP.**

Capacity :	55000
Fixed Capital Investment - FCI :	76.324 mln.
Product Value - PV :	100.875 mln.
Total Manufacturing Cost :	81.113 mln.
Profit :	19.762 mln.
Simple Rate of Return :	0.259
Back-pay Period :	3.862 years
Manufacturing Value Added - MVA :	41.189 mln.
MVA/FCI :	0.540
MVA/PV :	0.408
PV/FCI :	1.322
Energy Consumption :	427.834 TJ

Process : 79 **DI-OCTYL PHTALATE IRAN NIPPON**

Capacity :	40000
Fixed Capital Investment - FCI :	12.155 mln.

Product Value - PV :	40.000 mln.
Total Manufacturing Cost ·	33.482 mln.
Profit :	6.518 mln.
Simple Rate of Return :	0.536
Back-pay Period :	1.865 years
Manufacturing Value Added - MVA :	12.358 mln.
MVA/FCI :	1.017
MVA/PV :	0.309
PV/FCI :	3.291
Energy Consumption :	47.752 TJ

Process : 80 **PHTALIC ANHYDRIDE IRAN NIPPON**

Capacity :	22000
Fixed Capital Investment - FCI :	26.149 mln.
Product Value - PV :	11.480 mln.
Total Manufacturing Cost :	13.323 mln.
Profit :	-1.843 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	3.987 mln.
MVA/FCI :	0.152
MVA/PV :	0.347
PV/FCI :	0.439
Energy Consumption :	-37.589 TJ

Process : 82 **ACRYLONITRILE ARAK**

Capacity :	33000
Fixed Capital Investment - FCI :	69.837 mln.
Product Value - PV :	35.113 mln.
Total Manufacturing Cost :	28.651 mln.
Profit :	6.462 mln.
Simple Rate of Return :	0.093
Back-pay Period :	10.807 years
Manufacturing Value Added - MVA :	21.294 mln.
MVA/FCI :	0.305
MVA/PV :	0.606
PV/FCI :	0.503
Energy Consumption :	41.989 TJ

Process : 83 **VINYL CHLORIDE FROM ETHYLENE ARAK**

Capacity :	150000
Fixed Capital Investment - FCI :	41.188 mln.
Product Value - PV :	74.250 mln.
Total Manufacturing Cost :	59.181 mln.
Profit :	15.069 mln.
Simple Rate of Return :	0.366
Back-pay Period :	2.733 years
Manufacturing Value Added - MVA :	28.435 mln.
MVA/FCI :	0.690
MVA/PV :	0.383
PV/FCI :	1.803
Energy Consumption :	1335.300 TJ

Process : 84 **PVC ARAK**

Capacity :	150000
Fixed Capital Investment - FCI :	97.266 mln.
Product Value - PV :	92.850 mln.
Total Manufacturing Cost :	115.740 mln.

Profit :	-22.890 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	5.870 mln.
MVA/FCI :	0.060
MVA/PV :	0.063
PV/FCI :	0.955
Energy Consumption :	811.860 TJ

Process : 86 VINYLACETATE ARAK

Capacity :	30000
Fixed Capital Investment - FCI :	34.091 mln.
Product Value - PV :	22.710 mln.
Total Manufacturing Cost :	34.695 mln.
Profit :	-11.985 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	-2.363 mln.
MVA/FCI :	
MVA/PV :	
PV/FCI :	0.666
Energy Consumption :	6.264 TJ

Process : 87 ACETIC ACID ARAK

Capacity :	30000
Fixed Capital Investment - FCI :	40.024 mln.
Product Value - PV :	18.674 mln.
Total Manufacturing Cost :	21.599 mln.
Profit :	-2.925 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	6.018 mln.
MVA/FCI :	0.150
MVA/PV :	0.322
PV/FCI :	0.467
Energy Consumption :	421.698 TJ

Process : 88 PE HD ARAK

Capacity :	60000
Fixed Capital Investment - FCI :	36.609 mln.
Product Value - PV :	34.300 mln.
Total Manufacturing Cost :	37.869 mln.
Profit :	-3.489 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	6.954 mln.
MVA/FCI :	0.190
MVA/PV :	0.202
PV/FCI :	0.939
Energy Consumption :	83.721 TJ

Process : 89 CHLORINE ARAK

Capacity :	100000
Fixed Capital Investment - FCI :	98.280 mln.
Product Value - PV :	32.377 mln.
Total Manufacturing Cost :	48.664 mln.
Profit :	-16.287 mln.
Simple Rate of Return :	

Back-pay Period :	
Manufacturing Value Added - MVA :	5.521 mln.
MVA/FCI :	0.056
MVA/PV :	0.171
PV/FCI :	0.329
Energy Consumption :	813.910 TJ

Process : 90 **PE LLD ARAK**

Capacity :	60000
Fixed Capital Investment - FCI :	34.328 mln.
Product Value - PV :	42.220 mln.
Total Manufacturing Cost :	36.705 mln.
Profit :	5.515 mln.
Simple Rate of Return :	0.161
Back-pay Period :	6.225 years
Manufacturing Value Added - MVA :	15.388 mln.
MVA/FCI :	0.448
MVA/PV :	0.364
PV/FCI :	1.230
Energy Consumption :	65.270 TJ

Process : 91 **POLYPROPYLENE ARAK**

Capacity :	50000
Fixed Capital Investment - FCI :	33.697 mln.
Product Value - PV :	32.361 mln.
Total Manufacturing Cost :	25.814 mln.
Profit :	6.547 mln.
Simple Rate of Return :	0.194
Back-pay Period :	5.147 years
Manufacturing Value Added - MVA :	15.074 mln.
MVA/FCI :	0.447
MVA/PV :	0.466
PV/FCI :	0.960
Energy Consumption :	112.305 TJ

Process : 92 **BUTADIENE ARAK**

Capacity :	26000
Fixed Capital Investment - FCI :	12.717 mln.
Product Value - PV :	11.081 mln.
Total Manufacturing Cost :	13.567 mln.
Profit :	-2.485 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	1.183 mln.
MVA/FCI :	0.093
MVA/PV :	0.107
PV/FCI :	0.871
Energy Consumption :	197.896 TJ

Process : 93 **POLYBUTADIENE ARAK**

Capacity :	25000
Fixed Capital Investment - FCI :	74.074 mln.
Product Value - PV :	43.000 mln.
Total Manufacturing Cost :	32.045 mln.
Profit :	10.955 mln.
Simple Rate of Return :	0.148
Back-pay Period :	6.762 years
Manufacturing Value Added - MVA :	26.772 mln.

MVA/FCI :	0.361
MVA/PV :	0.623
PV/FCI :	0.581
Energy Consumption :	529.325 TJ

Process : 94 ETHYLENE ARAK

Capacity :	240000
Fixed Capital Investment - FCI :	350.805 mln.
Product Value - PV :	145.565 mln.
Total Manufacturing Cost :	153.153 mln.
Profit :	-7.588 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	66.853 mln.
MVA/FCI :	0.191
MVA/PV :	0.459
PV/FCI :	0.415
Energy Consumption :	-3573.298 TJ

Process : 95 DMT ISFEHAN

Capacity :	65000
Fixed Capital Investment - FCI :	111.134 mln.
Product Value - PV :	38.740 mln.
Total Manufacturing Cost :	56.713 mln.
Profit :	-17.973 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	6.999 mln.
MVA/FCI :	0.063
MVA/PV :	0.181
PV/FCI :	0.349
Energy Consumption :	716.703 TJ

Process : 96 BTX ISFEHAN

Capacity :	85000
Fixed Capital Investment - FCI :	24.725 mln.
Product Value - PV :	55.000 mln.
Total Manufacturing Cost :	59.427 mln.
Profit :	-4.428 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	6.214 mln.
MVA/FCI :	0.251
MVA/PV :	0.113
PV/FCI :	2.224
Energy Consumption :	983.875 TJ

Process : 97 P-XYLEN ISFEHAN

Capacity :	44000
Fixed Capital Investment - FCI :	28.561 mln.
Product Value - PV :	26.190 mln.
Total Manufacturing Cost :	29.201 mln.
Profit :	-3.010 mln.
Simple Rate of Return :	
Back-pay Period :	
Manufacturing Value Added - MVA :	4.923 mln.
MVA/FCI :	0.172
MVA/PV :	0.188

PV/FCI :	0.917
Energy Consumption :	1110.296 TJ

Appendix : A 2. Results of experiments

EXP.; NO

PDA : HTO – HIGH TONNAGE ORGANICS

Fixed Capital Investment – FCI :	2693.119 mln.$ (2403.906)
Domestic Investment :	807.936 mln.L.C.
PDA Net Income – NI :	111.224 mln.L.C.
NI/FCI :	0.041 (24.2 years)
PDA Import :	89.223 mln.$
Manufact. Value Added – MVA :	642.215 mln.L.C.
MVA/FCI :	0.238
Production Profit :	163.381 mln.L.C.
Simple Rate of Return :	0.061 (16.5 years)
Production Import :	37.067 mln.$
Manufact. Value Added – MVA :	694.371 mln.L.C.
MVA/FCI :	0.258
MVA/Value of Production :	0.593
Export :	0.000 mln.$
Domestic Purchase :	339.100 mln.L.C.
Domestic Sale :	1171.530 mln.L.C.
Energy Consumption :	17424.300 TJ
Direct Labour :	1390 men

EXP.; N1

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	1642.375 mln.$	(1500.000)
Domestic Investment :	492.712 mln.L.C.	
PDA Net Income - NI :	-29.777 mln.L.C.	
NI/FCI :		
PDA Import :	362.231 mln.$	
Manufact. Value Added - MVA :	352.171 mln.L.C.	
MVA/FCI :	0.214	
Production Profit :	274.473 mln.L.C.	
Simple Rate of Return :	0.167	(6.0 years)
Production Import :	57.982 mln.$	
Manufact. Value Added - MVA :	656.421 mln.L.C.	
MVA/FCI :	0.400	
MVA/Value of Production :	0.661	
Export :	0.000 mln.$	
Domestic Purchase :	216.456 mln.L.C.	
Domestic Sale :	992.448 mln.L.C.	
Energy Consumption :	10862.860 TJ	
Direct Labour :	742 men	

EXP.; N2

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	1841.359 mln.$	(1650.000)
Domestic Investment :	552.408 mln.L.C.	
PDA Net Income - NI :	9.489 mln.L.C.	
NI/FCI :	0.005	(194.0 years)
PDA Import :	296.664 mln.$	
Manufact. Value Added - MVA :	411.808 mln.L.C.	
MVA/FCI :	0.224	
Production Profit :	245.935 mln.L.C.	
Simple Rate of Return :	0.134	(7.5 years)
Production Import :	60.218 mln.$	
Manufact. Value Added - MVA :	648.254 mln.L.C.	
MVA/FCI :	0.352	
MVA/Value of Production :	0.641	
Export :	0.000 mln.$	
Domestic Purchase :	233.540 mln.L.C.	
Domestic Sale :	1011.063 mln.L.C.	
Energy Consumption :	11730.970 TJ	
Direct Labour :	857 men	

EXP.; N3

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	2030.813 mln.$	(1800.000)
Domestic Investment :	609.244 mln.L.C.	
PDA Net Income - NI :	35.543 mln.L.C.	
NI/FCI :	0.018	(57.1 years)
PDA Import :	252.544 mln.$	
Manufact. Value Added - MVA :	461.414 mln.L.C.	
MVA/FCI :	0.227	
Production Profit :	230.940 mln.L.C.	
Simple Rate of Return :	0.114	(8.8 years)
Production Import :	57.152 mln.$	
Manufact. Value Added - MVA :	656.806 mln.L.C.	
MVA/FCI :	0.323	
MVA/Value of Production :	0.631	
Export :	0.000 mln.$	
Domestic Purchase :	251.276 mln.L.C.	
Domestic Sale :	1041.390 mln.L.C.	
Energy Consumption :	12511.130 TJ	
Direct Labour :	1011 men	

EXP.; N4

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	2173.961 mln.$	(1950.000)
Domestic Investment :	652.188 mln.L.C.	
PDA Net Income - NI :	58.219 mln.L.C.	
NI/FCI :	0.027	(37.3 years)
PDA Import :	199.470 mln.$	
Manufact. Value Added - MVA :	511.454 mln.L.C.	
MVA/FCI :	0.235	
Production Profit :	225.845 mln.L.C.	
Simple Rate of Return :	0.104	(9.6 years)
Production Import :	31.843 mln.$	
Manufact. Value Added - MVA :	679.080 mln.L.C.	
MVA/FCI :	0.312	
MVA/Value of Production :	0.636	
Export :	0.000 mln.$	
Domestic Purchase :	275.573 mln.L.C.	
Domestic Sale :	1068.020 mln.L.C.	
Energy Consumption :	13583.790 TJ	
Direct Labour :	1095 men	

EXP.; N5

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	2338.592 mln.$	(2100.000)
Domestic Investment :	701.578 mln.L.C.	
PDA Net Income - NI :	78.767 mln.L.C.	
NI/FCI :	0.034	(29.7 years)
PDA Import :	160.142 mln.$	
Manufact. Value Added - MVA :	558.012 mln.L.C.	
MVA/FCI :	0.239	
Production Profit :	204.275 mln.L.C.	
Simple Rate of Return :	0.087	(11.4 years)
Production Import :	34.634 mln.$	
Manufact. Value Added - MVA :	683.521 mln.L.C.	
MVA/FCI :	0.292	
MVA/Value of Production :	0.617	
Export :	0.000 mln.$	
Domestic Purchase :	301.155 mln.L.C.	
Domestic Sale :	1107.007 mln.L.C.	
Energy Consumption :	14523.470 TJ	
Direct Labour :	1189 men	

EXP.; N6

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	2497.894 mln.$ (2250.000)
Domestic Investment :	749.368 mln.L.C.
PDA Net Income - NI :	97.776 mln.L.C.
NI/FCI :	0.039 (25.5 years)
PDA Import :	140.291 mln.$
Manufact. Value Added - MVA :	605.700 mln.L.C.
MVA/FCI :	0.242
Production Profit :	201.368 mln.L.C.
Simple Rate of Return :	0.081 (12.4 years)
Production Import :	36.699 mln.$
Manufact. Value Added - MVA :	709.292 mln.L.C.
MVA/FCI :	0.284
MVA/Value of Production :	0.611
Export :	0.000 mln.$
Domestic Purchase :	321.816 mln.L.C.
Domestic Sale :	1161.478 mln.L.C.
Energy Consumption :	15176.420 TJ
Direct Labour :	1239 men

EXP.; PO

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	3734.206 mln.$	(3661.287)
Domestic Investment :	1120.262 mln.L.C.	
PDA Net Income - NI :	196.729 mln.L.C.	
NI/FCI :	0.053	(19.0 years)
PDA Import :	139.690 mln.$	
Manufact. Value Added - MVA :	999.737 mln.L.C.	
MVA/FCI :	0.268	
Production Profit :	281.047 mln.L.C.	
Simple Rate of Return :	0.075	(13.3 years)
Production Import :	55.362 mln.$	
Manufact. Value Added - MVA :	1084.055 mln.L.C.	
MVA/FCI :	0.290	
MVA/Value of Production :	0.612	
Export :	0.000 mln.$	
Domestic Purchase :	491.498 mln.L.C.	
Domestic Sale :	1770.948 mln.L.C.	
Energy Consumption :	24600.690 TJ	
Direct Labour :	1613 men	

EXP.; P1

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	2341.768 mln.$	(2250.000)
Domestic Investment :	702.530 mln.L.C.	
PDA Net Income - NI :	-6.149 mln.L.C.	
NI/FCI : /		
PDA Import :	605.753 mln.$	
Manufact. Value Added - MVA :	563.773 mln.L.C.	
MVA/FCI :	0.241	
Production Profit :	518.065 mln.L.C.	
Simple Rate of Return :	0.221	(4.5 years)
Production Import :	81.539 mln.$	
Manufact. Value Added - MVA :	1087.986 mln.L.C.	
MVA/FCI :	0.465	
MVA/Value of Production :	0.692	
Export :	0.000 mln.$	
Domestic Purchase :	315.097 mln.L.C.	
Domestic Sale :	1572.439 mln.L.C.	
Energy Consumption :	13430.620 TJ	
Direct Labour :	923 men	

EXP.; P2

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	2525.236 mln.$	(2400.000)
[illegible]estic Investment :	757.571 mln.L.C.	
PDA Income - NI :	25.893 mln.L.C.	
N[illegible] CI :	0.010	(97.5 years)
PDA Import :	534.085 mln.$	
Manufact. Value Added - MVA :	614.928 mln.L.C.	
MVA/FCI :	0.244	
Production Profit :	476.946 mln.L.C.	
Simple Rate of Return :	0.189	(5.3 years)
Production Import :	83.032 mln.$	
Manufact. Value Added - MVA :	1065.981 mln.L.C.	
MVA/FCI :	0.422	
MVA/Value of Production :	0.679	
Export :	0.000 mln.$	
Domestic Purchase :	326.291 mln.L.C.	
Domestic Sale :	1570.001 mln.L.C.	
Energy Consumption :	14880.180 TJ	
Direct Labour :	1036 men	

EXP.; P3

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	2665.839 mln.$	(2550.000)
Domestic Investment :	799.752 mln.L.C.	
PDA Net Income - NI :	55.271 mln.L.C.	
NI/FCI :	0.021	(48.2 years)
PDA Import :	499.146 mln.$	
Manufact. Value Added - MVA :	670.601 mln.L.C.	
MVA/FCI :	0.252	
Production Profit :	451.791 mln.L.C.	
Simple Rate of Return :	0.169	(5.9 years)
Production Import :	102.627 mln.$	
Manufact. Value Added - MVA :	1067.121 mln.L.C.	
MVA/FCI :	0.400	
MVA/Value of Production :	0.663	
Export :	0.000 mln.$	
Domestic Purchase :	340.575 mln.L.C.	
Domestic Sale :	1610.292 mln.L.C.	
Energy Consumption :	15173.400 TJ	
Direct Labour :	1053 men	

EXP.; P4

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	2828.218	mln.$	(2700.000)
Domestic Investment :	848.465	mln.L.C.	
PDA Net Income - NI :	81.039	mln.L.C.	
NI/FCI :	0.029		(34.9 years)
PDA Import :	450.749	mln.$	
Manufact. Value Added - MVA :	720.562	mln.L.C.	
MVA/FCI :	0.255		
Production Profit :	454.446	mln.L.C.	
Simple Rate of Return :	0.161		(6.2 years)
Production Import :	77.343	mln.$	
Manufact. Value Added - MVA :	1093.969	mln.L.C.	
MVA/FCI :	0.387		
MVA/Value of Production :	0.669		
Export :	0.000	mln.$	
Domestic Purchase :	357.601	mln.L.C.	
Domestic Sale :	1634.971	mln.L.C.	
Energy Consumption :	16251.900	TJ	
Direct Labour :	1206	men	

EXP.; P5

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	2906.167 mln.$	(2850.000)
Domestic Investment :	895.850 mln.L.C.	
PDA Net Income - NI :	103.651 mln.L.C.	
NI/FCI :	0.035	(28.8 years)
PDA Import :	395.988 mln.$	
Manufact. Value Added - MVA :	769.176 mln.L.C.	
MVA/FCI :	0.258	
Production Profit :	450.053 mln.L.C.	
Simple Rate of Return :	0.151	(6.6 years)
Production Import :	49.586 mln.$	
Manufact. Value Added - MVA :	1115.578 mln.L.C.	
MVA/FCI :	0.374	
MVA/Value of Production :	0.674	
Export :	0.000 mln.$	
Domestic Purchase :	377.853 mln.L.C.	
Domestic Sale :	1654.999 mln.L.C.	
Energy Consumption :	17323.460 TJ	
Direct Labour :	1297 men	

EXP.; 96

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	3127.415	mln.$	(3000.000)
Domestic Investment :	938.225	mln.L.C.	
PDA Net Income - NI :	125.069	mln.L.C.	
NI/FCI :	0.040		(25.0 years)
PDA Import :	340.098	mln.$	
Manufact. Value Added - MVA :	814.338	mln.L.C.	
MVA/FCI :	0.260		
Production Profit :	418.323	mln.L.C.	
Simple Rate of Return :	0.134		(7.5 years)
Production Import :	46.844	mln.$	
Manufact. Value Added - MVA :	1107.593	mln.L.C.	
MVA/FCI :	0.354		
MVA/Value of Production :	0.664		
Export :	0.000	mln.$	
Domestic Purchase :	396.148	mln.L.C.	
Domestic Sale :	1667.863	mln.L.C.	
Energy Consumption :	18364.580	TJ	
Direct Labour :	1352	men	

EXP.; P7

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	3241.974 mln.$	(3150.000)
Domestic Investment :	972.322 mln.L.C.	
PDA Net Income - NI :	145.595 mln.L.C.	
NI/FCI :	0.045	(22.3 years)
PDA Import :	284.991 mln.$	
Manufact. Value Added - MVA :	860.981 mln.L.C.	
MVA/FCI :	0.266	
Production Profit :	380.163 mln.L.C.	
Simple Rate of Return :	0.117	(8.5 years)
Production Import :	50.423 mln.$	
Manufact. Value Added - MVA :	1095.549 mln.L.C.	
MVA/FCI :	0.338	
MVA/Value of Production :	0.648	
Export :	0.000 mln.$	
Domestic Purchase :	423.132 mln.L.C.	
Domestic Sale :	1690.644 mln.L.C.	
Energy Consumption :	19479.320 TJ	
Direct Labour :	1382 men	

EXP.; P8

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	3358.037 mln.$	(3300.000)
Domestic Investment :	1007.411 mln.L.C.	
PDA Net Income - NI :	165.034 mln.L.C.	
NI/FCI :	0.049	(20.3 years)
PDA Import :	2[illegible]4.080 mln.$	
Manufact. Value Added - MVA :	912.090 mln.L.C.	
MVA/FCI :	0.272	
Production Profit :	376.931 mln.L.C.	
Simple Rate of Return :	0.112	(8.9 years)
Production Import :	52.183 mln.$	
Manufact. Value Added - MVA :	1123.987 mln.L.C.	
MVA/FCI :	0.335	
MVA/Value of Production :	0.639	
Export :	0.000 mln.$	
Domestic Purchase :	456.191 mln.L.C.	
Domestic Sale :	1758.287 mln.L.C.	
Energy Consumption :	20449.130 TJ	
Direct Labour :	1414 men	

EXP.; P9

PDA : HTO - HIGH TONNAGE ORGANICS

Fixed Capital Investment - FCI :	3532.921 mln.$	(3450.000)
Domestic Investment :	1059.876 mln.L.C.	
PDA Net Income - NI :	180.693 mln.L.C.	
NI/FCI :	0.051	(19.6 years)
PDA Import :	216.053 mln.$	
Manufact. Value Added - MVA :	952.047 mln.L.C.	
MVA/FCI :	0.269	
Production Profit :	343.043 mln.L.C.	
Simple Rate of Return :	0.097	(10.3 years)
Production Import :	53.703 mln.$	
Manufact. Value Added - MVA :	1114.398 mln.L.C.	
MVA/FCI :	0.315	
MVA/Value of Production :	0.627	
Export :	0.000 mln.$	
Domestic Purchase :	478.165 mln.L.C.	
Domestic Sale :	1778.750 mln.L.C.	
Energy Consumption :	22366.770 TJ	
Direct Labour :	1554 men	

EXP. ; NN

PDA : HTO – HIGH TONNAGE ORGANICS

Fixed Capital Investment – FCI :	2434.705 mln.	(2191.791)
PDA Net Income – NI :	150.804 mln.	
NI/FCI :	0.062	(16.1 years)
PDA Import :	133.234 mln.	
Manufact. Value Added – MVA :	644.729 mln.	
MVA/FCI :	0.265	
Production Profit :	209.154 mln.	
Simple Rate of Return :	0.086	(11.6 years)
Production Import :	74.883 mln.	
Manufact. Value Added – MVA :	703.080 mln.	
MVA/FCI :	0.289	
MVA/Value of Production :	0.594	
Export :	0.000 mln.	
Domestic Purchase :	314.756 mln.	
Domestic Sale :	1184.030 mln.	
Energy Consumption :	16544.590 TJ	
Direct Labour :	1131 men	

EXP. ; NN Cont.

	Process	Level	%
	In operation		
76	NYLON 6 MELT PARSILON COMP.	16000 T	100
77	NYLON 6 MELT ALYAF COMP.	10000 T	100
78	POLYETYLENE TEREPHTALATE POLYACRYL COMP.	55000 T	100
79	DI-OCTYL PHTALATE IRAN NIPPON	40000 T	100
80	PHTALIC ANHYDRIDE IRAN NIPPON	22000 T	100
	Project		
75	OXYGEN BY AIR FRACTIONATION	89677 T	224
8	BENZENE FROM TOLUENE	87333 T	218
6	MIXED XYLENES FROM NAPHTENIC FEED	113276 T	123
62	CAPROLACTAM FROM CYCLOHEXANE	39816 T	114
10	P-XYLENE (PAREX)	75417 T	112
61	NYLON 6 MELT	16000 T	107
53	POLYETHYLENE HD (UCC)	160000 T	100
83	VINYL CHLORIDE FROM ETHYLENE ARAK	150000 T	100
84	PVC ARAK	150000 T	100
91	POLYPROPYLENE ARAK	50000 T	100
92	BUTADIENE ARAK	26000 T	100
94	ETHYLENE ARAK	240000 T	100
19	POLYOL TRIFUNCTIONAL POLYETHER	38500 T	96
36	POLYETHYLENE LLD (UCC)	150000 T	94
47	POLYSTYRENE HIGH IMPACT	50000 T	83
16	2-ETHYLHEXANOL (OXO PROCESS)	41400 T	83
65	CYCLOHEXANE BY HYDROGENATION OF BENZENE	40573 T	81
40	POLYVINYL CHLORIDE BY EMULSION POLIMER.	20000 T	80
56	STYRENE-BUTADIENE RUBBER BY EMUL.POLYM.	27489 T	79
3	ETHYLENE FROM WIDE RANGE NAPHTA MG	171236 T	76
20	BUTENE-1 FROM MTBE RAFFINATE	14790 T	74
32	CHLORINE (MEMBRANE PROCESS)	124235 T	69
29	PERCHLOROETHYLENE FROM EDC	8000 T	67
58	POLYBUTADIENE	29050 T	65
12	BUTADIENE FROM C4 EXTRACTION	32053 T	64
71	ACRYLONITRILE BY PROPYLENE AMMOOXIDATION	52508 T	58
22	DI-OCTYLPHTALATE FROM PHTALIC ANHYDRIDE	20000 T	57
14	ISOBUTYLENE BY ACID EXTRACTION (CFR)	18881 T	54
74	CARBON MONOOXIDE FROM SYNTGAS	14224360 m3	52
45	ACETIC ACID FROM METHANOL	33984 T	50
55	STYRENE-BUTADIENE LATEX	15000 T	43
48	ABS BY EMULSION/MASS POLYMERIZATION	10000 T	40
43	VINYL ACETATE FROM ETHYLENE	25000 T	37
70	ETHYLENE GLYCOL AND ETHYLENE OXIDE	32210 T	36
17	PROPYLENE OXIDE BY ETHYLBENZENE PROCESS	30052 T	33
50	ETHYLBENZENE LIQUID PHASE	82012 T	33
33	POLYPROPYLENE (AMOCO)	12000 T	32
24	METHYL ETHYL KETONE FROM MTBE RAFFINATE	4650 T	31
2	ETHYLENE FROM ETHANE-PROPANE MIXTURE	58714 T	26
26	TRIETHANOL AMINE FROM EO END NH3	10000 T	22
23	PHTHALIC ANHYDRIDE AIR OX. OF O-XYLENE	3040 T	20
67	POLYETHYLENE TEREPHTALATE MELT FROM TA	5000 T	20
31	PHENOL (CUMENE)	8000 T	18
41	VINYL CHLORIDE BY OXYCHLORINATION	31800 T	13
39	POLYVINYLCHLORIDE BY SUSPENSION POLYMER.	10000 T	11
27	POLYMETHYLMETHACRYLATE	1500 T	10
30	HYDROGEN FROM NATURAL GAS	40048780 m3	8
13	METHYL METHACRYLATE CYANOHYDRIN PROCESS	3500 T	8
73	SYNTGAS (3:1) FROM NATURAL GAS	57003670 m3	7
72	SYNTGAS (2:1) FROM NATURAL GAS	53447400 m3	6
68	TEREPHTHALIC ACID FROM P-XYLENE	4281 T	6

51	ETHYLENE DICHLORIDE BY CHLORINATION	6552 T	4
18	PROPYLENE OXIDE BY CHLOROHIDRINE PROCESS	2710 T	3
21	ISOPROPANOL BY CATION EXCHANGE RESIN	1000 T	2

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EXP. ; NO.

Problem title: HTO - HIGH TONNAGE ORGANICS

F r a c t i o n a l Optimization

Maximize:

$$\frac{\text{PDA Yearly Profit}}{\text{Investment}} = 0.046 \ \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:

2000.	<	Investment	<	2500.	(96.2%)	mil.$
8000.	<	ACETIC ACID	<	16000.	(100.0%)	T
		ACETONE	=	5900.	(100.0%)	T
		ACRYLONITRILE-BUTADIENE-STYRENE(ABS)	=	10000.	(100.0%)	T
25000.	<	ACRYLONITRILE	<	50000.	(100.0%)	T
35000.	<	BENZENE	<	40000.	(87.5%)	T
5.00E+03	<	BUTANOL-N	<	none	(0.0%)	T
1420.	<	CARBON TETRACHLORIDE	<	7000.	(20.3%)	T
48000.	<	DI-OCTYL PHTHALATE(DOP)	<	60000.	(100.0%)	T
4.00E+02	<	DIETHANOLAMINE	<	none	(0.0%)	T
1.50E+04	<	ETHYLENE GLYCOL	<	none	(0.0%)	T
		ETHYLENE OXIDE	=	15000.	(100.0%)	T
		ISOBUTANOL	=	1850.	(100.0%)	T
		ISOPROPANOL	=	1000.	(100.0%)	T
		METHANOL	=	47000.	(100.0%)	T
		METHYL ETHYL KETONE	=	4650.	(100.0%)	T
		METHYL METHACRYLATE	=	2000.	(100.0%)	T
9.00E+02	<	MONOETHANOLAMINE	<	none	(0.0%)	T
42000.	<	NYLON 6 MELT	<	50000.	(84.0%)	T
8000.	<	PHENOL	<	10000.	(80.0%)	T
		PHTHALIC ANHYDRIDE	=	10000.	(100.0%)	T
10500.	<	POLYBUTADIENE	<	25000.	(100.0%)	T
		POLYETHYLENE TEREPHTHALATE MELT	=	60000.	(100.0%)	T
160000.	<	POLYETHYLENE, HI DENSITY (POWDERD)	<	240000.	(66.7%)	T
50000.	<	POLYETHYLENE, LINEAR LD	<	150000.	(100.0%)	T
0.	<	POLYETHYLENE, LO DENSITY	<	150000.	(0.0%)	T
1500.	<	POLYMETHYLMETHACRYLATE SHEET	<	3000.	(50.0%)	T
		POLYOL, TRIFUNCTIONAL POLYETHER	=	38500.	(100.0%)	T
		POLYPROPYLENE	=	62000.	(100.0%)	T
		POLYSTYRENE, IMPACT MODIFIED	=	50000.	(100.0%)	T
		POLYVINYL CHLORIDE DISPERSION	=	20000.	(100.0%)	T
		POLYVINYL CHLORIDE	=	160000.	(100.0%)	T
0.	<	PROPYLENE OXIDE	<	9500.	(100.0%)	T
0.	<	PROPYLENE	<	5000.	(100.0%)	T
		STYRENE-BUTADIENE RUBBER	=	50000.	(100.0%)	T
2000.	<	STYRENE	<	10000.	(20.0%)	T
		TOLUENE	=	40000.	(100.0%)	T
5.00E+03	<	TRICHLOROETHYLENE	<	none	(0.0%)	T
8000.	<	TRIETHANOLAMINE	<	10000.	(100.0%)	T
25000.	<	VINYL AC[illegible]ATE	<	30000.	(100.0%)	T
		STYRENE-BUTADIENE LATEX	=	15000.	(100.0%)	T
5.00E+03	<	BUTYL RUBBER	<	none	(0.0%)	T
		PERCHLOROETHYLENE	=	8000.	(100.0%)	T
		ACRYLONITRILE ARAK	=	33000.	(100.0%)	T
		VINYL CHLORIDE FROM ETHYLENE ARAK	=	150000.	(100.0%)	T
		PVC ARAK	=	150000.	(100.0%)	T
		VINYLACETATE ARAK	=	30000.	(100.0%)	T
		ACETIC ACID ARAK	=	30000.	(100.0%)	T
		PE HD ARAK	=	60000.	(100.0%)	T
		CHLORINE ARAK	=	100000.	(100.0%)	T
		PE LLD ARAK	=	60000.	(100.0%)	T

POLYPROPYLENE ARAK	=	50000. (100.0%)	T
BUTADIENE ARAK	=	26000. (100.0%)	T
POLYBUTADIENE ARAK	=	25000. (100.0%)	T
ETHYLENE ARAK	=	240000. (100.0%)	T
DMT ISFEHAN	=	65000. (100.0%)	T
BTX ISFEHAN	=	85000. (100.0%)	T
P-XYLEN ISFEHAN	=	44000. (100.0%)	T

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G L O B A L   R E S U L T S

PDA Yearly Profit	111.	mil.$
PDA Value Added	648.	mil.$
Investment	2404.	mil.$
Energy Consumption	8518.	TJ
Yearly Import	89.	mil.$
Energy Input	17424.	TJ
Yearly Domestic Purchase	339.	mil.$
Yearly Domestic Sale	1172.	mil.$

S A L E

ACETIC ACID	16000.	T
ACETONE	5900.	T
ACRYLONITRILE-BUTADIENE-STYRENE(ABS)	10000.	T
ACRYLONITRILE	50000.	T
AMMONIUM SULFATE	85929.	T
BENZENE	35000.	T
BTX RAFFINATE	147870.	T
BUTANOL-N	5000.	T
C9 AROMATICS CRUDE	25801.	T
CARBON DIOXIDE	31227.	T
CARBON TETRACHLORIDE	1420.	T
CAUSTIC SODA	134918.	T
DI-OCTYL PHTHALATE(DOP)	60000.	T
DIETHANOLAMINE	700.	T
DIETHYLENE GLYCOL	3318.	T
DIMETHYL TEREPHTHALATE	4940.	T
ETHYLENE GLYCOL	15000.	T
ETHYLENE OXIDE	15000.	T
FUEL GAS	364603100.	T-cal
FUEL OIL	33937.	T
GASOLINE	7623.	T
HCL ACID (AS 20 BE)	7320.	T
HEAVY ENDS CREDIT	896.	T
HEAVY END	316.	T
HYDROGEN CYANIDE	4512.	T
HYDROGEN-RICH GAS	419231300.	T-cal
ISOBUTANOL	1850.	T
ISOBUTYLENE	17579.	T
ISOPROPANOL	1000.	T
LIGHT ENDS	7317.	T
METHANOL	47000.	T

METHYL ETHYL KETONE	4650.	T
METHYL METHACRYLATE	2000.	T
MIXED BUTYLENES(BUTADIENE RAFFINATE)	28129.	T
MONOETHANOLAMINE	900.	T
NITRIC ACID(DILUTE)	307.	T
NYLON 6 MELT	42000.	T
PHENOL	8000.	T
PHTHALIC ANHYDRIDE	10000.	T
POLYBUTADIENE	25000.	T
POLYETHYLENE TEREPHTHALATE MELT	60000.	T
POLYETHYLENE, HI DENSITY (POWDERD)	160000.	T
POLYETHYLENE, LINEAR LD	150000.	T
POLYMETHYLMETHACRYLATE SHEET	1500.	T
POLYOL, TRIFUNCTIONAL POLYETHER	38500.	T
POLYPROPYLENE	62000.	T
POLYSTYRENE, IMPACT MODIFIED	50000.	T
POLYVINYL CHLORIDE DISPERSION	20000.	T
POLYVINYL CHLORIDE	160000.	T
PROPYLENE OXIDE IN SOLUTION(IMPURE)	493.	T
PROPYLENE OXIDE	9500.	T
PROPYLENE, (DILUTE)	97.	T
PROPYLENE	5000.	T
PYROLYSIS GASOLINE	234680.	T
STYRENE-BUTADIENE RUBBER	50000.	T
STYRENE	2000.	T
SULFURIC ACID(IN 65%)	1159.	T
TAIL GAS	1018253000.	T-cal
TOLUENE	40000.	T
TRICHLOROETHYLENE	5000.	T
TRIETHANOLAMINE	10000.	T
TRIETHYLENE GLYCOL	870.	T
VINYL ACETATE	30000.	T
XYLENE-P	33482.	T
STYRENE-BUTADIENE LATEX	15000.	T
BUTYL RUBBER	5000.	T
POLIPROPYLENE ATACTIC	1860.	T
METHYL ACETATE	1080.	T
AMMONIUM BISULFATE	4025.	T
C4 ALKYLATION FEED	4574.	T
PROPYLENE DICHLORIDE	253.	T
PERCHLOROETHYLENE	8000.	T

