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United Nations Industrial Development Organization

Workshop on Fermentation Alcohol for Use as
Fuel and Chemical Feedstock in Developing Countries

Vienna, Austria, 26 - 30 March 1979

USE OF ETHYL ALCOHOL AS CHEMICAL FEEDSTOCK*

by

Akio Yamasoe**

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ABSTRACT

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A brief review is made on present status of technologies for making various organic compounds from ethyl alcohol.

Taking as an example a feasibility study on production of some compounds starting from carbohydrate raw material, problems in the realisation of such production scheme are discussed.

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ADDENDUM

The following pp. 1 - 31 should be added to the above paper as pp. 9 - 39.

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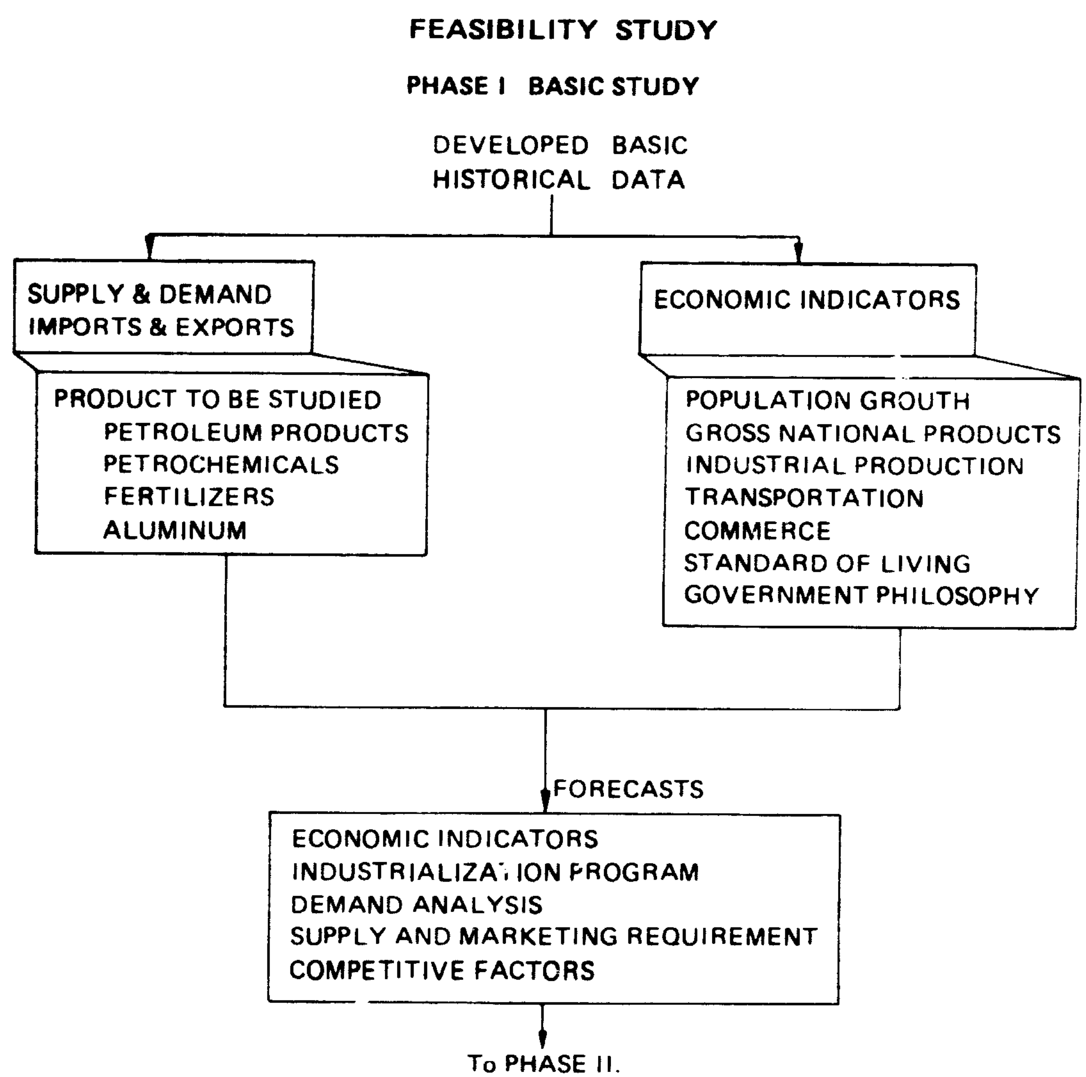
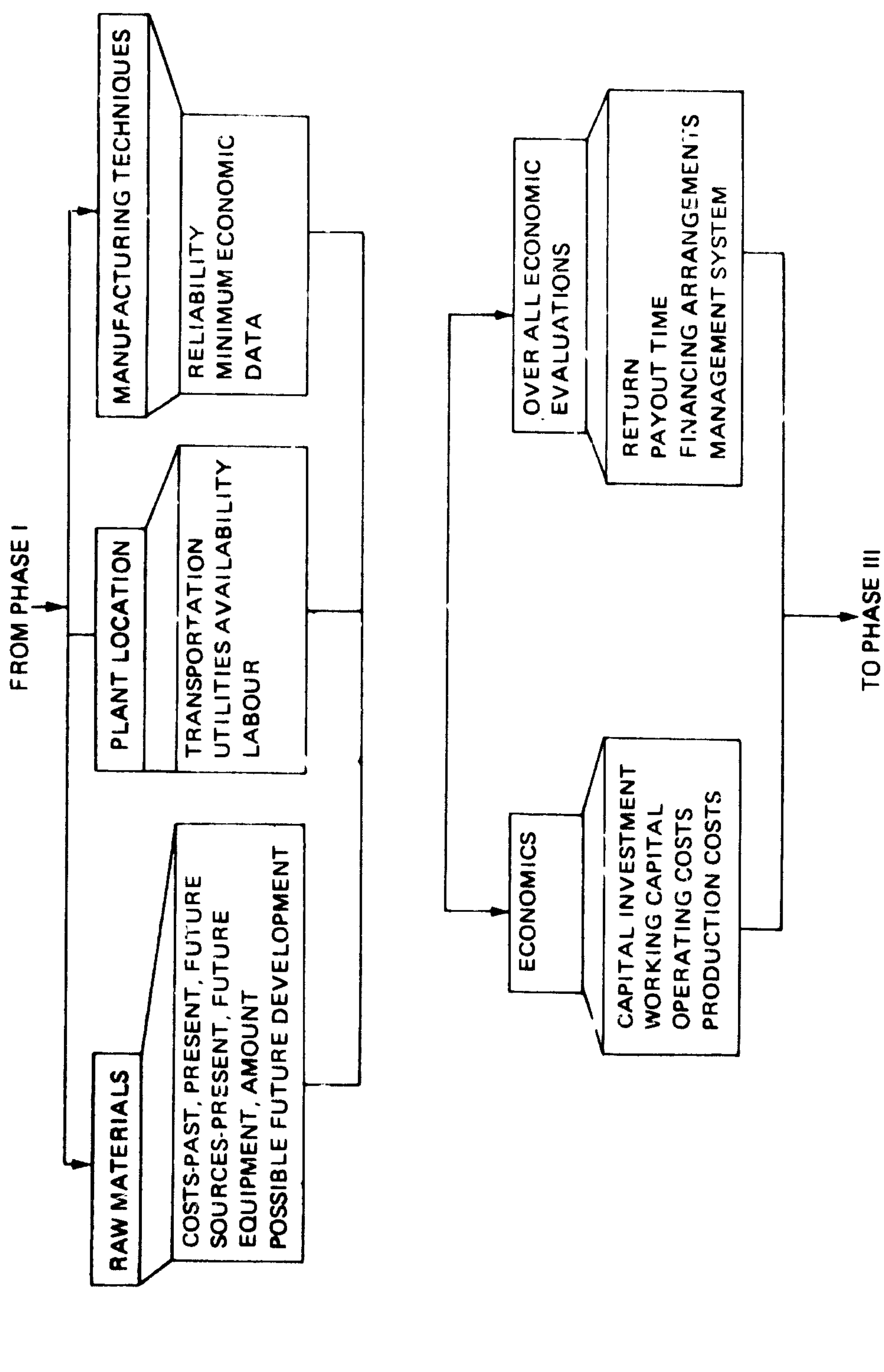
COMPREHENSIVE INDUSTRIAL DEVELOPMENT PLANNING

- IDENTIFICATION OF TYPES OF PRODUCTS NEEDED ON MARKETS
- ANALYSES OF MARKET CONDITIONS
- INVESTIGATION OF RAW MATERIAL SUPPLY SITUATION
- DETERMINATION OF OPTIMUM PRODUCTION SYSTEM AND OUTPUT
- DEVELOPMENT OF REALISTIC PLANS TO PREVENT ENVIRONMENTAL HAZARDS
- DRAWING UP OF BLUEPRINTS OF MOST LOGICAL ENGINEERING SCHEME

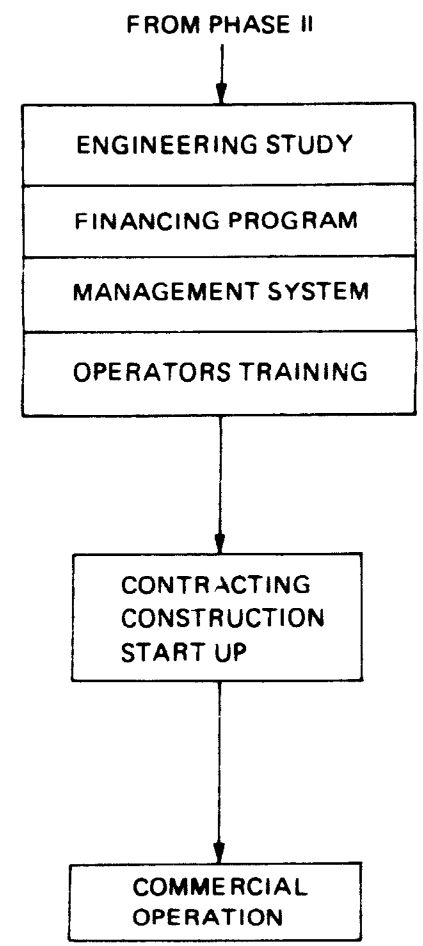

FEASIBILITY STUDY
PHASE I BASIC STUDY
DEVELOPED BASIC HISTORICAL DATA
SUPPLY & DEMAND IMPORTS & EXPORTS
PRODUCT TO BE STUDIED
PETROLEUM PRODUCTS
PETROCHEMICALS
FERTILIZERS
ALUMINUM
ECONOMIC INDICATORS
POPULATION GROUTH
GROSS NATIONAL PRODUCTS
INDUSTRIAL PRODUCTION
TRANSPORTATION
COMMERCE
STANDARD OF LIVING
GOVERNMENT PHILOSOPHY
FORECASTS
ECONOMIC INDICATORS
INDUSTRIALIZATION PROGRAM
DEMAND ANALYSIS
SUPPLY AND MARKETING REQUIREMENT
COMPETITIVE FACTORS
To PHASE II.