P U R C H A S E

COOLING WATER	505562900.	m3
PROCESS WATER	4247476.	m3
STEAM	4207148.	T
ELECTRICITY	935998000.	kWh
INERT GAS	42704160.	m3
ACETONITRILE	59.	T
ACTIVATED CARBON	15.	T
ADDITIVES,N6	420.	T
ALKYLBENZENE	160.	T
ALUMINA	107.	T
ALUMINA TRICHLORIDE	240.	T
AMMONIA	61830.	T
ANTIMONY TRIOXIDE	18.	T
ASCORBIC ACID	2.	T
BENTONITE	2272.	T
BENZOYL PEROXIDE	8.	T
BUTANOL-N	980.	T
BUTYL STEARATE	50.	T

BUTYL-T CATECHOL	5.	T
BUTYLLITHIUM -N	14.	T
CARBON TETRACHLORIDE	1420.	T
CATALYST AND CHEMICALS	11213840.	$
CATALYST,MTBE	2.	T
CHEMICALS	3952571.	$
COAGULANT	3.	T
COBALTOUS OCTANOATE	118.	T
CR-SI CATALIST	780000.	T
CU-PD CATALYST	11865000.	CC
CUPRIC NITRATE	1.	T
ETHANE	71905.	T
ETHYL ACETATE	165.	T
ETHYLENE GLYCOL	4354.	T
FILTER AID	15400.	T
FORMIC ACID (IN 85%)	21.	T
FUEL	365815200.	T-cal
GLYCERIN	1194.	T
HEXANE -N	877.	T
HYDROCHLORIC ACID	12117.	T
HYDROGEN (IN OFF-GAS)	32537520.	m3
HYDROGEN PEROXIDE	2.	T
ION-EXCHANGE RESIN	68820.	T
ISOBUTANE	1296.	T
ISOBUTANOL	1411.	T
LIME	3174.	T
MAGNESIUM SILICATE	578.	T
MANGANOUS OCATNOATE	125.	T
MEMBRANE	20717110.	SQCM
METHANE	937.	T
METHANOL	56577.	T
MMA-EHA COPOLYMER	10.	T
MOLYBDENUM POWDER	1.	T
MONOETHANOLAMINE	600.	T
NAPHTHA ,WIDE RANGE	618196.	T
NAPHTHA HEARTCUT (NAPHTHENIC)	167477.	T
NAPHTHENIC ACID	59.	T
NATURAL GAS	826885800.	T-cal
NYLON (WASTE)	2730.	T
OCTANE-N	30.	T
OCTANOIC ACID	335.	T
OLEUM	54150.	T
OXALIC ACID	26.	T
PALMITIC ACID	147.	T
PD ON ALUMINUM CATALIST	17207.	T
PHOSPHORIC ACID (INDUSTRIAL GRADE)	10.	T
PHOSPHORIC ACID CATALYST	19.	T
POTASSIUM CARBONATE	99.	T
POTASSIUM HYDROXIDE	894.	T
POTASSIUM PERSULFATE	5.	T
PROPANE	43943.	T
RHODIUM-HALIDE CATALIST	953.	GM
ROCK SALT	16.	T
SALT	301633.	T
SOAP	3006.	T
SODIUM CARBONATE	4282.	T
SODIUM CHLORIDE	8694.	T
SODIUM LAURATE	147.	T
SODIUM PYROPHOSPHATE	11.	T
SOYBEAN OIL	50.	T
STABILIZER, SBR	316.	T
STYRENE-BUTADIENE RUBBER	21744.	T
SULFOLANE	30.	T
SULFURIC ACID	19217.	T
SULFUR	4109.	T
TITANIUM DIOXIDE	252.	T

TRICHLOROETHYLENE	1000.	T
TRIPHENYLMETHANE	11.	T
WATER DEIONIZED	232189.	T
ZINC ACETATE	24.	T
STABILIZER	305.	T
BUTYL RUBBER	5000.	T
WASTE RECOVERY CHEMICALS	260.	T
HPMC	181.	T
DIIPC	45.	T
AIR	503537.	T
NAPHTHA LIGHT	631680.	T
BTX REFORMATE (HIGHLY NAPHT.)	320450.	tons

P R O C E S S E S

ETHYLENE FROM ETHANE-PROPANE MIXTURE	76503.	T
ETHYLENE FROM WIDE RANGE NAPHTA MS	172247.	T
BENZENE FROM PYROLYSIS GASOLINE	15742.	T
MIXED XYLENES FROM NAPHTENIC FEED	40307.	T
BENZENE FROM TOLUENE	87537.	T
P-XYLENE (PAREX)	30432.	T
BUTADIENE FROM C4 EXTRACTION	32612.	T
METHYL METHACRYLATE CYANOHYDRIN PROCESS	3500.	T
ISOBUTYLENE BY ACID EXTRACTION (CFR)	17579.	T
D-ETHYLHEXANOL (OXO PROCESS)	41400.	T
PROPYLENE OXIDE BY ETHYLBENZENE PROCESS	30125.	T
PROPYLENE OXIDE BY CHLOROHIDRINE PROCESS	2637.	T
POLYOL TRIFUNCTIONAL POLYETHER	38500.	T
B-1 FROM MTBE RAFFINATE	13236.	T
ISOPROPANOL BY CATION EXCHANGE RESIN	1000.	T
D-OCTYLPHTALATE FROM PHTALIC ANHYDRIDE	20000.	T
PHTHALIC ANHYDRIDE AIR OX. OF O-XYLENE	11400.	T
METHYL ETHYL KETONE FROM MTBE RAFFINATE	4650.	T
TRIETHANOL AMINE FROM EO END NH3	10000.	T
POLYMETHYLMETHACRYLATE	1500.	T
PERCHLOROETHYLENE FROM EDC	8000.	T
HYDROGEN FROM NATURAL GAS	65168630.	m
PHENOL (CUMENE)	13642.	T
CHLORINE (MEMBRANE PROCESS)	24129.	T
POLYETHYLENE LLD (UCC)	90000.	T
POLYPROPYLENE (AMOCO)	12000.	T
POLYVINYLCHLORIDE BY SUSPENSION POLYMER.	10000.	T
POLYVINYL CHLORIDE BY EMULSION POLIMER.	20000.	T
VINYL CHLORIDE BY OXYCHLORINATION	31800.	T
ACETIC ACID FROM METHANOL	7204.	T
POLYSTYRENE HIGH IMPACT	50000.	T
ABS BY EMULSION/MASS POLYMERIZATION	10000.	T
ETHYLBENZENE LIQUID PHASE	82211.	T
ETHYLENE DICHLORIDE BY CHLORINATION	6552.	T
POLYETHYLENE HD (UCC)	100000.	T
STYRENE-BUTADIENE LATEX	15000.	T
STYRENE-BUTADIENE RUBBER BY EMUL.POLYM.	28256.	T
POLYBUTADIENE	4050.	T
NYLON 6 MELT	16000.	T
CAPROLACTAM FROM CYCLOHEXANE	33684.	T
CAPROLACTAM FROM PHENOL	6132.	T
CYCLOHEXANE BY HYDROGENATION OF BENZENE	35044.	T
[illegible]ETHYLENE TEREPHTALATE MELT FROM DMT	5000.	T
[illegible]ENE GLYCOL AND ETHYLENE OXIDE	32210.	T
[illegible]TRILE BY PROPYLENE AMMOOXIDATION	19508.	T
SYNGAS (2:1) FROM NATURAL GAS	53447400.	n
SYNGAS (3:1) FROM NATURAL GAS	12284150.	n

CARBON MONOOXIDE FROM SYNTGAS	3033123.	m3
OXYGEN BY AIR FRACTIONATION	100707.	T
NYLON 6 MELT PARSILON COMP.	16000.	T
NYLON 6 MELT ALYAF COMP.	10000.	T
POLYETYLENE THEREFTALATE POLYACRYL COMP.	55000.	T
DI-OCTYL PHTALATE IRAN NIPPON	40000.	T
PHTALIC ANHYDRIDE IRAN NIPPON	22000.	T
ACRYLONITRILE ARAK	33000.	T
VINYL CHLORIDE FROM ETHYLENE ARAK	150000.	T
PVC ARAK	150000.	T
VINYLACETATE ARAK	30000.	T
ACETIC ACID ARAK	30000.	T
PE HD ARAK	60000.	T
CHLORINE ARAK	100000.	T
PE LLD ARAK	60000.	T
POLYPROPYLENE ARAK	50000.	T
BUTADIENE ARAK	26000.	T
POLYBUTADIENE ARAK	25000.	T
ETHYLENE ARAK	240000.	T
DMT ISFEHAN	65000.	T
BTX ISFEHAN	85000.	T
P-XYLEN ISFEHAN	44000.	T

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EXP. ; P O.

Problem title: HTO - HIGH TONNAGE ORGANICS

F r a c t i o n a l   Optimization

Maximize:

$$\frac{\text{PDA Net Income}}{\text{Investment}} = 0.054 \ \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:

12000.	<	ACETIC ACID	<	24000.	(100.0%)
		ACETONE	=	8500.	(100.0%)
		ACRYLONITRILE-BUTADIENE-STYRENE(ABS)	=	15000.	(100.0%)
85000.	<	ACRYLONITRILE	<	100000.	(100.0%)
62500.	<	BENZENE	<	80000.	(78.1%)
15000.	<	BUTANOL-N	<	22500.	(66.7%)
7000.	<	CARBON TETRACHLORIDE	<	11000.	(63.6%)
65000.	<	DI-OCTYL PHTHALATE(DOP)	<	75000.	(100.0%)
		DIETHANOLAMINE	=	600.	(100.0%)
20000.	<	ETHYLENE GLYCOL	<	25000.	(80.0%)
		ETHYLENE OXIDE	=	22500.	(100.0%)
		ISOBUTANOL	=	2600.	(100.0%)
		ISOPROPANOL	=	2000.	(100.0%)
70000.	<	METHANOL	<	75000.	(93.3%)
		METHYL ETHYL KETONE	=	7000.	(100.0%)
3000.	<	METHYL METHACRYLATE	<	4000.	(100.0%)
		MONOETHANOLAMINE	=	1300.	(100.0%)
50000.	<	NYLON 6 MELT	<	70000.	(71.4%)
15000.	<	PHENOL	<	20000.	(75.0%)
		PHTHALIC ANHYDRIDE	=	15000.	(100.0%)
18000.	<	POLYBUTADIENE	<	30000.	(100.0%)
82000.	<	POLYETHYLENE TEREPHTHALATE MELT	<	106000.	(100.0%)
240000.	<	POLYETHYLENE, HI DENSITY (POWDERD)	<	330000.	(72.7%)
200000.	<	POLYETHYLENE, LINEAR LD	<	250000.	(100.0%)
0.	<	POLYETHYLENE, LO DENSITY	<	250000.	(0.0%)
		POLYMETHYLMETHACRYLATE SHEET	=	6000.	(100.0%)
		POLYOL, TRIFUNCTIONAL POLYETHER	=	65000.	(100.0%)
		POLYPROPYLENE	=	85000.	(100.0%)
70000.	<	POLYSTYRENE, IMPACT MODIFIED	<	80000.	(100.0%)
		POLYVINYL CHLORIDE DISPERSION	=	30000.	(100.0%)
220000.	<	POLYVINYL CHLORIDE	<	260000.	(84.6%)
0.	<	PROPYLENE OXIDE	<	9500.	(100.0%)
0.	<	PROPYLENE	<	10000.	(100.0%)
		STYRENE-BUTADIENE RUBBER	=	80000.	(100.0%)
10000.	<	STYRENE	<	15000.	(66.7%)
		TOLUENE	=	60000.	(100.0%)
		TRICHLOROETHYLENE	=	7500.	(100.0%)
10000.	<	TRIETHANOLAMINE	<	18000.	(55.6%)
42000.	<	VINYL ACETATE	<	480[illegible]0.	(87.5%)
		STYRENE-BUTADIENE LATEX	=	250[illegible]0.	(100.0%)
		BUTYL RUBBER	=	10000.	(100.0%)
		PERCHLOROETHYLENE	=	12000.	(100.0%)
		ACRYLONITRILE ARAK	=	33000.	(100.0%)
		VINYL CHLORIDE FROM ETHYLENE ARAK	=	150000.	(100.0%)
		PVC ARAK	=	150000.	(100.0%)
		VINYLACETATE ARAK	=	30000.	(100.0%)
		ACETIC ACID ARAK	=	30000.	(100.0%)
		PE HD ARAK	=	60000.	(100.0%)
		CHLORINE ARAK	=	100000.	(100.0%)
		PE LLD ARAK	=	60000.	(100.0%)
		POLYPROPYLENE ARAK	=	50000.	(100.0%)

BUTADIENE ARAK	=	26000. (100.0%) T
POLYBUTADIENE ARAK	=	25000. (100.0%) T
ETHYLENE ARAK	=	240000. (100.0%) T
DMT ISFEHAN	=	65000. (100.0%) T
BTX ISFEHAN	=	85000. (100.0%) T
P-XYLEN ISFEHAN	=	44000. (100.0%) T

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G L O B A L   R E S U L T S

PDA Net Income	197.	mil.$
PDA Value Added	997.	mil.$
Investment	3661.	mil.$
Energy Consumption	11622.	TJ
Yearly Import	140.	mil.$
Energy Input	24601.	TJ
Yearly Domestic Purchase	491.	mil.$
Yearly Domestic Sale	1771.	mil.$

S A L E

ACETIC ACID	24000.	T
ACETONE	8500.	T
ACRYLONITRILE-BUTADIENE-STYRENE(ABS)	15000.	T
ACRYLONITRILE	100000.	T
AMMONIUM SULFATE	112336.	T
BENZENE	62500.	T
BTX RAFFINATE	176443.	T
BUTANOL-N	15000.	T
C9 AROMATICS CRUDE	31249.	T
CARBON DIOXIDE	41070.	T
CARBON TETRACHLORIDE	7000.	T
CAUSTIC SODA	183989.	T
DI-OCTYL PHTHALATE(DOP)	75000.	T
DIETHANOLAMINE	600.	T
DIETHYLENE GLYCOL	4363.	T
ETHYLENE GLYCOL	20000.	T
ETHYLENE OXIDE	22500.	T
FUEL GAS	490038800.	T-cal
FUEL OIL	46460.	T
GASOLINE	10496.	T
HCL ACID (AS 20 BE)	10980.	T
HEAVY ENDS CREDIT	1656.	T
HEAVY END	475.	T
HYDROGEN CYANIDE	7943.	T
HYDROGEN-RICH GAS	768219500.	T-cal
ISOBUTANOL	2600.	T
ISOBUTYLENE	29120.	T
ISOPROPANOL	2000.	T
LIGHT ENDS	9906.	T
METHANOL	70000.	T
METHYL ETHYL KETONE	7000.	T
METHYL METHACRYLATE	4000.	T

[illegible]	[illegible]	T
MONOETHANOLAMINE	1300.	T
NITRIC ACID(DILUTE)	554.	T
NYLON 6 MELT	50000.	T
PHENOL	15000.	T
PHTHALIC ANHYDRIDE	15000.	T
POLYBUTADIENE	30000.	T
POLYETHYLENE TEREPHTHALATE MELT	106000.	T
POLYETHYLENE, HI DENSITY (POWDERD)	240000.	T
POLYETHYLENE, LINEAR LD	250000.	T
POLYMETHYLMETHACRYLATE SHEET	6000.	T
POLYOL, TRIFUNCTIONAL POLYETHER	65000.	T
POLYPROPYLENE	85000.	T
POLYSTYRENE, IMPACT MODIFIED	80000.	T
POLYVINYL CHLORIDE DISPERSION	30000.	T
POLYVINYL CHLORIDE	220000.	T
PROPYLENE OXIDE IN SOLUTION(IMPURE)	832.	T
PROPYLENE OXIDE	9500.	T
PROPYLENE, (DILUTE)	146.	T
PROPYLENE	10000.	T
PYROLYSIS GASOLINE	362562.	T
STYRENE-BUTADIENE RUBBER	80000.	T
STYRENE	10000.	T
SULFURIC ACID(IN 65%)	1576.	T
TAIL GAS	1396032000.	T-cal
TOLUENE	60000.	T
TRICHLOROETHYLENE	7500.	T
TRIETHANOLAMINE	10000.	T
TRIETHYLENE GLYCOL	1144.	T
VINYL ACETATE	42000.	T
XYLENE-P	42590.	T
STYRENE-BUTADIENE LATEX	25000.	T
BUTYL RUBBER	10000.	T
POLIPROPYLENE ATACTIC	2550.	T
METHYL ACETATE	1080.	T
AMMONIUM BISULFATE	11500.	T
C4 ALKYLATION FEED	6886.	T
PERCHLOROETHYLENE	12000.	T

P U R C H A S E

COOLING WATER	728129000.	m3
PROCESS WATER	5843658.	m3
STEAM	5894048.	T
ELECTRICITY	1351633000.	kWh
INERT GAS	64474710.	m3
ACETONITRILE	96.	T
ACTIVATED CARBON	19.	T
ADDITIVES,NG	500.	T
ALKYLBENZENE	160.	T
ALUMINA	173.	T
ALUMINA TRICHLORIDE	300.	T
AMMONIA	94852.	T
ANTIMONY TRIOXIDE	32.	T
ASCORBIC ACID	3.	T
BENTONITE	3124.	T
BENZOYL PEROXIDE	30.	T
BUTANOL-N	9975.	T
BUTYL STEARATE	80.	T
BUTYL-T CATECHOL	8.	T
BUTYLLITHIUM -N	18.	T
CARBON TETRACHLORIDE	7000.	T

CATALYST (DEHYDRO)	1.	T
CATALYST AND CHEMICALS	16569820.	$
CATALYST(ALK)	1.	T
CATALYST,MTBE	4.	T
CHEMICALS	6932160.	$
COBALT ACETATE.4H2O	30.	T
COBALTOUS OCTANOATE	118.	T
CR-SI CATALIST	780000.	T
CU-PD CATALYST	11865000.	CC
CUPRIC NITRATE	1.	T
ETHANE	125965.	T
ETHYL ACETATE	165.	T
ETHYLENE GLYCOL	15734.	T
FILTER AID	26000.	T
FORMIC ACID (IN 85%)	32.	T
FUEL	526745100.	T-cal
GLYCERIN	2015.	T
HEXANE -N	1102.	T
HYDROBROMIC ACID	394.	T
HYDROCHLORIC ACID	12657.	T
HYDROGEN (IN OFF-GAS)	46845490.	m3
HYDROGEN PEROXIDE	4.	T
ION-EXCHANGE RESIN	103600.	T
ISOBUTANE	1296.	T
ISOBUTANOL	2051.	T
MAGNEZIUM ACETATE.4H2O	1.	T
MAGNESIUM SILICATE	975.	T
MANGANOUS OCATNOATE	125.	T
MEMBRANE	28154480.	SQCM
METHANE	1233.	T
METHANOL	90636.	T
MMA-EHA COPOLYMER	13.	T
MOLYBDENUM POWDER	1.	T
MONOETHANOLAMINE	1043.	T
NAPHTHA ,WIDE RANGE	1293505.	T
NAPHTHA HEARTCUT (NAPHTHENIC)	336401.	T
NAPHTHENIC ACID	96.	T
NATURAL GAS	1154828000.	T-cal
NYLON (WASTE)	3250.	T
OCTANE-N	48.	T
OCTANOIC ACID	418.	T
OLEUM	64464.	T
OXALIC ACID	52.	T
PALMITIC ACID	185.	T
PD ON ALUMINUM CATALIST	30025.	T
PHOSPHORIC ACID CATALYST	35.	T
POTASSIUM CARBONATE	130.	T
POTASSIUM HYDROXIDE	1455.	T
POTASSIUM PERSULFATE	7.	T
PROPANE	76981.	T
RHODIUM-HALIDE CATALIST	3457.	GM
ROCK SALT	24.	T
SALT	409918.	T
SOAP	6011.	T
SODIUM CARBONATE	7015.	T
SODIUM CHLORIDE	17383.	T
SODIUM HYDROGEN SULFIDE	7.	T
SODIUM LAURATE	220.	T
SODIUM PYROPHOSPHATE	17.	T
SOYBEAN OIL	80.	T
STABILIZER, SBR	689.	T
STYRENE-BUTADIENE RUBBER	18516.	T
SULFOLANE	47.	T
SULFURIC ACID	42164.	T
SULFUR	7430.	T
TITANIUM DIOXIDE	445.	T

TRICHLOROETHYLENE	1500.	T
TRIETHANOLAMINE	1429.	T
TRIPHENYLMETHANE	18.	T
WATER DEIONIZED	463633.	T
ZINC ACETATE	26.	T
STABILIZER	383.	T
BUTYL RUBBER	10000.	T
WASTE RECOVERY CHEMICALS	346.	T
HPMC	249.	T
DIIPC	62.	T
AIR	660836.	T
Naphta light	631680.	T
BTX REFORMATE (HIGHLY NAPHT.)	320450.	tons

P R O C E S S E S

ELTHYLENE FROM ETHANE-PROPANE MIXTURE	134020.	T
ETHYLENE FROM WIDE RANGE NAPHTA MS	360408.	T
BENZENE FROM PYROLYSIS GASOLINE	43599.	T
MIXED XYLENES FROM NAPHTENIC FEED	80963.	T
BENZENE FROM TOLUENE	126030.	T
P-XYLENE (PAREX)	63416.	T
BUTADIENE FROM C4 EXTRACTION	69600.	T
METHYL METHACRYLATE CYANOHYDRIN PROCESS	10000.	T
ISOBUTYLENE BY ACID EXTRACTION (CFR)	29120.	T
D-ETHYLHEXANOL (OXO PROCESS)	51750.	T
PROPYLENE OXIDE BY ETHYLBENZENE PROCESS	48773.	T
POLYOL TRIFUNCTIONAL POLYETHER	65000.	T
BUTENE-1 FROM MTBE RAFFINATE	23096.	T
ISOPROPANOL BY CATION EXCHANGE RESIN	2000.	T
DI-OCTYLPHTALATE FROM PHTALIC ANHYDRIDE	35000.	T
PHTHALIC ANHYDRIDE AIR OX. OF O-XYLENE	22250.	T
METHYL ETHYL KETONE FROM MTBE RAFFINATE	7000.	T
TRIETHANOL AMINE FROM EO END NH3	8571.	T
POLYMETHYLMETHACRYLATE	6000.	T
PERCHLOROETHYLENE FROM EDC	12000.	T
HYDROGEN FROM NATURAL GAS	54917230.	m3
PHENOL (CUMENE)	25202.	T
CHLORINE (MEMBRANE PROCESS)	68691.	T
POLYETHYLENE LLD (UCC)	190000.	T
POLYPROPYLENE (AMOCO)	35000.	T
POLYVINYLCHLORIDE BY SUSPENSION POLYMER.	70000.	T
POLYVINYL CHLORIDE BY EMULSION POLIMER.	30000.	T
VINYL CHLORIDE BY OXYCHLORINATION	102500.	T
VINYL ACETATE FROM ETHYLENE	12000.	T
ACETIC ACID FROM METHANOL	26129.	T
POLYSTYRENE HIGH IMPACT	80000.	T
ABS BY EMULSION/MASS POLYMERIZATION	15000.	T
STYRENE BY BENZENE ALKYLATION	9167.	T
ETHYLBENZENE LIQUID PHASE	133102.	T
ETHYLENE DICHLORIDE BY CHLORINATION	9828.	T
POLYETHYLENE HD (UCC)	180000.	T
STYRENE-BUTADIENE LATEX	25000.	T
STYRENE-BUTADIENE RUBBER BY EMUL.POLYM.	61484.	T
POLYBUTADIENE	11480.	T
NYLON 6 MELT	24000.	T
CAPROLACTAM FROM CYCLOHEXANE	36311.	T
CAPROLACTAM FROM PHENOL	11089.	T
CYCLOHEXANE BY HYDROGENATION OF BENZENE	37721.	T
POLYETHYLENE TEREPHTALATE MELT FROM DMT	9935.	T
POLYETHYLENE TEREPHTALATE MELT FROM TA	41065.	T
TEREPHTHATIC ACID FROM P-XYLENE	35164.	T

ETHYLENE GLYCOL AND ETHYLENE OXIDE	42362.	T
ACRYLONITRILE BY PROPYLENE AMMOXIDATION	70762.	T
SYNTGAS (2:1) FROM NATURAL GAS	66809250.	m3
SYNTGAS (3:1) FROM NATURAL GAS	44338270.	m3
CARBON MONOOXIDE FROM SYNTGAS	10947720.	m3
OXYGEN BY AIR FRACTIONATION	132167.	T
NYLON 6 MELT PARSILON COMP.	16000.	T
NYLON 6 MELT ALYAF COMP.	10000.	T
POLYETYLENE THEREFTALATE POLYACRYL COMP.	55000.	T
DI-OCTYL PHTALATE IRAN NIPPON	40000.	T
PHTALIC ANHYDRIDE IRAN NIPPON	22000.	T
ACRYLONITRILE ARAK	33000.	T
VINYL CHLORIDE FROM ETHYLENE ARAK	150000.	T
PVC ARAK	150000.	T
VINYLACETATE ARAK	30000.	T
ACETIC ACID ARAK	30000.	T
PE HD ARAK	60000.	T
CHLORINE ARAK	100000.	T
PE LLD ARAK	60000.	T
POLYPROPYLENE ARAK	50000	T
BUTADIENE ARAK	26000.	T
POLYBUTADIENE ARAK	25000.	T
ETHYLENE ARAK	240000.	T
DMT ISFEHAN	65000.	T
BTX ISFEHAN	85000.	T
P-XYLEN ISFEHAN	44000.	T

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EXP. ; A0.

Problem title: HTO - HIGH TONNAGE ORGANICS

F r a c t i o n a l Optimization

Maximize:

$$\frac{\text{PDA Yearly Profit}}{\text{Investment}} = 0.078 \ \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:

0.	<	ACETIC ACID	<	16000.	(100.0%)	T
0.	<	ACETONE	<	5900.	(0.0%)	T
0.	<	ACRYLONITRILE-BUTADIENE-STYRENE(ABS)	<	10000.	(100.0%)	T
0.	<	ACRYLONITRILE	<	50000.	(100.0%)	T
0.	<	BENZENE	<	40000.	(26.4%)	T
0.	<	BUTANOL-N	<	5000.	(80.4%)	T
0.	<	CARBON TETRACHLORIDE	<	7000.	(0.0%)	T
0.	<	DI-OCTYL PHTHALATE(DOP)	<	60000.	(100.0%)	T
0.	<	DIETHANOLAMINE	<	400.	(100.0%)	T
0.	<	ETHYLENE GLYCOL	<	15000.	(0.0%)	T
0.	<	ETHYLENE OXIDE	<	15000.	(0.0%)	T
0.	<	ISOBUTANOL	<	1850.	(23.7%)	T
0.	<	ISOPROPANOL	<	1000.	(100.0%)	T
0.	<	METHANOL	<	47000.	(0.0%)	T
0.	<	METHYL ETHYL KETONE	<	4650.	(56.1%)	T
0.	<	METHYL METHACRYLATE	<	2000.	(100.0%)	T
0.	<	MONOETHANOLAMINE	<	900.	(19.0%)	T
0.	<	NYLON 6 MELT	<	50000.	(0.0%)	T
0.	<	PHENOL	<	10000.	(0.0%)	T
0.	<	PHTHALIC ANHYDRIDE	<	10000.	(0.7%)	T
0.	<	POLYBUTADIENE	<	25000.	(100.0%)	T
0.	<	POLYETHYLENE TEREPHTHALATE MELT	<	60000.	(100.0%)	T
0.	<	POLYETHYLENE, HI DENSITY (POWDERD)	<	240000.	(39.2%)	T
0.	<	POLYETHYLENE, LINEAR LD	<	150000.	(100.0%)	T
0.	<	POLYETHYLENE, LO DENSITY	<	150000.	(0.0%)	T
0.	<	POLYMETHYLMETHACRYLATE SHEET	<	3000.	(0.0%)	T
0.	<	POLYOL, TRIFUNCTIONAL POLYETHER	<	38500.	(100.0%)	T
0.	<	POLYPROPYLENE	<	62000.	(80.6%)	T
0.	<	POLYSTYRENE, IMPACT MODIFIED	<	50000.	(100.0%)	T
0.	<	POLYVINYL CHLORIDE DISPERSION	<	20000.	(0.0%)	T
0.	<	POLYVINYL CHLORIDE	<	160000.	(93.8%)	T
0.	<	PROPYLENE OXIDE	<	9500.	(0.0%)	T
0.	<	PROPYLENE	<	5000.	(0.0%)	T
0.	<	STYRENE-BUTADIENE RUBBER	<	50000.	(0.0%)	T
0.	<	STYRENE	<	10000.	(0.0%)	T
0.	<	TOLUENE	<	40000.	(100.0%)	T
0.	<	TRICHLOROETHYLENE	<	5000.	(58.4%)	T
0.	<	TRIETHANOLAMINE	<	10000.	(57.1%)	T
0.	<	VINYL ACETATE	<	30000.	(100.0%)	T
0.	<	STYRENE-BUTADIENE LATEX	<	15000.	(0.0%)	T
0.	<	BUTYL RUBBER	<	5000.	(0.0%)	T
0.	<	PERCHLOROETHYLENE	<	8000.	(73.1%)	T
		ACRYLONITRILE ARAK	=	33000.	(100.0%)	T
		VINYL CHLORIDE FROM ETHYLENE ARAK	=	150000.	(100.0%)	T
		PVC ARAK	=	150000.	(100.0%)	T
		VINYLACETATE ARAK	=	30000.	(100.0%)	T
		ACETIC ACID ARAK	=	30000.	(100.0%)	T
		PE HD ARAK	=	60000.	(100.0%)	T
		CHLORINE ARAK	=	100000.	(100.0%)	T
		PE LLD ARAK	=	60000.	(100.0%)	T
		POLYPROPYLENE ARAK	=	50000.	(100.0%)	T

BUTADIENE ARAK	=	26000. (100.0%) T
POLYBUTADIENE ARAK	=	25000. (100.0%) T
ETHYLENE ARAK	=	240000. (100.0%) T
DMT ISFEHAN	=	65000. (100.0%) T
BTX ISFEHAN	=	85000. (100.0%) T
P-XYLEN ISFEHAN	=	44000. (100.0%) T

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G L O B A L   R E S U L T S

PDA Yearly Profit	130.	mil.$
PDA Value Added	502.	mil.$
Investment	1669.	mil.$
Energy Consumption	5411.	TJ
Yearly Import	36.	mil.$
Energy Input	11624.	TJ
Yearly Domestic Purchase	239.	mil.$
Yearly Domestic Sale	845.	mil.$

S A L E

ACETIC ACID	16000.	T
ACRYLONITRILE-BUTADIENE-STYRENE(ABS)	10000.	T
ACRYLONITRILE	50000.	T
BENZENE	10579.	T
BTX RAFFINATE	119850.	T
BUTANOL-N	4020.	T
C4 FRACTION	40692.	T
C9 AROMATICS CRUDE	20400.	T
CARBON DIOXIDE	10162.	T
CAUSTIC SODA	111511.	T
DI-OCTYL PHTHALATE(DOP)	60000.	T
DIETHANOLAMINE	400.	T
DIETHYLENE GLYCOL	1080.	T
DIMETHYL TEREPHTHALATE	4940.	T
FUEL GAS	220728100.	T-cal
FUEL OIL	30751.	T
GASOLINE	4974.	T
HCL ACID (AS 20 BE)	5348.	T
HEAVY END	231.	T
HYDROGEN CYANIDE	4986.	T
HYDROGEN-RICH GAS	91600000.	T-cal
HYDROGEN	1179652.	m3
ISOBUTANOL	439.	T
ISOBUTYLENE	14729.	T
ISOPROPANOL	1000.	T
LIGHT ENDS	4948.	T
METHYL ETHYL KETONE	2607.	T
METHYL METHACRYLATE	2000.	T
MONOETHANOLAMINE	171.	T
PHTHALIC ANHYDRIDE	73.	T
POLYBUTADIENE	25000.	T
POLYETHYLENE TEREPHTHALATE MELT	60000.	T

POLYETHYLENE, HI DENSITY (POWDERD)	93962.	T
POLYETHYLENE, LINEAR LD	150000.	T
POLYOL, TRIFUNCTIONAL POLYETHER	38500.	T
POLYPROPYLENE	50000.	T
POLYSTYRENE, IMPACT MODIFIED	50000.	T
POLYVINYL CHLORIDE	150000.	T
PROPYLENE OXIDE IN SOLUTION(IMPURE)	493.	T
PROPYLENE, (DILUTE)	69.	T
PYROLYSIS GASOLINE	219385.	T
SULFURIC ACID(IN 65%)	934.	T
TAIL GAS	878373000.	T-cal
TOLUENE	40000.	T
TRICHLOROETHYLENE	2922.	T
TRIETHANOLAMINE	5714.	T
TRIETHYLENE GLYCOL	283.	T
VINYL ACETATE	30000.	T
XYLENE-P	3303.	T
POLIPROPYLENE ATACTIC	1500.	T
METHYL ACETATE	1080.	T
AMMONIUM BISULFATE	2300.	T
C4 ALKYLATION FEED	2565.	T
PROPYLENE DICHLORIDE	83.	T
PERCHLOROETHYLENE	5845.	T

P U R C H A S E

COOLING WATER	344045200.	m3
PROCESS WATER	2850052.	m3
STEAM	2834670.	T
ELECTRICITY	697795500.	kWh
INERT GAS	32590060.	m3
ACETONE	1358.	T
ACETONITRILE	32.	T
ACTIVATED CARBON	15.	T
ALUMINA	80.	T
ALUMINA TRICHLORIDE	240.	T
AMMONIA	25208.	T
ANTIMONY TRIOXIDE	18.	T
BENTONITE	2130.	T
BUTYL STEARATE	50.	T
BUTYL-T CATECHOL	4.	T
BUTYLLITHIUM -N	14.	T
CATALYST AND CHEMICALS	8249275.	$
CATALYST,MTBE	2.	T
CHEMICALS	2892374.	$
COAGULANT	1.	T
COBALTOUS OCTANOATE	118.	T
CR-SI CATALIST	780000.	T
CU-PD CATALYST	11865000.	CC
ETHYL ACETATE	165.	T
ETHYLENE GLYCOL	11083.	T
FILTER AID	15400.	T
FUEL	242340100.	T-cal
GLYCERIN	1194.	T
HEXANE -N	877.	T
HYDROCHLORIC ACID	11759.	T
HYDROGEN (IN OFF-GAS)	14081690.	m3
ION-EXCHANGE RESIN	38586.	T
ISOBUTANE	1296.	T
LIME	1044.	T
MAGNESIUM SILICATE	578.	T
MANGANOUS OCATNOATE	125.	T

METHANE	305.	T
METHANOL	8974.	T
MMA-EHA COPOLYMER	9.	T
NAPHTHA ,WIDE RANGE	464892.	T
NAPHTHENIC ACID	44.	T
NATURAL GAS	475980600.	T-cal
OCTANE-N	22.	T
OCTANOIC ACID	335.	T
OXALIC ACID	26.	T
PALMITIC ACID	147.	T
PD ON ALUMINUM CATALIST	17207.	T
PHOSPHORIC ACID (INDUSTRIAL GRADE)	3.	T
POTASSIUM CARBONATE	32.	T
POTASSIUM HYDROXIDE	894.	T
RHODIUM-HALIDE CATALIST	942.	GM
ROCK SALT	9.	T
SALT	243000.	T
SODIUM CARBONATE	3450.	T
SOYBEAN OIL	50.	T
SULFOLANE	17.	T
SULFURIC ACID	15226.	T
TITANIUM DIOXIDE	252.	T
TRIPHENYLMETHANE	8.	T
WATER DEIONIZED	674.	T
ZINC ACETATE	24.	T
STABILIZER	305.	T
HPMC	170.	T
DIIPC	42.	T
AIR	291877.	T
Naphta light	631680.	T
BTX REFORMATE (HIGHLY NAPHT.)	320450.	tons

P R O C E S S E S

ETHYLENE FROM WIDE RANGE NAPHTA MS	129532.	T
BENZENE FROM TOLUENE	37885.	T
P-XYLENE (PAREX)	253.	T
BUTADIENE FROM C4 EXTRACTION	5741.	T
METHYL METHACRYLATE CYANOHYDRIN PROCESS	2000.	T
ISOBUTYLENE BY ACID EXTRACTION (CFR)	14729.	T
D-ETHYLHEXANOL (OXO PROCESS)	41400.	T
PROPYLENE OXIDE BY ETHYLBENZENE PROCESS	22394.	T
PROPYLENE OXIDE BY CHLOROHIDRINE PROCESS	867.	T
POLYOL TRIFUNCTIONAL POLYETHER	38500.	T
BUTENE-1 FROM MTBE RAFFINATE	13236.	T
ISOPROPANOL BY CATION EXCHANGE RESIN	1000.	T
DI-OCTYLPHTALATE FROM PHTALIC ANHYDRIDE	20000.	T
PHTHALIC ANHYDRIDE AIR OX. OF O-XYLENE	1473.	T
METHYL ETHYL KETONE FROM MTBE RAFFINATE	2607.	T
TRIETHANOL AMINE FROM EO END NH3	5714.	T
PERCHLOROETHYLENE FROM EDC	5845.	T
POLYETHYLENE LLD (UCC)	90000.	T
VINYL CHLORIDE BY OXYCHLORINATION	1500.	T
ACETIC ACID FROM METHANOL	7120.	T
POLYSTYRENE HIGH IMPACT	50000.	T
ABS BY EMULSION/MASS POLYMERIZATION	10000.	T
ETHYLBENZENE LIQUID PHASE	61114.	T
ETHYLENE DICHLORIDE BY CHLORINATION	4787.	T
POLYETHYLENE HD (UCC)	33962.	T
POLYBUTADIENE	4050.	T
CYCLOHEXANE BY HYDROGENATION OF BENZENE	720.	T

POLYETHYLENE TEREPHTALATE MELT FROM DMT	5000.	T
ETHYLENE GLYCOL AND ETHYLENE OXIDE	10481.	T
ACRYLONITRILE BY PROPYLENE AMMOOXIDATION	19508.	T
SYNTGAS (2:1) FROM NATURAL GAS	53447400.	m3
SYNTGAS (3:1) FROM NATURAL GAS	12141980.	m3
CARBON MONOOXIDE FROM SYNTGAS	2998019.	m3
OXYGEN BY AIR FRACTIONATION	58375.	T
POLYETYLENE THEREFTALATE POLYACRYL COMP.	55000.	T
DI-OCTYL PHTALATE IRAN NIPPON	40000.	T
PHTALIC ANHYDRIDE IRAN NIPPON	22000.	T
ACRYLONITRILE ARAK	33000.	T
VINYL CHLORIDE FROM ETHYLENE ARAK	150000.	T
PVC ARAK	150000.	T
VINYLACETATE ARAK	30000.	T
ACETIC ACID ARAK	30000.	T
PE HD ARAK	60000.	T
CHLORINE ARAK	100000.	T
PE LLD ARAK	60000.	T
POLYPROPYLENE ARAK	50000.	T
BUTADIENE ARAK	26000.	T
POLYBUTADIENE ARAK	25000.	T
ETHYLENE ARAK	240000.	T
DMT ISFEHAN	65000.	T
BTX ISFEHAN	85000.	T
P-XYLEN ISFEHAN	44000.	T

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EXP. ; B0.

Problem title: HTO - HIGH TONNAGE ORGANICS

F r a c t i o n a l Optimization

Maximize:

$$\frac{\text{PDA Yearly Profit}}{\text{Investment}} = 0.101 \, \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:

2.10E+03	<	Investment	<	none	(0.0%)	mil.$
0.	<	ACETIC ACID	<	24000.	(100.0%)	T
0.	<	ACETONE	<	8500.	(0.0%)	T
0.	<	ACRYLONITRILE-BUTADIENE-STYRENE(ABS)	<	15000.	(100.0%)	T
0.	<	ACRYLONITRILE	<	100000.	(69.0%)	T
0.	<	BENZENE	<	80000.	(0.0%)	T
0.	<	BUTANOL-N	<	22500.	(22.3%)	T
0.	<	CARBON TETRACHLORIDE	<	11000.	(0.0%)	T
0.	<	DI-OCTYL PHTHALATE(DOP)	<	75000.	(100.0%)	T
0.	<	DIETHANOLAMINE	<	600.	(100.0%)	T
0.	<	ETHYLENE GLYCOL	<	25000.	(0.0%)	T
0.	<	ETHYLENE OXIDE	<	22500.	(0.0%)	T
0.	<	ISOBUTANOL	<	2600.	(21.1%)	T
0.	<	ISOPROPANOL	<	2000.	(100.0%)	T
0.	<	METHANOL	<	75000.	(0.0%)	T
0.	<	METHYL ETHYL KETONE	<	7000.	(1.0%)	T
0.	<	METHYL METHACRYLATE	<	4000.	(100.0%)	T
0.	<	MONOETHANOLAMINE	<	1300.	(19.8%)	T
0.	<	NYLON 6 MELT	<	70000.	(0.0%)	T
0.	<	PHENOL	<	20000.	(0.0%)	T
0.	<	PHTHALIC ANHYDRIDE	<	15000.	(0.0%)	T
0.	<	POLYBUTADIENE	<	30000.	(100.0%)	T
0.	<	POLYETHYLENE TEREPHTHALATE MELT	<	106000.	(100.0%)	T
0.	<	POLYETHYLENE, HI DENSITY (POWDERD)	<	330000.	(18.2%)	T
0.	<	POLYETHYLENE, LINEAR LD	<	250000.	(100.0%)	T
0.	<	POLYETHYLENE, LO DENSITY	<	250000.	(0.0%)	T
0.	<	POLYMETHYLMETHACRYLATE SHEET	<	6000.	(0.0%)	T
0.	<	POLYOL, TRIFUNCTIONAL POLYETHER	<	65000.	(100.0%)	T
0.	<	POLYPROPYLENE	<	85000.	(58.8%)	T
0.	<	POLYSTYRENE, IMPACT MODIFIED	<	80000.	(100.0%)	T
0.	<	POLYVINYL CHLORIDE DISPERSION	<	30000.	(0.0%)	T
0.	<	POLYVINYL CHLORIDE	<	260000.	(57.7%)	T
0.	<	PROPYLENE OXIDE	<	9500.	(0.0%)	T
0.	<	PROPYLENE	<	10000.	(0.0%)	T
0.	<	STYRENE-BUTADIENE RUBBER	<	80000.	(0.0%)	T
0.	<	STYRENE	<	15000.	(0.0%)	T
0.	<	TOLUENE	<	60000.	(100.0%)	T
0.	<	TRICHLOROETHYLENE	<	7500.	(24.0%)	T
0.	<	TRIETHANOLAMINE	<	10000.	(47.6%)	T
0.	<	VINYL ACETATE	<	48000.	(62.5%)	T
0.	<	STYRENE-BUTADIENE LATEX	<	25000.	(0.0%)	T
0.	<	BUTYL RUBBER	<	10000.	(0.0%)	T
0.	<	PERCHLOROETHYLENE	<	12000.	(30.0%)	T
		ACRYLONITRILE ARAK	=	33000.	(100.0%)	T
		VINYL CHLORIDE FROM ETHYLENE ARAK	=	150000.	(100.0%)	T
		PVC ARAK	=	150000.	(100.0%)	T
		VINYLACETATE ARAK	=	30000.	(100.0%)	T
		ACETIC ACID ARAK	=	30000.	(100.0%)	T
		PE HD ARAK	=	60000.	(100.0%)	T
		CHLORINE ARAK	=	100000.	(100.0%)	T
		PE LLD ARAK	=	60000.	(100.0%)	T

POLYPROPYLENE ARAK	=	50000.	(100.0%)	T
BUTADIENE ARAK	=	26000.	(100.0%)	T
POLYBUTADIENE ARAK	=	25000.	(100.0%)	T
ETHYLENE ARAK	=	240000.	(100.0%)	T
DMT ISFEHAN	=	65000.	(100.0%)	T
BTX ISFEHAN	=	85000.	(100.0%)	T
P-XYLEN ISFEHAN	=	44000.	(100.0%)	T

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G L O B A L R E U L T S

PDA Yearly Profit	216.	mil.$
PDA Value Added	686.	mil.$
Investment	2133.	mil.$
Energy Consumption	6768.	TJ
Yearly Import	59.	mil.$
Energy Input	14642.	TJ
Yearly Domestic Purchase	295.	mil.$
Yearly Domestic Sale	1125.	mil.$

S A L E

ACETIC ACID	24000.	T
ACRYLONITRILE-BUTADIENE-STYRENE(ABS)	15000.	T
ACRYLONITRILE	68981.	T
BTX RAFFINATE	134512.	T
BUTANOL-N	5025.	T
C4 FRACTION	55342.	T
C9 AROMATICS CRUDE	23268.	T
CARBON DIOXIDE	16054.	T
CAUSTIC SODA	111133.	T
DI-OCTYL PHTHALATE(DOP)	75000.	T
DIETHANOLAMINE	600.	T
DIETHYLENE GLYCOL	1706.	T
FUEL GAS	271109900.	T-cal
FUEL OIL	35791.	T
GASOLINE	6235.	T
HCL ACID (AS 20 BE)	3291.	T
HEAVY END	142.	T
HYDROGEN CYANIDE	6520.	T
HYDROGEN-RICH GAS	253842300.	T-cal
HYDROGEN	9841475.	m3
ISOBUTANOL	549.	T
ISOBUTYLENE	19457.	T
ISOPROPANOL	2000.	T
LIGHT ENDS	6067.	T
METHYL ETHYL KETONE	72.	T
METHYL METHACRYLATE	4000.	T
MONOETHANOLAMINE	257.	T
POLYBUTADIENE	30000.	T
POLYETHYLENE TEREPHTHALATE MELT	106000.	T
POLYETHYLENE, HI DENSITY (POWDERD)	60000.	T
POLYETHYLENE, LINEAR LD	250000.	T

POLYOL, TRIFUNCTIONAL POLYETHER	65000.	T
POLYPROPYLENE	50000.	T
POLYSTYRENE, IMPACT MODIFIED	80000.	T
POLYVINYL CHLORIDE	150000.	T
PROPYLENE OXIDE IN SOLUTION(IMPURE)	832.	T
PROPYLENE, (DILUTE)	116.	T
PYROLYSIS GASOLINE	291553.	T
SULFURIC ACID(IN 65%)	934.	T
TAIL GAS	1014056000.	T-cal
TOLUENE	60000.	T
TRICHLOROETHYLENE	1798.	T
TRIETHANOLAMINE	8571.	T
TRIETHYLENE GLYCOL	447.	T
VINYL ACETATE	30000.	T
POLIPROPYLENE ATACTIC	1500.	T
METHYL ACETATE	1080.	T
AMMONIUM BISULFATE	4600.	T
C4 ALKYLATION FEED	71.	T
PROPYLENE DICHLORIDE	354.	T
PERCHLOROETHYLENE	3597.	T

P U R C H A S E

COOLING WATER	416944600.	m3
PROCESS WATER	3473525.	m3
STEAM	3522670.	T
ELECTRICITY	806854100.	kWh
INERT GAS	42508780.	m3
ACETONE	2716.	T
ACETONITRILE	40.	T
ACTIVATED CARBON	19.	T
ALUMINA	126.	T
ALUMINA TRICHLORIDE	300.	T
AMMONIA	34940.	T
ANTIMONY TRIOXIDE	32.	T
BENTONITE	2130.	T
BUTYL STEARATE	80.	T
BUTYL-T CATECHOL	6.	T
BUTYLLITHIUM -N	18.	T
CATALYST AND CHEMICALS	9648721.	$
CATALYST,MTBE	4.	T
CHEMICALS	4776026.	$
COAGULANT	4.	T
COBALT ACETATE.4H2O	22.	T
COBALTOUS OCTANOATE	118.	T
CR-SI CATALIST	780000.	T
CU-PD CATALYST	11865000.	CC
DIMETHYL TEREPHTHALATE	10886.	T
ETHYL ACETATE	165.	T
ETHYLENE GLYCOL	21537.	T
FILTER AID	26000.	T
FUEL	271480000.	T-cal
GLYCERIN	2015.	T
HEXANE -N	1102.	T
HYDROBROMIC ACID	290.	T
HYDROCHLORIC ACID	11842.	T
HYDROGEN (IN OFF-GAS)	16322710.	m3
ION-EXCHANGE RESIN	1063.	T
ISOBUTANE	1296.	T
LIME	4440.	T
MAGNEZIUM ACETATE.4H2O	1.	T
MAGNESIUM SILICATE	975.	T

MANGANOUS OCATNOATE	125.	T
MEMBRANE	16690000.	SQCM
METHANE	482.	T
METHANOL	9724.	T
MMA-EHA COPOLYMER	9.	T
MOLYBDENUM POWDER	1.	T
NAPHTHA ,WIDE RANGE	743637.	T
NAPHTHA HEARTCUT (NAPHTHENIC)	88934.	T
NAPHTHENIC ACID	70.	T
NATURAL GAS	719859100.	T-cal
OCTANE-N	35.	T
OCTANOIC ACID	418.	T
OXALIC ACID	36.	T
PALMITIC ACID	185.	T
PD ON ALUMINUM CATALIST	30025.	T
PHOSPHORIC ACID (INDUSTRIAL GRADE)	14.	T
PHTHALIC ANHYDRIDE	1090.	T
POTASSIUM CARBONATE	51.	T
POTASSIUM HYDROXIDE	1455.	T
RHODIUM-HALIDE CATALIST	2240.	GM
SALT	243000.	T
SODIUM CARBONATE	4329.	T
SODIUM HYDROGEN SULFIDE	5.	T
SOYBEAN OIL	80.	T
SULFOLANE	20.	T
SULFURIC ACID	22721.	T
TITANIUM DIOXIDE	445.	T
TRIPHENYLMETHANE	13.	T
WATER DEIONIZED	19.	T
ZINC ACETATE	30.	T
STABILIZER	383.	T
HPMC	170.	T
DIIPC	42.	T
AIR	345333.	T
Naphta light	631680.	T
BTX REFORMATE (HIGHLY NAPHT.)	320450.	tons

P R O C E S S E S

ETHYLENE FROM WIDE RANGE NAPHTA MS	207199.	T
MIXED XYLENES FROM NAPHTENIC FEED	21404.	T
BENZENE FROM TOLUENE	43914.	T
P-XYLENE (PAREX)	14503.	T
BUTADIENE FROM C4 EXTRACTION	14339.	T
METHYL METHACRYLATE CYANOHYDRIN PROCESS	4000.	T
ISOBUTYLENE BY ACID EXTRACTION (CFR)	19457.	T
D-ETHYLHEXANOL (OXO PROCESS)	51750.	T
PROPYLENE OXIDE BY ETHYLBENZENE PROCESS	35535.	T
PROPYLENE OXIDE BY CHLOROHIDRINE PROCESS	3688.	T
POLYOL TRIFUNCTIONAL POLYETHER	65000.	T
BUTENE-1 FROM MTBE RAFFINATE	23096.	T
ISOPROPANOL BY CATION EXCHANGE RESIN	2000.	T
DI-OCTYLPHTALATE FROM PHTALIC ANHYDRIDE	35000.	T
PHTHALIC ANHYDRIDE AIR OX. OF O-XYLENE	6160.	T
METHYL ETHYL KETONE FROM MTBE RAFFINATE	72.	T
TRIETHANOL AMINE FROM EO END NH3	8571.	T
PERCHLOROETHYLENE FROM EDC	3597.	T
POLYETHYLENE LLD (UCC)	190000.	T
VINYL CHLORIDE BY OXYCHLORINATION	1500.	T
ACETIC ACID FROM METHANOL	16930.	T
POLYSTYRENE HIGH IMPACT	80000.	T
ABS BY EMULSION/MASS POLYMERIZATION	15000.	T

ETHYLBENZENE LIQUID PHASE	97112.	T
ETHYLENE DICHLORIDE BY CHLORINATION	2946.	T
POLYBUTADIENE	11480.	T
CYCLOHEXANE BY HYDROGENATION OF BENZENE	720.	T
POLYETHYLENE TEREPHTALATE MELT FROM DMT	20810.	T
POLYETHYLENE TEREPHTALATE MELT FROM TA	30190.	T
TEREPHTHATIC ACID FROM P-XYLENE	25852.	T
ETHYLENE GLYCOL AND ETHYLENE OXIDE	16559.	T
ACRYLONITRILE BY PROPYLENE AMMOOXIDATION	39743.	T
SYNTGAS (2:1) FROM NATURAL GAS	66809250.	m3
SYNTGAS (3:1) FROM NATURAL GAS	28767570.	m3
CARBON MONOOXIDE FROM SYNTGAS	7103102.	m3
OXYGEN BY AIR FRACTIONATION	69067.	T
POLYETYLENE THEREFTALATE POLYACRYL COMP.	55000.	T
DI-OCTYL PHTALATE IRAN NIPPON	40000.	T
PHTALIC ANHYDRIDE IRAN NIPPON	22000.	T
ACRYLONITRILE ARAK	33000.	T
VINYL CHLORIDE FROM ETHYLENE ARAK	150000.	T
PVC ARAK	150000.	T
VINYLACETATE ARAK	30000.	T
ACETIC ACID ARAK	30000.	T
PE HD ARAK	60000.	T
CHLORINE ARAK	100000.	T
PE LLD ARAK	60000.	T
POLYPROPYLENE ARAK	50000.	T
BUTADIENE ARAK	26000.	T
POLYBUTADIENE ARAK	25000.	T
ETHYLENE ARAK	240000.	T
DMT ISFEHAN	65000.	T
BTX ISFEHAN	85000.	T
P-XYLEN ISFEHAN	44000.	T

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EXP. ; K 2.

Problem title: HTO - HIGH TONNAGE ORGANICS

F r a c t i o n a l Optimization

Maximize:

$$\frac{\text{PDA Yearly Profit}}{\text{Investment}} = 0.072 \ \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:

8000.	<	ACETIC ACID	<	24000.	(33.3%)	T
5900.	<	ACETONE	<	8500.	(69.4%)	T
10000.	<	ACRYLONITRILE-BUTADIENE-STYRENE(ABS)	<	15000.	(100.0%)	T
25000.	<	ACRYLONITRILE	<	100000.	(100.0%)	T
35000.	<	BENZENE	<	80000.	(43.8%)	T
5.00E+03	<	BUTANOL-N	<	none	(0.0%)	T
1420.	<	CARBON TETRACHLORIDE	<	11000.	(12.9%)	T
48000.	<	DI-OCTYL PHTHALATE(DOP)	<	75000.	(100.0%)	T
4.00E+02	<	DIETHANOLAMINE	<	none	(0.0%)	T
1.50E+04	<	ETHYLENE GLYCOL	<	none	(0.0%)	T
15000.	<	ETHYLENE OXIDE	<	22500.	(66.7%)	T
1850.	<	ISOBUTANOL	<	2600.	(71.2%)	T
1000.	<	ISOPROPANOL	<	2000.	(50.0%)	T
47000.	<	METHANOL	<	75000.	(62.7%)	T
4650.	<	METHYL ETHYL KETONE	<	7000.	(100.0%)	T
2000.	<	METHYL METHACRYLATE	<	4000.	(100.0%)	T
9.00E+02	<	MONOETHANOLAMINE	<	none	(0.0%)	T
42000.	<	NYLON 6 MELT	<	70000.	(60.0%)	T
8000.	<	PHENOL	<	20000.	(40.0%)	T
10000.	<	PHTHALIC ANHYDRIDE	<	15000.	(80.5%)	T
10500.	<	POLYBUTADIENE	<	25000.	(74.1%)	T
60000.	<	POLYETHYLENE TEREPHTHALATE MELT	<	100000.	(100.0%)	T
160000.	<	POLYETHYLENE, HI DENSITY (POWDERD)	<	330000.	(48.5%)	T
50000.	<	POLYETHYLENE, LINEAR LD	<	250000.	(100.0%)	T
0.	<	POLYETHYLENE, LO DENSITY	<	150000.	(0.0%)	T
1500.	<	POLYMETHYLMETHACRYLATE SHEET	<	6000.	(25.0%)	T
38500.	<	POLYOL, TRIFUNCTIONAL POLYETHER	<	65000.	(100.0%)	T
62000.	<	POLYPROPYLENE	<	85000.	(100.0%)	T
50000.	<	POLYSTYRENE, IMPACT MODIFIED	<	80000.	(100.0%)	T
20000.	<	POLYVINYL CHLORIDE DISPERSION	<	30000.	(66.7%)	T
160000.	<	POLYVINYL CHLORIDE	<	260000.	(61.5%)	T
0.	<	PROPYLENE OXIDE	<	9500.	(64.4%)	T
0.	<	PROPYLENE	<	10000.	(100.0%)	T
50000.	<	STYRENE-BUTADIENE RUBBER	<	80000.	(62.5%)	T
2000.	<	STYRENE	<	15000.	(13.3%)	T
40000.	<	TOLUENE	<	60000.	(100.0%)	T
5.00E+03	<	TRICHLOROETHYLENE	<	none	(0.0%)	T
8000.	<	TRIETHANOLAMINE	<	18000.	(100.0%)	T
25000.	<	VINYL ACETATE	<	48000.	(62.5%)	T
15000.	<	STYRENE-BUTADIENE LATEX	<	25000.	(60.0%)	T
5.00E+03	<	BUTYL RUBBER	<	none	(0.0%)	T
8000.	<	PERCHLOROETHYLENE	<	12000.	(83.3%)	T
		ACRYLONITRILE ARAK	=	33000.	(100.0%)	T
		VINYL CHLORIDE FROM ETHYLENE ARAK	=	150000.	(100.0%)	T
		PVC ARAK	=	150000.	(100.0%)	T
		VINYLACETATE ARAK	=	30000.	(100.0%)	T
		ACETIC ACID ARAK	=	30000.	(100.0%)	T
		PE HD ARAK	=	60000.	(100.0%)	T
		CHLORINE ARAK	=	100000.	(100.0%)	T
		PE LLD ARAK	=	60000.	(100.0%)	T
		POLYPROPYLENE ARAK	=	50000.	(100.0%)	T

BUTADIENE ARAK	=	26000. (100.0%) T
POLYBUTADIENE ARAK	=	25000. (100.0%) T
ETHYLENE ARAK	=	240000. (100.0%) T
DMT ISFEHAN	=	65000. (100.0%) T
BTX ISFEHAN	=	85000. (100.0%) T
P-XYLEN ISFEHAN	=	44000. (100.0%) T

G L O B A L R E S U L T S

PDA Yearly Profit	224.	mil.$
PDA Value Added	902.	mil.$
Investment	3086.	mil.$
Energy Consumption	8554.	TJ
Yearly Import	92.	mil.$
Energy Input	20642.	TJ
Yearly Domestic Purchase	433.	mil.$
Yearly Domestic Sale	1548.	mil.$

S A L E

ACETIC ACID	8000.	T
ACETONE	5900.	T
ACRYLONITRILE-BUTADIENE-STYRENE(ABS)	15000.	T
ACRYLONITRILE	100000.	T
AMMONIUM SULFATE	69678.	T
BENZENE	35000.	T
BTX RAFFINATE	175674.	T
BUTANOL-N	5025.	T
C4 FRACTION	47951.	T
C9 AROMATICS CRUDE	31320.	T
CARBON DIOXIDE	42386.	T
CARBON TETRACHLORIDE	1420.	T
CAUSTIC SODA	127010.	T
DI-OCTYL PHTHALATE(DOP)	75000.	T
DIETHANOLAMINE	1260.	T
DIETHYLENE GLYCOL	4503.	T
DIMETHYL TEREPHTHALATE	9945.	T
ETHYLENE GLYCOL	15000.	T
ETHYLENE OXIDE	15000.	T
FUEL GAS	448241000.	T-cal
FUEL OIL	45253.	T
GASOLINE	9720.	T
HCL ACID (AS 20 BE)	9150.	T
HEAVY END	396.	T
HYDROGEN CYANIDE	9365.	T
HYDROGEN-RICH GAS	725081300.	T-cal
ISOBUTANOL	1850.	T
ISOBUTYLENE	29120.	T
ISOPROPANOL	1000.	T
LIGHT ENDS	9207.	T
METHANOL	47000.	T
METHYL ETHYL KETONE	7000.	T

METHYL METHACRYLATE	4000.	T
MIXED BUTYLENES(BUTADIENE RAFFINATE)	17325.	T
MONOETHANOLAMINE	900.	T
NYLON 6 MELT	42000.	T
PHENOL	8000.	T
PHTHALIC ANHYDRIDE	12070.	T
POLYBUTADIENE	18520.	T
POLYETHYLENE TEREPHTHALATE MELT	100000.	T
POLYETHYLENE, HI DENSITY (POWDERD)	160000.	T
POLYETHYLENE, LINEAR LD	250000.	T
POLYMETHYLMETHACRYLATE SHEET	1500.	T
POLYOL, TRIFUNCTIONAL POLYETHER	65000.	T
POLYPROPYLENE	85000.	T
POLYSTYRENE, IMPACT MODIFIED	80000.	T
POLYVINYL CHLORIDE DISPERSION	20000.	T
POLYVINYL CHLORIDE	160000.	T
PROPYLENE OXIDE IN SOLUTION(IMPURE)	832.	T
PROPYLENE OXIDE	6120.	T
PROPYLENE, (DILUTE)	136.	T
PROPYLENE	10000.	T
PYROLYSIS GASOLINE	426589.	T
STYRENE-BUTADIENE RUBBER	50000.	T
STYRENE	2000.	T
SULFURIC ACID(IN 65%)	1103.	T
TAIL GAS	1279406000.	T-cal
TOLUENE	60000.	T
TRICHLOROETHYLENE	5000.	T
TRIETHANOLAMINE	18000.	T
TRIETHYLENE GLYCOL	1180.	T
VINYL ACETATE	30000.	T
XYLENE-P	27907.	T
STYRENE-BUTADIENE LATEX	15000.	T
BUTYL RUBBER	5000.	T
POLIPROPYLENE ATACTIC	2550.	T
METHYL ACETATE	1080.	T
AMMONIUM BISULFATE	6325.	T
C4 ALKYLATION FEED	6886.	T
PERCHLOROETHYLENE	10000.	T

P U R C H A S E

COOLING WATER	618491100.	m3
PROCESS WATER	4813890.	m3
STEAM	4899556.	T
ELECTRICITY	1086052000.	kWh
INERT GAS	56949720.	m3
ACETIC ACID	2261.	T
ACETONE	9634.	T
ACETONITRILE	71.	T
ACTIVATED CARBON	19.	T
ADDITIVES,NG	420.	T
ALKYLBENZENE	160.	T
ALUMINA	161.	T
ALUMINA TRICHLORIDE	300.	T
AMMONIA	82321.	T
ANTIMONY TRIOXIDE	32.	T
ASCORBIC ACID	2.	T
BENTONITE	2130.	T
BENZOYL PEROXIDE	8.	T
BUTYL STEARATE	80.	T
BUTYL-T CATECHOL	7.	T
BUTYLLITHIUM -N	12.	T

CARBON TETRACHLORIDE	1420.	T
CATALYST AND CHEMICALS	14237510.	$
CATALYST,MTBE	4.	T
CHEMICALS	6279909.	$
COBALT ACETATE.4H2O	38.	T
COBALTOUS OCTANOATE	118.	T
CR-SI CATALIST	780000.	T
CU-PD CATALYST	11865000.	CC
CUPRIC NITRATE	1.	T
ETHANE	14150.	T
ETHYL ACETATE	165.	T
ETHYLENE GLYCOL	9377.	T
FILTER AID	26000.	T
FORMIC ACID (IN 85%)	21.	T
FUEL	393665400.	T-cal
GLYCERIN	2015.	T
HEXANE -N	755.	T
HYDROBROMIC ACID	489.	T
HYDROCHLORIC ACID	11954.	T
HYDROGEN (IN OFF-GAS)	40181920.	m3
HYDROGEN PEROXIDE	2.	T
ION-EXCHANGE RESIN	103600.	T
ISOBUTANE	1296.	T
ISOBUTANOL	1301.	T
ISOPROPANOL	1000.	T
MAGNEZIUM ACETATE.4H2O	2.	T
MAGNESIUM SILICATE	975.	T
MANGANOUS OCATNOATE	125.	T
MEMBRANE	19706460.	SQCM
METHANE	1272.	T
METHANOL	55085.	T
MMA-EHA COPOLYMER	9.	T
MOLYBDENUM POWDER	1.	T
MONOETHANOLAMINE	360.	T
NAPHTHA ,WIDE RANGE	1262382.	T
NAPHTHA HEARTCUT (NAPHTHENIC)	338608.	T
NAPHTHENIC ACID	89.	T
NATURAL GAS	1082025000.	T-cal
NYLON (WASTE)	2730.	T
OCTANE-N	45.	T
OCTANOIC ACID	418.	T
OLEUM	54150.	T
OXALIC ACID	52.	T
PALMITIC ACID	127.	T
PD ON ALUMINUM CATALIST	30025.	T
PHENOL	8000.	T
POLYVINYL CHLORIDE	10000.	T
POTASSIUM CARBONATE	134.	T
POTASSIUM HYDROXIDE	1455.	T
POTASSIUM PERSULFATE	5.	T
PROPANE	8648.	T
ROCK SALT	24.	T
SALT	286919.	T
SOAP	4518.	T
SODIUM CARBONATE	5558.	T
SODIUM CHLORIDE	13065.	T
SODIUM HYDROGEN SULFIDE	9.	T
SODIUM LAURATE	147.	T
SODIUM PYROPHOSPHATE	11.	T
SOYBEAN OIL	80.	T
STABILIZER, SBR	560.	T
SULFOLANE	30.	T
SULFURIC ACID	33460.	T
TITANIUM DIOXIDE	445.	T
TRIPHENYLMETHANE	16.	T
WATER DEIONIZED	348911.	T

ZINC ACETATE	22.	T
STABILIZER	262.	T
BUTYL RUBBER	5000.	T
WASTE RECOVERY CHEMICALS	260.	T
HPMC	170.	T
DIIPC	42.	T
AIR	597912.	T
NAPHTHA LIGHT	631600.	T
BTX REFORMATE (HIGHLY NAPHT.)	320450.	tons

P R O C E S S E S

ETHYLENE FROM ETHANE-PROPANE MIXTURE	150[illegible]	T
ETHYLENE FROM WIDE RANGE NAPHTA MS	3517[illegible].	T
MIXED XYLENES FROM NAPHTENIC FEED	81494.	T
BENZENE FROM TOLUENE	108103.	T
P-XYLENE (PAREX)	54510.	T
BUTADIENE FROM C4 EXTRACTION	45272.	T
METHYL METHACRYLATE CYANHYDRIN PROCESS	5500.	T
ISOBUTYLENE BY ACID EXTRACTION (CFR)	29120.	T
D-ETHYLHEXANOL (OXO PROCESS)	51750.	T
PROPYLENE OXIDE BY ETHYLBENZENE PROCESS	45393.	T
POLYOL TRIFUNCTIONAL POLYETHER	65000.	T
BUTENE-1 FROM MTBE RAFFINATE	23096.	T
DI-OCTYLPHTALATE FROM PHTALIC ANHYDRIDE	35000.	T
PHTHALIC ANHYDRIDE AIR OX. OF O-XYLENE	19320.	T
METHYL ETHYL KETONE FROM MTBE RAFFINATE	7000.	T
TRIETHANOL AMINE FROM EO END NH3	18000.	T
POLYMETHYLMETHACRYLATE	1500.	T
PERCHLOROETHYLENE FROM EDC	10000.	T
HYDROGEN FROM NATURAL GAS	85402460.	m3
CHLORINE (MEMBRANE PROCESS)	18073.	T
POLYETHYLENE LLD (UCC)	190000.	T
POLYPROPYLENE (AMOCO)	35000.	T
POLYVINYL CHLORIDE BY EMULSION POLIMER.	20000.	T
VINYL CHLORIDE BY OXYCHLORINATION	21700.	T
POLYSTYRENE HIGH IMPACT	80000.	T
ABS BY EMULSION/MASS POLYMERIZATION	15000.	T
ETHYLBENZENE LIQUID PHASE	123876.	T
ETHYLENE DICHLORIDE BY CHLORINATION	8190.	T
POLYETHYLENE HD (UCC)	100000.	T
STYRENE-BUTADIENE LATEX	15000.	T
STYRENE-BUTADIENE RUBBER BY EMUL.POLYM.	50000.	T
NYLON 6 MELT	16000.	T
CAPROLACTAM FROM CYCLOHEXANE	39816.	T
CYCLOHEXANE BY HYDROGENATION OF BENZENE	41293.	T
POLYETHYLENE TEREPHTALATE MELT FROM TA	51000.	T
TEREPHTHALIC ACID FROM P-XYLENE	43671.	T
ETHYLENE GLYCOL AND ETHYLENE OXIDE	43720.	T
ACRYLONITRILE BY PROPYLENE AMMOXIDATION	70762.	T
SYNGAS (2:1) FROM NATURAL GAS	66009250.	m3
SYNGAS (3:1) FROM NATURAL GAS	114267.	m3
CARBON MONOXIDE FROM SYNGAS	28214.	m3
OXYGEN BY AIR FRACTIONATION	119582.	T
NYLON 6 MELT PARSILON COMP.	16000.	T
NYLON 6 MELT ALYAF COMP.	10000.	T
POLYETYLENE THEREFTALATE POLYACRYL COMP.	55000.	T
DI-OCTYL PHTALATE IRAN NIPPON	40000.	T
PHTALIC ANHYDRIDE IRAN NIPPON	22000.	T
ACRYLONITRILE ARAK	33000.	T
VINYL CHLORIDE FROM ETHYLENE ARAK	150000.	T
PVC ARAK	150000.	T

VINYLACETATE ARAK	30000.	T
ACETIC ACID ARAK	30000.	T
PE HD ARAK	60000.	T
CHLORINE ARAK	100000.	T
PE LLD ARAK	60000.	T
POLYPROPYLENE ARAK	50000.	T
BUTADIENE ARAK	26000.	T
POLYBUTADIENE ARAK	25000.	T
ETHYLENE ARAK	240000.	T
DMT ISFEHAN	65000.	T
BTX ISFEHAN	85000.	T
P-XYLEN ISFEHAN	44000.	T

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EXP. ; KM 1.