FEASIBILITY STUDY

PHASE II PRE-INVESTMENT STUDY



PHASE III IMPLEMENTATION OF PROJECT



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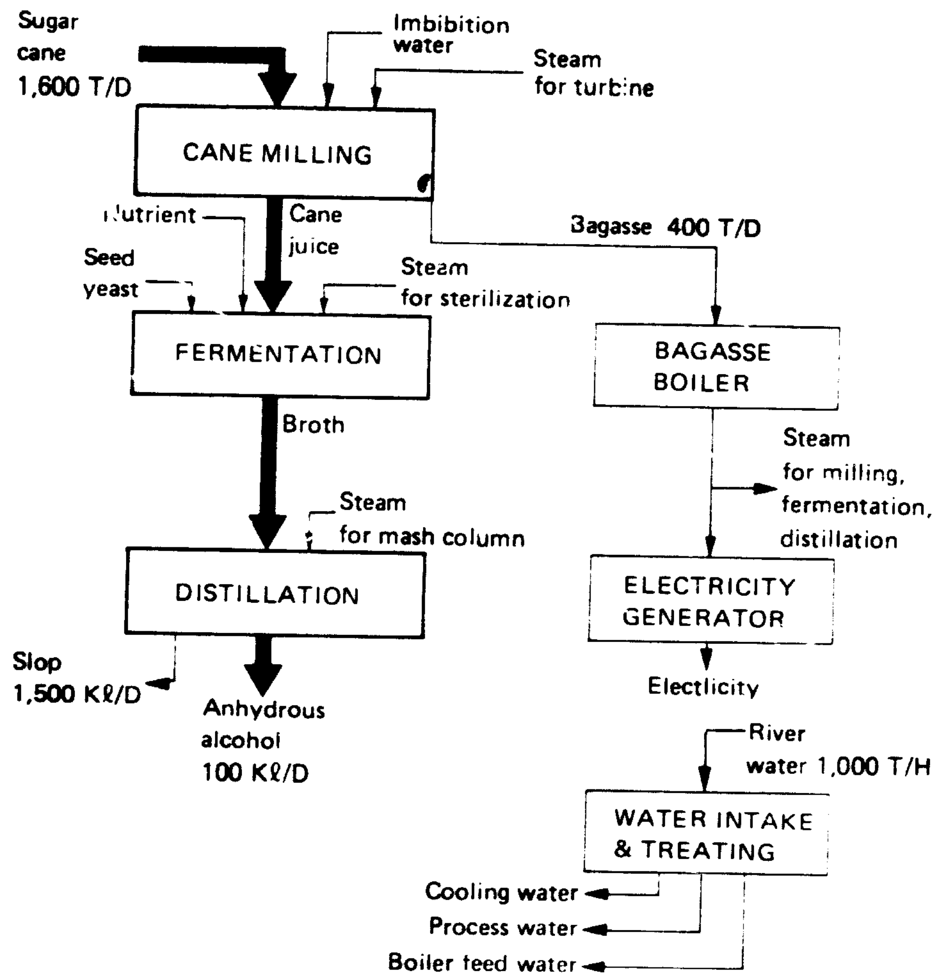
• Studies for Natural Gas Utilization	Govt. of India
• Industrial Survey for Petrochemicals based on Natural Gas	Govt. of Pakistan
• Survey of Petrochemical Industries in Indonesia	UNIDO
• Study concerning Industrialization of Synthetic Rubbe	UNIDO
• Consultation on Installation of Petroleum Refinery	Petrobras
• Master Plan of Industries of Petroleum Down-Stream in Malaysia	Petronas
• Feasibility Study of Production of Carbon Black in Algeria	Sonatrach
• Feasibility Study of Utilization of Natural Gas	Abu Dhabi Petro. Corp.

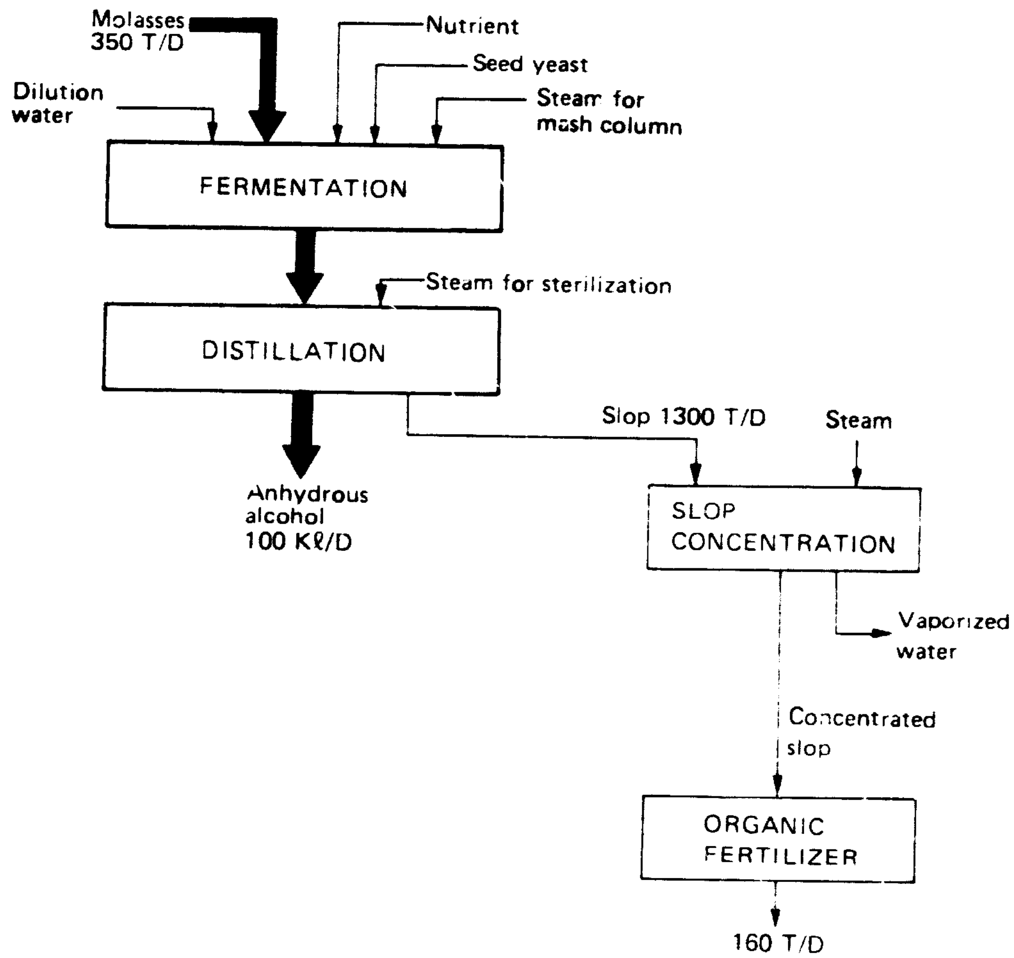
BLOCK FLOW DIAGRAM FOR ALCOHOL MANUFACTURING PROCESS