Problem title: HTO - HIGH TONNAGE ORGANICS

F r a c t i o n a l Optimization

Maximize:

$$\frac{\text{PDA Yearly Profit}}{\text{Investment}} = 0.041 \ \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:

8000.	<	ACETIC ACID	<	16000.	(55.0%)	T
		ACETONE	=	5900.	(100.0%)	T
		ACRYLONITRILE-BUTADIENE-STYRENE(ABS)	=	10000.	(100.0%)	T
25000.	<	ACRYLONITRILE	<	50000.	(100.0%)	T
35000.	<	BENZENE	<	40000.	(87.5%)	T
5.00E+03	<	BUTANOL-N	<	none	(0.0%)	T
1420.	<	CARBON TETRACHLORIDE	<	7000.	(20.3%)	T
48000.	<	DI-OCTYL PHTHALATE(DOP)	<	60000.	(100.0%)	T
4.00E+02	<	DIETHANOLAMINE	<	none	(0.0%)	T
1.50E+04	<	ETHYLENE GLYCOL	<	none	(0.0%)	T
		ETHYLENE OXIDE	=	15000.	(100.0%)	T
		ISOBUTANOL	=	1850.	(100.0%)	T
		ISOPROPANOL	=	1000.	(100.0%)	T
		METHANOL	=	47000.	(100.0%)	T
		METHYL ETHYL KETONE	=	4650.	(100.0%)	T
		METHYL METHACRYLATE	=	2000.	(100.0%)	T
9.00E+02	<	MONOETHANOLAMINE	<	none	(0.0%)	T
42000.	<	NYLON 6 MELT	<	50000.	(84.0%)	T
8000.	<	PHENOL	<	10000.	(80.0%)	T
10000.	<	PHTHALIC ANHYDRIDE	<	15000.	(70.9%)	T
10500.	<	POLYBUTADIENE	<	25000.	(83.8%)	T
		POLYETHYLENE TEREPHTHALATE MELT	=	60000.	(100.0%)	T
60000.	<	POLYETHYLENE, HI DENSITY (POWDERD)	<	180000.	(82.7%)	T
0.	<	POLYETHYLENE, LINEAR LD	<	60000.	(100.0%)	T
1500.	<	POLYMETHYLMETHACRYLATE SHEET	<	3000.	(50.0%)	T
		POLYOL, TRIFUNCTIONAL POLYETHER	=	38500.	(100.0%)	T
12000.	<	POLYPROPYLENE	<	62000.	(80.6%)	T
		POLYSTYRENE, IMPACT MODIFIED	=	50000.	(100.0%)	T
		POLYVINYL CHLORIDE DISPERSION	=	20000.	(100.0%)	T
120000.	<	POLYVINYL CHLORIDE	<	160000.	(93.8%)	T
0.	<	PROPYLENE OXIDE	<	9500.	(53.9%)	T
0.	<	PROPYLENE	<	5000.	(100.0%)	T
10000.	<	STYRENE-BUTADIENE RUBBER	<	50000.	(20.0%)	T
2000.	<	STYRENE	<	10000.	(20.0%)	T
		TOLUENE	=	40000.	(100.0%)	T
5.00E+03	<	TRICHLOROETHYLENE	<	none	(0.0%)	T
8000.	<	TRIETHANOLAMINE	<	10000.	(100.0%)	T
25000.	<	VINYL ACETATE	<	30000.	(100.0%)	T
		STYRENE-BUTADIENE LATEX	=	15000.	(100.0%)	T
5.00E+03	<	BUTYL RUBBER	<	none	(0.0%)	T
		PERCHLOROETHYLENE	=	8000.	(100.0%)	T
		ACRYLONITRILE ARAK	=	33000.	(100.0%)	T
		VINYL CHLORIDE FROM ETHYLENE ARAK	=	150000.	(100.0%)	T
		PVC ARAK	=	150000.	(100.0%)	T
		VINYLACETATE ARAK	=	30000.	(100.0%)	T
		ACETIC ACID ARAK	=	30000.	(100.0%)	T
		PE HD ARAK	=	60000.	(100.0%)	T
		CHLORINE ARAK	=	100000.	(100.0%)	T
		PE LLD ARAK	=	60000.	(100.0%)	T
		POLYPROPYLENE ARAK	=	50000.	(100.0%)	T
		BUTADIENE ARAK	=	20000.	(100.0%)	T

POLYBUTADIENE ARAK	=	25000.	(100.0%)	T
ETHYLENE ARAK	=	240000.	(100.0%)	T
DMT ISFEHAN	=	65000.	(100.0%)	T
BTX ISFEHAN	=	85000.	(100.0%)	T
P-XYLEN ISFEHAN	=	44000.	(100.0%)	T

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G L O B A L   R E S U L T S

PDA Yearly Profit	85.	mil.$
PDA Value Added	556.	mil.$
Investment	2081.	mil.$
Energy Consumption	7523.	TJ
Yearly Import	86.	mil.$
Energy Input	16055.	TJ
Yearly Domestic Purchase	304.	mil.$
Yearly Domestic Sale	1029.	mil.$

S A L E

ACETIC ACID	8796.	T
ACETONE	5900.	T
ACRYLONITRILE-BUTADIENE-STYRENE(ABS)	10000.	T
ACRYLONITRILE	50000.	T
AMMONIUM SULFATE	69678.	T
BENZENE	35000.	T
BTX RAFFINATE	152872.	T
BUTANOL-N	5000.	T
C4 FRACTION	25155.	T
C9 AROMATICS CRUDE	26860.	T
CARBON DIOXIDE	31227.	T
CARBON TETRACHLORIDE	1420.	T
CAUSTIC SODA	107226.	T
CHLORINE	208.	T
DI-OCTYL PHTHALATE(DOP)	60000.	T
DIETHANOLAMINE	700.	T
DIETHYLENE GLYCOL	3318.	T
DIMETHYL TEREPHTHALATE	9945.	T
ETHYLENE GLYCOL	15000.	T
ETHYLENE OXIDE	15000.	T
FUEL GAS	372010400.	T-cal
FUEL OIL	31730.	T
GASOLINE	7790.	T
HYDROGEN CYANIDE	4512.	T
HYDROGEN-RICH GAS	457007400.	T-cal
ISOBUTANOL	1850.	T
ISOBUTYLENE	10141.	T
ISOPROPANOL	1000.	T
LIGHT ENDS	7467.	T
METHANOL	47000.	T
METHYL ETHYL KETONE	4650.	T
METHYL METHACRYLATE	2000.	T
MIXED BUTYLENES(BUTADIENE RAFFINATE)	23052.	T

MONOETHANOLAMINE	900.	T
NYLON 6 MELT	42000.	T
PHENOL	8000.	T
PHTHALIC ANHYDRIDE	10630.	T
POLYBUTADIENE	20950.	T
POLYETHYLENE TEREPHTHALATE MELT	60000.	T
POLYETHYLENE, HI DENSITY (POWDERD)	148917.	T
POLYETHYLENE, LINEAR LD	60000.	T
POLYMETHYLMETHACRYLATE SHEET	1500.	T
POLYOL, TRIFUNCTIONAL POLYETHER	38500.	T
POLYPROPYLENE	50000.	T
POLYSTYRENE, IMPACT MODIFIED	50000.	T
POLYVINYL CHLORIDE DISPERSION	20000.	T
POLYVINYL CHLORIDE	150000.	T
PROPYLENE OXIDE IN SOLUTION(IMPURE)	493.	T
PROPYLENE OXIDE	5120.	T
PROPYLENE, (DILUTE)	85.	T
PROPYLENE	5000.	T
PYROLYSIS GASOLINE	233413.	T
STYRENE-BUTADIENE RUBBER	10000.	T
STYRENE	2000.	T
SULFURIC ACID(IN 65%)	934.	T
TAIL GAS	904746200.	T-cal
TOLUENE	40000.	T
TRICHLOROETHYLENE	5000.	T
TRIETHANOLAMINE	10000.	T
TRIETHYLENE GLYCOL	870.	T
VINYL ACETATE	30000.	T
XYLENE-P	35398.	T
STYRENE-BUTADIENE LATEX	15000.	T
BUTYL RUBBER	5000.	T
POLIPROPYLENE ATACTIC	1500.	T
METHYL ACETATE	1080.	T
AMMONIUM BISULFATE	4025.	T
C4 ALKYLATION FEED	4574.	T
PERCHLOROETHYLENE	8000.	T

P U R C H A S E

COOLING WATER	453364500.	m3
PROCESS WATER	3684208.	m3
STEAM	3835415.	T
ELECTRICITY	789909200.	kWh
INERT GAS	36569420.	m3
ACETONE	8276.	T
ACETONITRILE	41.	T
ACTIVATED CARBON	15.	T
ADDITIVES,NG	420.	T
ALKYLBENZENE	160.	T
ALUMINA	101.	T
ALUMINA TRICHLORIDE	240.	T
AMMONIA	57627.	T
ANTIMONY TRIOXIDE	16.	T
ASCORBIC ACID	2.	T
BENTONITE	2130.	T
BENZOYL PEROXIDE	8.	T
BUTANOL-N	980.	T
BUTYL STEARATE	50.	T
BUTYL-T CATECHOL	5.	T
BUTYLLITHIUM N	12.	T
CARBON TETRACHLORIDE	1420.	T
CATALYST AND CHEMICALS	9339105.	$

CATALYST,MTBE	1.	T
CHEMICALS	3465505.	$
COBALTOUS OCTANOATE	118.	T
CR-SI CATALIST	780000.	T
CU-PD CATALYST	11865000.	CC
CUPRIC NITRATE	1.	T
ETHYL ACETATE	165.	T
ETHYLENE GLYCOL	2557.	T
FILTER AID	15400.	T
FORMIC ACID (IN 85%)	21.	T
FUEL	346064600.	T-cal
GLYCERIN	1194.	T
HEXANE -N	755.	T
HYDROCHLORIC ACID	11748.	T
HYDROGEN (IN OFF-GAS)	33222510.	m3
HYDROGEN PEROXIDE	2.	T
ION-EXCHANGE RESIN	68820.	T
ISOBUTANE	1296.	T
ISOBUTANOL	1411.	T
ISOPROPANOL	1000.	T
MAGNESIUM SILICATE	578.	T
MANGANOUS OCATNOATE	125.	T
MEMBRANE	16690000.	SQCM
METHANE	937.	T
METHANOL	54342.	T
MMA-EHA COPOLYMER	9.	T
MOLYBDENUM POWDER	1.	T
MONOETHANOLAMINE	600.	T
NAPHTHA ,WIDE RANGE	519072.	T
NAPHTHA HEARTCUT (NAPHTHENIC)	200299.	T
NAPHTHENIC ACID	56.	T
NATURAL GAS	836137300.	T-cal
NYLON (WASTE)	2730.	T
OCTANE-N	28.	T
OCTANOIC ACID	335.	T
OLEUM	54150.	T
OXALIC ACID	26.	T
PALMITIC ACID	127.	T
PD ON ALUMINUM CATALIST	5671.	T
PHENOL	8000.	T
POLYETHYLENE TEREPHTHALATE MELT	5000.	T
POTASSIUM CARBONATE	99.	T
POTASSIUM HYDROXIDE	894.	T
POTASSIUM PERSULFATE	5.	T
ROCK SALT	16.	T
SALT	243000.	T
SOAP	1738.	T
SODIUM CARBONATE	3450.	T
SODIUM CHLORIDE	5025.	T
SODIUM LAURATE	147.	T
SODIUM PYROPHOSPHATE	11.	T
SOYBEAN OIL	50.	T
STABILIZER, SBR	112.	T
SULFOLANE	25.	T
SULFURIC ACID	18173.	T
TITANIUM DIOXIDE	231.	T
TRICHLOROETHYLENE	5000.	T
TRIPHENYLMETHANE	10.	T
WATER DEIONIZED	134703.	T
ZINC ACETATE	2.	T
STABILIZER	262.	T
BUTYL RUBBER	5000.	T
WASTE RECOVERY CHEMICALS	260.	T
HFMC	170.	T
DIIPC	42.	T
PERCHLOROETHYLENE	8000.	T

AIR	496684.	T
NAPHTHA LIGHT	631680.	T
BTX REFORMATE (HIGHLY NAPHT.)	32045[illegible].	tons

PROCESSES

ETHYLENE FROM WIDE RANGE NAPHTA MS	144629.	T
MIXED XYLENES FROM NAPHTENIC FEED	48207.	T
BENZENE FROM TOLUENE	89380.	T
P-XYLENE (PAREX)	32348.	T
BUTADIENE FROM C4 EXTRACTION	15170.	T
METHYL METHACRYLATE CYANOHYDRIN PROCESS	3500.	T
ISOBUTYLENE BY ACID EXTRACTION (CFR)	10141.	T
D-ETHYLHEXANOL (OXO PROCESS)	41400.	T
PROPYLENE OXIDE BY ETHYLBENZENE PROCESS	28382.	T
POLYOL TRIFUNCTIONAL POLYETHER	38500.	T
BUTENE-1 FROM MTBE RAFFINATE	4362.	T
DI-OCTYLPHTALATE FROM PHTALIC ANHYDRIDE	20000.	T
PHTHALIC ANHYDRIDE AIR OX. OF O-XYLENE	12030.	T
METHYL ETHYL KETONE FROM MTBE RAFFINATE	4650.	T
TRIETHANOL AMINE FROM EO END NH3	10000.	T
POLYMETHYLMETHACRYLATE	1500.	T
HYDROGEN FROM NATURAL GAS	80786480.	m3
POLYVINYL CHLORIDE BY EMULSION POLIMER.	20000.	T
VINYL CHLORIDE BY OXYCHLORINATION	21700.	T
POLYSTYRENE HIGH IMPACT	50000.	T
ABS BY EMULSION/MASS POLYMERIZATION	10000.	T
ETHYLBENZENE LIQUID PHASE	77453.	T
POLYETHYLENE HD (UCC)	83917.	T
STYRENE-BUTADIENE LATEX	15000.	T
STYRENE-BUTADIENE RUBBER BY EMUL.POLYM.	10000.	T
NYLON 6 MELT	16000.	T
CAPROLACTAM FROM CYCLOHEXANE	39816.	T
CYCLOHEXANE BY HYDROGENATION OF BENZENE	41293.	T
ETHYLENE GLYCOL AND ETHYLENE OXIDE	32210.	T
ACRYLONITRILE BY PROPYLENE AMMOOXIDATION	19508.	T
SYNTGAS (2:1) FROM NATURAL GAS	53447400.	m3
SYNTGAS (3:1) FROM NATURAL GAS	91414.	m3
CARBON MONOOXIDE FROM SYNTGAS	22571.	m3
OXYGEN BY AIR FRACTIONATION	99337.	T
NYLON 6 MELT PARSILON COMP.	16000.	T
NYLON 6 MELT ALYAF COMP.	10000.	T
POLYETYLENE THEREFTALATE POLYACRYL COMP.	55000.	T
DI-OCTYL PHTALATE IRAN NIPPON	40000.	T
PHTALIC ANHYDRIDE IRAN NIPPON	22000.	T
ACRYLONITRILE ARAK	33000.	T
VINYL CHLORIDE FROM ETHYLENE ARAK	150000.	T
PVC ARAK	150000.	T
VINYLACETATE ARAK	30000.	T
ACETIC ACID ARAK	30000.	T
PE HD ARAK	60000.	T
CHLORINE ARAK	100000.	T
PE LLD ARAK	60000.	T
POLYPROPYLENE ARAK	50000.	T
BUTADIENE ARAK	26000.	T
POLYBUTADIENE ARAK	25000.	T
ETHYLENE ARAK	240000.	T
DMT ISFEHAN	65000.	T
BTX ISFEHAN	85000.	T
P-XYLEN ISFEHAN	44000.	T

Appendix : B1. Process input and output prinout

Process : 1 ANTIMONY TRIOXIDE

13	Antimony trioxide	o	1.00000
160	Solid waste	o	0.01700
1	Electrical energy	i	117.00000
12	Antimony (metalic)	i	0.86100
35	Coal	i	0.50000

Process : 2 ALUMINUM SULPHATE

88	Aluminum sulphate (14% A1203)	o	1.00000
1	Electrical energy	i	40.00000
2	Water	i	2.00000
3	Steam	i	1.44000
140	Sulphuric acid	i	0.50000
152	Bauxite (87% A1203)	i	0.32000

Process : 3 ARGON

14	Argon	o	1.00000
91	Purge gas	i	7.00000
1	Electrical energy	i	2.97000
2	Water	i	1.66000
78	Nitrogen	i	1.66000
7	Compressed air	i	1.04500
3	Steam	i	0.00840

Process : 4 BARIUM CHLORIDE

20	Barium chloride (BaC12.2H20 100%)	o	1.00000
61	Hydrogen sulfide	o	0.13000
160	Solid waste	o	0.03000
2	Water	i	160.00000
166	Fuel gas	i	94.10000
1	Electrical energy	i	36.00000
3	Steam	i	11.00000
16	Barite ore (as 100% BaSO4)	i	1.51000
37	Coke	i	0.45200
53	Hydrochloric acid (as 100%)	i	0.33500
115	Sodium hydroxide (98%)	i	0.01000

Process : 5 BARIUM CARBONATE

18	Barium Carbonate	o	1.00000
125	Sodium sulfide	o	0.30400

166	Fuel gas	i	235.00000
1	Electrical energy	i	100.00000
3	Steam	i	14.00000
16	Barite ore (as 100% BaSO4)	i	2.00000
108	Sodium carbonate 98%	i	0.64400
37	Coke	i	0.56000

Process : 6 LITHOPONE 30%

159	Liquid waste	o	20.00000
66	Lithopone (30%)	o	1.00000

171	Coke oven gas	i	500.00000
1	Electrical energy	i	139.00000
2	Water	i	18.00000
3	Steam	i	4.20000
23	Barium ore (as 100% BaS)	i	0.53500
195	Zinc sulphate (as raw mat.)	i	0.50700

Process : 7 LITHOPONE 60%

159	Liquid waste	o	20.00000
21	Barium chloride (BaCl2.2H2O) by-product	o	1.14000
67	Lithopone (60%)	o	1.00000

171	Coke oven gas	i	700.00000
1	Electrical energy	i	325.00000
2	Water	i	50.00000
3	Steam	i	6.28000
23	Barium ore (as 100% BaS)	i	1.02000
146	Zinc chloride (as 100% ZnCl2)	i	0.72500
66	Lithopone (30%)	i	0.24000
124	Sodium sulfate (as 100% Na2SO4)	i	0.07500
195	Zinc sulphate (as raw mat.)	i	0.07000
36	Cobaltus sulfate	i	0.00005

Process : 8 BARIUM HYDROXIDE

159	Liquid waste	o	5.00000
22	Barium hydroxide	o	1.00000

1	Electrical energy	i	160.00000
2	Water	i	45.00000
5	Process water	i	5.00000
3	Steam	i	3.35000
20	Barium chloride (BaCl2.2H2O 100%)	i	1.00800
114	Sodium hydroxide (50%)	i	0.66400

Process : 9 SODIUM TETRABORATE (BORAX)

133	Sodium tetraborate (Borax)	o	1.00000
160	Solid waste	o	1.00000

1	Electrical energy	i	165.00000
2	Water	i	21.00000
166	Fuel gas	i	15.80000
3	Steam	i	9.63000
39	Colemanite (boron ore 40%)	i	0.96000
102	Sodium bicarbonate	i	0.35000
97	Soda ash (100%)	i	0.12900

Process : 10 **BORIC ACID**

160	Solid waste	o	1.40400
24	Boric acid	o	1.00000

1	Electrical energy	i	200.00000
2	Water	i	140.00000
166	Fuel gas	i	84.70000
3	Steam	i	2.20000
39	Colemanite (boron ore 40%)	i	1.70000
140	Sulphuric acid	i	0.78000

Process : 11 **SODIUM PERBORATE**

158	Gas waste	o	25.50000
120	Sodium perborate	o	1.00000
160	Solid waste	o	0.06000

1	Electrical energy	i	120.00000
2	Water	i	92.00000
5	Process water	i	10.00000
3	Steam	i	1.40000
39	Colemanite (boron ore 40%)	i	0.70100
114	Sodium hydroxide (50%)	i	0.26800
59	Hydrogen peroxide	i	0.23600
68	Magnesium sulphate	i	0.00400
123	Sodium silicate	i	0.00400
172	Filtration agent	i	0.00140

Process : 12 **PRECIPITATED CALCIUM CARBONATE**

159	Liquid waste	o	1.50000
89	Precipitated calcium carbonate	o	1.00000
160	Solid waste	o	0.08000

1	Electrical energy	i	220.00000
4	Cooling water	i	16.00000
65	Limestone (98% CaCO3)	i	1.45000
37	Coke	i	0.13000
141	Diesel oil	i	0.07500

Process : 13 **PRECIPITATED CALCIUM CARBONATE(TOOTH P.)**

90	Precipitated calcium carbonate(tooth p.)	o	1.00000

1	Electrical energy	i	[illegible]

170	Carbon dioxide (CO2) food grade)	i	150.00000
3	Steam	i	22.00000
6	Demineralized water	i	22.00000
83	Post distillation slurry	i	20.00000
2	Water	i	10.00000
191	Soda ash in solution	i	1.03900
130	Sodium tripolyphosphate	i	0.01000
150	Active carbon	i	0.00160

Process : 14 **CALCIUM CARBIDE**

158	Gas waste	o	35000.00000
104	Calcium carbide	o	1.00000
159	Liquid waste	o	0.05000
160	Solid waste	o	0.04600
1	Electrical energy	i	3000.00000
2	Water	i	75.00000
7	Compressed air	i	45.00000
17	Compressed nitrogen	i	5.00000
27	Burnt lime (CaO)	i	1.95000
37	Coke	i	0.60000
60	Elecrode mass	i	0.01800
38	Electrodes	i	0.00300
180	Iron sheet	i	0.00150

Process : 15 **CALCIUM HYPOCHLORITE**

159	Liquid waste	o	25.00000
50	Calcium hypochloride	o	1.00000
158	Gas waste	o	0.67000
160	Solid waste	o	0.01500
7	Compressed air	i	660.00000
1	Electrical energy	i	100.00000
2	Water	i	9.00000
139	Lime	i	0.70000
174	Chlorine (100%)	i	0.40500
3	Steam	i	0.20000

Process : 16 **CALCIUM CHLORIDE**

159	Liquid waste	o	2.50000
26	Calcium chloride	o	1.00000
4	Cooling water	i	80.00000
1	Electrical energy	i	50.00000
3	Steam	i	12.30000
83	Post distillation slurry	i	9.00000
34	Carbon dioxide (CO2 gas 40%)	i	0.04000

Process : 17 **AMMONIUM CHLORIDE**

159	Liquid waste	o	80.00000
[illegible]	Ammonium chloride	o	1.00000

1	Electrical energy	i	260.00000
2	Water	i	95.00000
83	Post distillation slurry	i	10.00000
3	Steam	i	5.18400
173	Drinking water	i	1.20000
154	Ammonia NH3	i	0.38000
11	Antilumper	i	0.00600

Process : 18 SODIUM BICHROMATE

160	Solid waste	o	4.00000
103	Sodium bichromate	o	1.00000
1	Electrical energy	i	550.00000
7	Compressed air	i	150.00000
2	Water	i	100.00000
3	Steam	i	28.22400
5	Process water	i	7.00000
48	Dolomite	i	1.68000
32	Chromium ore	i	1.60000
97	Soda ash (100%)	i	0.87000
141	Diesel oil	i	0.60000
140	Sulphuric acid	i	0.38000

Process : 19 SODIUM CHROMATE

110	Sodium chromate	o	1.00000
1	Electrical energy	i	140.00000
7	Compressed air	i	50.00000
2	Water	i	20.00000
3	Steam	i	14.97600
30	Chromate and bichromate(calc.66.3%CrO3)	i	0.68000
97	Soda ash (100%)	i	0.31000

Process : 20 POTASSIUM BICHROMATE

84	Potassium bichromate	o	1.00000
160	Solid waste	o	0.42000
1	Electrical energy	i	200.00000
2	Water	i	30.00000
3	Steam	i	14.11200
7	Compressed air	i	10.00000
5	Process water	i	3.00000
103	Sodium bichromate	i	1.01000
87	Potassium chloride	i	0.50500

Process : 21 ANHYDROUS CHROMIC ACID

160	Solid waste	o	1.80000
31	Chromic acid anhydrous	o	1.00000

169	Natural gas	i	320.00000
1	Electrical energy	i	50.00000
2	Water	i	12.00000
3	Steam	i	6.91200
192	Sodium bichromate impure	i	1.70000
140	Sulphuric acid	i	1.34000

Process : 22 **CHROMOSAL - BASIC CHROMIUM SULPHATE**

33	Chromosal - basic chromium sulphate	o	1.00000
7	Compressed air	i	1400.00000
1	Electrical energy	i	140.00000
2	Water	i	43.00000
5	Process water	i	3.50000
3	Steam	i	2.30400
103	Sodium bichromate	i	0.54000
141	Diesel oil	i	0.25000
136	Sulphur	i	0.18000

Process : 23 **COPPER OXIDE (BLACK)**

158	Gas waste	o	3024.00000
40	Copper oxide (black)	o	1.00000
1	Electrical energy	i	11.57000
35	Coal	i	1.00000
42	Copper scrap	i	1.00000

Process : 24 **COPPER OXIDE (RED)**

158	Gas waste	o	1209.00000
41	Copper oxide (red)	o	1.00000
1	Electrical energy	i	3.00500
42	Copper scrap	i	1.02500
35	Coal	i	1.00000

Process : 25 **COPPER SULPHATE**

44	Copper sulphate	o	1.00000
160	Solid waste	o	0.04000
1	Electrical energy	i	260.00000
2	Water	i	60.00000
3	Steam	i	6.91200
5	Process water	i	4.00000
140	Sulphuric acid	i	0.51000
42	Copper scrap	i	0.26000

Process : 26 **CRYOLITE - ALUMINUM SODIUM FLUORIDE**

159	Liquid waste	o	34.00000
45	Cryolite (Na_3AlF_6)	o	1.00000
160	Solid waste	o	0.30000

1	Electrical energy	i	520.00000
2	Water	i	420.00000
166	Fuel gas	i	81.90000
3	Steam	i	37.00000
109	Sodium chloride	i	1.09000
49	Fluosilicic acid as waste	i	0.93000
114	Sodium hydroxide (50%)	i	0.51000
153	Aluminum hydroxide (as 100% Al_2O_3)	i	0.28000
154	Ammonia NH_3	i	0.23000

Process : 27 **ALUMINUM FLUORIDE**

158	Gas waste	o	330.00000
159	Liquid waste	o	8.00000
160	Solid waste	o	1.60000
151	Aluminum fluoride	o	1.00000

1	Electrical energy	i	380.00000
3	Steam	i	2.88000
2	Water	i	2.00000
49	Fluosilicic acid as waste	i	1.20000
153	Aluminum hydroxide (as 100% Al_2O_3)	i	0.85000
141	Diesel oil	i	0.30000

Process : 28 **HYDROGEN FLUORIDE**

159	Liquid waste	o	44.00000
195	Sulphuric acid 75%	o	30.20000
158	Gas waste	o	7.20000
160	Solid waste	o	2.00000
58	Hydrogen fluoride	o	1.00000

4	Cooling water	i	680.00000
1	Electrical energy	i	600.00000
7	Compressed air	i	45.00000
140	Sulphuric acid	i	25.65000
3	Steam	i	20.16000
186	Cooling brine	i	2.09000
49	Fluosilicic acid as waste	i	1.50000

Process : 29 **IRON OXIDE (RED)**

175	Iron oxide (red)	o	1.00000
160	Solid waste	o	0.20000

169	Natural gas	i	155.00000
1	Electrical energy	i	91.00000
177	Post-reduction aniline (55% Fe_2O_3)	i	2.15000

Process : 30 **FERROFERRIC OXIDES (BLACK)**

176	Ferroferric oxide (black)	o	1.00000
1	Electrical energy	i	200.00000
169	Natural gas	i	200.00000
3	Steam	i	20.90000
2	Water	i	20.00000
194	Ferrous sulphate as waste	i	4.55000
154	Ammonia NH_3	i	0.50000
10	Ammonium nitrate	i	0.13000

Process : 31 **FERROUS SULPHATE**

159	Liquid waste	o	180.00000
43	Pickling acid (24% H_2SO_4, 10% $FeSO_4$)	o	5.25000
19	Ferrous sulphate - 7 hydrate	o	1.00000
7	Compressed air	i	4000.00000
2	Water	i	110.00000
1	Electrical energy	i	50.00000
148	Spent pickling acid	i	6.35000
140	Sulphuric acid	i	0.56500
3	Steam	i	0.15000

Process : 32 **LEAD OXIDE (RED)**

158	Gas waste	o	9000.00000
64	Lead oxide (red)	o	1.00000
159	Liquid waste	o	0.20000
160	Solid waste	o	0.00300
1	Electrical energy	i	103.00000
79	Lead (as metal)	i	0.91350
35	Coal	i	0.47000
29	Charcoal	i	0.00250

Process : 33 **MAGNESIUM OXIDE**

25	Calcium carbonate	o	2.90000
158	Gas waste	o	2.00000
157	Magnesium oxide	o	1.00000
160	Solid waste	o	0.23000
1	Electrical energy	i	2300.00000
166	Fuel gas	i	1180.00000
2	Water	i	30.00000
[illegible]	Burnt dolomite (57% MgO 38% CaO)	i	2.90000
138	Carbon dioxide (100%)	i	0.72900
[illegible]	Ammonium nitrate	i	[illegible]

55	Nitric acid (as 65% HNO3)	i	0.03000

Process : 34 MANGANESE DIOXIDE

159	Liquid waste	o	15.60000
158	Gas waste	o	12.00000
160	Solid waste	o	4.95000
69	Manganese dioxide	o	1.00000
1	Electrical energy	i	4400.00000
7	Compressed air	i	400.00000
3	Steam	i	64.05800
2	Water	i	25.00000
70	Manganese ore (30% Mn)	i	2.25000
96	Sulphur dioxide SO2 (as 100% H2SO4)	i	0.80000
56	Hydrate lime [99.5 Ca(OH)2]	i	0.70000
141	Diesel oil	i	0.22000
101	Soda lye (45% NaOH)	i	0.07100

Process : 35 MOLYBDENUM TRIOXIDE

159	Liquid waste	o	10.00000
73	Molybdenum trioxide III	o	1.00000
160	Solid waste	o	0.22500
1	Electrical energy	i	683.00000
35	Coal'	i	2.80000
179	Ammonia water (29.4% NH3)	i	2.50000
55	Nitric acid (as 65% HNO3)	i	2.24000
72	Molybdenum ore	i	1.10600

Process : 36 NICKEL SULFATE

76	Nickel sulphate	o	1.00000
160	Solid waste	o	0.80000
159	Liquid waste	o	0.70000
1	Electrical energy	i	220.00000
4	Cooling water	i	63.00000
3	Steam	i	10.36800
92	Raw nickel sulphate	i	1.00700
6	Demineralized water	i	0.18000
25	Calcium carbonate	i	0.18000
59	Hydrogen peroxide	i	0.04000
57	Hydrofluoric acid 70%	i	0.01000
140	Sulphuric acid	i	0.00700

Process : 37 SODIUM TRIPOLYPHOSPHATE

130	Sodium tripolyphosphate	o	1.00000
7	Compressed air	i	175.00000
1	Electrical energy	i	150.00000
4	Cooling water	i	50.00000

3	Steam	i	4.32000
5	Process water	i	1.50000
82	Phosphoric acid (75% H3PO4)	i	1.16000
97	Soda ash (100%)	i	0.78000
141	Diesel oil	i	0.13500
51	Ground phosphate rock	i	0.10000
10	Ammonium nitrate	i	0.00600
46	Diatomite	i	0.00500
163	Filter cloth	i	0.00008

Process : 38 **SODIUM HEXAMETAPHOSPHATE**

112	Sodium hexametaphosphate	o	1.00000
1	Electrical energy	i	1270.00000
2	Water	i	75.00000
3	Steam	i	12.00000
82	Phosphoric acid (75% H3PO4)	i	0.98000
97	Soda ash (100%)	i	0.54400

Process : 39 **SODIUM PYROPHOSPHATE (DIBASIC)**

159	Liquid waste	o	53.00000
160	Solid waste	o	11.00000
158	Gas waste	o	10.00000
121	Sodium pyrophosphate - dibasic	o	1.00000
1	Electrical energy	i	400.00000
166	Fuel gas	i	77.60000
2	Water	i	68.00000
3	Steam	i	13.00000
82	Phosphoric acid (75% H3PO4)	i	1.57300
108	Sodium carbonate 98%	i	0.63000

Process : 40 **TRISODIUM PHOSPHATE**

159	Liquid waste	o	28.00000
160	Solid waste	o	9.00000
144	Trisodium phosphate	o	1.00000
1	Electrical energy	i	192.00000
2	Water	i	32.00000
3	Steam	i	10.90000
82	Phosphoric acid (75% H3PO4)	i	0.42000
108	Sodium carbonate 98%	i	0.35000
113	Sodium hydroxide (100% NaOH)	i	0.15000

Process : 41 **DICALCIUM PHOSPHATE**

158	Gas waste	o	5200.00000
47	Dicalcium phosphate	o	1.00000
159	Liquid waste	o	0.40000
1	Electrical energy	i	116.00000

7	Compressed air	i	70.00000
2	Water	i	3.50000
81	Phosphoric acid (38% P2O5)	i	1.08000
3	Steam	i	0.50000
116	Soda lye (45%) solution	i	0.44000
48	Dolomite	i	0.24000
56	Hydrate lime [99.5 Ca(OH)2]	i	0.06000
141	Diesel oil	i	0.05000
132	Sodium water glass (36% grade..)	i	0.02000

Process : 42 **POTASSIUM CARBONATE**

159	Liquid waste	o	7.00000
85	Potassium carbonate (K2CO3)	o	1.00000
1	Electrical energy	i	376.00000
3	Steam	i	81.80000
165	Condensate	i	28.00000
2	Water	i	18.00000
35	Coal	i	4.74000
71	Molasses oven coke	i	3.00000

Process : 43 **POTASSIUM CHLORATE**

158	Gas waste	o	550.00000
86	Potassium chlorate	o	1.00000
160	Solid waste	o	0.01810
1	Electrical energy	i	5500.00000
2	Water	i	720.00000
3	Steam	i	12.10000
87	Potassium chloride	i	0.70500
53	Hydrochloric acid (as 100%)	i	0.06200
63	Potassium hydroxide 90%	i	0.04900
15	Barium chloride (BaCl2)	i	0.00900
62	Potassium carbonate (99% K2CO3)	i	0.00250

Process : 44 **POTASSIUM NITRATE**

100	Potassium nitrate	o	1.00000
160	Solid waste	o	0.97000
159	Liquid waste	o	0.10000
1	Electrical energy	i	77.90000
2	Water	i	76.60000
3	Steam	i	22.90000
119	Sodium nitrate	i	1.00000
87	Potassium chloride	i	0.89000

Process : 45 **SODIUM GLAZE**

158	Gas waste	o	18.00000
111	Sodium glaze	o	1.00000

166	Fuel gas	i	232.50000
7	Compressed air	i	90.00000
1	Electrical energy	i	24.00000
94	Sand	i	0.82000
4	Cooling water	i	0.50000
97	Soda ash (100%)	i	0.41000

Process : 46 SODIUM WATER GLASS

132	Sodium water glass (36% grade..)	o	1.00000
4	Cooling water	i	11.00000
1	Electrical energy	i	3.30000
3	Steam	i	0.72000
5	Process water	i	0.60000
111	Sodium glaze	i	0.40000
74	Sodium hydroxide (45%)	i	0.02000

Process : 47 MOLECURAL SIEVE-ZEOLITES (cl. 3A)

142	Zeolites cl.3A	o	1.00000
159	Liquid waste	o	0.41000
160	Solid waste	o	0.00100
1	Electrical energy	i	8000.00000
7	Compressed air	i	1800.00000
6	Demineralized water	i	82.00000
3	Steam	i	6.62400
132	Sodium water glass (36% grade..)	i	1.66000
2	Water	i	1.60000
114	Sodium hydroxide (50%)	i	1.27000
87	Potassium chloride	i	0.85000
153	Aluminum hydroxide (as 100% Al2O3)	i	0.42500

Process : 48 SILICA GEL (MACRO)

159	Liquid waste	o	430.00000
95	Silica gel (macro)	o	1.00000
160	Solid waste	o	0.08000
1	Electrical energy	i	1740.00000
2	Water	i	427.00000
3	Steam	i	148.30000
132	Sodium water glass (36% grade..)	i	4.75000
140	Sulphuric acid	i	0.57600

Process : 49 SILICA GEL (MICRO)

159	Liquid waste	o	430.00000
167	Silica gel (micro)	o	1.00000
160	Solid waste	o	0.08000
1	Electrical energy	i	1760.00000
2	Water	i	429.60000

3	Steam	i	148.30000
132	Sodium water glass (36% grade..)	i	4.75000
140	Sulphuric acid	i	0.57600
161	Aluminium sulphate (17% Al203)	i	0.50000

Process : 50 **SODIUM METASILICATE**

118	Sodium metasilicate pentahydrate	o	1.00000
1	Electrical energy	i	30.00000
3	Steam	i	3.77000
2	Water	i	1.30000
132	Sodium water glass (36% grade..)	i	1.11600
114	Sodium hydroxide (50%)	i	0.18450

Process : 51 **SODIUM THIOSULPHATE**

158	Gas waste	o	126.50000
129	Sodium thiosulfate	o	1.00000
160	Solid waste	o	0.02870
7	Compressed air	i	252.00000
1	Electrical energy	i	171.00000
2	Water	i	5.20000
3	Steam	i	3.20000
114	Sodium hydroxide (50%)	i	0.26800
96	Sulphur dioxide SO2 (as 100% H2SO4)	i	0.23500
97	Soda ash (100%)	i	0.23100
136	Sulphur	i	0.13200
126	Sodium sulfite	i	0.00585

Process : 52 **SODIUM HYDROGEN SULFITE**

158	Gas waste	o	12800.00000
106	Sodium hydrogen sulfite	o	1.00000
7	Compressed air	i	150.00000
1	Electrical energy	i	115.00000
8	Hot air	i	8.00000
3	Steam	i	5.59000
96	Sulphur dioxide SO2 (as 100% H2SO4)	i	0.73000
108	Sodium carbonate 98%	i	0.58000
2	Water	i	0.15000

Process : 53 **SODIUM SULFITE**

158	Gas waste	o	18.00000
126	Sodium sulfite	o	1.00000

1	Electrical energy	i	100.00000
8	Hot air	i	17.00000
122	Sodium pyrosulfite	i	0.79800
108	Sodium carbonate 98%	i	0.45000

Process : 54 **SODIUM HYDROSULFITE**

158	Gas waste	o	1950.00000
159	Liquid waste	o	6.50000
160	Solid waste	o	1.15000
117	Sodium hydrosulfite	o	1.00000
7	Compressed air	i	3000.00000
1	Electrical energy	i	550.00000
5	Process water	i	150.00000
3	Steam	i	17.00000
2	Water	i	5.00000
114	Sodium hydroxide (50%)	i	1.60000
93	Rock salt (100% NaCL)	i	1.55000
145	Zinc ash (100% Zn)	i	0.58000
136	Sulphur	i	0.51400
156	Alcohol	i	0.06500

Process : 55 **SODIUM CHLORIDE (MEDICAL)**

158	Gas waste	o	1000.00000
159	Liquid waste	o	20.00000
182	Sodium chloride (medical)	o	1.00000
160	Solid waste	o	0.11200
1	Electrical energy	i	685.00000
3	Steam	i	57.50000
2	Water	i	2.70000
93	Rock salt (100% NaCL)	i	2.40000

Process : 56 **SODIUM NITRATE**

158	Gas waste	o	1730.00000
119	Sodium nitrate	o	1.00000
159	Liquid waste	o	0.02500
1	Electrical energy	i	295.00000
3	Steam	i	13.40000
2	Water	i	10.00000
77	Nitric oxides as byproduct	i	0.70500
97	Soda ash (100%)	i	0.66800
54	Nitric acid (as 100% HNO3)	i	0.08200

Process : 57 **TITANIUM DIOXIDE**

159	Liquid waste	o	24.00000
160	Solid waste	o	3.00000
185	Titanium dioxide	o	1.00000

1	Electrical energy	i	830.00000
2	Water	i	768.00000
3	Steam	i	60.00000
190	Other compounds	i	50.00000
140	Sulphuric acid	i	5.90000
98	Illemanite ore (49.5% TiO2)	i	2.85000
141	Diesel oil	i	0.30000
184	Scrap-iron	i	0.17500

Process : 58 ZINC SULFATE

158	Gas waste	o	2500.00000
159	Liquid waste	o	9.50000
149	Zinc sulphate (as 100% ZnSO4)	o	1.00000
160	Solid waste	o	0.20000

1	Electrical energy	i	350.00000
4	Cooling water	i	85.00000
3	Steam	i	10.00000
5	Process water	i	3.50000
140	Sulphuric acid	i	0.37500
147	Zinc scrap in zinc extraction (100% Zn)	i	0.25500

Process : 59 ZINC CHLORIDE

146	Zinc chloride (as 100% ZnCl2)	o	1.00000
160	Solid waste	o	0.05500

1	Electrical energy	i	110.00000
7	Compressed air	i	8.00000
2	Water	i	6.00000
3	Steam	i	2.80500
105	Zinc oxide (ash)	i	0.60000
53	Hydrochloric acid (as 100%)	i	0.54000
75	Calcium hydroxide CaOH2	i	0.00400
157	Potassium permanganate (KMnO4)	i	0.00060

Process : 60 MOLECULAR SIEVE - ZEOLITES (cl. 4A)

187	Zeolites cl.4A	o	1.00000
159	Liquid waste	o	0.41000
160	Solid waste	o	0.00100

1	Electrical energy	i	6000.00000
7	Compressed air	i	990.00000
6	Demineralized water	i	46.60000
3	Steam	i	6.90000
132	Sodium water glass (36% grade..)	i	1.68000
114	Sodium hydroxide (50%)	i	1.26000
2	Water	i	0.82000
155	Aluminum hydroxide (as 100% Al2O3)	i	0.41500

Process : 61 MOLECURAL SIEVE - ZEOLITES (cl. 5A)

159	Liquid waste	o	0.41000
160	Solid waste	o	0.00100

1	Electrical energy	i	15000.00000
7	Compressed air	i	1080.00000
6	Demineralized water	i	84.00000
3	Steam	i	11.80000
2	Water	i	1.90000
132	Sodium water glass (36% grade..)	i	1.80000
114	Sodium hydroxide (50%)	i	1.35000
26	Calcium chloride	i	0.48000
153	Aluminum hydroxide (as 100% Al2O3)	i	0.44900

Process : 62 MOLECURAL SIEVE - ZEOLITES (cl. 13X)

189	Zeolites cl.13X	o	1.00000
159	Liquid waste	o	0.41000
160	Solid waste	o	0.00100

7	Compressed air	i	1800.00000
6	Demineralized water	i	34.00000
3	Steam	i	7.49000
132	Sodium water glass (36% grade..)	i	2.40000
114	Sodium hydroxide (50%)	i	1.40000
2	Water	i	0.90000
153	Aluminum hydroxide (as 100% Al2O3)	i	0.35800

Process : 63 SODA ASH

159	Liquid waste	o	9.00000
97	Soda ash (100%)	o	1.00000
160	Solid waste	o	0.25000

2	Water	i	150.00000
1	Electrical energy	i	120.00000
3	Steam	i	10.00000
109	Sodium chloride	i	1.60000
65	Limestone (98% CaCO3)	i	1.30000
37	Coke	i	0.11000
154	Ammonia NH3	i	0.00500

B2. LIST OF IND PDA PRODUCTS WITH PRICES

name of product	product unit	price
Active carbon	tons	2800.00
Alcohol	tons	380.00
Aluminium sulphate (17% Al_2O_3)	tons	292.10
Aluminum fluoride	tons	1212.50
Aluminum hydroxide (as 100% Al_2O_3)	tons	179.00
Aluminum sulphate (14% Al_2O_3)	tons	259.00
Ammonia NH_3	tons	165.00
Ammonia water (29.4% NH_3)	tons	260.00
Ammonium chloride	tons	400.00
Ammonium nitrate	tons	165.30
Antilumper	tons	4000.00
Antimony (metalic)	tons	2900.00
Antimony trioxide	tons	3400.00
Argon	m3	1.70
Barite ore (as 100% $BaSO_4$)	tons	100.00
Barium Carbonate	tons	562.20
Barium chloride ($BaCl_2$)	tons	518.00
Barium chloride ($BaCl_2.2H_2O$ 100%)	tons	470.00
Barium chloride ($BaCl_2.2H_2O$) by-product	tons	400.00
Barium hydroxide	tons	885.00
Barium ore (as 100% BaS)	tons	160.00
Bauxite (87% Al_2O_3)	tons	252.70
Boric acid	tons	676.80
Burnt dolomite (37% MgO+58% CaO)	tons	45.00
Burnt lime (CaO)	tons	46.30
Calcium carbide	tons	900.00
Calcium carbonate	tons	100.00
Calcium chloride	tons	239.20
Calcium hydroxide $CaOH_2$	tons	95.00
Calcium hypochloride	tons	700.00
Carbon dioxide (100%)	tons	97.00
Carbon dioxide (CO_2 gas 40%)	tons	39.00
Carbon dioxide (CO_2) food grade)	m3	0.29
Charcoal	tons	400.00
Chlorine (100%)	tons	210.00
Chromate and bichromate(calc.66.3%CrO_3)	tons	680.00
Chromic acid anhydrous	tons	2601.39
Chromium ore	tons	170.00
Chromosal - basic chromium sulphate	tons	1330.00
Coal	tons	38.00
Cobaltus sulfate	tons	2800.00
Coke	tons	60.00
Coke oven gas	Nm3	0.06
Colemanite (boron ore 40%)	tons	225.00
Compressed air	Nm3	**********
Compressed nitrogen	Nm3	0.05
Condensate	tons	0.02
Cooling brine	GJ	3.40
Cooling water	m3	0.03
Copper oxide (black)	tons	2667.50
Copper oxide (red)	tons	2634.50
Copper scrap	tons	850.00
Copper sulphate	tons	1024.00
Cryolite (Na_3AlF_6)	tons	690.30
Demineralized water	m3	0.17
Diatomite	tons	580.00
Dicalcium phosphate	tons	1200.00

Dolomite	tons	40.00
Drinking water	m3	0.17
[illegible]	tons	[illegible]
Electrical energy	kWh	0.06
Electrodes	tons	8200.00
Ferroferric oxide (black)	tons	970.00
Ferrous sulphate - 7 hydrate	tons	165.30
Ferrous sulphate as waste	tons	60.00
Filter cloth	tons	10000.00
Filtriation agent	tons	500.00
Fluosilicic acid as waste	tons	50.00
Fuel gas	Nm3	0.13
Gas waste	m3	0.00
Ground phosphate rock	tons	35.00
Hot air	Nm3	##########
Hydrate lime [79.5 Ca(OH)2]	tons	52.90
Hydrochloric acid (as 100%)	tons	297.60
Hydrofluoric acid 70%	tons	948.00
Hydrogen fluoride	tons	1515.70
Hydrogen peroxide	tons	970.00
Hydrogen sulfide	tons	500.00
Illmenite ore (49.5% TiO2)	tons	40.00
Iron oxide (red)	tons	758.00
Iron sheet	tons	250.00
Lead (as metal)	tons	396.00
Lead oxide (red)	tons	859.80
Lime	tons	48.00
Limestone (98% CaCO3)	tons	30.00
Liquid waste	m3	0.00
Lithopone (30%)	tons	560.00
Lithopone (60%)	tons	700.00
Magnesium oxide	tons	383.70
Magnesium sulphate	tons	950.00
Manganese dioxide	tons	1736.10
Manganese ore (50% Mn)	tons	80.00
Molasses oven coke	tons	20.00
Molybdenum ore	tons	5000.00
Molybdenum trioxide III	tons	10300.00
Natural gas	Nm3	0.13
Nickel sulphate	tons	1873.90
Nitric acid (as 100% HNO3)	tons	308.60
Nitric acid (as 65% HNO3)	tons	214.90
Nitric oxides as byproduct	tons	80.00
Nitrogen	m3	0.03
Other compounds	US$	1.00
Phosphoric acid (30% P2O5)	tons	300.00
Phosphoric acid (75% H3PO4)	tons	363.00
Pickling acid (24% H2SO4,10% FeSO4)	tons	41.00
Post distillation slurry	m3	5.00
Post reduction aniline (95% FeSO3)	tons	120.00
Potassium bichromate	tons	1630.00
Potassium carbonate (99% K2CO3)	tons	792.00
Potassium carbonate (K2CO3)	tons	948.00
Potassium chlorate	tons	800.00
Potassium chloride	tons	115.70
Potassium hydroxide 90%	tons	820.00
Potassium nitrate	tons	700.00
Potassium permanganate (KMnO4)	tons	2400.00
Precipitated calcium carbonate	tons	407.80
Precipitated calcium carbonate(tooth p.)	tons	905.00
Process water	m3	0.10
Purge gas	m3	##########
Raw nickel sulphate	tons	700.00
Rock salt (100% NaCL)	tons	19.60
Sand	tons	18.00
Scrap iron	tons	40.00

Silica gel (macro)	tons	1570.00
Silica gel (micro)	tons	1700.00
Soda ash (100%)	tons	165.30
Soda ash in solution	tons	45.80
Soda lye (45% NaOH)	tons	173.60
Soda lye (45%) solution	tons	173.60
Sodium bicarbonate	tons	375.00
Sodium bichromate	tons	1256.60
Sodium bichromate impure	tons	780.00
Sodium carbonate 98%	tons	89.71
Sodium chloride	tons	19.80
Sodium chloride (medical)	tons	950.50
Sodium chromate	tons	1477.01
Sodium glaze	tons	230.00
Sodium hexametaphosphate	tons	1355.80
Sodium hydrogen sulfite	tons	454.10
Sodium hydrosulfite	tons	1563.30
Sodium hydroxide (100% NaOH)	tons	551.10
Sodium hydroxide (45%)	tons	173.60
Sodium hydroxide (50%)	tons	192.90
Sodium hydroxide (98%)	tons	540.00
Sodium metasilicate pentahydrate	tons	455.00
Sodium nitrate	tons	341.91
Sodium perborate	tons	1100.00
Sodium pyrophosphate - dibasic	tons	1284.00
Sodium pyrosulfite	tons	360.00
Sodium silicate	tons	594.00
Sodium sulfate (as 100% Na2SO4)	tons	112.40
Sodium sulfide	tons	264.60
Sodium sulfite	tons	523.80
Sodium tetraborate (Borax)	tons	1102.00
Sodium thiosulfate	tons	1003.10
Sodium tripolyphosphate	tons	876.30
Sodium water glass (36% grade..)	tons	136.00
Solid waste	tons	0.00
Spent pickling acid	tons	20.00
Steam	GJ	1.95
Sulphur	tons	135.00
Sulphur dioxide SO2 (as 100% H2SO4)	tons	80.00
Sulphuric acid	tons	80.00
Sulphuric acid 75%	tons	55.00
Titanium dioxide	tons	2000.00
Trisodium phosphate	tons	1157.40
Water	m3	0.03
Zeolites cl.13X	tons	2200.00
Zeolites cl.3A	tons	1600.00
Zeolites cl.4A	tons	3200.00
Zeolites cl.5A	tons	2800.00
Zinc ash (100% Zn)	tons	610.00
Zinc chloride (as 100% ZnCl2)	tons	745.00
Zinc oxide (ash)	tons	450.00
Zinc scrap in zinc extraction (100% Zn)	tons	500.00
Zinc sulphate (as 100% ZnSO4)	tons	400.00
Zinc sulphate (as raw mat.)	tons	250.00

B 3. LIST OF INO PDA PLANTS (after first rescaling)

name of plants	th.tons/year	fci in Mill.$
ANTIMONY TRIOXIDE	2000.00	2.27
ALUMINUM SULPHATE	30000.00	7.97
ARGON	750000.00	4.29
BARIUM CHLORIDE	4000.00	3.19
BARIUM CARBONATE	6000.00	5.18
LITHOPONE	20000.00	15.53
LITHOPONE	20000.00	15.53
BARIUM HYDROXIDE	3000.00	4.94
SODIUM TETRABORATE (BORAX)	5000.00	4.28
BORIC ACID	12000.00	7.19
SODIUM PERBORATE	20000.00	5.89
PRECIPITATED CALCIUM CARBONATE	10000.00	5.18
PRECIPITATED CALCIUM CARBONATE(TOOTH P.)	2000.00	2.85
CALCIUM CARBIDE	60000.00	25.02
CALCIUM HYPOCHLORITE	5000.00	1.76
CALCIUM CHLORIDE	10000.00	5.65
AMMONIUM CHLORIDE	4000.00	2.71
SODIUM BICHROMATE	3000.00	3.63
SODIUM CHROMATE	1000.00	2.03
POTASSIUM BICHROMATE	1700.00	3.01
ANHYDROUS CHROMIC ACID	1000.00	0.71
CHROMOSAL-BASIC CHROMIUM SULPHATE	2000.00	2.39
COPPER OXIDE (BLACK)	80.00	0.41
COPPER OXIDE (RED)	350.00	1.37
COPPER SULPHATE	2000.00	1.29
CRYOLITE -ALUMINUM SODIUM FLUORIDE	4200.00	3.16
ALUMINUM FLUORIDE	2200.00	3.56
HYDROGEN FLUORIDE	1000.00	2.38
IRON OXIDE (RED)	2000.00	0.89
FERROFERRIC OXIDE (BLACK)	1000.00	0.79
FERROUS SULFATE	2000.00	1.23
LEAD OXIDE (RED)	2000.00	1.08
MAGNESIUM OXIDE	50000.00	7.67
MANGANESE DIOXIDE	2000.00	2.59
MOLYBDENUM TRIOXIDE	140.00	0.59
NICKEL SULFATE	500.00	0.85
SODIUM TRIPOLYPHOSPHATE	50000.00	17.40
SODIUM HEXAMETAPHOSPHATE	1000.00	0.93
SODIUM PYROSPHOSPHATE (DIBASIC)	600.00	1.48
TRISODIUM PHOSPHATE	7500.00	4.57
DICALCIUM PHOSPHATE	40000.00	7.35
POTASSIUM CARBONATE	3000.00	4.68
POTASSIUM CHLORATE	4000.00	6.99
POTASSIUM NITRATE	6000.00	3.02
SODIUM GLAZE	32000.00	16.47
SODIUM WATER GLASS	80000.00	17.77
MOLECULAR SIEVE-ZEOLITES CL..3A	1000.00	3.51
SILICA GEL	1500.00	1.27
SILICA GEL	1500.00	1.27
SODIUM METASILICATE	10000.00	3.36
SODIUM THIOSULPHATE	1000.00	1.74
SODIUM BISULFITE - SODIUM PYROSULFITE	4000.00	2.60
SODIUM SULFITE	2000.00	1.00
SODIUM HYDROSULFITE	2000.00	2.47
SODIUM CHLORIDE (MEDICAL)	1500.00	2.88
SODIUM NITRATE	12000.00	8.76
TITANIUM DIOXIDE	20000.00	65.82
ZINC SULFATE	1400.00	2.31
ZINC CHLORIDE	4700.00	2.96
MOLECULAR SIEVE-ZEOLITES CL..3A	1000.00	3.51

install_name	capacity	fci
MOLECULAR SIEVE-ZEOLITES CL.3A	1000.00	3.51
MOLECULAR SIEVE-ZEOLITES CL.3A	1000.00	3.51
SODA ASH	150000.00	43.44

B4. Single plant evaluation

Process : 1 **ANTIMONY TRIOXIDE**

Capacity :	2000
Fixed Capital Investment - FCI :	2.261 mln.
Product Value - PV :	6.800 mln.
Total Manufacturing Cost :	5.894 mln.
Profit :	0.906 mln.
Simple Rate of Return :	0.572
Back-pay Period :	1.747 years
PV/FCI Factor :	4.296
Manufacturing Value Added - MVA :	1.684 mln.
MVA/FCI Factor :	1.064

Process : 2 **ALUMINUM SULPHATE**

Capacity :	30000
Fixed Capital Investment - FCI :	7.952 mln.
Product Value - PV :	7.770 mln.
Total Manufacturing Cost :	5.507 mln.
Profit :	2.263 mln.
Simple Rate of Return :	0.407
Back-pay Period :	2.460 years
PV/FCI Factor :	1.396
Manufacturing Value Added - MVA :	3.754 mln.
MVA/FCI Factor :	0.674

Process : 3 **ARGON**

Capacity :	750000
Fixed Capital Investment - FCI :	4.283 mln.
Product Value - PV :	1.272 mln.
Total Manufacturing Cost :	1.028 mln.
Profit :	0.244 mln.
Simple Rate of Return :	0.082
Back-pay Period :	12.264 years
PV/FCI Factor :	0.424
Manufacturing Value Added - MVA :	0.929 mln.
MVA/FCI Factor :	0.310

Process : 4 **BARIUM CHLORIDE**

Capacity :	2000
Fixed Capital Investment - FCI :	2.027 mln.
Product Value - PV :	1.070 mln.
Total Manufacturing Cost :	1.239 mln.
Profit :	-0.169 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	0.754
Manufacturing Value Added - MVA :	0.354 mln.
MVA/FCI Factor :	0.250

Process : 5 **BARIUM CARBONATE**

Capacity :	3000
Fixed Capital Investment - FCI :	3.276 mln.
Product Value - PV :	1.928 mln.
Total Manufacturing Cost :	1.944 mln.
Profit :	-0.016 mln.
Simple Rate of Return :	

Back-pay Period :	
PV/FCI Factor :	0.836
Manufacturing Value Added - MVA :	0.757 mln.
MVA/FCI Factor :	0.328

Process : 6 **LITHOPONE 30%**

Capacity :	10000
Fixed Capital Investment - FCI :	9.875 mln.
Product Value - PV :	5.600 mln.
Total Manufacturing Cost :	4.642 mln.
Profit :	0.958 mln.
Simple Rate of Return :	0.139
Back-pay Period :	7.219 years
PV/FCI Factor :	0.810
Manufacturing Value Added - MVA :	2.699 mln.
MVA/FCI Factor :	0.390

Process : 7 **LITHOPONE 60%**

Capacity :	10000
Fixed Capital Investment - FCI :	9.875 mln.
Product Value - PV :	11.560 mln.
Total Manufacturing Cost :	11.885 mln.
Profit :	-0.325 mln.
Simple Rate of Return :	
Back-pay Period.:	
PV/FCI Factor :	1.672
Manufacturing Value Added - MVA :	1.922 mln.
MVA/FCI Factor :	0.278

Process : 8 **BARIUM HYDROXIDE**

Capacity :	1500
Fixed Capital Investment - FCI :	3.143 mln.
Product Value - PV :	1.327 mln.
Total Manufacturing Cost :	1.695 mln.
Profit :	-0.368 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	0.603
Manufacturing Value Added - MVA :	0.298 mln.
MVA/FCI Factor :	0.135

Process : 9 **SODIUM TETRABORATE (BORAX)**

Capacity :	5000
Fixed Capital Investment - FCI :	4.267 mln.
Product Value - PV :	5.510 mln.
Total Manufacturing Cost :	3.086 mln.
Profit :	2.424 mln.
Simple Rate of Return :	0.812
Back-pay Period :	1.232 years
PV/FCI Factor :	1.845
Manufacturing Value Added - MVA :	3.392 mln.
MVA/FCI Factor :	1.136

Process : 10 **BORIC ACID**

Capacity :	8000
Fixed Capital Investment - FCI :	[illegible] mln.

Product Value - PV :	5.414 mln.
Total Manufacturing Cost :	5.288 mln.
Profit :	0.127 mln.
Simple Rate of Return :	0.033
Back-pay Period :	30.475 years
PV/FCI Factor :	1.403
Manufacturing Value Added - MVA :	1.467 mln.
MVA/FCI Factor :	0.380

Process : 11 **SODIUM PERBORATE**

Capacity :	20000
Fixed Capital Investment - FCI :	5.879 mln.
Product Value - PV :	22.000 mln.
Total Manufacturing Cost :	11.083 mln.
Profit :	10.917 mln.
Simple Rate of Return :	2.653
Back-pay Period :	0.377 years
PV/FCI Factor :	5.346
Manufacturing Value Added - MVA :	12.609 mln.
MVA/FCI Factor :	3.064

Process : 12 **PRECIPITATED CALCIUM CARBONATE**

Capacity :	10000
Fixed Capital Investment - FCI :	5.171 mln.
Product Value - PV :	4.078 mln.
Total Manufacturing Cost :	1.855 mln.
Profit :	2.223 mln.
Simple Rate of Return :	0.614
Back-pay Period :	1.628 years
PV/FCI Factor :	1.127
Manufacturing Value Added - MVA :	3.177 mln.
MVA/FCI Factor :	0.878

Process : 13 **PRECIPITATED CALCIUM CARBONATE(TOOTH P.)**

Capacity :	1000
Fixed Capital Investment - FCI :	1.814 mln.
Product Value - PV :	0.905 mln.
Total Manufacturing Cost :	0.703 mln.
Profit :	0.202 mln.
Simple Rate of Return :	0.159
Back-pay Period :	6.300 years
PV/FCI Factor :	0.713
Manufacturing Value Added - MVA :	0.587 mln.
MVA/FCI Factor :	0.462

Process : 14 **CALCIUM CARBIDE**

Capacity :	60000
Fixed Capital Investment - FCI :	24.963 mln.
Product Value - PV :	54.000 mln.
Total Manufacturing Cost :	29.706 mln.
Profit :	24.294 mln.
Simple Rate of Return :	1.390
Back-pay Period :	0.719 years
PV/FCI Factor :	3.090
Manufacturing Value Added - MVA :	30.448 mln.
MVA/FCI Factor :	1.742

Process : 15 CALCIUM HYPOCHLORITE

Capacity :	5000
Fixed Capital Investment - FCI :	1.756 mln.
Product Value - PV :	3.500 mln.
Total Manufacturing Cost :	1.102 mln.
Profit :	2.398 mln.
Simple Rate of Return :	1.952
Back-pay Period :	0.512 years
PV/FCI Factor :	2.848
Manufacturing Value Added - MVA :	2.829 mln.
MVA/FCI Factor :	2.302

Process : 16 CALCIUM CHLORIDE

Capacity :	10000
Fixed Capital Investment - FCI :	5.638 mln.
Product Value - PV :	2.392 mln.
Total Manufacturing Cost :	1.951 mln.
Profit :	0.441 mln.
Simple Rate of Return :	0.112
Back-pay Period :	8.956 years
PV/FCI Factor :	0.606
Manufacturing Value Added - MVA :	1.456 mln.
MVA/FCI Factor :	0.369

Process : 17 AMMONIUM CHLORIDE

Capacity :	4000
Fixed Capital Investment - FCI :	2.704 mln.
Product Value - PV :	1.600 mln.
Total Manufacturing Cost :	1.227 mln.
Profit :	0.373 mln.
Simple Rate of Return :	0.197
Back-pay Period :	5.077 years
PV/FCI Factor :	0.845
Manufacturing Value Added - MVA :	0.881 mln.
MVA/FCI Factor :	0.466

Process : 18 SODIUM BICHROMATE

Capacity :	3000
Fixed Capital Investment - FCI :	3.624 mln.
Product Value - PV :	3.770 mln.
Total Manufacturing Cost :	3.070 mln.
Profit :	0.700 mln.
Simple Rate of Return :	0.276
Back-pay Period :	3.626 years
PV/FCI Factor :	1.486
Manufacturing Value Added - MVA :	1.527 mln.
MVA/FCI Factor :	0.602

Process : 19 SODIUM CHROMATE

Capacity :	1000
Fixed Capital Investment - FCI :	2.027 mln.
Product Value - PV :	1.477 mln.
Total Manufacturing Cost :	1.008 mln.
Profit :	0.469 mln.
Simple Rate of Return :	0.331
Back-pay Period :	3.025 years
PV/FCI Factor :	[illegible]

Manufacturing Value Added - MVA :	0.860 mln.
MVA/FCI Factor :	0.606

Process : 20 **POTASSIUM BICHROMATE**

Capacity :	1000
Fixed Capital Investment - FCI :	2.128 mln.
Product Value - PV :	1.820 mln.
Total Manufacturing Cost :	1.963 mln.
Profit :	-0.143 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	1.222
Manufacturing Value Added - MVA :	0.385 mln.
MVA/FCI Factor :	0.259

Process : 21 **ANHYDROUS CHROMIC ACID**

Capacity :	1000
Fixed Capital Investment - FCI :	0.704 mln.
Product Value - PV :	2.601 mln.
Total Manufacturing Cost :	1.826 mln.
Profit :	0.775 mln.
Simple Rate of Return :	1.573
Back-pay Period :	0.636 years
PV/FCI Factor :	5.282
Manufacturing Value Added - MVA :	1.086 mln.
MVA/FCI Factor :	2.206

Process : 22 **CHROMOSAL - BASIC CHROMIUM SULPHATE**

Capacity :	2000
Fixed Capital Investment - FCI :	2.382 mln.
Product Value - PV :	2.760 mln.
Total Manufacturing Cost :	2.136 mln.
Profit :	0.624 mln.
Simple Rate of Return :	0.374
Back-pay Period :	2.674 years
PV/FCI Factor :	1.655
Manufacturing Value Added - MVA :	1.152 mln.
MVA/FCI Factor :	0.691

Process : 23 **COPPER OXIDE (BLACK)**

Capacity :	40
Fixed Capital Investment - FCI :	0.258 mln.
Product Value - PV :	0.107 mln.
Total Manufacturing Cost :	0.101 mln.
Profit :	0.006 mln.
Simple Rate of Return :	0.034
Back-pay Period :	29.269 years
PV/FCI Factor :	0.591
Manufacturing Value Added - MVA :	0.062 mln.
MVA/FCI Factor :	0.345

Process : 24 **COPPER OXIDE (RED)**

Capacity :	100
Fixed Capital Investment - FCI :	0.606 mln.
Product Value - PV :	0.263 mln.

Profit :	0.043 mln.
Simple Rate of Return :	0.102
Back-pay Period :	9.776 years
PV/FCI Factor :	0.621
Manufacturing Value Added - MVA :	0.152 mln.
MVA/FCI Factor :	0.357

Process : 25 **COPPER SULPHATE**

Capacity :	2000
Fixed Capital Investment - FCI :	1.285 mln.
Product Value - PV :	2.048 mln.
Total Manufacturing Cost :	0.944 mln.
Profit :	1.104 mln.
Simple Rate of Return :	1.228
Back-pay Period :	0.814 years
PV/FCI Factor :	2.277
Manufacturing Value Added - MVA :	1.436 mln.
MVA/FCI Factor :	1.596

Process : 26 **CRYOLITE - ALUMINUM SODIUM FLUORIDE**

Capacity :	4200
Fixed Capital Investment - FCI :	3.153 mln.
Product Value - PV :	2.899 mln.
Total Manufacturing Cost :	2.690 mln.
Profit :	0.209 mln.
Simple Rate of Return :	0.095
Back-pay Period :	10.568 years
PV/FCI Factor :	1.313
Manufacturing Value Added - MVA :	1.265 mln.
MVA/FCI Factor :	0.573

Process : 27 **ALUMINUM FLUORIDE**

Capacity :	2200
Fixed Capital Investment - FCI :	3.548 mln.
Product Value - PV :	2.667 mln.
Total Manufacturing Cost :	1.411 mln.
Profit :	1.256 mln.
Simple Rate of Return :	0.506
Back-pay Period :	1.977 years
PV/FCI Factor :	1.074
Manufacturing Value Added - MVA :	1.913 mln.
MVA/FCI Factor :	0.770

Process : 28 **HYDROGEN FLUORIDE**

Capacity :	1000
Fixed Capital Investment - FCI :	2.377 mln.
Product Value - PV :	3.177 mln.
Total Manufacturing Cost :	2.883 mln.
Profit :	0.294 mln.
Simple Rate of Return :	0.177
Back-pay Period :	5.661 years
PV/FCI Factor :	1.909
Manufacturing Value Added - MVA :	0.886 mln.
MVA/FCI Factor :	0.532

Process : 29 **IRON OXIDE (RED)**

Capacity :	2000
Fixed Capital Investment - FCI :	0.890 mln.
Product Value - PV :	1.918 mln.
Total Manufacturing Cost :	0.896 mln.
Profit :	1.022 mln.
Simple Rate of Return :	1.641
Back-pay Period :	0.609 years
PV/FCI Factor :	3.079
Manufacturing Value Added - MVA :	1.325 mln.
MVA/FCI Factor :	2.128

Process : 30 **FERROFERRIC OXIDES (BLACK)**

Capacity :	1000
Fixed Capital Investment - FCI :	0.789 mln.
Product Value - PV :	0.970 mln.
Total Manufacturing Cost :	0.781 mln.
Profit :	0.189 mln.
Simple Rate of Return :	0.342
Back-pay Period :	2.925 years
PV/FCI Factor :	1.757
Manufacturing Value Added - MVA :	0.493 mln.
MVA/FCI Factor :	0.893

Process : 31 **FERROUS SULPHATE**

Capacity :	1000
Fixed Capital Investment - FCI :	0.781 mln.
Product Value - PV :	0.381 mln.
Total Manufacturing Cost :	0.434 mln.
Profit :	-0.053 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	0.696
Manufacturing Value Added - MVA :	0.175 mln.
MVA/FCI Factor :	0.320

Process : 32 **LEAD OXIDE (RED)**

Capacity :	2000
Fixed Capital Investment - FCI :	1.079 mln.
Product Value - PV :	1.720 mln.
Total Manufacturing Cost :	1.100 mln.
Profit :	0.620 mln.
Simple Rate of Return :	0.821
Back-pay Period :	1.218 years
PV/FCI Factor :	2.277
Manufacturing Value Added - MVA :	0.916 mln.
MVA/FCI Factor :	1.213

Process : 33 **MAGNESIUM OXIDE**

Capacity :	50000
Fixed Capital Investment - FCI :	7.653 mln.
Product Value - PV :	33.685 mln.
Total Manufacturing Cost :	25.018 mln.
Profit :	8.667 mln.
Simple Rate of Return :	1.618
Back-pay Period :	0.618 years
PV/FCI Factor :	6.288
Manufacturing Value Added - MVA :	11.568 mln.
MVA/FCI Factor :	2.160

Process : 34 MANGANESE DIOXIDE

Capacity :	2000
Fixed Capital Investment - FCI :	2.580 mln.
Product Value - PV :	3.472 mln.
Total Manufacturing Cost :	1.945 mln.
Profit :	1.527 mln.
Simple Rate of Return :	0.845
Back-pay Period :	1.183 years
PV/FCI Factor :	1.922
Manufacturing Value Added - MVA :	2.237 mln.
MVA/FCI Factor :	1.238

Process : 35 MOLYBDENUM TRIOXIDE

Capacity :	140
Fixed Capital Investment - FCI :	0.588 mln.
Product Value - PV :	1.428 mln.
Total Manufacturing Cost :	1.185 mln.
Profit :	0.243 mln.
Simple Rate of Return :	0.590
Back-pay Period :	1.694 years
PV/FCI Factor :	3.470
Manufacturing Value Added - MVA :	0.453 mln.
MVA/FCI Factor :	1.113

Process : 36 NICKEL SULFATE

Capacity :	500
Fixed Capital Investment - FCI :	0.850 mln.
Product Value - PV :	0.937 mln.
Total Manufacturing Cost :	0.739 mln.
Profit :	0.198 mln.
Simple Rate of Return :	0.333
Back-pay Period :	3.004 years
PV/FCI Factor :	1.575
Manufacturing Value Added - MVA :	0.477 mln.
MVA/FCI Factor :	0.802

Process : 37 SODIUM TRIPOLYPHOSPHATE

Capacity :	50000
Fixed Capital Investment - FCI :	19.358 mln.
Product Value - PV :	43.815 mln.
Total Manufacturing Cost :	35.662 mln.
Profit :	8.153 mln.
Simple Rate of Return :	0.602
Back-pay Period :	1.662 years
PV/FCI Factor :	3.233
Manufacturing Value Added - MVA :	13.308 mln.
MVA/FCI Factor :	0.982

Process : 38 SODIUM HEXAMETAPHOSPHATE

Capacity :	1000
Fixed Capital Investment - FCI :	0.931 mln.
Product Value - PV :	1.356 mln.
Total Manufacturing Cost :	0.802 mln.
Profit :	0.554 mln.
Simple Rate of Return :	0.850

Back-pay Period :	1.176 years
PV/FCI Factor :	2.080
Manufacturing Value Added - MVA :	0.823 mln.
MVA/FCI Factor :	1.262

Process : 39 **SODIUM PYROPHOSPHATE (DIBASIC)**

Capacity :	300
Fixed Capital Investment - FCI :	0.940 mln.
Product Value - PV :	0.385 mln.
Total Manufacturing Cost :	0.486 mln.
Profit :	-0.101 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	0.585
Manufacturing Value Added - MVA :	0.151 mln.
MVA/FCI Factor :	0.230

Process : 40 **TRISODIUM PHOSPHATE**

Capacity :	7500
Fixed Capital Investment - FCI :	4.565 mln.
Product Value - PV :	8.681 mln.
Total Manufacturing Cost :	3.302 mln.
Profit :	5.379 mln.
Simple Rate of Return :	1.683
Back-pay Period :	0.594 years
PV/FCI Factor :	2.717
Manufacturing Value Added - MVA :	6.328 mln.
MVA/FCI Factor :	1.980

Process : 41 **DICALCIUM PHOSPHATE**

Capacity :	40000
Fixed Capital Investment - FCI :	7.336 mln.
Product Value - PV :	48.000 mln.
Total Manufacturing Cost :	23.658 mln.
Profit :	24.342 mln.
Simple Rate of Return :	4.740
Back-pay Period :	0.211 years
PV/FCI Factor :	9.347
Manufacturing Value Added - MVA :	27.095 mln.
MVA/FCI Factor :	5.276

Process : 42 **POTASSIUM CARBONATE**

Capacity :	1000
Fixed Capital Investment - FCI :	2.288 mln.
Product Value - PV :	0.948 mln.
Total Manufacturing Cost :	1.350 mln.
Profit :	-0.402 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	0.592
Manufacturing Value Added - MVA :	0.459 mln.
MVA/FCI Factor :	0.287

Process : 43 **POTASSIUM CHLORATE**

Capacity :	1000
Fixed Capital Investment - FCI :	[illegible] mln.