– Sugar Cane Feedstock –

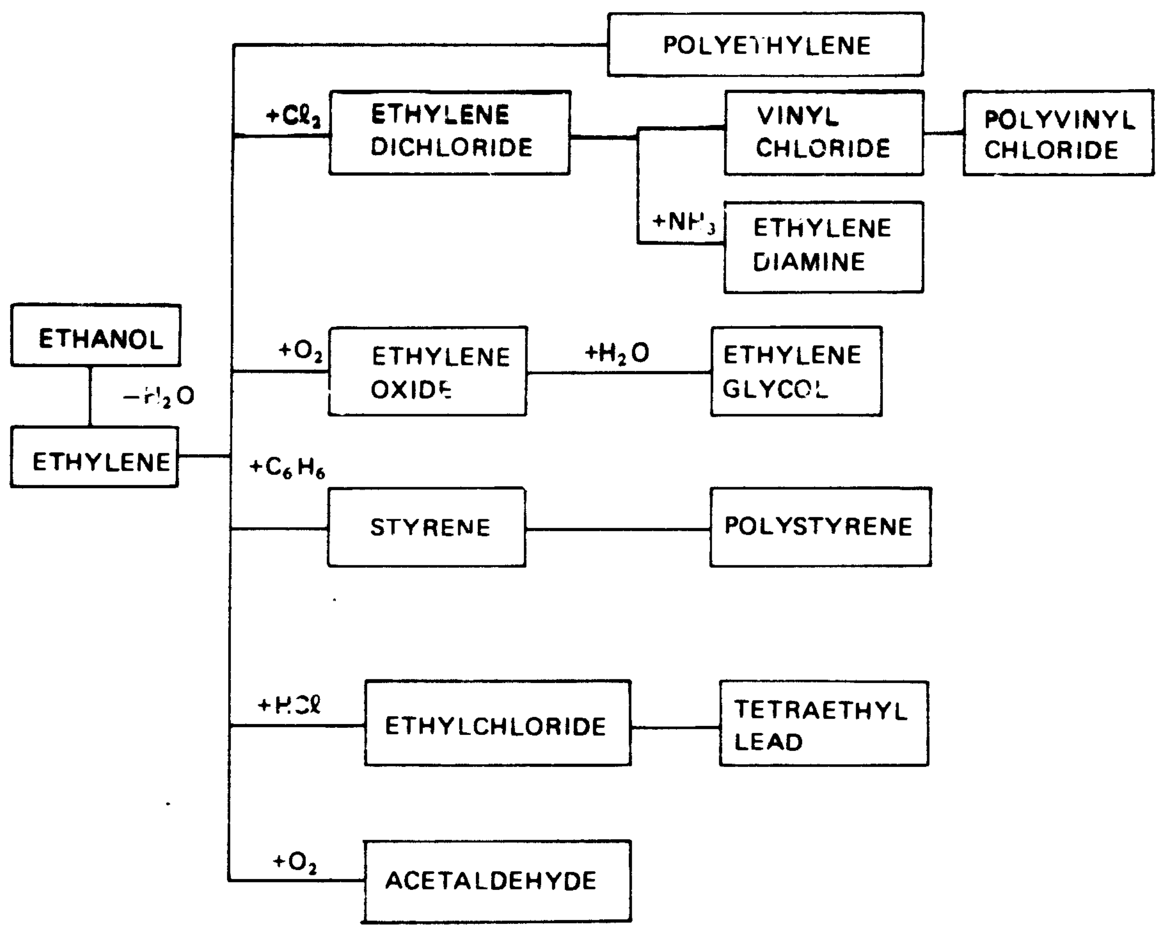


BLOCK FLOW DIAGRAM FOR ALCOHOL MANUFACTURING PROCESS

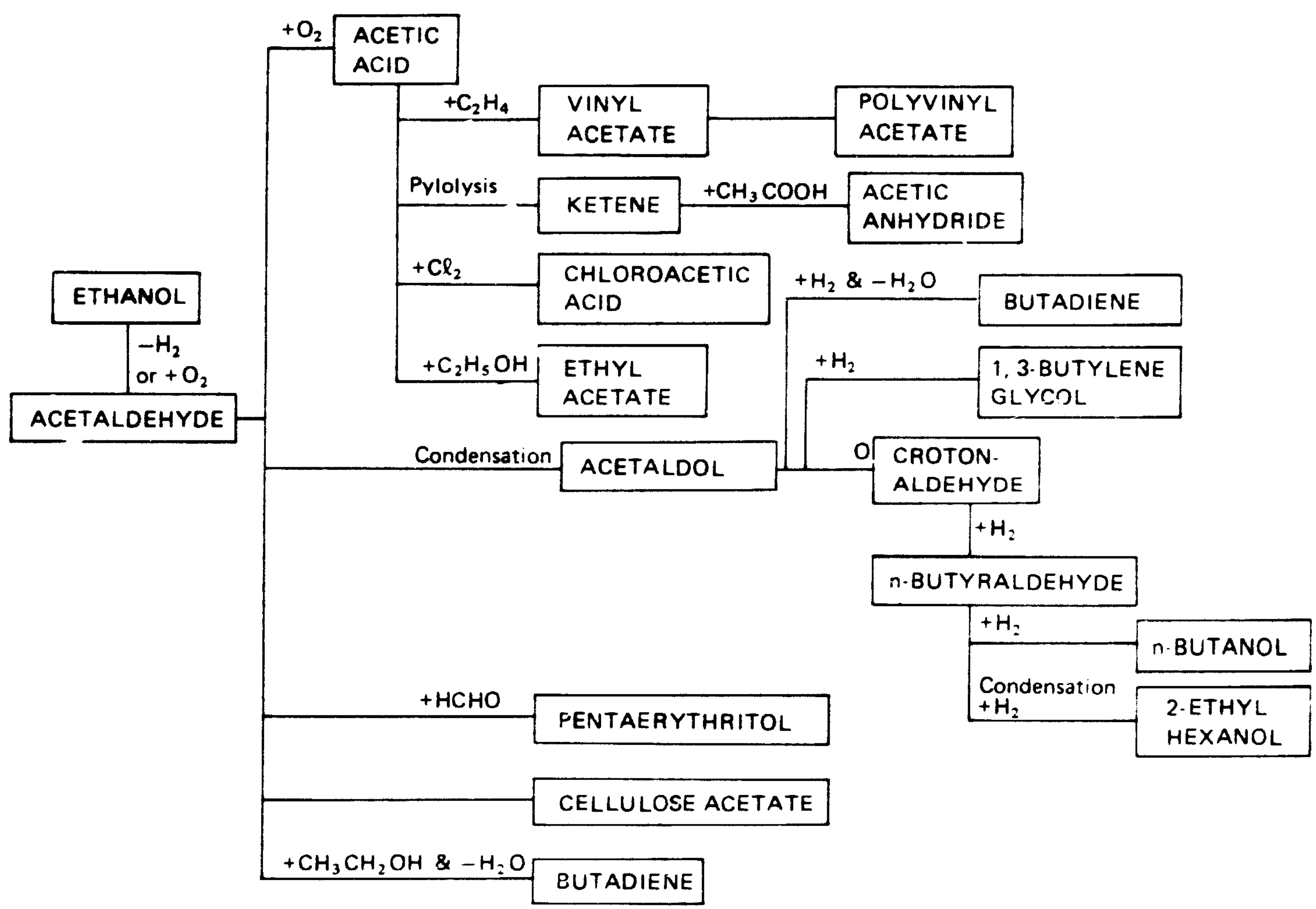
– Molasses Feedstock –



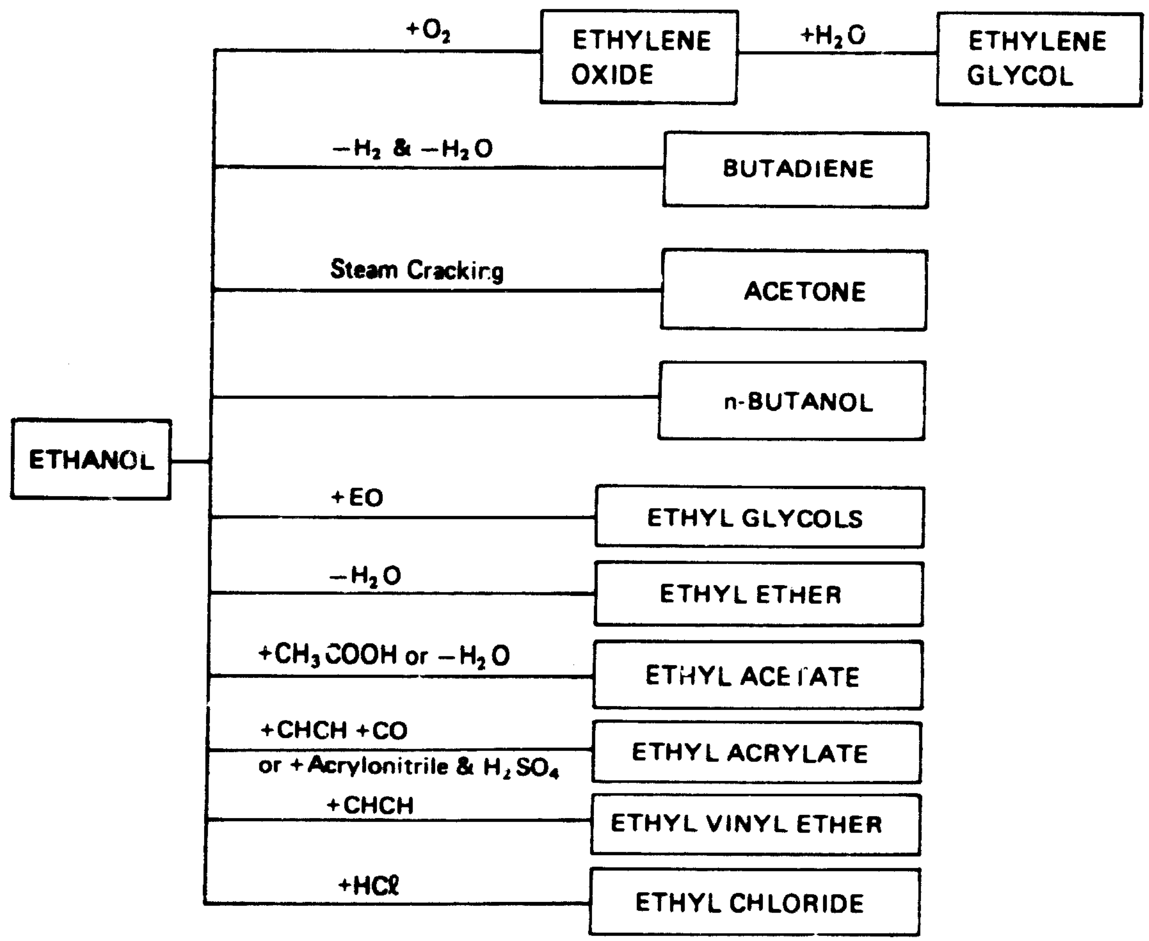
ETHANOL-BASED ETHYLENE AND IT'S DERIVATIVES



ETHANOL-BASED ACETALDEHYDE AND IT'S DERIVATIVES



OTHER ETHANOL-BASED CHEMICALS AND IT'S DERIVATIVES



ETHANOL-BASED CHEMICALS MANUFACTURING PROCESS

PRODUCT	ETHANOL-BASED PROCESS		PETROCHEMICAL PROCESS
	PROCESS OUTLINE	COMMERCIAL PLANT	
ETHYLENE	ETHANOL DEHYDRATION $C_2H_5OH \longrightarrow C_2H_4 + H_2O$	OPERATED/OPERATING? IN INDIA (15,000 T/Y) BRAZIL (5,000 T/Y), PERU	ETHANE, NAPHTHA, GAS OIL CRACKING
ACETALDEHYDE	DEHYDROGENATION (UCC) $C_2H_5OH \longrightarrow CH_3CHO + H_2$ OXIDATIVE DEHYDROGENATION $C_2H_5OH + \frac{1}{2}O_2 \longrightarrow CH_3CHO + H_2O$	OPERATING IN USA (120,000 T/Y), ENGLAND, FRANCE	HOECHST-WACKER $H_2C = CH_2 + \frac{1}{2}O_2 \longrightarrow CH_3CHO$
ACRYLIC ETHYL ESTER	1) MODIFIED REPPE PROCESS $C_2H_2 + C_2H_5OH + CO \longrightarrow CH_2 = CHCOOC_2H_5$	OPERATING IN JAPAN AND ITALY	1) MODIFIED REPPE 2) ACRYLONITRILE CRACKING BY ETHANOL 3) PROPYLENE OXIDATION
	2) ACRYLONITRILE CRACKING BY ETHANOL $CH_2 = CHCN + C_2H_5OH + H_2SO_4 + H_2O$ $\longrightarrow CH_2 = CHCOOC_2H_5 + NH_4HSO_4$	OPERATING IN JAPAN AND ITALY	
VINYL ETHYL ETHER	REPPE PROCESS $C_2H_5OH + HC \equiv CH \longrightarrow ROCH = CH_2$	OPERATING IN USA AND WEST GERMANY	REPPE PROCESS