Product Value - PV :	0.880 mln.
Total Manufacturing Cost :	0.972 mln.
Profit :	-0.092 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	0.444
Manufacturing Value Added - MVA :	0.453 mln.
MVA/FCI Factor :	0.228

Process : 44 **POTASSIUM NITRATE**

Capacity :	2000
Fixed Capital Investment - FCI :	1.474 mln.
Product Value - PV :	1.400 mln.
Total Manufacturing Cost :	1.450 mln.
Profit :	-0.050 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	1.357
Manufacturing Value Added - MVA :	0.362 mln.
MVA/FCI Factor :	0.351

Process : 45 **SODIUM GLAZE**

Capacity :	25000
Fixed Capital Investment - FCI :	13.996 mln.
Product Value - PV :	5.750 mln.
Total Manufacturing Cost :	5.626 mln.
Profit :	0.124 mln.
Simple Rate of Return :	0.013
Back-pay Period :	79.044 years
PV/FCI Factor :	0.587
Manufacturing Value Added - MVA :	2.414 mln.
MVA/FCI Factor :	0.246

Process : 46 **SODIUM WATER GLASS**

Capacity :	60000
Fixed Capital Investment - FCI :	14.706 mln.
Product Value - PV :	8.160 mln.
Total Manufacturing Cost :	8.947 mln.
Profit :	-0.787 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	0.793
Manufacturing Value Added - MVA :	1.812 mln.
MVA/FCI Factor :	0.176

Process : 47 **MOLECURAL SIEVE-ZEOLITES (cl. 3A)**

Capacity :	500
Fixed Capital Investment - FCI :	2.230 mln.
Product Value - PV :	0.800 mln.
Total Manufacturing Cost :	1.198 mln.
Profit :	0.398 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	0.512
Manufacturing Value Added - MVA :	0.237 mln.
MVA/FCI Factor :	0.184

Process : 60 MOLECULAR SIEVE - ZEOLITES (cl. 4A)

Capacity :	500
Fixed Capital Investment - FCI :	2.230 mln.
Product Value - PV :	1.600 mln.
Total Manufacturing Cost :	1.114 mln.
Profit :	0.486 mln.
Simple Rate of Return :	0.311
Back-pay Period :	3.216 years
PV/FCI Factor :	1.025
Manufacturing Value Added - MVA :	1.164 mln.
MVA/FCI Factor :	0.746

Process : 61 MOLECURAL SIEVE - ZEOLITES (cl. 5A)

Capacity :	500
Fixed Capital Investment - FCI :	2.230 mln.
Product Value - PV :	1.400 mln.
Total Manufacturing Cost :	1.327 mln.
Profit :	0.073 mln.
Simple Rate of Return :	0.047
Back-pay Period :	21.416 years
PV/FCI Factor :	0.897
Manufacturing Value Added - MVA :	0.766 mln.
MVA/FCI Factor :	0.491

Process : 62 MOLECURAL SIEVE - ZEOLITES (cl. 13X)

Capacity :	500
Fixed Capital Investment - FCI :	2.230 mln.
Product Value - PV :	1.100 mln.
Total Manufacturing Cost :	1.095 mln.
Profit :	0.005 mln.
Simple Rate of Return :	0.003
Back-pay Period :	322.671 years
PV/FCI Factor :	0.705
Manufacturing Value Added - MVA :	0.682 mln.
MVA/FCI Factor :	0.437

Process : 48 SILICA GEL (MACRO)

Capacity :	1500
Fixed Capital Investment - FCI :	1.262 mln.
Product Value - PV :	2.355 mln.
Total Manufacturing Cost :	2.105 mln.
Profit :	0.250 mln.
Simple Rate of Return :	0.283
Back-pay Period :	3.536 years
PV/FCI Factor :	2.665
Manufacturing Value Added - MVA :	0.755 mln.
MVA/FCI Factor :	0.855

Process : 49 SILICA GEL (MICRO)

Capacity :	1500
Fixed Capital Investment - FCI :	1.262 mln.
Product Value - PV :	2.550 mln.
Total Manufacturing Cost :	2.342 mln.
Profit :	0.208 mln.
Simple Rate of Return :	0.236
Back-pay Period :	4.239 years
PV/FCI Factor :	[illegible]

Manufacturing Value Added - MVA :	0.730 mln.
MVA/FCI Factor :	0.826

Process : 50 SODIUM METASILICATE

Capacity :	10000
Fixed Capital Investment - FCI :	3.354 mln.
Product Value - PV :	4.550 mln.
Total Manufacturing Cost :	2.890 mln.
Profit :	1.660 mln.
Simple Rate of Return :	0.707
Back-pay Period :	1.415 years
PV/FCI Factor :	1.938
Manufacturing Value Added - MVA :	2.479 mln.
MVA/FCI Factor :	1.056

Process : 51 SODIUM THIOSULPHATE

Capacity :	1000
Fixed Capital Investment - FCI :	1.733 mln.
Product Value - PV :	1.003 mln.
Total Manufacturing Cost :	0.671 mln.
Profit :	0.332 mln.
Simple Rate of Return :	0.274
Back-pay Period :	3.650 years
PV/FCI Factor :	0.827
Manufacturing Value Added - MVA :	0.803 mln.
MVA/FCI Factor :	0.662

Process : 52 SODIUM HYDROGEN SULFITE

Capacity :	4000
Fixed Capital Investment - FCI :	2.599 mln.
Product Value - PV :	1.816 mln.
Total Manufacturing Cost :	1.093 mln.
Profit :	0.723 mln.
Simple Rate of Return :	0.398
Back-pay Period :	2.515 years
PV/FCI Factor :	0.998
Manufacturing Value Added - MVA :	1.230 mln.
MVA/FCI Factor :	0.676

Process : 53 SODIUM SULFITE

Capacity :	2000
Fixed Capital Investment - FCI :	0.994 mln.
Product Value - PV :	1.048 mln.
Total Manufacturing Cost :	0.948 mln.
Profit :	0.100 mln.
Simple Rate of Return :	0.144
Back-pay Period :	6.954 years
PV/FCI Factor :	1.506
Manufacturing Value Added - MVA :	0.353 mln.
MVA/FCI Factor :	0.508

Process : 54 SODIUM HYDROSULFITE

Capacity :	2000
Fixed Capital Investment - FCI :	2.468 mln.
Product Value - PV :	3.177 mln.
Total Manufacturing Cost :	2.428 mln.

Profit :	0.699 mln.
Simple Rate of Return :	0.404
Back-pay Period :	2.472 years
PV/FCI Factor :	1.809
Manufacturing Value Added - MVA :	1.340 mln.
MVA/FCI Factor :	0.776

Process : 55 SODIUM CHLORIDE (MEDICAL)

Capacity :	1500
Fixed Capital Investment - FCI :	2.877 mln.
Product Value - PV :	1.426 mln.
Total Manufacturing Cost :	0.897 mln.
Profit :	0.529 mln.
Simple Rate of Return :	0.263
Back-pay Period :	3.806 years
PV/FCI Factor :	0.708
Manufacturing Value Added - MVA :	1.061 mln.
MVA/FCI Factor :	0.527

Process : 56 SODIUM NITRATE

Capacity :	8000
Fixed Capital Investment - FCI :	6.718 mln.
Product Value - PV :	2.735 mln.
Total Manufacturing Cost :	3.314 mln.
Profit :	-0.579 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	0.582
Manufacturing Value Added - MVA :	0.696 mln.
MVA/FCI Factor :	0.148

Process : 57 TITANIUM DIOXIDE

Capacity :	20000
Fixed Capital Investment - FCI :	65.677 mln.
Product Value - PV :	40.000 mln.
Total Manufacturing Cost :	31.402 mln.
Profit :	8.598 mln.
Simple Rate of Return :	0.187
Back-pay Period :	5.347 years
PV/FCI Factor :	0.870
Manufacturing Value Added - MVA :	20.458 mln.
MVA/FCI Factor :	0.445

Process : 58 ZINC SULFATE

Capacity :	1000
Fixed Capital Investment - FCI :	1.850 mln.
Product Value - PV :	0.480 mln.
Total Manufacturing Cost :	0.588 mln.
Profit :	-0.108 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	0.371
Manufacturing Value Added - MVA :	0.228 mln.
MVA/FCI Factor :	0.176

Process : 59 ZINC CHLORIDE

Capacity :	4700
Fixed Capital Investment - FCI :	2.953 mln.
Product Value - PV :	3.502 mln.
Total Manufacturing Cost :	2.879 mln.
Profit :	0.622 mln.
Simple Rate of Return :	0.301
Back-pay Period :	3.322 years
PV/FCI Factor :	1.694
Manufacturing Value Added - MVA :	1.327 mln.
MVA/FCI Factor :	0.642

Process : 63 SODA ASH

Capacity :	100000
Fixed Capital Investment - FCI :	33.303 mln.
Product Value - PV :	16.530 mln.
Total Manufacturing Cost :	18.171 mln.
Profit :	-1.641 mln.
Simple Rate of Return :	
Back-pay Period :	
PV/FCI Factor :	0.709
Manufacturing Value Added - MVA :	4.855 mln.
MVA/FCI Factor :	0.208

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B5. Reporte on experiments (I 50 - I 384)

Problem title: INORGANIC INDUSTRY

F r a c t i o n a l Optimization

Maximize:

$$\frac{\text{Yearly Profit}}{\text{Investment}} = 1.284 \ \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:

5.00E+01 < Investment < 1.00E+20 (0.0%) mil.$

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M A I N   P A R A M E T E R S

Yearly Profit	64.	mil.$
Manufacturing Value Added	79.	mil.$
Investment	50.	mil.$
Yearly Import	11.	mil.$
Yearly Domestic Purchase	57.	mil.$
Yearly Domestic Sale	147.	mil.$

S A L E

Calcium carbonate	145000.	tons
Chromic acid anhydrous	1000.	tons
Dicalcium phosphate	40000.	tons
Calcium hypochloride	5000.	tons
Calcium carbide	29964.	tons
Sodium perborate	20000.	tons
Magnesium oxide	50000.	tons
Trisodium phosphate	7500.	tons
Gas waste	1257372000.	m3
Liquid waste	353679.	m3
Solid waste	83886.	tons
Iron oxide (red)	2000.	tons

P U R C H A S E

Electrical energy	214131200.	kwh
Water	6044008.	m3
Steam	139560.	GJ
Cooling water	8960.	m3
Process water	200400.	m3
Compressed air	2477196.	Nm3

Ammonium nitrate	4250.	tons
Compressed nitrogen	149822.	Nm3
Burnt lime (CaO)	58431.	tons
Coke	17993.	tons
Electrodes	90.	tons
Colemanite (boron ore 40%)	14020.	tons
Dolomite	9600.	tons
Nitric acid (as 65% HNO_3)	1500.	tons
Hydrate lime [99.5 $Ca(OH)_2$]	2400.	tons
Hydrogen peroxide	4720.	tons
Elecrode mass	539.	tons
Limestone (98% $CaCO_3$)	171.	tons
Magnesium sulphate	80.	tons
Sodium hydroxide (45%)	16.	tons
Phosphoric acid (38% P_2O_5)	43200.	tons
Phosphoric acid (75% H_3PO_4)	3150.	tons
Sand	262.	tons
Burnt dolomite (37% MgO+58% CaO)	145000.	tons
Sodium carbonate 98%	2625.	tons
Sodium chloride	210.	tons
Sodium hydroxide (100% NaOH)	1125.	tons
Sodium hydroxide (50%)	5360.	tons
Soda lye (45%) solution	17600.	tons
Sodium silicate	80.	tons
Carbon dioxide (100%)	36450.	tons
Lime	3500.	tons
Sulphuric acid	1340.	tons
Diesel oil	2000.	tons
Ammonia NH_3	1.	tons
Fuel gas	59074400.	Nm3
Natural gas	630000.	Nm3
Filtriation agent	28.	tons
Chlorine (100%)	2025.	tons
Post-reduction aniline (55% Fe_2O_3)	4300.	tons
Iron sheet	45.	tons
Sodium bichromate impure	1700.	tons

P R O C E S S E S

SODIUM PERCORATE	20000.	tons
CALCIUM CARBIDE	29964.	tons
CALCIUM HYPOCHLORITE	5000.	tons
ANHYDROUS CHROMIC ACID	1000.	tons
IRON OXIDE (RED)	2000.	tons
MAGNESIUM OXIDE	50000.	tons
TRISODIUM PHOSPHATE	7500.	tons
DICALCIUM PHOSPHATE	40000.	tons
SODIUM GLAZE	320.	tons
SODIUM WATER GLASS	800.	tons
SODA ASH	131.	tons

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Problem title: INORGANIC INDUSTRY

Fractional Optimization

Maximize:

$$\frac{\text{Yearly Profit}}{\text{Investment}} = 0.739 \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:
1.25E+02 < Investment < 1.00E+20 (0.0%) mil.$

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MAIN PARAMETERS

Yearly Profit	92.	mil.$
Manufacturing Value Added	125.	mil.$
Investment	125.	mil.$
Yearly Import	17.	mil.$
Yearly Domestic Purchase	93.	mil.$
Yearly Domestic Sale	236.	mil.$

SALE

Antimony trioxide	2000.	tons
Calcium carbonate	145000.	tons
Chromic acid anhydrous	1000.	tons
Copper sulphate	2000.	tons
Dicalcium phosphate	40000.	tons
Calcium hypochloride	5000.	tons
Lead oxide (red)	2000.	tons
Manganese dioxide	2000.	tons
Molybdenum trioxide III	140.	tons
Aluminum sulphate (14% Al2O3)	30000.	tons
Precipitated calcium carbonate	10000.	tons
Calcium carbide	60000.	tons
Sodium hydrogen sulfite	4000.	tons
Sodium hexametaphosphate	1000.	tons
Sodium hydrosulfite	2000.	tons
Sodium perborate	20000.	tons
Sodium tetraborate (Borax)	5000.	tons
Sodium tripolyphosphate	22999.	tons
Magnesium oxide	50000.	tons
Trisodium phosphate	7500.	tons
Aluminum fluoride	2200.	tons
Gas waste	2382469000.	m3
Liquid waste	605937.	m3
Solid waste	111721.	tons
Iron oxide (red)	2000.	tons

PURCHASE

Electrical energy	327730000.	kwh
Water	11590940.	m3
Steam	739718.	GJ
Cooling water	1318924.	m3
Process water	542979.	m3
Compressed air	20253670.	Nm3
Hot air	32000.	Nm3
Ammonium nitrate	4388.	tons
Antimony (metalic)	1722.	tons
Compressed nitrogen	300000.	Nm3
Burnt lime, (CaO)	117000.	tons
Charcoal	5.	tons
Coal	2344.	tons
Coke	39419.	tons
Electrodes	180.	tons
Colemanite (boron ore 40%)	18820.	tons
Copper scrap	520.	tons
Diatomite	115.	tons
Dolomite	9600.	tons
Fluosilicic acid as waste	2640.	tons
Ground phosphate rock	2300.	tons
Nitric acid (as 65% HNO3)	1814.	tons
Hydrate lime [99.5 Ca(OH)2]	3800.	tons
Hydrogen peroxide	4720.	tons
Elecrode mass	1080.	tons
Limestone (98% CaCO3)	39538.	tons
Magnesium sulphate	80.	tons
Manganese ore (30% Mn)	4500.	tons
Molybdenum ore	155.	tons
Sodium hydroxide (45%)	16.	tons
Lead (as metal)	1827.	tons
Phosphoric acid (38% P2O5)	43200.	tons
Phosphoric acid (75% H3PO4)	30809.	tons
Rock salt (100% NaCL)	3100.	tons
Sand	262.	tons
Sulphur dioxide SO2 (as 100% H2SO4)	4520.	tons
Burnt dolomite (37% MgO+58% CaO)	145000.	tons
Soda lye (45% NaOH)	142.	tons
Sodium bicarbonate	1750.	tons
Sodium carbonate 98%	4945.	tons
Sodium chloride	30815.	tons
Sodium hydroxide (100% NaOH)	1125.	tons
Sodium hydroxide (50%)	8560.	tons
Soda lye (45%) solution	17600.	tons
Sodium silicate	80.	tons
Sulphur	1028.	tons
Carbon dioxide (100%)	36450.	tons
Lime	3500.	tons
Sulphuric acid	17360.	tons
Diesel oil	6955.	tons
Zinc ash (100% Zn)	1160.	tons
Bauxite (87% Al2O3)	9600.	tons
Aluminum hydroxide (as 100% Al2O3)	1870.	tons
Ammonia NH3	96.	tons
Alcohol	130.	tons
Filter cloth	2.	tons
Fuel gas	59153400.	Nm3
Natural gas	630000.	Nm3
Filtriation agent	[illegible]	tons

Chlorine (100%)	2025.	tons
Post-reduction aniline (55% Fe2O3)	4300.	tons
Ammonia water (29.4% NH3)	350.	tons
Iron sheet	90.	tons
Sodium bichromate impure	1700.	tons

P R O C E S S E S

ANTIMONY TRIOXIDE	2000.	tons
ALUMINUM SULPHATE	30000.	tons
SODIUM TETRABORATE (BORAX)	5000.	tons
SODIUM PERBORATE	20000.	tons
PRECIPITATED CALCIUM CARBONATE	10000.	tons
CALCIUM CARBIDE	60000.	tons
CALCIUM HYPOCHLORITE	5000.	tons
ANHYDROUS CHROMIC ACID	1000.	tons
COPPER SULPHATE	2000.	tons
ALUMINUM FLUORIDE	2200.	tons
IRON OXIDE (RED)	2000.	tons
LEAD OXIDE (RED)	2000.	tons
MAGNESIUM OXIDE	50000.	tons
MANGANESE DIOXIDE	2000.	tons
MOLYBDENUM TRIOXIDE	140.	tons
SODIUM TRIPOLYPHOSPHATE	22999.	tons
SODIUM HEXAMETAPHOSPHATE	1000.	tons
TRISODIUM PHOSPHATE	7500.	tons
DICALCIUM PHOSPHATE	40000.	tons
SODIUM GLAZE	320.	tons
SODIUM WATER GLASS	800.	tons
SODIUM HYDROGEN SULFITE	4000.	tons
SODIUM HYDROSULFITE	2000.	tons
SODA ASH	19260.	tons

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Problem title: INORGANIC INDUSTRY

Fractional Optimization

Maximize:

$$\frac{\text{Yearly Profit}}{\text{Investment}} = 0.646 \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:
1.50E+02 < Investment < 1.00E+20 (0.0%) mil.$

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MAIN PARAMETERS

Yearly Profit	97.	mil.$
Manufacturing Value Added	136.	mil.$
Investment	150.	mil.$
Yearly Import	17.	mil.$
Yearly Domestic Purchase	109.	mil.$
Yearly Domestic Sale	262.	mil.$

SALE

Antimony trioxide	2000.	tons
Calcium carbonate	145000.	tons
Chromic acid anhydrous	1000.	tons
Chromosal - basic chromium sulphate	1683.	tons
Copper sulphate	2000.	tons
Dicalcium phosphate	40000.	tons
Calcium hypochloride	5000.	tons
Lead oxide (red)	2000.	tons
Manganese dioxide	2000.	tons
Molybdenum trioxide III	140.	tons
Aluminum sulphate (14% Al2O3)	30000.	tons
Precipitated calcium carbonate	10000.	tons
Calcium carbide	60000.	tons
Sodium hydrogen sulfite	4000.	tons
Sodium hexametaphosphate	1000.	tons
Sodium hydrosulfite	2000.	tons
Sodium perborate	20000.	tons
Sodium tetraborate (Borax)	5000.	tons
Sodium tripolyphosphate	50000.	tons
Magnesium oxide	50000.	tons
Trisodium phosphate	7500.	tons
Aluminum fluoride	2200.	tons
Gas waste	2382469000.	m3
Liquid waste	802598.	m3
Solid waste	120820.	tons

Iron oxide (red)	2000.	tons

PURCHASE

Electrical energy	335137700.	kwh
Water	15031890.	m3
Steam	1106151.	GJ
Cooling water	2668960.	m3
Process water	595732.	m3
Compressed air	27471380.	Nm3
Hot air	32000.	Nm3
Ammonium nitrate	4550.	tons
Antimony (metalic)	1722.	tons
Compressed nitrogen	300000.	Nm3
Burnt lime (CaO)	117000.	tons
Charcoal	5.	tons
Chromium ore	1454.	tons
Coal	2344.	tons
Coke	41822.	tons
Electrodes	180.	tons
Colemanite (boron ore 40%)	18820.	tons
Copper scrap	520.	tons
Diatomite	250.	tons
Dolomite	11127.	tons
Fluosilicic acid as waste	2640.	tons
Ground phosphate rock	5000.	tons
Nitric acid (as 65% HNO3)	1814.	tons
Hydrate lime [99.5 Ca(OH)2]	3800.	tons
Hydrogen peroxide	4720.	tons
Elecrode mass	1080.	tons
Limestone (98% CaCO3)	67944.	tons
Magnesium sulphate	80.	tons
Manganese ore (30% Mn)	4500.	tons
Molybdenum ore	155.	tons
Sodium hydroxide (45%)	16.	tons
Lead (as metal)	1827.	tons
Phosphoric acid (38% P2O5)	43200.	tons
Phosphoric acid (75% H3PO4)	62130.	tons
Rock salt (100% NaCL)	3100.	tons
Sand	262.	tons
Sulphur dioxide SO2 (as 100% H2SO4)	4520.	tons
Burnt dolomite (37% MgO+58% CaO)	145000.	tons
Soda lye (45% NaOH)	142.	tons
Sodium bicarbonate	1750.	tons
Sodium carbonate 98%	4945.	tons
Sodium chloride	65777.	tons
Sodium hydroxide (100% NaOH)	1125.	tons
Sodium hydroxide (50%)	8560.	tons
Soda lye (45%) solution	17600.	tons
Sodium silicate	80.	tons
Sulphur	1331.	tons
Carbon dioxide (100%)	36450.	tons
Lime	3500.	tons
Sulphuric acid	17705.	tons
Diesel oil	11566.	tons
Zinc ash (100% Zn)	1160.	tons
Bauxite (87% Al2O3)	9600.	tons
Aluminum hydroxide (as 100% Al2O3)	1870.	tons
Ammonia NH3	206.	tons
Alcohol	130.	tons
Filter cloth	4.	tons
Fuel gas	59153400.	Nm3

Natural gas	630000.	Nm3
Filtriation agent	28.	tons
Chlorine (100%)	2025.	tons
Post-reduction aniline (55% Fe_2O_3)	4300.	tons
Ammonia water (29.4% NH_3)	350.	tons
Iron sheet	90.	tons
Sodium bichromate impure	1700.	tons

P R O C E S S E S

ANTIMONY TRIOXIDE	2000.	tons
ALUMINUM SULPHATE	30000.	tons
SODIUM TETRABORATE (BORAX)	5000.	tons
SODIUM PERBORATE	20000.	tons
PRECIPITATED CALCIUM CARBONATE	10000.	tons
CALCIUM CARBIDE	60000.	tons
CALCIUM HYPOCHLORITE	5000.	tons
SODIUM BICHROMATE	909.	tons
ANHYDROUS CHROMIC ACID	1000.	tons
CHROMOSAL - BASIC CHROMIUM SULPHATE	1683.	tons
COPPER SULPHATE	2000.	tons
ALUMINUM FLUORIDE	2200.	tons
IRON OXIDE (RED)	2000.	tons
LEAD OXIDE (RED)	2000.	tons
MAGNESIUM OXIDE	50000.	tons
MANGANESE DIOXIDE	2000.	tons
MOLYBDENUM TRIOXIDE	140.	tons
SODIUM TRIPOLYPHOSPHATE	50000.	tons
SODIUM HEXAMETAPHOSPHATE	1000.	tons
TRISODIUM PHOSPHATE	7500.	tons
DICALCIUM PHOSPHATE	40000.	tons
SODIUM GLAZE	320.	tons
SODIUM WATER GLASS	800.	tons
SODIUM HYDROGEN SULFITE	4000.	tons
SODIUM HYDROSULFITE	2000.	tons
SODA ASH	41111.	tons

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Problem title: INORGANIC INDUSTRY

Fractional Optimization

Maximize:

$$\frac{\text{Yearly Profit}}{\text{Investment}} = 0.513 \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:
2.00E+02 < Investment < 1.00E+20 (0.0%) mil.$.

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MAIN PARAMETERS

Yearly Profit	103.	mil.$
Manufacturing Value Added	152.	mil.$
Investment	200.	mil.$
Yearly Import	17.	mil.$
Yearly Export	5.	mil.$
Yearly Domestic Purchase	118.	mil.$
Yearly Domestic Sale	284.	mil.$

SALE

Ammonium chloride	4000.	tons
Antimony trioxide	2000.	tons
Calcium carbonate	144910.	tons
Chromic acid anhydrous	1000.	tons
Chromosal - basic chromium sulphate	2000.	tons
Copper sulphate	2000.	tons
Dicalcium phosphate	40000.	tons
Calcium hypochloride	5000.	tons
Lead oxide (red)	2000.	tons
Manganese dioxide	2000.	tons
Molybdenum trioxide III	140.	tons
Nickel sulphate	500.	tons
Aluminum sulphate (14% Al2O3)	30000.	tons
Precipitated calcium carbonate	10000.	tons
Sodium bichromate	1920.	tons
Calcium carbide	60000.	tons
Sodium hydrogen sulfite	4000.	tons
Sodium chromate	1000.	tons
Sodium hexametaphosphate	1000.	tons
Sodium hydrosulfite	2000.	tons
Sodium metasilicate pentahydrate	10000.	tons
Sodium perborate	20000.	tons
Sodium tetraborate (Borax)	5000.	tons
Sodium thiosulfate	1000.	tons

Sodium tripolyphosphate	50000.	tons
Magnesium oxide	50000.	tons
Trisodium phosphate	7500.	tons
Zinc chloride (as 100% $ZnCl_2$)	4700.	tons
Aluminum fluoride	2200.	tons
Gas waste	2384182000.	m3
Liquid waste	1281080.	m3
Solid waste	142244.	tons
Iron oxide (red)	2000.	tons
Ferroferric oxide (black)	1000.	tons
Sodium chloride (medical)	1500.	tons
Titanium dioxide	3707.	tons
Zeolites cl.4A	500.	tons

P U R C H A S E

Electrical energy	346589500.	kwh
Water	19221860.	m3
Steam	1646182.	GJ
Cooling water	2834860.	m3
Process water	618680.	m3
Demineralized water	23390.	m3
Compressed air	29495400.	Nm3
Hot air	32099.	Nm3
Ammonium nitrate	4680.	tons
Antilumper	24.	tons
Antimony (metalic)	1722.	tons
Compressed nitrogen	300000.	Nm3
Burnt lime (CaO)	117000.	tons
Charcoal	5.	tons
Chromate and bichromate(calc.66.3%CrO_3)	680.	tons
Chromium ore	4800.	tons
Coal	2344.	tons
Coke	42298.	tons
Electrodes	180.	tons
Colemanite (boron ore 40%)	18820.	tons
Copper scrap	520.	tons
Diatomite	250.	tons
Dolomite	14640.	tons
Fluosilicic acid as waste	2640.	tons
Ground phosphate rock	5000.	tons
Hydrochloric acid (as 100%)	2538.	tons
Nitric acid (as 65% HNO_3)	1814.	tons
Hydrate lime [99.5 $Ca(OH)_2$]	3800.	tons
Hydrofluoric acid 70%	5.	tons
Hydrogen peroxide	4740.	tons
Elecrode mass	1080.	tons
Limestone (98% $CaCO_3$)	73571.	tons
Magnesium sulphate	80.	tons
Manganese ore (30% Mn)	4500.	tons
Molybdenum ore	155.	tons
Sodium hydroxide (45%)	256.	tons
Calcium hydroxide $CaOH_2$	19.	tons
Lead (as metal)	1827.	tons
Phosphoric acid (38% P_2O_5)	43200.	tons
Phosphoric acid (75% H_3PO_4)	62130.	tons
Post distillation slurry	40000.	m3
Raw nickel sulphate	504.	tons
Rock salt (100% NaCl)	6700.	tons
Sand	4198.	tons
Sulphur dioxide SO_2 (as 100% H_2SO_4)	4755.	tons
Illemanite ore (49.5% TiO_2)	10565.	tons

Burnt dolomite (37% MgO+58% CaO)	145000.	tons
Soda lye (45% NaOH)	142.	tons
Sodium bicarbonate	1750.	tons
Zinc oxide (ash)	2820.	tons
Sodium carbonate 90%	4948.	tons
Sodium chloride	72703.	tons
Sodium hydroxide (100% NaOH)	1125.	tons
Sodium hydroxide (50%)	11303.	tons
Soda lye (45%) solution	17600.	tons
Sodium pyrosulfite	5.	tons
Sodium silicate	80.	tons
Sulphur	1520.	tons
Carbon dioxide (100%)	36450.	tons
Lime	3500.	tons
Sulphuric acid	40376.	tons
Diesel oil	14012.	tons
Zinc ash (100% Zn)	1160.	tons
Bauxite (87% Al2O3)	9600.	tons
Aluminum hydroxide (as 100% Al2O3)	2078.	tons
Ammonia NH3	2247.	tons
Alcohol	130.	tons
Potassium permanganate (KMnO4)	3.	tony
Filter cloth	4.	tons
Fuel gas	60269400.	Nm3
Natural gas	830000.	Nm3
Filtriation agent	28.	tons
Drinking water	4800.	m3
Chlorine (100%)	2025.	tons
Post-reduction aniline (55% Fe2O3)	4300.	tons
Ammonia water (29.4% NH3)	350.	tons
Iron sheet	90.	tons
Scrap-iron	649.	tons
Other compounds	185359.	US$
Sodium bichromate impure	1700.	tons
Ferrous sulphate as waste	4550.	tons

P R O C E S S E S

ANTIMONY TRIOXIDE	2000.	tons
ALUMINUM SULPHATE	30000.	tons
SODIUM TETRABORATE (BORAX)	5000.	tons
SODIUM PERBORATE	20000.	tons
PRECIPITATED CALCIUM CARBONATE	10000.	tons
CALCIUM CARBIDE	60000.	tons
CALCIUM HYPOCHLORITE	5000.	tons
AMMONIUM CHLORIDE	4000.	tons
SODIUM BICHROMATE	3000.	tons
SODIUM CHROMATE	1000.	tons
ANHYDROUS CHROMIC ACID	1000.	tons
CHROMOSAL - BASIC CHROMIUM SULPHATE	2000.	tons
COPPER SULPHATE	2000.	tons
ALUMINUM FLUORIDE	2200.	tons
IRON OXIDE (RED)	2000.	tons
FERROFERRIC OXIDES (BLACK)	1000.	tons
LEAD OXIDE (RED)	2000.	tons
MAGNESIUM OXIDE	50000.	tons
MANGANESE DIOXIDE	2000.	tons
MOLYBDENUM TRIOXIDE	140.	tons
NICKEL SULFATE	500.	tons
SODIUM TRIPOLYPHOSPHATE	50000.	tons
SODIUM HEXAMETAPHOSPHATE	1000.	tons
TRISODIUM PHOSPHATE	7500.	tons

DICALCIUM PHOSPHATE	40000.	tons
SODIUM GLAZE	5120.	tons
SODIUM WATER GLASS	12800.	tons
MOLECULAR SIEVE - ZEOLITES (cl. 4A)	500.	tons
SODIUM METASILICATE	10000.	tons
SODIUM THIOSULPHATE	1000.	tons
SODIUM HYDROGEN SULFITE	4000.	tons
SODIUM SULFITE	6.	tons
SODIUM HYDROSULFITE	2000.	tons
SODIUM CHLORIDE (MEDICAL)	1500.	tons
TITANIUM DIOXIDE	3707.	tons
ZINC CHLORIDE	4700.	tons
SODA ASH	45439.	tons

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Problem title: INORGANIC INDUSTRY

Fractional Optimization

Maximize:

$$\frac{\text{Yearly Profit}}{\text{Investment}} = 0.426 \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:
2.50E+02 < Investment < 1.00E+20 (0.0%) mil.$

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M A I N   P A R A M E T E R S

Yearly Profit	107.	mil.$
Manufacturing Value Added	166.	mil.$
Investment	250.	mil.$
Yearly Import	18.	mil.$
Yearly Export	5.	mil.$
Yearly Domestic Purchase	129.	mil.$
Yearly Domestic Sale	310.	mil.$

S A L E

Ammonium chloride	4000.	tons
Antimony trioxide	2000.	tons
Calcium carbonate	144910.	tons
Chromic acid anhydrous	1000.	tons
Chromosal - basic chromium sulphate	2000.	tons
Copper sulphate	2000.	tons
Dicalcium phosphate	40000.	tons
Calcium hypochloride	5000.	tons
Lead oxide (red)	2000.	tons
Manganese dioxide	2000.	tons
Molybdenum trioxide III	140.	tons
Nickel sulphate	500.	tons
Aluminum sulphate (14% Al2O3)	30000.	tons
Precipitated calcium carbonate	10000.	tons
Sodium bichromate	1920.	tons
Calcium carbide	60000.	tons
Sodium hydrogen sulfite	4000.	tons
Sodium chromate	1000.	tons
Sodium hexametaphosphate	1000.	tons
Sodium hydrosulfite	2000.	tons
Sodium metasilicate pentahydrate	10000.	tons
Sodium perborate	20000.	tons
Sodium tetraborate (Borax)	5000.	tons
Sodium thiosulfate	1000.	tons

Sodium tripolyphosphate	50000.	tons
Magnesium oxide	50000.	tons
Trisodium phosphate	7500.	tons
Zinc chloride (as 100% ZnCl2)	4700.	tons
Aluminum fluoride	2200.	tons
Gas waste	2384182000.	m3
Liquid waste	1585602.	m3
Solid waste	180309.	tons
Iron oxide (red)	2000.	tons
Ferroferric oxide (black)	1000.	tons
Sodium chloride (medical)	1500.	tons
Titanium dioxide	16396.	tons
Zeolites cl.4A	500.	tons

PURCHASE

Electrical energy	357120900.	kwh
Water	28966570.	m3
Steam	2407487.	GJ
Cooling water	2834860.	m3
Process water	618680.	m3
Demineralized water	23390.	m3
Compressed air	29495400.	Nm3
Hot air	32099.	Nm3
Ammonium nitrate	4680.	tons
Antilumper	24.	tons
Antimony (metalic)	1722.	tons
Compressed nitrogen	300000.	Nm3
Burnt lime (CaO)	117000.	tons
Charcoal	5.	tons
Chromate and bichromate(calc.66.3%CrO3)	680.	tons
Chromium ore	4800.	tons
Coal	2344.	tons
Coke	42298.	tons
Electrodes	180.	tons
Colemanite (boron ore 40%)	18820.	tons
Copper scrap	520.	tons
Diatomite	250.	tons
Dolomite	14640.	tons
Fluosilicic acid as waste	2640.	tons
Ground phosphate rock	5000.	tons
Hydrochloric acid (as 100%)	2538.	tons
Nitric acid (as 65% HNO3)	1814.	tons
Hydrate lime [99.5 Ca(OH)2]	3800.	tons
Hydrofluoric acid 70%	5.	tons
Hydrogen peroxide	4740.	tons
Elecrode mass	1080.	tons
Limestone (98% CaCO3)	73571.	tons
Magnesium sulphate	80.	tons
Manganese ore (30% Mn)	4500.	tons
Molybdenum ore	155.	tons
Sodium hydroxide (45%)	256.	tons
Calcium hydroxide CaOH2	19.	tons
Lead (as metal)	1827.	tons
Phosphoric acid (38% P2O5)	43200.	tons
Phosphoric acid (75% H3PO4)	62130.	tons
Post distillation slurry	40000.	m3
Raw nickel sulphate	504.	tons
Rock salt (100% NaCl)	6700.	tons
Sand	4198.	tons
Sulphur dioxide SO2 (as 100% H2SO4)	4755.	tons
Illemanite ore (49.5% TiO2)	46727.	tons

Burnt dolomite (37% MgO+58% CaO)	145000.	tons
Soda lye (45% NaOH)	142.	tons
Sodium bicarbonate	1750.	tons
Zinc oxide (ash)	2820.	tons
Sodium carbonate 98%	4948.	tons
Sodium chloride	72703.	tons
Sodium hydroxide (100% NaOH)	1125.	tons
Sodium hydroxide (50%)	11303.	tons
Soda lye (45%) solution	17600.	tons
Sodium pyrosulfite	5.	tons
Sodium silicate	80.	tons
Sulphur	1520.	tons
Carbon dioxide (100%)	36450.	tons
Lime	3500.	tons
Sulphuric acid	115238.	tons
Diesel oil	17819.	tons
Zinc ash (100% Zn)	1160.	tons
Bauxite (87% Al_2O_3)	9600.	tons
Aluminum hydroxide (as 100% Al_2O_3)	2078.	tons
Ammonia NH_3	2247.	tons
Alcohol	130.	tons
Potassium permanganate ($KMnO_4$)	3.	tons
Filter cloth	4.	tons
Fuel gas	60269400.	Nm^3
Natural gas	830000.	Nm^3
Filtriation agent	28.	tons
Drinking water	4800.	m^3
Chlorine (100%)	2025.	tons
Post-reduction aniline (55% Fe_2O_3)	4300.	tons
Ammonia water (29.4% NH_3)	350.	tons
Iron sheet	90.	tons
Scrap-iron	2869.	tons
Other compounds	819780.	US$
Sodium bichromate impure	1700.	tons
Ferrous sulphate as waste	4550.	tons

P R O C E S S E S

ANTIMONY TRIOXIDE	2000.	tons
ALUMINUM SULPHATE	30000.	tons
SODIUM TETRABORATE (BORAX)	5000.	tons
SODIUM PERBORATE	20000.	tons
PRECIPITATED CALCIUM CARBONATE	10000.	tons
CALCIUM CARBIDE	60000.	tons
CALCIUM HYPOCHLORITE	5000.	tons
AMMONIUM CHLORIDE	4000.	tons
SODIUM BICHROMATE	3000.	tons
SODIUM CHROMATE	1000.	tons
ANHYDROUS CHROMIC ACID	1000.	tons
CHROMOSAL - BASIC CHROMIUM SULPHATE	2000.	tons
COPPER SULPHATE	2000.	tons
ALUMINUM FLUORIDE	2200.	tons
IRON OXIDE (RED)	2000.	tons
FERROFERRIC OXIDES (BLACK)	1000.	tons
LEAD OXIDE (RED)	2000.	tons
MAGNESIUM OXIDE	50000.	tons
MANGANESE DIOXIDE	2000.	tons
MOLYBDENUM TRIOXIDE	140.	tons
NICKEL SULFATE	500.	tons
SODIUM TRIPOLYPHOSPHATE	50000.	tons
SODIUM HEXAMETAPHOSPHATE	1000.	tons
TRISODIUM PHOSPHATE	7500.	tons

DICALCIUM PHOSPHATE	40000.	tons
SODIUM GLAZE	5120.	tons
SODIUM WATER GLASS	12800.	tons
MOLECULAR SIEVE - ZEOLITES (cl. 4A)	500.	tons
SODIUM METASILICATE	10000.	tons
SODIUM THIOSULPHATE	1000.	tons
SODIUM HYDROGEN SULFITE	4000.	tons
SODIUM SULFITE	6.	tons
SODIUM HYDROSULFITE	2000.	tons
SODIUM CHLORIDE (MEDICAL)	1500.	tons
TITANIUM DIOXIDE	16396.	tons
ZINC CHLORIDE	4700.	tons
SODA ASH	45439.	tons

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Problem title: INORGANIC INDUSTRY

F r a c t i o n a l Optimization

Maximize:

$$\frac{\text{Yearly Profit}}{\text{Investment}} = 0.364 \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:

3.00E+02 < Investment < 1.00E+20 (0.0%) mil.$

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M A I N P A R A M E T E R S

Yearly Profit	109.	mil.$
Manufacturing Value Added	180.	mil.$
Investment	300.	mil.$
Yearly Import	20.	mil.$
Yearly Export	5.	mil.$
Yearly Domestic Purchase	139.	mil.$
Yearly Domestic Sale	336.	mil.$