ETHANOL-BASED CHEMICALS MANUFACTURING PROCESS

PRODUCT	ETHANOL-BASED PROCESS		PETROCHEMICAL PROCESS
	PROCESS OUTLINE	COMMERCIAL PLANT	
BUTADIENE	1) LEVEDEV PROCESS (USSR) $2C_2H_5OH \longrightarrow CH_2=CHCH=CH_2+H_2+2H_2O$ ONE STEP VAPOR PHASE CATALYTIC REACTION $T = 400^{\circ}C$, P = REDUCED PRESSURE	OPERATED BEFORE 1966 IN USSR	1) SOLVENT EXTRACTION OF C_4 FRACTION 2) DEHYDROGENATION OF BUTYLENE OR BUTANE
	2) UCC PROCESS $C_2H_5OH \longrightarrow CH_3CHO + H_2$ $CH_3CHO + C_2H_5OH \longrightarrow CH_2=CHCH=CH_2 + 2H_2O$ TWO STEP REACTION	OPERATING IN INDIA, CHINA	
EO	1) DEHYDRATION OF ETHANOL $C_2H_5OH \longrightarrow \underset{\diagdown O \diagup}{CH_2-CH_2} + H_2O$		1) CATALYTIC OXIDATION OF ETHYLENE
ACETONE	1) STEAM CRACKING OF ETHANOL $2C_2H_5OH + H_2O \longrightarrow CH_3COCH_3 + CO_2 + 4H_2$ $T = 470^{\circ}C$	OPERATED	1) CUMENE PROCESS 2) PROPYLENE OXIDATION (WACKER PROCESS) 3) IPA DEHYDROGENATION

ETHANOL-BASED CHEMICALS MANUFACTURING PROCESS

PRODUCT	ETHANOL-BASED PROCESS		PETROCHEMICAL PROCESS
	PROCESS OUTLINE	COMMERCIAL PLANT	
N-BUTANOL	1) ALDOL PROCESS $2C_2H_5OH \text{——} 2CH_3CHO + H_2$ $2CH_3CHO \text{——} CH_3CH(OH)CH_2OH$ $CH_3CH(OH)CH_2OH \text{——} CH_3CH = CHCHO + H_2O$ $CH_3CH = CHCHO + 2H_2 \text{——} CH_3CH_2CH_2CH_2OH$	OPERATED	1) ACETALDEHYDE ALDOL CONDENSATION 2) PROPYLENE HYDROFORMYLATION 3) REPPE PROCESS
	2) ONE STEP DIRECT SYNTHESIS $2C_2H_5OH \text{——} CH_3CH_2CH_2CH_2OH + H_2O$	——	
ETHYL GLYCOL	ETHANOL + EO—— ETHYL GLYCOL	OPERATING	ETHANOL + EO——ETHYL GLYCOL
ETHYL ETHER	ETHANOL DEHYDRATION $2C_2H_5OH \text{——} C_2H_5OC_2H_5 + H_2O$	OPERATING	1) ETHANOL DEHYDRATION 2) ETHYLENE HYDRATION
ETHYL ACETATE ESTER	1) BACKHAUS PROCESS $CH_3COOH + C_2H_5OH \text{——} CH_3COOC_2H_5 + H_2O$	OPERATING	1) BACKHAUS PROCESS 2) TISHCHENKO PROCESS
	2) DU PONT PROCESS $2C_2H_5OH \text{——} CH_3COOC_2H_5 + 2H_2$	——	

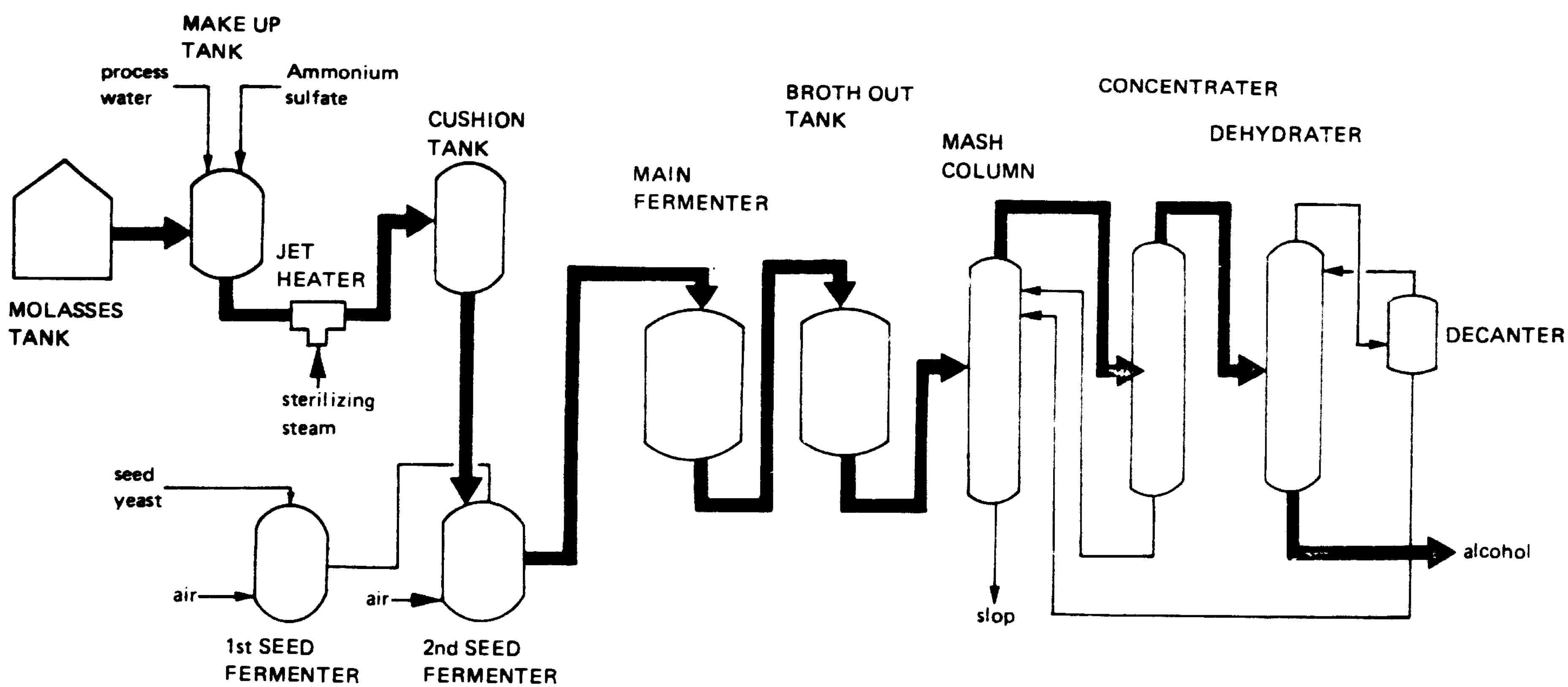
OUTLINE OF ETHANOL BASED CHEMICAL INDUSTRY IN JAPAN

TOTAL ETHANOL CONSUMPTION IN 1977		138,000 Kℓ
ETHANOL CONSUMPTION FOR CHEMICAL INDUSTRY IN 1977		83,000 Kℓ
USES OF ETHANOL		
COSMETICS		17,000 Kℓ
LIQUID DETERGENT		11,000 Kℓ
ACRYLIC ETHYL ESTER		9,600 Kℓ
LACQUER		!5,600 Kℓ
ESTERS		4,900 Kℓ
OTHERS		34,900 Kℓ
	TOTAL	83,000 Kℓ

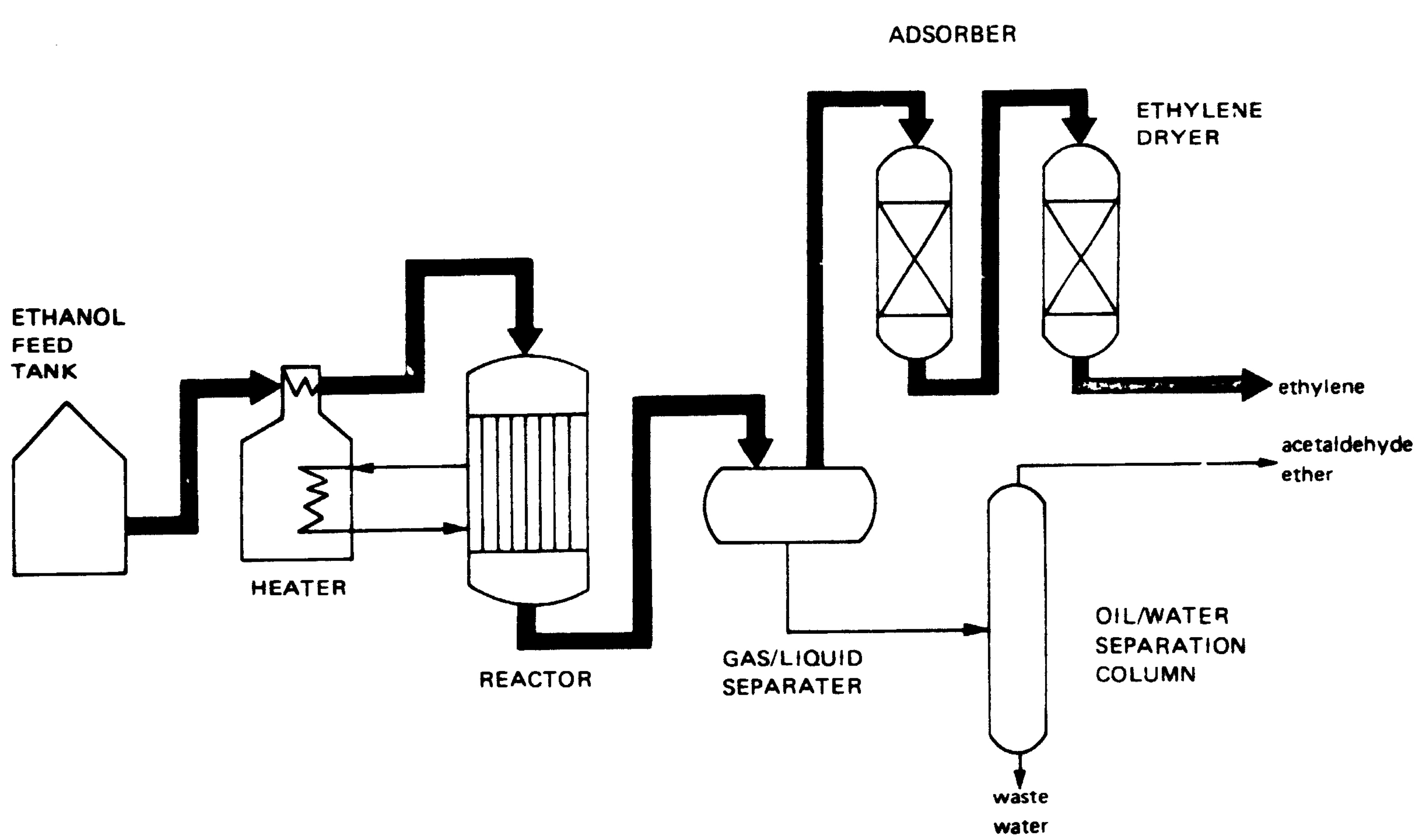
TYPICAL ETH ^NOL-BASED CHEMICALS

	USES
ACRYL ETHYL ESTER	ACRYL FIBER, PAINT
ETHYL METHACRYLATE	PAINT, ADHESIVES
DIACETIC ETHER	ANTIFEBRILE
CHLORAL	PESTICIDE