S A L E

Ammonium chloride	4000.	tons
Antimony trioxide	2000.	tons
Boric acid	181.	tons
Calcium carbonate	144910.	tons
Calcium chloride	10000.	tons
Chromic acid anhydrous	1000.	tons
Chromosal - basic chromium sulphate	2000.	tons
Copper oxide (black)	40.	tons
Copper oxide (red)	100.	tons
Copper sulphate	2000.	tons
Cryolite (Na3AlF6)	4200.	tons
Dicalcium phosphate	40000.	tons
Calcium hypochloride	5000.	tons
Hydrogen fluoride	1000.	tons
Lead oxide (red)	2000.	tons
Lithopone (30%)	10000.	tons
Manganese dioxide	2000.	tons
Molybdenum trioxide III	140.	tons
Nickel sulphate	500.	tons
Aluminum sulphate (14% Al2O3)	30000.	tons
Precipitated calcium carbonate	10000.	tons
Precipitated calcium carbonate(tooth p.)	1000.	tons
Silica gel (macro)	1500.	tons
Sodium bichromate	1920.	tons

Calcium carbide	60000.	tons
Sodium hydrogen sulfite	4000.	tons
Sodium chromate	1000.	tons
Sodium hexametaphosphate	1000.	tons
Sodium hydrosulfite	2000.	tons
Sodium metasilicate pentahydrate	10000.	tons
Sodium perborate	20000.	tons
Sodium sulfite	1994.	tons
Sodium tetraborate (Borax)	5000.	tons
Sodium thiosulfate	1000.	tons
Sodium tripolyphosphate	49990.	tons
Magnesium oxide	50000.	tons
Trisodium phosphate	7500.	tons
Zinc chloride (as 100% ZnCl2)	4700.	tons
Aluminum fluoride	2200.	tons
Gas waste	2384518000.	m3
Liquid waste	2739424.	m3
Solid waste	195048.	tons
Iron oxide (red)	2000.	tons
Ferroferric oxide (black)	1000.	tons
Sodium chloride (medical)	1500.	tons
Titanium dioxide	20000.	tons
Zeolites cl.4A	500.	tons
Sulphuric acid 75%	30200.	tons

P U R C H A S E

Electrical energy	368060100.	kwh
Water	34529870.	m3
Steam	3226068.	GJ
Cooling water	4394660.	m3
Process water	622955.	m3
Demineralized water	45390.	m3
Compressed air	29796900.	Nm3
Hot air	66000.	Nm3
Ammonium nitrate	4680.	tons
Antilumper	24.	tons
Antimony (metalic)	1722.	tons
Compressed nitrogen	300000.	Nm3
Barium ore (as 100% BaS)	5350.	tons
Burnt lime (CaO)	117000.	tons
Charcoal	5.	tons
Chromate and bichromate(calc.66.3%CrO3)	680.	tons
Chromium ore	4800.	tons
Carbon dioxide (CO2 gas 40%)	400.	tons
Coal	2484.	tons
Coke	42427.	tons
Electrodes	180.	tons
Colemanite (boron ore 40%)	19128.	tons
Copper scrap	662.	tons
Diatomite	250.	tons
Dolomite	14640.	tons
Fluosilicic acid as waste	8046.	tons
Ground phosphate rock	5000.	tons
Hydrochloric acid (as 100%)	2538.	tons
Nitric acid (as 65% HNO3)	1814.	tons
Hydrate lime [99.5 Ca(OH)2]	3800.	tons
Hydrofluoric acid 70%	5.	tons
Hydrogen peroxide	4740.	tons
Elecrode mass	1080.	tons
Limestone (98% CaCO3)	75090.	tons
Magnesium sulphate	80.	tons

Manganese ore (30% Mn)	4500.	tons
Molybdenum ore	155.	tons
Sodium hydroxide (45%)	398.	tons
Calcium hydroxide Ca(OH)2	19.	tons
Lead (as metal)	1827.	tons
Phosphoric acid (30% P2O5)	43200.	tons
Phosphoric acid (75% H3PO4)	62130.	tons
Post distillation slurry	150000.	m3
Raw nickel sulphate	504.	tons
Rock salt (100% NaCL)	6700.	tons
Sand	6535.	tons
Sulphur dioxide SO2 (as 100% H2SO4)	4755.	tons
Illemanite ore (49.5% TiO2)	57000.	tons
Burnt dolomite (37% MgO+58% CaO)	145000.	tons
Soda lye (45% NaOH)	142.	tons
Sodium bicarbonate	1750.	tons
Zinc oxide (ash)	2820.	tons
Sodium carbonate 98%	5845.	tons
Sodium chloride	79150.	tons
Sodium hydroxide (100% NaOH)	1125.0	tons
Sodium hydroxide (50%)	13445.	tons
Soda lye (45%) solution	17600.	tons
Sodium pyrosulfite	1596.	tons
Sodium silicate	80.	tons
Sulphur	1520.	tons
Carbon dioxide (100%)	36450.	tons
Lime	3500.	tons
Sulphuric acid	163159.	tons
Diesel oil	18900.	tons
Zinc ash (100% Zn)	1160.	tons
Active carbon	2.	tons
Bauxite (87% Al2O3)	9600.	tons
Aluminum hydroxide (as 100% Al2O3)	3254.	tons
Ammonia NH3	3219.	tons
Alcohol	130.	tons
Potassium permanganate (KMnO4)	3.	tony
Filter cloth	4.	tons
Fuel gas	61291340.	Nm3
Natural gas	830000.	Nm3
Carbon dioxide (CO2) food grade)	150000.	m3
Coke oven gas	5000000.	Nm3
Filtriation agent	28.	tons
Drinking water	4800.	m3
Chlorine (100%)	2025.	tons
Post-reduction aniline (55% Fe2O3)	4300.	tons
Ammonia water (29.4% NH3)	350.	tons
Iron sheet	90.	tons
Scrap-iron	3500.	tons
Cooling brine	2090.	GJ
Other compounds	1000000.	US$
Soda ash in solution	1039.	tons
Sodium bichromate impure	1700.	tons
Ferrous sulphate as waste	4550.	tons
Zinc sulphate (as raw mat.)	5070.	tons

P R O C E S S E S

ANTIMONY TRIOXIDE	2000.	tons
ALUMINUM SULPHATE	30000.	tons
LITHOPONE 30%	10000.	tons
SODIUM TETRABORATE (BORAX)	5000.	tons
BORIC ACID	181.	tons

SODIUM PERBORATE	20000. tons
PRECIPITATED CALCIUM CARBONATE	10000. tons
PRECIPITATED CALCIUM CARBONATE(TOOTH P.)	1000. tons
CALCIUM CARBIDE	60000. tons
CALCIUM HYPOCHLORITE	5000. tons
CALCIUM CHLORIDE	10000. tons
AMMONIUM CHLORIDE	4000. tons
SODIUM BICHROMATE	3000. tons
SODIUM CHROMATE	1000. tons
ANHYDROUS CHROMIC ACID	1000. tons
CHROMOSAL - BASIC CHROMIUM SULPHATE	2000. tons
COPPER OXIDE (BLACK)	40. tons
COPPER OXIDE (RED)	100. tons
COPPER SULPHATE	2000. tons
CRYOLITE - ALUMINUM SODIUM FLUORIDE	4200. tons
ALUMINUM FLUORIDE	2200. tons
HYDROGEN FLUORIDE	1000. tons
IRON OXIDE (RED)	2000. tons
FERROFERRIC OXIDES (BLACK)	1000. tons
LEAD OXIDE (RED)	2000. tons
MAGNESIUM OXIDE	50000. tons
MANGANESE DIOXIDE	2000. tons
MOLYBDENUM TRIOXIDE	140. tons
NICKEL SULFATE	500. tons
SODIUM TRIPOLYPHOSPHATE	50000. tons
SODIUM HEXAMETAPHOSPHATE	1000. tons
TRISODIUM PHOSPHATE	7500. tons
DICALCIUM PHOSPHATE	40000. tons
SODIUM GLAZE	7970. tons
SODIUM WATER GLASS	19925. tons
MOLECULAR SIEVE - ZEOLITES (cl. 4A)	500. tons
SILICA GEL (MACRO)	1500. tons
SODIUM METASILICATE	10000. tons
SODIUM THIOSULPHATE	1000. tons
SODIUM HYDROGEN SULFITE	4000. tons
SODIUM SULFITE	2000. tons
SODIUM HYDROSULFITE	2000. tons
SODIUM CHLORIDE (MEDICAL)	1500. tons
TITANIUM DIOXIDE	20000. tons
ZINC CHLORIDE	4700. tons
SODA ASH	46608. tons

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Problem title: INORGANIC INDUSTRY

Fractional Optimization

Maximize:

$$\frac{\text{Yearly Profit}}{\text{Investment}} = 0.306 \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:
3.50E+02 < Investment < 1.00E+20 (0.0%) mil.$

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MAIN PARAMETERS

Yearly Profit	107.	mil.$
Manufacturing Value Added	188.	mil.$
Investment	350.	mil.$
Yearly Import	20.	mil.$
Yearly Export	7.	mil.$
Yearly Domestic Purchase	147.	mil.$
Yearly Domestic Sale	351.	mil.$

SALE

Ammonium chloride	4000.	tons
Antimony trioxide	2000.	tons
Barium Carbonate	3000.	tons
Boric acid	8000.	tons
Calcium carbonate	144910.	tons
Calcium chloride	10000.	tons
Chromic acid anhydrous	1000.	tons
Chromosal - basic chromium sulphate	2000.	tons
Copper oxide (black)	40.	tons
Copper oxide (red)	100.	tons
Copper sulphate	2000.	tons
Cryolite (Na_3AlF_6)	4200.	tons
Dicalcium phosphate	40000.	tons
Calcium hypochloride	5000.	tons
Hydrogen fluoride	1000.	tons
Lead oxide (red)	2000.	tons
Lithopone (30%)	10000.	tons
Manganese dioxide	2000.	tons
Molybdenum trioxide III	140.	tons
Nickel sulphate	500.	tons
Potassium bichromate	1000.	tons
Potassium chlorate	1000.	tons
Aluminum sulphate (14% Al_2O_3)	30000.	tons
Precipitated calcium carbonate	10000.	tons

Precipitated calcium carbonate(tooth p.)	1000.	tons
Silica gel (macro)	1500.	tons
Soda ash (100%)	8231.	tons
Potassium nitrate	2000.	tons
Sodium bichromate	910.	tons
Calcium carbide	60000.	tons
Sodium hydrogen sulfite	4000.	tons
Sodium chromate	1000.	tons
Sodium glaze	1000.	tons
Sodium hexametaphosphate	1000.	tons
Sodium hydrosulfite	2000.	tons
Sodium metasilicate pentahydrate	10000.	tons
Sodium perborate	20000.	tons
Sodium sulfide	912.	tons
Sodium sulfite	1994.	tons
Sodium tetraborate (Borax)	5000.	tons
Sodium thiosulfate	1000.	tons
Sodium tripolyphosphate	49990.	tons
Sodium water glass (36% grade..)	40075.	tons
Magnesium oxide	50000.	tons
Trisodium phosphate	7500.	tons
Zinc chloride (as 100% ZnCl2)	4700.	tons
Aluminum fluoride	2200.	tons
Gas waste	2388835000.	m3
Liquid waste	2888620.	m3
Solid waste	212542.	tons
Iron oxide (red)	2000.	tons
Ferroferric oxide (black)	1000.	tons
Sodium chloride (medical)	1500.	tons
Titanium dioxide	20000.	tons
Zeolites cl.4A	500.	tons
Sulphuric acid 75%	30200.	tons

P U R C H A S E

Electrical energy	378896500.	kwh
Water	39030150.	m3
Steam	3579755.	GJ
Cooling water	4844000.	m3
Process water	650000.	m3
Demineralized water	45390.	m3
Compressed air	31339600.	Nm3
Hot air	66000.	Nm3
Ammonium nitrate	4680.	tons
Antilumper	24.	tons
Antimony (metalic)	1722.	tons
Barium chloride (BaCl2)	9.	tons
Barite ore (as 100% BaSO4)	6000.	tons
Compressed nitrogen	300000.	Nm3
Barium ore (as 100% BaS)	5350.	tons
Burnt lime (CaO)	117000.	tons
Charcoal	5.	tons
Chromate and bichromate(calc.66.3%CrO3)	680.	tons
Chromium ore	4800.	tons
Carbon dioxide (CO2 gas 40%)	400.	tons
Coal	2484.	tons
Coke	45927.	tons
Electrodes	180.	tons
Colemanite (boron ore 40%)	32420.	tons
Copper scrap	662.	tons
Diatomite	250.	tons
Dolomite	14640.	tons

Fluosilicic acid as waste	8046.	tons
Ground phosphate rock	5000.	tons
Hydrochloric acid (as 100%)	2600.	tons
Nitric acid (as 100% HNO3)	164.	tons
Nitric acid (as 65% HNO3)	1814.	tons
Hydrate lime [99.5 Ca(OH)2]	3800.	tons
Hydrofluoric acid 70%	5.	tons
Hydrogen peroxide	4740.	tons
Elecrode mass	1080.	tons
Potassium carbonate (99% K2CO3)	2.	tons
Potassium hydroxide 90%	49.	tons
Limestone (98% CaCO3)	96604.	tons
Magnesium sulphate	80.	tons
Manganese ore (30% Mn)	4500.	tons
Molybdenum ore	155.	tons
Sodium hydroxide (45%)	1200.	tons
Calcium hydroxide CaOH2	19.	tons
Nitric oxides as byproduct	1410.	tons
Lead (as metal)	1827.	tons
Phosphoric acid (38% P2O5)	43200.	tons
Phosphoric acid (75% H3PO4)	62130.	tons
Post distillation slurry	150000.	m3
Potassium chloride	2990.	tons
Raw nickel sulphate	504.	tons
Rock salt (100% NaCL)	6700.	tons
Sand	20500.	tons
Sulphur dioxide SO2 (as 100% H2SO4)	4755.	tons
Illemanite ore (49.5% TiO2)	57000.	tons
Burnt dolomite (37% MgO+58% CaO)	145000.	tons
Soda lye (45% NaOH)	142.	tons
Sodium bicarbonate	1750.	tons
Zinc oxide (ash)	2820.	tons
Sodium carbonate 98%	7777.	tons
Sodium chloride	105630.	tons
Sodium hydroxide (100% NaOH)	1125.	tons
Sodium hydroxide (50%)	13445.	tons
Soda lye (45%) solution	17600.	tons
Sodium pyrosulfite	1596.	tons
Sodium silicate	80.	tons
Sulphur	1520.	tons
Carbon dioxide (100%)	36450.	tons
Lime	3500.	tons
Sulphuric acid	169258.	tons
Diesel oil	18900.	tons
Zinc ash (100% Zn)	1160.	tons
Active carbon	2.	tons
Bauxite (87% Al2O3)	9600.	tons
Aluminum hydroxide (as 100% Al2O3)	3254.	tons
Ammonia NH3	3302.	tons
Alcohol	130.	tons
Potassium permanganate (KMnO4)	3.	tony
Filter cloth	4.	tons
Fuel gas	66618000.	Nm3
Natural gas	830000.	Nm3
Carbon dioxide (CO2) food grade)	150000.	m3
Coke oven gas	5000000.	Nm3
Filtriation agent	28.	tons
Drinking water	4800.	m3
Chlorine (100%)	2025.	tons
Post-reduction aniline (55% Fe2O3)	4300.	tons
Ammonia water (29.4% NH3)	350.	tons
Iron sheet	90.	tons
Scrap-iron	3500.	tons
Cooling brine	2090.	GJ
Other compounds	1000000.	US$
Soda ash in solution	1039.	tons

Sodium bichromate impure	1700.	tons
Ferrous sulphate as waste	4550.	tons
Zinc sulphate (as raw mat.)	5070.	tons

PROCESSES

ANTIMONY TRIOXIDE	2000.	tons
ALUMINUM SULPHATE	30000.	tons
BARIUM CARBONATE	3000.	tons
LITHOPONE 30%	10000.	tons
SODIUM TETRABORATE (BORAX)	5000.	tons
BORIC ACID	8000.	tons
SODIUM PERBORATE	20000.	tons
PRECIPITATED CALCIUM CARBONATE	10000.	tons
PRECIPITATED CALCIUM CARBONATE(TOOTH P.)	1000.	tons
CALCIUM CARBIDE	60000.	tons
CALCIUM HYPOCHLORITE	5000.	tons
CALCIUM CHLORIDE	10000.	tons
AMMONIUM CHLORIDE	4000.	tons
SODIUM BICHROMATE	3000.	tons
SODIUM CHROMATE	1000.	tons
POTASSIUM BICHROMATE	1000.	tons
ANHYDROUS CHROMIC ACID	1000.	tons
CHROMOSAL - BASIC CHROMIUM SULPHATE	2000.	tons
COPPER OXIDE (BLACK)	40.	tons
COPPER OXIDE (RED)	100.	tons
COPPER SULPHATE	2000.	tons
CRYOLITE - ALUMINUM SODIUM FLUORIDE	4200.	tons
ALUMINUM FLUORIDE	2200.	tons
HYDROGEN FLUORIDE	1000.	tons
IRON OXIDE (RED)	2000.	tons
FERROFERRIC OXIDES (BLACK)	1000.	tons
LEAD OXIDE (RED)	2000.	tons
MAGNESIUM OXIDE	50000.	tons
MANGANESE DIOXIDE	2000.	tons
MOLYBDENUM TRIOXIDE	140.	tons
NICKEL SULFATE	500.	tons
SODIUM TRIPOLYPHOSPHATE	50000.	tons
SODIUM HEXAMETAPHOSPHATE	1000.	tons
TRISODIUM PHOSPHATE	7500.	tons
DICALCIUM PHOSPHATE	40000.	tons
POTASSIUM CHLORATE	1000.	tons
POTASSIUM NITRATE	2000.	tons
SODIUM GLAZE	25000.	tons
SODIUM WATER GLASS	60000.	tons
MOLECULAR SIEVE - ZEOLITES (cl. 4A)	500.	tons
SILICA GEL (MACRO)	1500.	tons
SODIUM METASILICATE	10000.	tons
SODIUM THIOSULPHATE	1000.	tons
SODIUM HYDROGEN SULFITE	4000.	tons
SODIUM SULFITE	2000.	tons
SODIUM HYDROSULFITE	2000.	tons
SODIUM CHLORIDE (MEDICAL)	1500.	tons
SODIUM NITRATE	2000.	tons
TITANIUM DIOXIDE	20000.	tons
ZINC CHLORIDE	4700.	tons
SODA ASH	63157.	tons

Problem title: INORGANIC INDUSTRY

Fractional Optimization

Maximize:

$$\frac{\text{Yearly Profit}}{\text{Investment}} = 0.271 \frac{\text{mil.\$}}{\text{mil.\$}}$$

Scenario:

3.84E+02 < Investment < 1.00E+20 (0.0%) mil.$

MAIN PARAMETERS

Yearly Profit	104.	mil.$
Manufacturing Value Added	193.	mil.$
Investment	384.	mil.$
Yearly Import	20.	mil.$
Yearly Export	7.	mil.$
Yearly Domestic Purchase	154.	mil.$
Yearly Domestic Sale	362.	mil.$

SALE

Ammonium chloride	4000.	tons
Antimony trioxide	2000.	tons
Barium Carbonate	3000.	tons
Ferrous sulphate - 7 hydrate	1000.	tons
Barium chloride (BaCl2.2H2O 100%)	488.	tons
Barium hydroxide	1500.	tons
Boric acid	8000.	tons
Calcium carbonate	144910.	tons
Calcium chloride	10000.	tons
Chromic acid anhydrous	1000.	tons
Chromosal - basic chromium sulphate	2000.	tons
Copper oxide (black)	40.	tons
Copper oxide (red)	100.	tons
Pickling acid (24% H2SO4,10% FeSO4)	5250.	tons
Copper sulphate	2000.	tons
Cryolite (Na3AlF6)	4200.	tons
Dicalcium phosphate	40000.	tons
Calcium hypochloride	5000.	tons
Hydrogen fluoride	1000.	tons
Hydrogen sulfide	200.	tons
Lead oxide (red)	2000.	tons
Lithopone (30%)	10000.	tons
Manganese dioxide	2000.	tons
Molybdenum trioxide III	140.	tons

Nickel sulphate	500.	tons
Potassium bichromate	1000.	tons
Potassium carbonate (K2CO3)	999.	tons
Potassium chlorate	1000.	tons
Aluminum sulphate (14% Al2O3)	30000.	tons
Precipitated calcium carbonate	10000.	tons
Precipitated calcium carbonate(tooth p.)	1000.	tons
Silica gel (macro)	1500.	tons
Soda ash (100%)	41066.	tons
Potassium nitrate	2000.	tons
Sodium bichromate	910.	tons
Calcium carbide	60000.	tons
Sodium hydrogen sulfite	4000.	tons
Sodium chrómate	1000.	tons
Sodium gláze	1000.	tons
Sodium hexametaphosphate	1000.	tons
Sodium hydrosulfite	2000.	tons
Sodium metasilicate pentahydrate	10000.	tons
Sodium nitrate	6000.	tons
Sodium perborate	20000.	tons
Sodium pyrophosphate - dibasic	300.	tons
Sodium sulfide	912.	tons
Sodium sulfite	1994.	tons
Sodium tetraborate (Borax)	5000.	tons
Sodium thiosulfate	1000.	tons
Sodium tripolyphosphate	49990.	tons
Sodium water glass (36% grade..)	40075.	tons
Magnesium oxide	50000.	tons
Trisodium phosphate	7500.	tons
Zinc chloride (as 100% ZnCl2)	4700.	tons
Zinc sulphate (as 100% ZnSO4)	1000.	tons
Aluminum fluoride	2200.	tons
Gas waste	2401718000.	m3
Liquid waste	3440245.	m3
Solid waste	225312.	tons
Iron oxide (red)	2000.	tons
Ferroferric oxide (black)	1000.	tons
Sodium chloride (medical)	1500.	tons
Titanium dioxide	20000.	tons
Zeolites cl.4A	500.	tons
Sulphuric acid 75%	30200.	tons

P U R C H A S E

Electrical energy	386295200.	kwh
Water	45152440.	m3
Steam	4154291.	GJ
Cooling water	4929000.	m3
Process water	661000.	m3
Demineralized water	45390.	m3
Compressed air	35339600.	Nm3
Hot air	66000.	Nm3
Ammonium nitrate	4600.	tons
Antilumper	24.	tons
Antimony (metalic)	1722.	tons
Barium chloride (BaCl2)	9.	tons
Barite ore (as 100% BaSO4)	9020.	tons
Compressed nitrogen	300000.	Nm3
Barium ore (as 100% BaS)	5350.	tons
Burnt lime (CaO)	117000.	tons
Charcoal	5.	tons
Chromate and bichromate(calc.as.33%CrO3)	600.	tons

Chromium ore	4800.	tons
Carbon dioxide (CO_2 gas 40%)	400.	tons
Coal	7217.	tons
Coke	50884.	tons
Electrodes	180.	tons
Colemanite (boron ore 40%)	32420.	tons
Copper scrap	662.	tons
Diatomite	250.	tons
Dolomite	14640.	tons
Fluosilicic acid as waste	8046.	tons
Ground phosphate rock	5000.	tons
Hydrochloric acid (as 100%)	3270.	tons
Nitric acid (as 100% HNO_3)	656.	tons
Nitric acid (as 65% HNO_3)	1814.	tons
Hydrate lime [99.5 $Ca(OH)_2$]	3800.	tons
Hydrofluoric acid 70%	5.	tons
Hydrogen peroxide	4740.	tons
Elecrode mass	1080.	tons
Potassium carbonate (99% K_2CO_3)	2.	tons
Potassium hydroxide 90%	49.	tons
Limestone (98% $CaCO_3$)	144500.	tons
Magnesium sulphate	80.	tons
Manganese ore (30% Mn)	4500.	tons
Molasses oven coke	2996.	tons
Molybdenum ore	155.	tons
Sodium hydroxide (45%)	1200.	tons
Calcium hydroxide $CaOH_2$	19.	tons
Nitric oxides as byproduct	5640.	tons
Lead (as metal)	1827.	tons
Phosphoric acid (38% P_2O_5)	43200.	tons
Phosphoric acid (75% H_3PO_4)	62602.	tons
Post distillation slurry	150000.	m3
Potassium chloride	2990.	tons
Raw nickel sulphate	504.	tons
Rock salt,(100% NaCl)	6700.	tons
Sand	20500.	tons
Sulphur dioxide SO_2 (as 100% H_2SO_4)	4755.	tons
Illemanite ore (49.5% TiO_2)	57000.	tons
Burnt dolomite (37% MgO+58% CaO)	145000.	tons
Soda lye (45% NaOH)	142.	tons
Sodium bicarbonate	1750.	tons
Zinc oxide (ash)	2820.	tons
Sodium carbonate 98%	7966.	tons
Sodium chloride	164578.	tons
Sodium hydroxide (100% NaOH)	1125.	tons
Sodium hydroxide (50%)	14441.	tons
Sodium hydroxide (98%)	20.	tons
Soda lye (45%) solution	17600.	tons
Sodium pyrosulfite	1596.	tons
Sodium silicate	80.	tons
Sulphur	1520.	tons
Carbon dioxide (100%)	36450.	tons
Lime	3500.	tons
Sulphuric acid	170198.	tons
Diesel oil	18900.	tons
Zinc ash (100% Zn)	1160.	tons
Zinc scrap in zinc extraction (100% Zn)	255.	tons
Spent pickling acid	6350.	tons
Active carbon	2.	tons
Bauxite (87% Al_2O_3)	9600.	tons
Aluminum hydroxide (as 100% Al_2O_3)	3254.	tons
Ammonia NH_3	3486.	tons
Alcohol	130.	tons
Potassium permanganate ($KMnO_4$)	3.	tony
Filter cloth	4.	tons
Condensate	27961.	tons

Fuel gas	66829560.	Nm3
Natural gas	830000.	Nm3
Carbon dioxide (CO_2) food grade)	150000.	m3
Coke oven gas	5000000.	Nm3
Filtriation agent	28.	tons
Drinking water	4800.	m3
Chlorine (100%)	2025.	tons
Post-reduction aniline (55% Fe_2O_3)	4300.	tons
Ammonia water (29.4% NH_3)	350.	tons
Iron sheet	90.	tons
Scrap-iron	3500.	tons
Cooling brine	2090.	GJ
Other compounds	1000000.	US$
Soda ash in solution	1039.	tons
Sodium bichromate impure	1700.	tons
Ferrous sulphate as waste	4550.	tons
Zinc sulphate (as raw mat.)	5070.	tons

P R O C E S S E S

ANTIMONY TRIOXIDE	2000.	tons
ALUMINUM SULPHATE	30000.	tons
BARIUM CHLORIDE	2000.	tons
BARIUM CARBONATE	3000.	tons
LITHOPONE 30%	10000.	tons
BARIUM HYDROXIDE	1500.	tons
SODIUM TETRABORATE (BORAX)	5000.	tons
BORIC ACID	8000.	tons
SODIUM PERBORATE	20000.	tons
PRECIPITATED CALCIUM CARBONATE	10000.	tons
PRECIPITATED CALCIUM CARBONATE(TOOTH P.)	1000.	tons
CALCIUM CARBIDE	60000.	tons
CALCIUM HYPOCHLORITE	5000.	tons
CALCIUM CHLORIDE	10000.	tons
AMMONIUM CHLORIDE	4000.	tons
SODIUM BICHROMATE	3000.	tons
SODIUM CHROMATE	1000.	tons
POTASSIUM BICHROMATE	1000.	tons
ANHYDROUS CHROMIC ACID	1000.	tons
CHROMOCAL - BASIC CHROMIUM SULPHATE	2000.	tons
COPPER OXIDE (BLACK)	40.	tons
COPPER OXIDE (RED)	100.	tons
COPPER SULPHATE	2000.	tons
CRYOLITE - ALUMINUM SODIUM FLUORIDE	4200.	tons
ALUMINUM FLUORIDE	2200.	tons
HYDROGEN FLUORIDE	1000.	tons
IRON OXIDE (RED)	2000.	tons
FERROFERRIC OXIDES (BLACK)	1000.	tons
FERROUS SULPHATE	1000.	tons
LEAD OXIDE (RED)	2000.	tons
MAGNESIUM OXIDE	50000.	tons
MANGANESE DIOXIDE	2000.	tons
MOLYBDENUM TRIOXIDE	140.	tons
NICKEL SULFATE	500.	tons
SODIUM TRIPOLYPHOSPHATE	50000.	tons
SODIUM HEXAMETAPHOSPHATE	1000.	tons
SODIUM PYROPHOSPHATE (DIBASIC)	300.	tons
TRISODIUM PHOSPHATE	7500.	tons
DICALCIUM PHOSPHATE	40000.	tons
POTASSIUM CARBONATE	999.	tons
POTASSIUM CHLORATE	1000.	tons
POTASSIUM NITRATE	2000.	tons

SODIUM GLAZE	25000.	tons
SODIUM WATER GLASS	60000.	tons
MOLECULAR SIEVE - ZEOLITES (cl. 4A)	500.	tons
SILICA GEL (MACRO)	1500.	tons
SODIUM METASILICATE	10000.	tons
SODIUM THIOSULPHATE	1000.	tons
SODIUM HYDROGEN SULFITE	4000.	tons
SODIUM SULFITE	2000.	tons
SODIUM HYDROSULFITE	2000.	tons
SODIUM CHLORIDE (MEDICAL)	1500.	tons
SODIUM NITRATE	8000.	tons
TITANIUM DIOXIDE	20000.	tons
ZINC SULFATE	1000.	tons
ZINC CHLORIDE	4700.	tons
SODA ASH	100000.	tons

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B6. Final experiments reports

PDA : INORGANIC INDUSTRY

Fixed Capital Investment - FCI :	426.151 mln.$	(425.488)
Domestic Investment :	417.361 mln.L.C.	
PDA Net Income - NI :	228.407 mln.L.C.	
NI/FCI :	0.536	(1.9 years)
PDA Import :	32.400 mln.$	
Manufact. Value Added - MVA :	318.938 mln.L.C.	
MVA/FCI :	0.748	
Production Profit :	228.407 mln.L.C.	
Simple Rate of Return :	0.536	(1.9 years)
Production Import :	32.400 mln.$	
Manufact. Value Added - MVA :	318.938 mln.L.C.	
MVA/FCI :	0.748	
MVA/Value of Production :	0.539	
Export :	106.462 mln.$	
Domestic Purchase :	225.302 mln.L.C.	
Domestic Sale :	484.880 mln.L.C.	
Energy Consumption :	421660.600 TJ	
Direct Labour :	1994 men	
Supervision :	248 men	
Lab & Control :	202 men	

Process Project		Level	%
1	ANTIMONY TRIOXIDE	3000 tons	100
2	ALUMINUM SULPHATE	35000 tons	100
9	SODIUM TETRABORATE (BORAX)	15000 tons	100
10	BORIC ACID	12000 tons	100
11	SODIUM PERBORATE	50000 tons	100
12	PRECIPITATED CALCIUM CARBONATE	100000 tons	100
13	PRECIPITATED CALCIUM CARBONATE(TOOTH P.)	4000 tons	100
14	CALCIUM CARBIDE	60000 tons	100
15	CALCIUM HYPOCHLORITE	7000 tons	100
17	AMMONIUM CHLORIDE	1000 tons	100
19	SODIUM CHROMATE	1500 tons	100
20	POTASSIUM BICHROMATE	2000 tons	100
21	ANHYDROUS CHROMIC ACID	1500 tons	100
23	COPPER OXIDE (BLACK)	40 tons	100
24	COPPER OXIDE (RED)	400 tons	100
25	COPPER SULPHATE	2000 tons	100
26	CRYOLITE - ALUMINUM SODIUM FLUORIDE	2700 tons	100
27	ALUMINUM FLUORIDE	2700 tons	100
29	IRON OXIDE (RED)	7000 tons	100
30	FERROFERRIC OXIDES (BLACK)	5000 tons	100
31	FERROUS SULPHATE	3500 tons	100
32	LEAD OXIDE (RED)	4000 tons	100
34	MANGANESE DIOXIDE	11000 tons	100
35	MOLYBDENUM TRIOXIDE	2500 tons	100
36	NICKEL SULFATE	300 tons	100
37	SODIUM TRIPOLYPHOSPHATE	70000 tons	100
38	SODIUM HEXAMETAPHOSPHATE	1000 tons	100
40	TRISODIUM PHOSPHATE	7500 tons	100
41	DICALCIUM PHOSPHATE	40000 tons	100
42	POTASSIUM CARBONATE	3000 tons	100
43	POTASSIUM CHLORATE	4000 tons	100
44	POTASSIUM NITRATE	6000 tons	100
45	SODIUM GLAZE	32000 tons	100
46	SODIUM WATER GLASS	80000 tons	100
47	MOLECURAL SIEVE-ZEOLITES (cl. 3A)	1000 tons	100
51	SODIUM THIOSULPHATE	1000 tons	100
52	SODIUM HYDROGEN SULFITE	8000 tons	100
53	SODIUM SULFITE	12000 tons	100
54	SODIUM HYDROSULFITE	9000 tons	100
55	SODIUM CHLORIDE (MEDICAL)	2500 tons	100
56	SODIUM NITRATE	12000 tons	100
57	TITANIUM DIOXIDE	50000 tons	100
59	ZINC CHLORIDE	6500 tons	100
63	SODA ASH	150000 tons	100
50	SODIUM METASILICATE	69480 tons	87

	Medium	Import	Value %
59	Hydrogen peroxide	11812 tors	36.093
60	Elecrode máss	1080 tons	27.667
122	Sodium pyrosulfite	9576 tons	10.640
190	Other compounds	2500000 US$	7.716
177	Post-reduction aniline (55% Fe2O3)	15050 tons	5.574
38	Electrodes	180 tons	4.556
87	Potassium chloride	10020 tons	3.578
153	Aluminum hydroxide (as 100% Al2O3)	3476 tons	1.920
51	Ground phosphate rock	7000 tons	0.756
68	Magnesium sulphate	200 tons	0.596
63	Potassium hydroxide 90%	196 tons	0.496
163	Filter cloth	6 tons	0.173
172	Filtriation agent	70 tons	0.108
11	Antilumper	6 tons	0.074
157	Potassium permanganate (KMnO4)	4 tony	0.029
62	Potassium carbonate (99% K2CO3)	10 tons	0.024
57	Hydrofluoric acid 70%	3 tons	0.009

	Medium	Export	Value %
104	Calcium carbide	40000 tons	33.815
185	Titanium dioxide	15000 tons	28.179
120	Sodium perborate	10000 tons	10.332
128	Sodium tetraborate (Borax)	5000 tons	5.176
69	Manganese dioxide	3000 tons	4.892
13	Antimony trioxide	1500 tons	4.790
31	Chromic acid anhydrous	1000 tons	2.443
84	Potassium bichromate	1300 tons	2.222
90	Precipitated calcium carbonate(tooth p.)	2000 tons	1.700
144	Trisodium phosphate	1500 tons	1.631
64	Lead oxide (red)	2000 tons	1.615
117	Sodium hydrosulfite	1000 tons	1.468
110	Sodium chromate	700 tons	0.971
112	Sodium hexametaphosphate	600 tons	0.764

	Medium	Domestic Purchase	Value %
82	Phosphoric acid (75% H_3PO_4)	85330 tons	13.672
140	Sulphuric acid	326870 tons	11.606
81	Phosphoric acid (33% P_2O_5)	43200 tons	7.286
39	Colemanite (boron ore 40%)	69850 tons	6.976
3	Steam	7590380 GJ	6.570
72	Molybdenum ore	2765 tons	6.136
65	Limestone (98% $CaCO_3$)	340000 tons	4.527
1	Electrical energy	397670500 kwh	4.413
114	Sodium hydroxide (50%)	43534 tons	3.727
12	Antimony (metalic)	2583 tons	3.325
141	Diesel oil	37180 tons	3.300
98	Illemanite ore (49.5% TiO_2)	142500 tons	2.530
27	Burnt lime (CaO)	117000 tons	2.404
109	Sodium chloride	242943 tons	2.135
37	Coke	65500 tons	1.744
145	Zinc ash (100% Zn)	5220 tons	1.413
116	Soda lye (45%) solution	17600 tons	1.356
152	Bauxite (87% Al_2O_3)	11200 tons	1.256
103	Sodium bichromate	2020 tons	1.127
2	Water	78548070 m3	1.046
192	Sodium bichromate impure	2550 tons	0.883
70	Manganese ore (30% Mn)	24750 tons	0.879
102	Sodium bicarbonate	5250 tons	0.874
105	Zinc oxide (ash)	3900 tons	0.779
179	Ammonia water (29.4% NH_3)	6250 tons	0.721
79	Lead (as metal)	3654 tons	0.642
194	Ferrous sulphate as waste	22750 tons	0.606
55	Nitric acid (as 65% HNO_3)	5600 tons	0.534
96	Sulphur dioxide SO_2 (as 100% H_2SO_4)	14875 tons	0.528
166	Fuel gas	8914530 Nm3	0.526
108	Sodium carbonate 98%	12665 tons	0.504
53	Hydrochloric acid (as 100%)	3758 tons	0.496
35	Coal	25064 tons	0.423
42	Copper scrap	970 tons	0.366
154	Ammonia NH_3	4251 tons	0.311
30	Chromate and bichromate(calc.66.3%CrO_3)	1020 tons	0.308
77	Nitric oxides as byproduct	8460 tons	0.300
136	Sulphur	4758 tons	0.285
113	Sodium hydroxide (100% NaOH)	1125 tons	0.275
174	Chlorine (100%)	2835 tons	0.264
56	Hydrate lime [99.5 $Ca(OH)_2$]	10100 tons	0.237
94	Sand	26240 tons	0.210
83	Post distillation slurry	90000 m3	0.200
148	Spent pickling acid	22225 tons	0.197
93	Rock salt (100% NaCl.)	19950 tons	0.175
48	Dolomite	9600 tons	0.170
184	Scrap-iron	8750 tons	0.155
169	Natural gas	2565000 Nm3	0.151
54	Nitric acid (as 100% HNO_3)	934 tons	0.135
49	Fluosilicic acid as waste	5751 tons	0.128
74	Sodium hydroxide (45%)	1600 tons	0.123
139	Lime	4900 tons	0.104
92	Raw nickel sulphate	302 tons	0.102
156	Alcohol	585 tons	0.099
46	Diatomite	350 tons	0.090
5	Process water	2017000 m3	0.090
191	Soda ash in solution	4156 tons	0.084
4	Cooling water	6014900 m3	0.080
71	Molasses oven coke	9000 tons	0.080
10	Ammonium nitrate	1070 tons	0.079