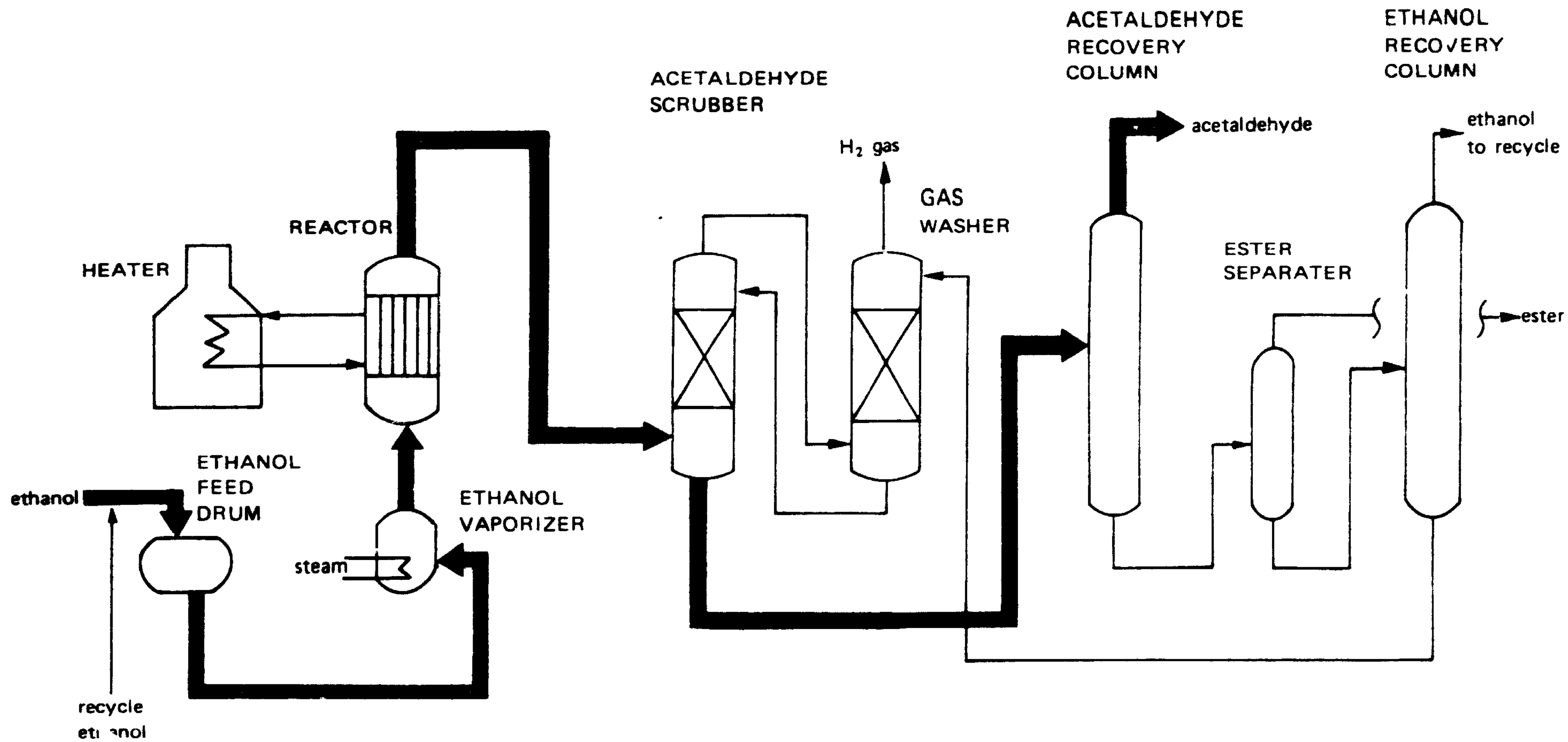
MOLASSES-BASED ETHANOL MANUFACTURING PROCESS



ETHANOL-BASED ETHYLENE MANUFACTURING PROCESS



ETHANOL-BASED ACETALDEHYDE MANUFACTURING PROCESS



MOLASSES-BASED ETHANOL MANUFACTURING COST

– EVALUATION BASIS –

FEEDSTOCK MOLASSES PER Kℓ OF ALCOHOL			3.5 TON
PLANT OPERATING DAYS			300 Days/Yr.
PRODUCT ALCOHOL			100 Kℓ/Day
UTILITIES CONSUMPTION PER Kℓ OF ALCOHOL			
	ELECTRICITY		90 KWH
	STEAM		3.5 TON
	COOLING WATER		250 TON
	PROCESS WATER		25 TON
CHEMICALS CONSUMPTION PER Kℓ OF ALCOHOL			
	AMMONIUM SULFATE		5.8 Kg
	BENSOL		0.5 ℓ
LABOR	CHIEF	1 man	1
		2 men/shift	8
			9 men
FIXED COST	ESTIMATED PLANT COST	US$8,000,000	
	DEPRECIATION	(6.7%/Y OF PLANT COST)	
	INTEREST	(8.0%/Y OF PLANT COST)	
	MAINTENANCE	(1.5%/Y OF PLANT COST)	

MOLASSES-BASED ETHANOL MANUFACTURING COST

FEEDSTOCK MOLASSES PER Kℓ OF ALCOHOL		3.5 x (US$/T, MOLASSES PRICE)	
UTILITIES COST PER Kℓ OF ALCOHOL			US$/Kℓ
	STEAM	(10 US$/T)	35
	COOLING WATER	(0.05 US$/T)	13
	PROCESS WATER	(0.3 US$/T)	8
	ELECTRICITY	(0.03 US$/KWH)	3
			59
CHEMICALS COST PER Kℓ OF ALCOHOL			US$/Kℓ
	AMMONIUM SULFATE	(0.05 US$/Kg)	0.3
	BENZOL	(0.4 US$/ℓ)	0.2
			0.5
			US$/Kℓ
LABOR			2.5
FIXED COST			US$/Kℓ
	DEPRECIATION		18
	INTEREST		21
	MAINTENANCE		4
			43

ALCOHOL MANUFACTURING COST	3.5 x (US$/T, MOLASSES PRICE) + 105		
MOLASSES PRICE 10 US$/T	ETHANOL	140 US$/Kℓ	(= 175 US$/T)
MOLASSES PRICE 20 US$/T	ETHANOL	175 US$/Kℓ	(= 219 US$/T)
MOLASSES PRICE 30 US$/T	ETHANOL	210 US$/Kℓ	(= 263 US$/T)

ETHANOL-BASED ETHYLENE MANUFACTURING COST

– EVALUATION BASIS–

FEEDSTOCK ETHANOL CAPACITY			91 Kℓ/Day
PLANT OPERATING DAYS			330 Days/Year
PRODUCT ETHYLENE			14,000 T/Y
UTILITIES CONSUMPTION PER TON OF ETHYLENE			
	STEAM		2,500 Kg
	COOLING WATER		100 M^3
	ELECTRICITY		50 KWH
	FUEL		700,000 Kcal
LABOR	CHIEF	1 man	1 man
	OPERATORS	2 men/shift	8 men
			9 men
FIXED COST	ESTIMATED PLANT COST		US$ 4,600,000
	DEPRECIATION	(6.7%/Y OF PLANT COST)	
	INTEREST	(8.0%/Y OF PLANT COST)	
	MAINTENANCE	(1.5%/Y OF PLANT COST)	

ETHANOL-BASED ETHYLENE MANUFACTURING COST

FEEDSTOCK ETHANOL COST PER TON OF ETHYLENE — 1.7 x (ETHANOL PRICE US$/T)

UTILITIES COST PER TON OF ETHYLENE		US$/T
STEAM	(10 US$/T)	25
COOLING WATER	(0.05 US$/T)	5
ELECTRICITY	(0.03 US$/KWH)	2
FUEL	(0.014 US$/M Kcal)	10
		42

CATALYST AND CHEMICALS COST PER TON OF ETHYLENE	US$/T
	3

LABOR COST PER TON OF ETHYLENE	US$/T
	5

FIXED COST PER TON OF ETHYLENE	US$/T
DEPRECIATION	22
INTEREST	26
MAINTENANCE	5
	53

ETHYLENE MANUFACTURING COST (US$/T) — 1.7 x (ETHANOL PRICE US$/T) + 103

ETHANOL PRICE	100 US$/T	ETHYLENE	273 US$/T
ETHANOL PRICE	200	ETHYLENE	443 US$/T
ETHANOL PRICE	300	ETHYLENE	613 US$/T

ETHANOL-BASED ACETALDEHYDE MANUFACTURING COST

– EVALUATION BASIS –

FEEDSTOCK ETHANOL CAPACITY			91 Kℓ/Day
PLANT OPERATING DAYS			330 Days/Year
PRODUCT ACETALDEHYDE			20,000 T/Y
UTILITIES CONSUMPTION PER TON OF ACETALDEHYDE			
	STEAM		4,500 Kg
	ELECTRICITY		50 KWH
	COOLING WATER		380 M^3
	FUEL		830,000 Kcal
LABOR	CHIEF	1 man	1
	OPERATORS	2 men/shift	8
			9 men
FIXED COST	ESTIMATED PLANT COST		US$ 4,500,000
	DEPRECIATION	(6.7%/Y OF PLANT COST)	
	INTEREST	(8.0%/Y OF PLANT COST)	
	MAINTENANCE	(1.5%/Y OF PLANT COST)	