170	Carbon dioxide (CO_2) food grade)	600000 m3	0.076
101	Soda lye (45% NaOH)	781 tons	0.060
123	Sodium silicate	200 tons	0.053
7	Compressed air	74049000 Nm3	0.013
6	Demineralized water	170054 m3	0.013
180	Iron sheet	90 tons	0.010
15	Barium chloride ($BaCl_2$)	36 tons	0.008
150	Active carbon	6 tons	0.008
17	Compressed nitrogen	300000 Nm3	0.007
25	Calcium carbonate	54 tons	0.002
29	Charcoal	10 tons	0.002
75	Calcium hydroxide $Ca(OH)_2$	26 tons	0.001
165	Condensate	84000 tons	0.001
173	Drinking water	1200 m3	0.000
8	Hot air	268000 Nm3	0.000

	Medium	Domestic Sale	Value %
185	Titanium dioxide	35000 tons	14.437
130	Sodium tripolyphosphate	69960 tons	12.644
47	Dicalcium phosphate	40000 tons	9.899
120	Sodium perborate	40000 tons	9.074
89	Precipitated calcium carbonate	100000 tons	8.410
118	Sodium métasilicate pentahydrate	69480 tons	6.520
73	Molybdenum trioxide III	2500 tons	5.259
104	Calcium carbide	20000 tons	3.712
69	Manganese dioxide	8000 tons	2.864
117	Sodium hydrosulfite	8000 tons	2.579
97	Soda ash (100%)	71089 tons	2.423
128	Sodium tetraborate (Borax)	10000 tons	2.273
88	Aluminum sulphate (14% Al2O3)	35000 tons	1.870
24	Boric acid	12000 tons	1.675
144	Trisodium phosphate	6000 tons	1.432
175	Iron oxide (red)	7000 tons	1.384
126	Sodium sulfite	11994 tons	1.296
13	Antimony trioxide	1500 tons	1.052
50	Calcium hypochloride	7000 tons	1.011
176	Ferroferric oxide (black)	5000 tons	1.000
146	Zinc chloride (as 100% ZnCl2)	6500 tons	0.999
100	Potassium nitrate	6000 tons	0.866
106	Sodium hydrogen sulfite	8000 tons	0.749
86	Potassium chlorate	4000 tons	0.726
151	Aluminum fluoride	2700 tons	0.675
85	Potassium carbonate (K2CO3)	3000 tons	0.587
182	Sodium chloride (medical)	2500 tons	0.490
119	Sodium nitrate	6000 tons	0.423
44	Copper sulphate	2000 tons	0.422
45	Cryolite (Na3AlF6)	2700 tons	0.384
90	Precipitated calcium carbonate(tooth p.)	2000 tons	0.373
64	Lead oxide (red)	2000 tons	0.355
142	Zeolites cl.3A	1000 tons	0.330
31	Chromic acid anhydrous	500 tons	0.268
84	Potassium bichromate	700 tons	0.263
110	Sodium chromate	800 tons	0.244
41	Copper oxide (red)	400 tons	0.217
129	Sodium thiosulfate	1000 tons	0.207
43	Pickling acid (24% H2SO4,10% FeSO4)	18375 tons	0.155
19	Ferrous sulphate - 7 hydrate	3500 tons	0.119
76	Nickel sulphate	300 tons	0.116
112	Sodium hexametaphosphate	400 tons	0.112
9	Ammonium chloride	1000 tons	0.082
40	Copper oxide (black)	40 tons	0.022
158	Gas waste	2493236000 m3	0.000
159	Liquid waste	4255820 m3	0.000
160	Solid waste	383008 tons	0.000

Medium : 1 Electrical energy

47	MOLECURAL SIEVE-ZEOLITES (cl. 3A)	i	8000000	kwh
43	POTASSIUM CHLORATE	i	22000000	kwh
34	MANGANESE DIOXIDE	i	48400000	kwh
14	CALCIUM CARBIDE	i	180000000	kwh
38	SODIUM HEXAMETAPHOSPHATE	i	1270000	kwh
57	TITANIUM DIOXIDE	i	41500000	kwh
55	SODIUM CHLORIDE (MEDICAL)	i	1712500	kwh
35	MOLYBDENUM TRIOXIDE	i	1707500	kwh
54	SODIUM HYDROSULFITE	i	4950000	kwh
26	CRYOLITE - ALUMINUM SODIUM FLUORIDE	i	1404000	kwh
27	ALUMINUM FLUORIDE	i	1026000	kwh
42	POTASSIUM CARBONATE	i	1128000	kwh
56	SODIUM NITRATE	i	3540000	kwh
17	AMMONIUM CHLORIDE	i	260000	kwh
25	COPPER SULPHATE	i	520000	kwh
12	PRECIPITATED CALCIUM CARBONATE	i	22000000	kwh
36	NICKEL SULFATE	i	66000	kwh
10	BORIC ACID	i	2400000	kwh
20	POTASSIUM BICHROMATE	i	400000	kwh
30	FERROFERRIC OXIDES (BLACK)	i	1000000	kwh
13	PRECIPITATED CALCIUM CARBONATE(TOOTH P.)	i	780000	kwh
40	TRISODIUM PHOSPHATE	i	1440000	kwh
51	SODIUM THIOSULPHATE	i	171000	kwh
9	SODIUM TETRABORATE (BORAX)	i	2475000	kwh
37	SODIUM TRIPOLYPHOSPHATE	i	10500000	kwh
19	SODIUM CHROMATE	i	210000	kwh
11	SODIUM PERBORATE	i	6000000	kwh
63	SODA ASH	i	18000000	kwh
1	ANTIMONY TRIOXIDE	i	351000	kwh
41	DICALCIUM PHOSPHATE	i	4640000	kwh
52	SODIUM HYDROGEN SULFITE	i	920000	kwh
59	ZINC CHLORIDE	i	715000	kwh
32	LEAD OXIDE (RED)	i	412000	kwh
15	CALCIUM HYPOCHLORITE	i	700000	kwh
53	SODIUM SULFITE	i	1200000	kwh
29	IRON OXIDE (RED)	i	637000	kwh
44	POTASSIUM NITRATE	i	467400	kwh
21	ANHYDROUS CHROMIC ACID	i	75000	kwh
31	FERROUS SULPHATE	i	175000	kwh
2	ALUMINUM SULPHATE	i	1400000	kwh
50	SODIUM METASILICATE	i	2084408	kwh
45	SODIUM GLAZE	i	768000	kwh
23	COPPER OXIDE (BLACK)	i	463	kwh
46	SODIUM WATER GLASS	i	264000	kwh
24	COPPER OXIDE (RED)	i	1202	kwh

Problem title: INORGANIC INDUSTRY

Single Objective Optimization

Maximize:

PDA Yearly Profit	229.885 mil.$

Scenario:

	Antimony trioxide	=	1500.	(100.0%)	tons
1.20E+04 <	Boric acid	<	none	(0.0%)	tons
	Chromic acid anhydrous	=	500.	(100.0%)	tons
	Lead oxide (red)	=	2000.	(100.0%)	tons
	Manganese dioxide	=	8000.	(100.0%)	tons
	Potassium bichromate	=	700.	(100.0%)	tons
3.50E+04 <	Aluminum sulphate (14% Al2O3)	<	none	(0.0%)	tons
	Precipitated calcium carbonate(tooth p.)	=	2000.	(100.0%)	tons
0. <	Soda ash (100%)	<	40000.	(0.0%)	tons
	Calcium carbide	=	20000.	(100.0%)	tons
	Sodium chromate	=	800.	(100.0%)	tons
	Sodium hexametaphosphate	=	400.	(100.0%)	tons
	Sodium hydrosulfite	=	8000.	(100.0%)	tons
	Sodium perborate	=	40000.	(100.0%)	tons
0. <	Sodium sulfite	<	3000.	(0.0%)	tons
	Sodium tetraborate (Borax)	=	10000.	(100.0%)	tons
	Trisodium phosphate	=	6000.	(100.0%)	tons
0. <	Iron oxide (red)	<	10000.	(70.0%)	tons
0. <	Iron oxide (red)	<	3000.	(0.0%)	tons
	Titanium dioxide	=	35000.	(100.0%)	tons

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GLOBAL RESULTS

PDA Yearly Profit	230.	mil.$
PDA Value Added	312.	mil.$
Investment	385.	mil.$
Energy Consumption	412368.	TJ
Yearly Import	34.	mil.$
Energy Input	412368.	TJ
Yearly Export	104.	mil.$
Yearly Domestic Purchase	213.	mil.$
Yearly Domestic Sale	468.	mil.$

SALE

Antimony trioxide	1500.	tons
Antimony trioxide	1500.	tons
Ferrous sulphate - 7 hydrate	3500.	tons
Boric acid	12000.	tons

[illegible]	[illegible]	[illegible]
Chromic acid anhydrous	500.	tons
Copper oxide (black)	40.	tons
Copper oxide (red)	400.	tons
Pickling acid (24% H_2SO_4, 10% $FeSO_4$)	18375.	tons
Copper sulphate	2000.	tons
Dicalcium phosphate	40000.	tons
Calcium hypochloride	7000.	tons
Lead oxide (red)	2000.	tons
Lead oxide (red)	2000.	tons
Manganese dioxide	3000.	tons
Manganese dioxide	8000.	tons
Molybdenum trioxide III	2500.	tons
Nickel sulphate	300.	tons
Potassium bichromate	700.	tons
Potassium carbonate (K_2CO_3)	3000.	tons
Potassium chlorate	4000.	tons
Aluminum sulphate (14% Al_2O_3)	35000.	tons
Precipitated calcium carbonate	100000.	tons
Precipitated calcium carbonate(tooth p.)	2000.	tons
Precipitated calcium carbonate(tooth p.)	2000.	tons
Potassium nitrate	6000.	tons
Calcium carbide	20000.	tons
Calcium carbide	40000.	tons
Sodium hydrogen sulfite	8000.	tons
Sodium chromate	800.	tons
Sodium chromate	700.	tons
Sodium hexametaphosphate	600.	tons
Sodium hexametaphosphate	400.	tons
Sodium hydrosulfite	8000.	tons
Sodium hydrosulfite	1000.	tons
Sodium metasilicate pentahydrate	70968.	tons
Sodium perborate	40000.	tons
Sodium perborate	10000.	tons
Sodium sulfite	11994.	tons
Sodium tetraborate (Borax)	10000.	tons
Sodium tetraborate (Borax)	5000.	tons
Sodium thiosulfate	1000.	tons
Sodium tripolyphosphate	69960.	tons
Trisodium phosphate	1500.	tons
Trisodium phosphate	6000.	tons
Zinc chloride (as 100% $ZnCl_2$)	6500.	tons
Aluminum fluoride	2700.	tons
Gas waste	2472476000.	m3
Liquid waste	3371365.	m3
Solid waste	361955.	tons
Iron oxide (red)	7000.	tons
Ferroferric oxide (black)	5000.	tons
Sodium chloride (medical)	2500.	tons
Titanium dioxide	35000.	tons
Titanium dioxide	15000.	tons

P U R C H A S E

Electrical energy	374758500.	kwh
Water	65294660.	m3
Steam	6507756.	GJ
Cooling water	6014900.	m3
Process water	2013100.	m3
Demineralized water	88054.	m3
Compressed air	72236000.	Nm3
Hot air	268000.	Nm3

[illegible]	1070.	tons
Antimony (metalic)	2583.	tons
Barium chloride ($RaCl_2$)	36.	tons
Compressed nitrogen	300000.	Nm^3
Calcium carbonate	54.	tons
Burnt lime (CaO)	117000.	tons
Charcoal	10.	tons
Chromate and bichromate(calc.66.3%CrO_3)	1020.	tons
Coal	25064.	tons
Coke	56798.	tons
Electrodes	180.	tons
Colemanite (boron ore 40%)	69850.	tons
Copper scrap	970.	tons
Diatomite	350.	tons
Dolomite	9600.	tons
Fluosilicic acid as waste	3240.	tons
Ground phosphate rock	7000.	tons
Hydrochloric acid (as 100%)	3758.	tons
Nitric acid (as 65% HNO_3)	5600.	tons
Hydrate lime [99.5 $Ca(OH)_2$]	10100.	tons
Hydrofluoric acid 70%	3.	tons
Hydrogen peroxide	11812.	tons
Elecrode mass	1080.	tons
Potassium carbonate (99% K_2CO_3)	10.	tons
Potassium hydroxide 90%	196.	tons
Limestone (98% $CaCO_3$)	237164.	tons
Magnesium sulphate	200.	tons
Manganese ore (30% Mn)	24750.	tons
Molasses oven coke	9000.	tons
Molybdenum ore	2765.	tons
Sodium hydroxide (45%)	1600.	tons
Calcium hydroxide $CaOH_2$	26.	tons
Lead (as metal)	3654.	tons
Phosphoric acid (38% P_2O_5)	43200.	tons
Phosphoric acid (75% H_3PO_4)	85330.	tons
Post distillation slurry	80000.	m^3
Potassium chloride	8514.	tons
Raw nickel sulphate	302.	tons
Rock salt (100% NaCL)	19950.	tons
Sand	26240.	tons
Sulphur dioxide SO_2 (as 100% H_2SO_4)	14875.	tons
Illemanite ore (49.5% TiO_2)	142500.	tons
Soda lye (45% NaOH)	781.	tons
Sodium bicarbonate	5250.	tons
Sodium bichromate	707.	tons
Zinc oxide (ash)	3900.	tons
Sodium carbonate 98%	12665.	tons
Sodium chloride	113432.	tons
Sodium hydroxide (100% NaOH)	1125.	tons
Sodium hydroxide (50%)	41162.	tons
Soda lye (45%) solution	17600.	tons
Sodium nitrate	6000.	tons
Sodium pyrosulfite	9576.	tons
Sodium silicate	200.	tons
Sulphur	4758.	tons
Lime	4900.	tons
Sulphuric acid	326870.	tons
Diesel oil	37180.	tons
Zinc ash (100% Zn)	5220.	tons
Spent pickling acid	22225.	tons
Active carbon	6.	tons
Bauxite (87% Al_2O_3)	11200.	tons
Aluminum hydroxide (as 100% Al_2O_3)	2295.	tons
Ammonia NH_3	2854.	tons
Alcohol	585.	tons
Potassium permanganate ($KMnO_4$)	4.	tony

Filter cloth	6.	tons
Condensate	84000.	tons
Fuel gas	8693400.	Nm3
Natural gas	2565000.	Nm3
Carbon dioxide (CO2) food grade)	600000.	m3
Filtriation agent	70.	tons
Chlorine (100%)	2835.	tons
Post-reduction aniline (55% Fe2O3)	15050.	tons
Ammonia water (29.4% NH3)	6250.	tons
Iron sheet	90.	tons
Scrap-iron	8750.	tons
Other compounds	2500000.	US$
Soda ash in solution	4156.	tons
Sodium bichromate impure	2550.	tons
Ferrous sulphate as waste	22750.	tons

P R O C E S S E S

ANTIMONY TRIOXIDE	3000.	tons
ALUMINUM SULPHATE	35000.	tons
SODIUM TETRABORATE (BORAX)	15000.	tons
BORIC ACID	12000.	tons
SODIUM PERBORATE	50000.	tons
PRECIPITATED CALCIUM CARBONATE	100000.	tons
PRECIPITATED CALCIUM CARBONATE(TOOTH P.)	4000.	tons
CALCIUM CARBIDE	60000.	tons
CALCIUM HYPOCHLORITE	7000.	tons
SODIUM CHROMATE	1500.	tons
POTASSIUM BICHROMATE	700.	tons
ANHYDROUS CHROMIC ACID	1500.	tons
COPPER OXIDE (BLACK)	40.	tons
COPPER OXIDE (RED)	400.	tons
COPPER SULPHATE	2000.	tons
ALUMINUM FLUORIDE	2700.	tons
IRON OXIDE (RED)	7000.	tons
FERROFERRIC OXIDES (BLACK)	5000.	tons
FERROUS SULPHATE	3500.	tons
LEAD OXIDE (RED)	4000.	tons
MANGANESE DIOXIDE	11000.	tons
MOLYBDENUM TRIOXIDE	2500.	tons
NICKEL SULFATE	300.	tons
SODIUM TRIPOLYPHOSPHATE	70000.	tons
SODIUM HEXAMETAPHOSPHATE	1000.	tons
TRISODIUM PHOSPHATE	7500.	tons
DICALCIUM PHOSPHATE	40000.	tons
POTASSIUM CARBONATE	3000.	tons
POTASSIUM CHLORATE	4000.	tons
POTASSIUM NITRATE	6000.	tons
SODIUM GLAZE	32000.	tons
SODIUM WATER GLASS	80000.	tons
SODIUM METASILICATE	70968.	tons
SODIUM THIOSULPHATE	1000.	tons
SODIUM HYDROGEN SULFITE	8000.	tons
SODIUM SULFITE	12000.	tons
SODIUM HYDROSULFITE	9000.	tons
SODIUM CHLORIDE (MEDICAL)	2500.	tons
TITANIUM DIOXIDE	50000.	tons
ZINC CHLORIDE	6500.	tons
SODA ASH	70395.	tons

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Problem title: INORGANIC INDUSTRY

F r a c t i o n a l Optimization

Maximize:

$$\frac{\text{PDA Yearly Profit}}{\text{Energy Consumption}} = 0.003 \frac{\text{mil.\$}}{\text{TJ}}$$

Scenario:

	Antimony trioxide	=	1500.	(100.0%)	tons
1.20E+04 <	Boric acid	<	none	(0.0%)	tons
	Chromic acid anhydrous	=	500.	(100.0%)	tons
	Lead oxide (red)	=	2000.	(100.0%)	tons
	Manganese dioxide	=	8000.	(100.0%)	tons
	Potassium bichromate	=	700.	(100.0%)	tons
3.50E+04 <	Aluminum sulphate (14% Al2O3)	<	none	(0.0%)	tons
	Precipitated calcium carbonate(tooth p.)	=	2000.	(100.0%)	tons
0. <	Soda ash (100%)	<	40000.	(0.0%)	tons
	Calcium carbide	=	20000.	(100.0%)	tons
	Sodium chromate	=	800.	(100.0%)	tons
	Sodium hexametaphosphate	=	400.	(100.0%)	tons
	Sodium hydrosulfite	=	8000.	(100.0%)	tons
	Sodium perborate	=	40000.	(100.0%)	tons
0. <	Sodium sulfite	<	3000.	(0.0%)	tons
	Sodium tetraborate (Borax)	=	10000.	(100.0%)	tons
	Trisodium phosphate	=	6000.	(100.0%)	tons
0. <	Iron oxide (red)	<	10000.	(0.0%)	tons
0. <	Iron oxide (red)	<	3000.	(0.0%)	tons
	Titanium dioxide	=	35000.	(100.0%)	tons

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G L O B A L   R E S U L T S

PDA Yearly Profit	204.	mil.$
PDA Value Added	274.	mil.$
Investment	320.	mil.$
Energy Consumption	60345.	TJ
Yearly Import	30.	mil.$
Energy Input	60345.	TJ
Yearly Export	96.	mil.$
Yearly Domestic Purchase	199.	mil.$
Yearly Domestic Sale	417.	mil.$

S A L E

Antimony trioxide	1500.	tons
Antimony trioxide	1500.	tons

Ferrous sulphate - 7 hydrate	3500.	tons
Boric acid	12000.	tons
Chromic acid anhydrous	500.	tons
Copper oxide (black)	40.	tons
Copper oxide (red)	400.	tons
Pickling acid (24% H_2SO_4, 10% $FeSO_4$)	18375.	tons
Copper sulphate	2000.	tons
Dicalcium phosphate	40000.	tons
Calcium hypochloride	7000.	tons
Lead oxide (red)	2000.	tons
Lead oxide (red)	2000.	tons
Manganese dioxide	3000.	tons
Manganese dioxide	8000.	tons
Molybdenum trioxide III	2500.	tons
Nickel sulphate	300.	tons
Potassium bichromate	700.	tons
Potassium chlorate	4000.	tons
Aluminum sulphate (14% Al_2O_3)	35000.	tons
Precipitated calcium carbonate	100000.	tons
Precipitated calcium carbonate(tooth p.)	2000.	tons
Precipitated calcium carbonate(tooth p.)	2000.	tons
Calcium carbide	20000.	tons
Calcium carbide	40000.	tons
Sodium hydrogen sulfite	8000.	tons
Sodium chromate	800.	tons
Sodium chromate	700.	tons
Sodium hexametaphosphate	600.	tons
Sodium hexametaphosphate	400.	tons
Sodium hydrosulfite	8000.	tons
Sodium hydrosulfite	1000.	tons
Sodium perborate	40000.	tons
Sodium perborate	10000.	tons
Sodium sulfite	11994.	tons
Sodium tetraborate (Borax)	10000.	tons
Sodium thiosulfate	1000.	tons
Sodium tripolyphosphate	69960.	tons
Trisodium phosphate	1500.	tons
Trisodium phosphate	6000.	tons
Zinc chloride (as 100% $ZnCl_2$)	6500.	tons
Aluminum fluoride	2700.	tons
Gas waste	2471906000.	m3
Liquid waste	3227061.	m3
Solid waste	344526.	tons
Sodium chloride (medical)	2500.	tons
Titanium dioxide	35000.	tons
Titanium dioxide	15000.	tons

P U R C H A S E

Electrical energy	365864300.	kwh
Water	62426730.	m3
Steam	5303393.	GJ
Cooling water	51278б0.	m3
Process water	1965580.	m3
Demineralized water	88054.	m3
Compressed air	69384800.	Nm3
Hot air	268000.	Nm3
Ammonium nitrate	420.	tons
Antimony (metalic)	2583.	tons
Barium chloride ($BaCl_2$)	36.	tons
Compressed nitrogen	300000.	Nm3
Calcium carbonate	54.	tons

Burnt lime (CaO)	117000.	tons
Charcoal	10.	tons
Chromate and bichromate(calc.66.3%CrO3)	1020.	tons
Coal	10844.	tons
Coke	55299.	tons
Electrodes	180.	tons
Colemanite (boron ore 40%)	65050.	tons
Copper scrap	970.	tons
Diatomite	350.	tons
Dolomite	9600.	tons
Fluosilicic acid as waste	3240.	tons
Ground phosphate rock	7000.	tons
Hydrochloric acid (as 100%)	3758.	tons
Nitric acid (as 65% HNO3)	5600.	tons
Hydrate lime [99.5 Ca(OH)2]	10100.	tons
Hydrofluoric acid 70%	3.	tons
Hydrogen peroxide	11812.	tons
Elecrode mass	1090.	tons
Potassium carbonate (99% K2CO3)	10.	tons
Potassium hydroxide 90%	196.	tons
Limestone (98% CaCO3)	219440.	tons
Magnesium sulphate	200.	tons
Manganese ore (30% Mn)	24750.	tons
Molybderum ore	2765.	tons
Sodium hydroxide (45%)	16.	tons
Calcium hydroxide CaOH2	26.	tons
Lead (as metal)	3654.	tons
Phosphoric acid (38% P2O5)	43200.	tons
Phosphoric acid (75% H3PO4)	85330.	tons
Post distillation slurry	80000.	m3
Potassium chloride	3174.	tons
Raw nickel sulphate	302.	tons
Rock salt (100% NaCL)	19950.	tons
Sand	262.	tons
Sulphur dioxide SO2 (as 100% H2SO4)	14875.	tons
Illemanite ore (49.5% TiO2)	142500.	tons
Soda lye (45% NaOH)	781.	tons
Sodium bicarbonate	3500.	tons
Sodium bichromate	707.	tons
Zinc oxide (ash)	3900.	tons
Sodium carbonate 98%	12665.	tons
Sodium chloride	91618.	tons
Sodium hydroxide (100% NaOH)	1125.	tons
Sodium hydroxide (50%)	28068.	tons
Soda lye (45%) solution	17600.	tons
Sodium pyrosulfite	9576.	tons
Sodium silicate	200.	tons
Sulphur	4758.	tons
Lime	4900.	tons
Sulphuric acid	325530.	tons
Diesel oil	37180.	tons
Zinc ash (100% Zn)	5220.	tons
Spent pickling acid	22225.	tons
Active carbon	6.	tons
Bauxite (87% Al2O3)	11200.	tons
Aluminum hydroxide (as 100% Al2O3)	2295.	tons
Ammonia NH3	286.	tons
Alcohol	585.	tons
Potassium permanganate (KMnO4)	4.	tony
Filter cloth	6.	tons
Fuel gas	1248800.	Nm3
Natural gas	160000.	Nm3
Carbon dioxide (CO2) food grade)	600000.	m3
Filtriation agent	70.	tons
Chlorine (100%)	2835.	tons
Ammonia water (29.4% NH3)	6250.	tons

Iron sheet	90.	tons
Scrap-iron	8750.	tons
Other compounds	2500000.	US$
Soda ash in solution	4156.	tons
Sodium bichromate impure	850.	tons

P R O C E S S E S

ANTIMONY TRIOXIDE	3000.	tons
ALUMINUM SULPHATE	35000.	tons
SODIUM TETRABORATE (BORAX)	10000.	tons
BORIC ACID	12000.	tons
SODIUM PERBORATE	50000.	tons
PRECIPITATED CALCIUM CARBONATE	100000.	tons
PRECIPITATED CALCIUM CARBONATE(TOOTH P.)	4000.	tons
CALCIUM CARBIDE	60000.	tons
CALCIUM HYPOCHLORITE	7000.	tons
SODIUM CHROMATE	1500.	tons
POTASSIUM BICHROMATE	700.	tons
ANHYDROUS CHROMIC ACID	500.	tons
COPPER OXIDE (BLACK)	40.	tons
COPPER OXIDE (RED)	400.	tons
COPPER SULPHATE	2000.	tons
ALUMINUM FLUORIDE	2700.	tons
FERROUS SULPHATE	3500.	tons
LEAD OXIDE (RED)	4000.	tons
MANGANESE DIOXIDE	11000.	tons
MOLYBDENUM TRIOXIDE	2500.	tons
NICKEL SULFATE	300.	tons
SODIUM TRIPOLYPHOSPHATE	70000.	tons
SODIUM HEXAMETAPHOSPHATE	1000.	tons
TRISODIUM PHOSPHATE	7500.	tons
DICALCIUM PHOSPHATE	40000.	tons
POTASSIUM CHLORATE	4000.	tons
SODIUM GLAZE	320.	tons
SODIUM WATER GLASS	800.	tons
SODIUM THIOSULPHATE	1000.	tons
SODIUM HYDROGEN SULFITE	8000.	tons
SODIUM SULFITE	12000.	tons
SODIUM HYDROSULFITE	9000.	tons
SODIUM CHLORIDE (MEDICAL)	2500.	tons
TITANIUM DIOXIDE	50000.	tons
ZINC CHLORIDE	6500.	tons
SODA ASH	57261.	tons

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Problem title: INORGANIC INDUSTRY

Multi Objective Optimization

Name	value	rfp	unit
max PDA Yearly Profit	1.000E+02	3.00E+02	mil.$
min Investment	3.049E+02	3.00E+02	mil.$
max PDA Value Added	1.609E+02	3.00E+02	mil.$
min Energy Consumption	4.167E+05	5.00E+02	TJ

Scenario:

		Antimony trioxide	=	1500.	(100.0%)	tons
1.20E+04	<	Boric acid	<	none	(0.0%)	tons
		Chromic acid anhydrous	=	500.	(100.0%)	tons
		Lead oxide (red)	=	2000.	(100.0%)	tons
		Manganese dioxide	=	8000.	(100.0%)	tons
		Potassium bichromate	=	700.	(100.0%)	tons
3.50E+04	<	Aluminum sulphate (14% Al2O3)	<	none	(0.0%)	tons
		Precipitated calcium carbonate(tooth p.)	=	2000.	(100.0%)	tons
0.	<	Soda ash (100%)	<	40000.	(0.0%)	tons
		Calcium carbide	=	20000.	(100.0%)	tons
		Sodium chromate	=	800.	(100.0%)	tons
		Sodium hexametaphosphate	=	400.	(100.0%)	tons
		Sodium hydrosulfite	=	8000.	(100.0%)	tons
		Sodium perborate	=	40000.	(100.0%)	tons
0.	<	Sodium sulfite	<	3000.	(0.0%)	tons
		Sodium tetraborate (Borax)	=	10000.	(100.0%)	tons
		Trisodium,phosphate	=	6000.	(100.0%)	tons
0.	<	Iron oxide (red)	<	10000.	(70.0%)	tons
0.	<	Iron oxide (red)	<	3000.	(0.0%)	tons
		Titanium dioxide	=	35000.	(100.0%)	tons

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GLOBAL RESULTS

PDA Yearly Profit	100.	mil.$
PDA Value Added	161.	mil.$
Investment	305.	mil.$
Energy Consumption	416693.	TJ
Yearly Import	19.	mil.$
Energy Input	416693.	TJ
Yearly Export	38.	mil.$
Yearly Domestic Purchase	119.	mil.$
Yearly Domestic Sale	271.	mil.$

SALE

Ammonium chloride	1000.	tons

Antimony trioxide	1500.	tons
Ferrous sulphate - 7 hydrate	3500.	tons
Boric acid	12000.	tons
Chromic acid anhydrous	1000.	tons
Chromic acid anhydrous	500.	tons
Copper oxide (black)	40.	tons
Copper oxide (red)	400.	tons
Pickling acid (24% H2SO4, 10% FeSO4)	18375.	tons
Cryolite (Na3AlF6)	2700.	tons
Lead oxide (red)	2000.	tons
Manganese dioxide	8000.	tons
Potassium bichromate	1300.	tons
Potassium bichromate	700.	tons
Potassium carbonate (K2CO3)	3000.	tons
Potassium chlorate	4000.	tons
Aluminum sulphate (14% Al2O3)	35000.	tons
Precipitated calcium carbonate(tooth p.)	2000.	tons
Soda ash (100%)	126724.	tons
Potassium nitrate	6000.	tons
Calcium carbide	20000.	tons
Sodium chromate	800.	tons
Sodium hexametaphosphate	400.	tons
Sodium hydrosulfite	8000.	tons
Sodium nitrate	6000.	tons
Sodium perborate	40000.	tons
Sodium tetraborate (Borax)	10000.	tons
Sodium tetraborate (Borax)	2857.	tons
Sodium water glass (36% grade..)	78340.	tons
Zeolites cl.3A	1000.	tons
Trisodium phosphate	6000.	tons
Gas waste	761356500.	m3
Liquid waste	3770310.	m3
Solid waste	335280.	tons
Iron oxide (red)	7000.	tons
Ferroferric oxide (black)	5000.	tons
Sodium chloride (medical)	2500.	tons
Titanium dioxide	35000.	tons
Titanium dioxide	15000.	tons

P U R C H A S E

Electrical energy	214200400.	kwh
Water	73911940.	m3
Steam	6592018.	GJ
Cooling water	897000.	m3
Process water	1654030.	m3
Demineralized water	126000.	m3
Compressed air	46843500.	Nm3
Ammonium nitrate	650.	tons
Antilumper	6.	tons
Antimony (metalic)	1292.	tons
Barium chloride (BaCl2)	36.	tons
Compressed nitrogen	100000.	Nm3
Burnt lime (CaO)	39000.	tons
Charcoal	5.	tons
Chromate and bichromate(calc.66.3%CrO3)	544.	tons
Coal	16362.	tons
Coke	28500.	tons
Electrodes	60.	tons
Colemanite (boron ore 40%)	60783.	tons
Copper scrap	450.	tons
Fluosilicic acid as waste	2511.	tons

Ground phosphate rock	2.	tons
Hydrochloric acid (as 100%)	248.	tons
Nitric acid (as 100% HNO_3)	984.	tons
Hydrate lime [99.5 $Ca(OH)_2$]	5600.	tons
Hydrogen peroxide	9440.	tons
Elecrode mass	360.	tons
Potassium carbonate (99% K_2CO_3)	10.	tons
Potassium hydroxide 90%	196.	tons
Limestone (98% $CaCO_3$)	195000.	tons
Magnesium sulphate	160.	tons
Manganese ore (30% Mn)	18000.	tons
Molasses oven coke	9000.	tons
Sodium hydroxide (45%)	1600.	tons
Nitric oxides as byproduct	8460.	tons
Lead (as metal)	1827.	tons
sphoric acid (75% H_3PO_4)	2935.	tons
Post distillation slurry	50000.	m3
Potassium chloride	10020.	tons
Rock salt (100% NaCL)	18400.	tons
Sand	26240.	tons
Sulphur dioxide SO_2 (as 100% H_2SO_4)	6400.	tons
Illemanite ore (49.5% TiO_2)	142500.	tons
Soda lye (45% NaOH)	568.	tons
Sodium bicarbonate	4500.	tons
Sodium bichromate	2020.	tons
Sodium carbonate 98%	2100.	tons
Sodium chloride	242943.	tons
Sodium hydroxide (100% NaOH)	900.	tons
Sodium hydroxide (50%)	26167.	tons
Sodium silicate	160.	tons
Sulphur	4112.	tons
Sulphuric acid	325848.	tons
Diesel oil	16763.	tons
Zinc ash (100% Zn)	4640.	tons
Spent pickling acid	22225.	tons
Active carbon /	3.	tons
Bauxite (87% Al_2O_3)	11200.	tons
Aluminum hydroxide (as 100% Al_2O_3)	1181.	tons
Ammonia NH_3	4251.	tons
Alcohol	520.	tons
Condensate	84000.	tons
Fuel gas	8880669.	Nm3
Natural gas	2565000.	Nm3
Carbon dioxide (CO_2) food grade)	300000.	m3
Filtriation agent	56.	tons
Drinking water	1200.	m3
Post-reduction aniline (55% Fe_2O_3)	15050.	tons
Iron sheet	30.	tons
Scrap-iron	8750.	tons
Other compounds	2500000.	US$
Soda ash in solution	2078.	tons
Sodium bichromate impure	2550.	tons
Ferrous sulphate as waste	22750.	tons

P R O C E S S E S

ANTIMONY TRIOXIDE	1500.	tons
ALUMINUM SULPHATE	35000.	tons
SODIUM TETRABORATE (BORAX)	12857.	tons
BORIC ACID	12000.	tons
SODIUM PERBORATE	40000.	tons
PRECIPITATED CALCIUM CARBONATE (TOOTH P.)	2000.	tons

CALCIUM CARBIDE	20000.	tons
AMMONIUM CHLORIDE	1000.	tons
SODIUM CHROMATE	800.	tons
POTASSIUM BICHROMATE	2000.	tons
ANHYDROUS CHROMIC ACID	1500.	tons
COPPER OXIDE (BLACK)	40.	tons
COPPER OXIDE (RED)	400.	tons
CRYOLITE - ALUMINUM SODIUM FLUORIDE	2700.	tons
IRON OXIDE (RED)	7000.	tons
FERROFERRIC OXIDES (BLACK)	5000.	tons
FERROUS SULPHATE	3500.	tons
LEAD OXIDE (RED)	2000.	tons
MANGANESE DIOXIDE	8000.	tons
SODIUM TRIPOLYPHOSPHATE	20.	tons
SODIUM HEXAMETAPHOSPHATE	400.	tons
TRISODIUM PHOSPHATE	6000.	tons
POTASSIUM CARBONATE	3000.	tons
POTASSIUM CHLORATE	4000.	tons
POTASSIUM NITRATE	6000.	tons
SODIUM GLAZE	32000.	tons
SODIUM WATER GLASS	80000.	tons
MOLECURAL SILVE-ZEOLITES (cl. 3A)	1000.	tons
SODIUM HYDROSULFITE	8000.	tons
SODIUM CHLORIDE (MEDICAL)	2500.	tons
SODIUM NITRATE	12000.	tons
TITANIUM DIOXIDE	50000.	tons
SODA ASH	150000.	tons

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