ETHANOL-BASED ACETALDEHYDE MANUFACTURING COST

FEEDSTOCK ETHANOL COST PER TON OF ACETALDEHYDE — 1.2 x (ETHANOL PRICE, US$/T)

UTILITIES COST PER TON OF ETHYLENE		US$/T
STEAM	(10 US$/T)	45
ELECTRICITY	(0.03 US$/KWH)	2
COOLING WATER	(0.05 US$/T)	19
FUEL	(0.014 US$/M Kcal)	12
		78

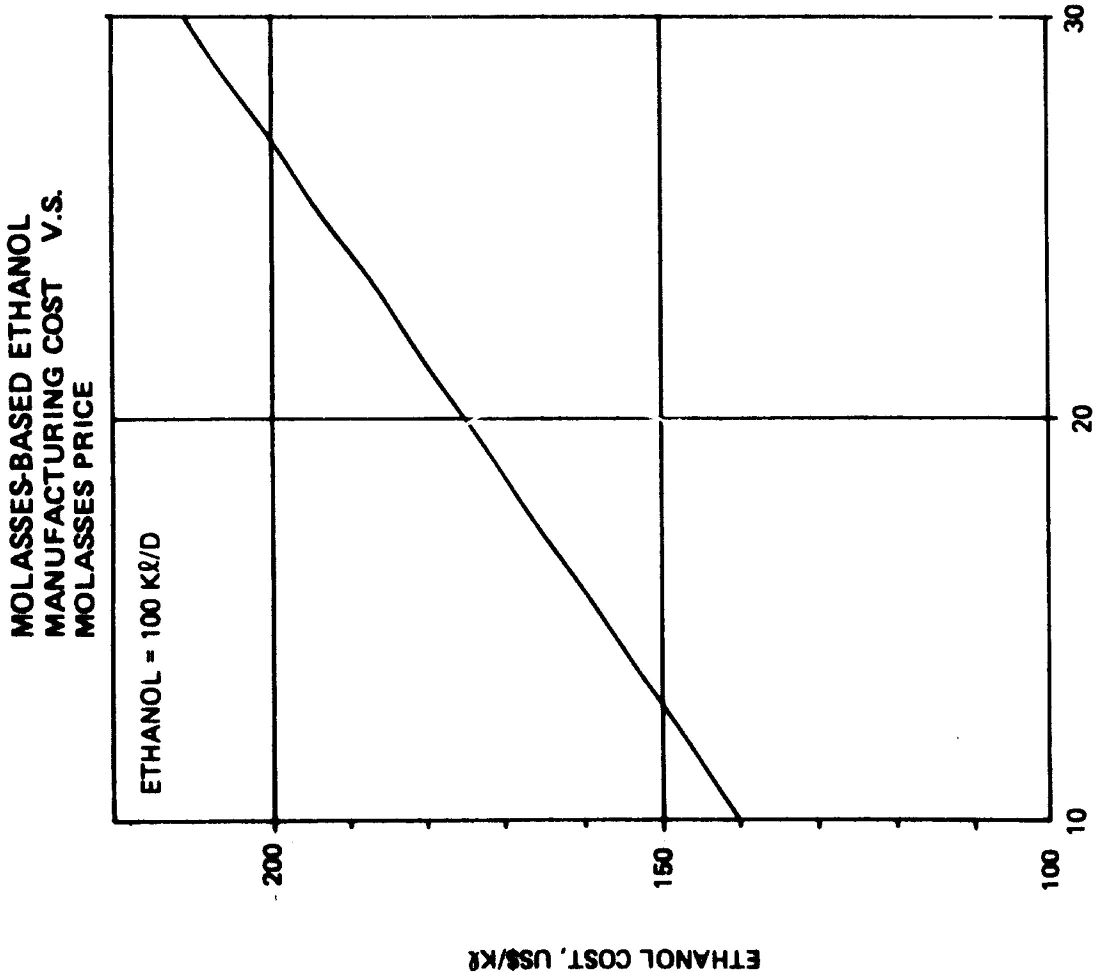
CATALYST AND CHEMICALS COST PER TON OF ACETALDEHYDE	US$/T
	6

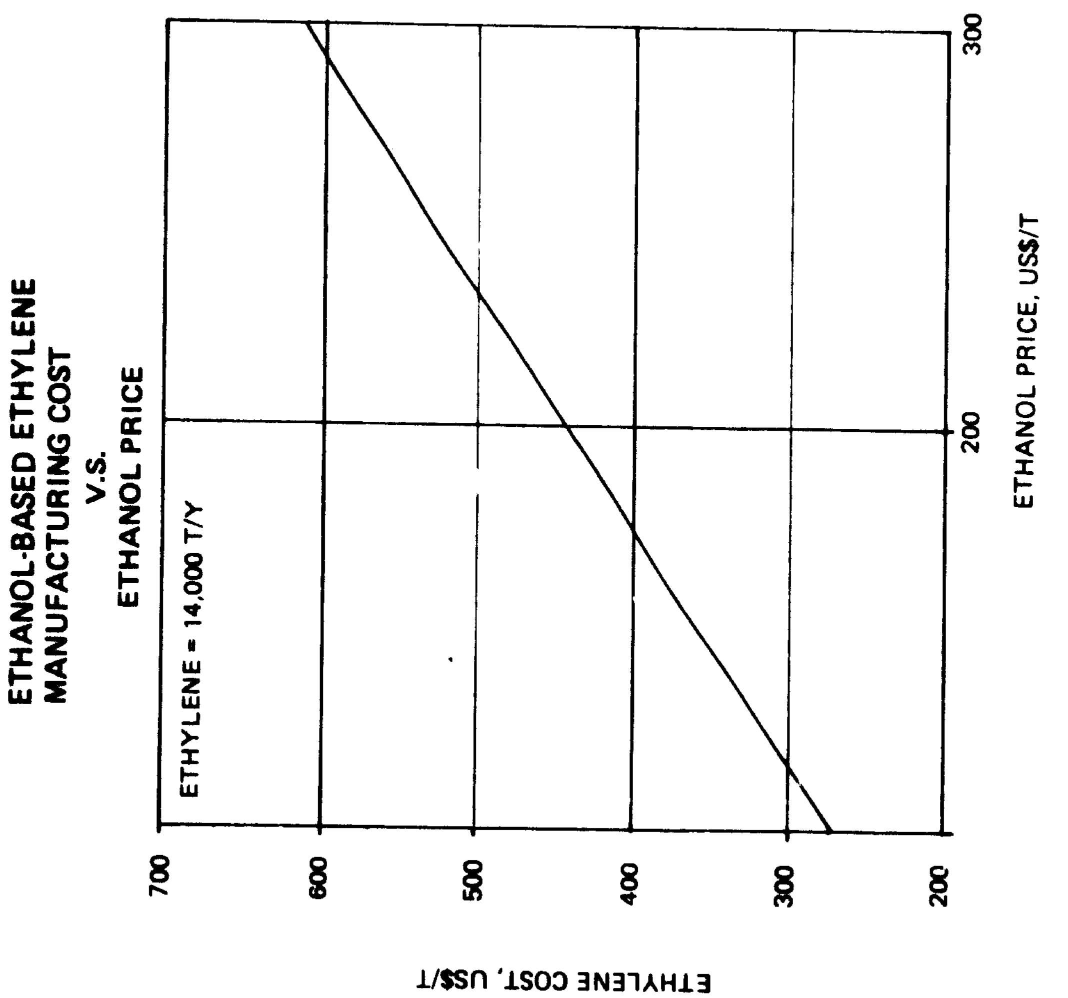
LABOR COST PER TON OF ACETALDEHYDE		US$/T
CHIEF	(1,100 US$/M)	4
OPERATOR	(700 US$/M)	

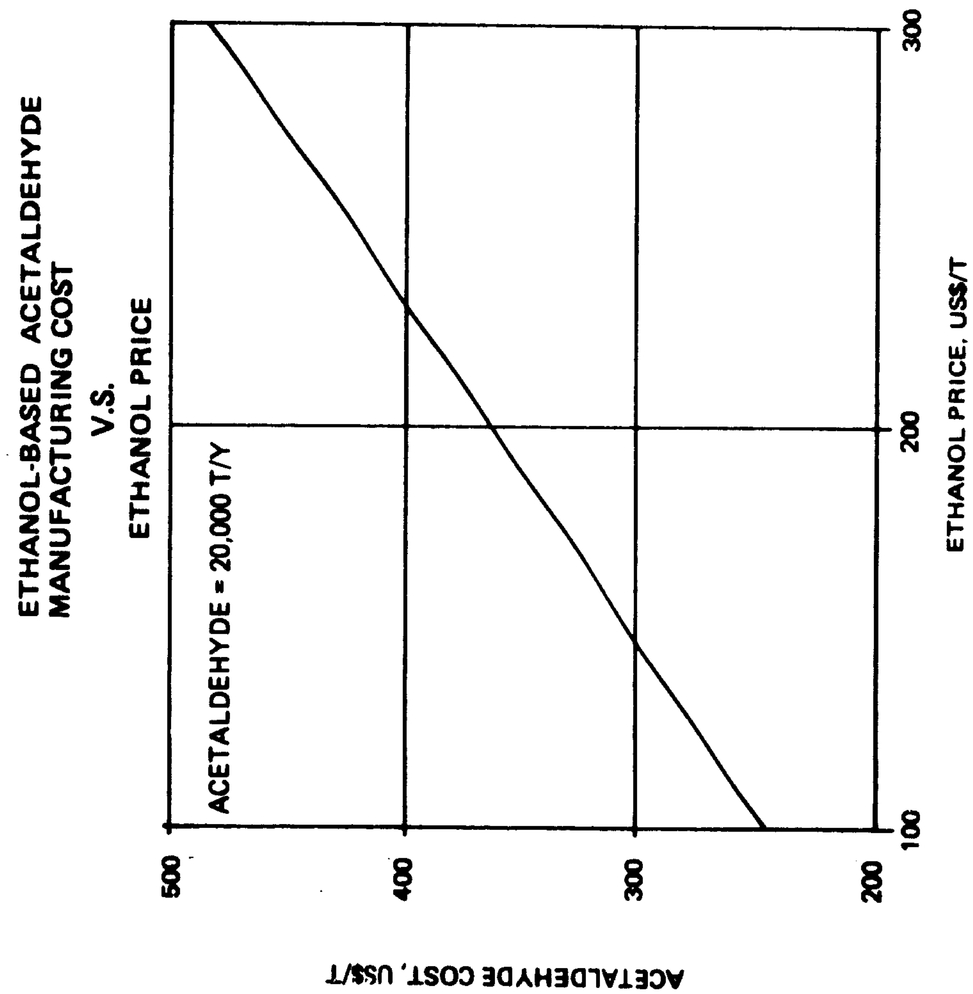
FIXED COST PER TON OF ACETALDEHYDE	US$/T
DEPRECIATION	15
INTEREST	18
MAINTENANCE	3
	36

ACETALDEHYDE MANUFACTURING COST — 1.2 x (ETHANOL PRICE, US$/T) + 124

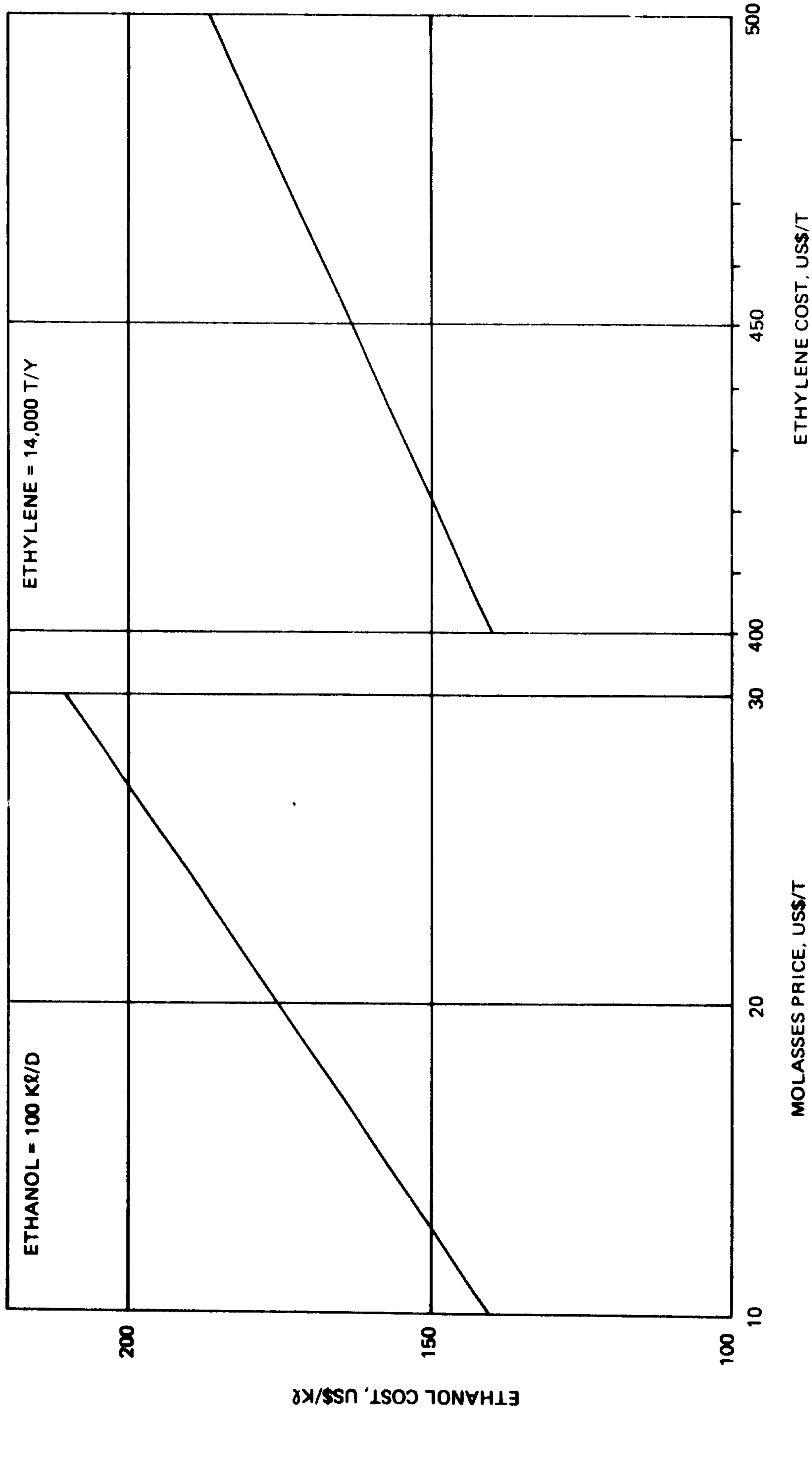
ETHANOL PRICE	100 US$/T	ACETALDEHYDE	244 US$/T
ETHANOL PRICE	200 US$/T	ACETALDEHYDE	364 US$/T
ETHANOL PRICE	300 US$/T	ACETALDEHYDE	484 US$/T


MOLASSES-BASED ETHANOL
MANUFACTURING COST V.S.
MOLASSES PRICE
ETHANOL = 100 Kℓ/D
200
150
100
10
20
30
MOLASSES PRICE, US$/T
ETHANOL COST, US$/Kℓ

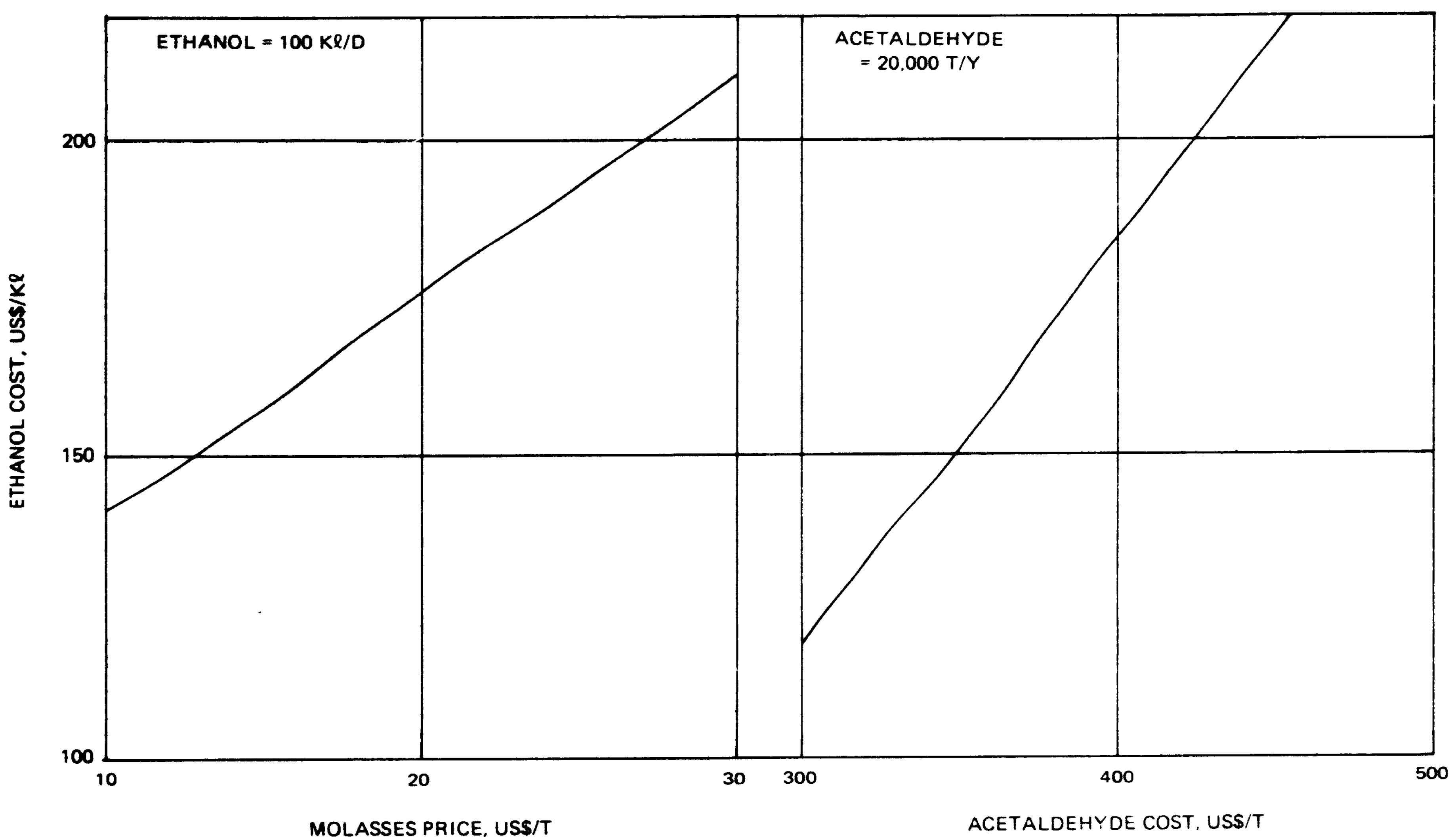

ETHANOL-BASED ETHYLENE
MANUFACTURING COST
V.S.
ETHANOL PRICE
ETHYLENE = 14,000 T/Y
ETHYLENE COST, US$/T
700
600
500
400
300
200
ETHANOL PRICE, US$/T
200
300


ETHANOL-BASED ACETALDEHYDE
MANUFACTURING COST
V.S.
ETHANOL PRICE
ACETALDEHYDE = 20,000 T/Y
500
400
300
200
100
200
300
ETHANOL PRICE, US$/T
ACETALDEHYDE COST, US$/T

MOLASSES-ETHANOL-ETHYLENE COST RELATIONSHIP



MOLASSES-ETHANOL-ACETALDEHYDE COST RELATIONSHIP



ETHANOL-BASED CHEMICALS ESTIMATED PRICE FOR REFERENCE

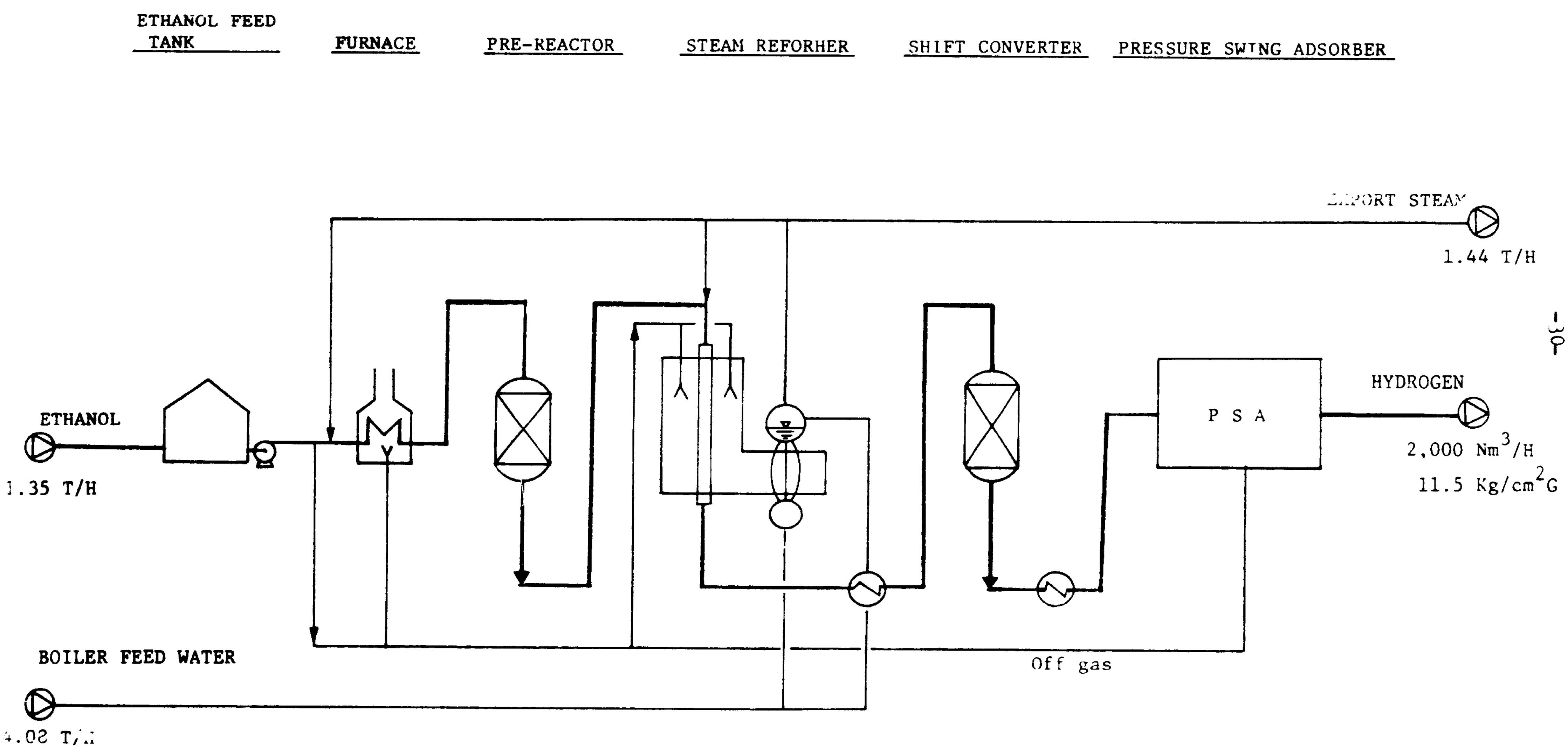
ESTIMATION BASIS

MOLASSES 15 US$/T

ETHANOL 160 US$/Kℓ (= 200 US$/T)

PRODUCT	PETROLEUM-BASED CHEMICALS MARKET PRICE IN JAPAN	ETHANOL-BASED CHEMICALS ESTIMATED PRICE
ETHYLENE	410 ~ 450	430
POLYETHYLENE	930 ~ 1,050	990
PVC	730 ~ 780	760
ETHYLENE DIAMINE	2,750 ~ 2,830	2,790
ETHYLENE GLYCOL	800 ~ 850	830
POLYSTYLENE	900 ~ 1,250	920
ACETALDEHYDE	450 ~ 550	360
POLYVINYL ACETATE	800 ~ 1,000	650
CHLOROACETIC ACID	1,350 ~ 1,380	990
ETHYL ACETATE	600 ~ 630	450
N-BUTANOL	900 ~ 950	670
2-ETHYLHEXANOL	800 ~ 850	600

ETHANOL-BASED HYDROGEN MANUFACTURING PROCESS



ETHANOL-BASED HYDROGEN MANUFACTURING COST

BASIS: HYDROGEN PRODUCTION RATE 2,000 Nm^3/H (99.99 Vol.%)

HYDROGEN PRESSURE 11 Kg/cm^2G

UTILITIES COST PER 1,000 Nm^3 OF HYDROGEN		US$/1,000 Nm^3
BOILER FEED WATER	(0.5 US$/T)	1.0
COOLING WATER	(0.05 US$/T)	0.5
ELECTRICITY	(0.03 US$/KWH)	3.0
		4.5

CATALYST AND CHEMICALS COST PER 1,000 Nm^3 OF HYDROGEN	US$/1,000 Nm^3
	1.5

LABOR COST PER 1,000 Nm^3 OF HYDROGEN	US$/1,000 Nm^3
	5

FIXED COST PER 1,000 Nm^3 OF HYDROGEN	US$/1,000 Nm^3
DEPRECIATION	23.4
INTEREST	27.6
MAINTENANCE	5.3
	56.3

HYDROGEN MANUFACTURING COST (US$/1,000 Nm^3)

ETHANOL PRICE	100 US$/T	HYDROGEN	138.0 US$/1,000 Nm^3
ETHANOL PRICE	200 "	HYDROGEN	208.7 US$/1,000 Nm^3
ETHANOL PRICE	300 "	HYDROGEN	279.4 US$/1,000 Nm^3

1. Introduction

In recent years, increasing attention is given to biomass, i.e., vegetal renewable resources, as a substitute for fossil resources like petroleum and coal.

A highly notable substitute in a very advanced state of industrialisation is fermentation alcohol from sugar cane or other vegetal resources, and its uses as fuel or raw material for chemical products. Today, petroleum constitutes the basic driving force for almost all industries, and since there are unexpected fluctuations in its supplies and sharp rises in purchase costs, it is considered important to minimise the effects of such changes on each country's economy. It is therefore, natural to expect alcohol to be another starting material for basic chemical products because it provides means of development of domestic industries while making use of indigenous agricultural products.

The desirability of alcohol as a substitute for petroleum can be explained by the following advantages from a chemical industry's standpoint:

Close ties with agriculture ...Agricultural products are used as raw materials.

Ease of production ....No need for complicated operations; with ease in mastering operation know-how

Ease of management ....No need for sophisticated techniques and skilled labor.

Ease of maintenance ....No complicated equipment or materials are involved.

Infinite chemical derivatives..Of the dervatives that are produced in the petrochemical industry, a substantial number of derivatives can be obtained from alcohol.

Promotion of labor employment..Effective in both agriculture and industry.

This means that there exists within our reach a chemical industry that may depend on nearby natural resources.
The products will make contributions to the country's own economic development, providing incentive to the creation of further industries.
Thus, it is possible to create new resources in resources-poor developing nations assuring an effective combination of agriculture and industry for the structural reinforcement and development of domestic industries.

However, for the realisation of such an agro-chemical industry, it is of importance to prepare careful plans based on long-term national economic policies in harmony with the country's industrial structures and regional and international environments.

The first step required in the planning is a general feasibility study.

This paper discusses an example of a roughly summarised feasibility study for the production of fermentation alcohol and the manufacture of chemicals therefrom.

2. Feasibility Study

- Comprehensive Industrial Development Planning for Developing Countries -

To plan and promote the establishment of any key industries in a country, it is necessary to primarily conduct precise surveys and analyses such as:

- o Identification of types of market products needed
- o Analyses of market conditions
- o Investigation of raw material supply
- o Determination of optimum production system and output
- o Development of realistic plans to prevent environmental hazards
- o Drawing up of blueprints of most logical engineering scheme

Feasibility studies for industrialization are generally conducted in the following steps:

Phase I	Basic Study
Phase II	Pre-investment Study
Phase III	Implementation of Project

To make sure of correct judgements based on such an over-all feasibility study, one of the most appropriate means is to entrust the services of a company who has wide experience with various cases, such as a general engineering company with consulting experience.

3. <u>Production of Fermentation Alcohol</u>

For the development of the fermentation alcohol industry, the specific features of the following items need to be clarified.

<u>Raw Materials</u>

- Sugar cane, molasses, cassava, corn, etc.
- Available amount and fluctuation
- Future prospects
- Price fluctuation

<u>Plant Location</u>

- Supply sources of raw materials
- Product delivery
- Utilities availability
- Waste disposal regulations
- Climatic conditions

<u>Labor</u>

- Raw materials gathering
- Plant operation
- Control
- Maintenance

<u>By-products</u>

- Liquid/solid fertilisers
- Paper manufacture

It is difficult to define principles of raw materials selection because it largely depends on the country's agricultural promotion policies and its reality. From the standpoint of alcohol manufacturing-cost alone, sugar cane is the most feasible raw material.

When sugar cane is used as raw materials, prevailing local conditions must be fully studied to enable a decision on a) whether to produce sugar and alcohol from molasses or alcohol directly from cane juice, b) what would be the requirements for annual operation, c) whether to be completely self-sufficient in fuel (bagasse can be used as paper feed) or use extaneous energy sources and d) what to do with waste liquor for useful applications (directly returned to farms?). The capacity of the processing plant need not only be studied from the standpoint of requirement of raw materials for chemicals but also in terms of raw material gathering.

In terms of manufacturing technology, attention should be given to technical improvements in energy savings especially in the distilling section. At the same time, further attention should desirably be given to the trend in the research and development in the fermentation section, as a future question.

4. <u>Alcohol-based Chemical Industry</u>

The main items of chemicals based on ethyl alcohol of which a commercial production can be envisaged may be classified as follows:

1. Derivatives to be manufactured from ethylene,
2. Derivatives to be manufactured from acetaldehyde,
3. Chemicals to be derived directly from ethyl alcohol.

On many of these items, production processes were already studied in the past, some of which are still in actual operation in commercial plants even today.
For example, in India, there is a successful commercial production of polyethylene, vinyl chloride monomer, SBR, polystyrene, etc. from ethanol-based ethylene.

In Brasil, there is an example of manufacturing styrene monomer and polyvinyl chloride from ethanol-based ethylene. In this country, today's trend is toward vinyl chloride production in connection with its national alcohol program. In Japan too, there were examples of production of ethyl glycol, ethyl ether, ethyl acrylate, chloral, etc. based on ethyl alcohol feed.

In view of the prevailing particular conditions of international oil supply, it would be of significance to re-evaluate fermentation alcohol as feed stock for chemical products including fine chemicals.

5. Conclusion

Today, it is difficult to predict when and how biomass could take the place of fossil resources.

The patterns would not only depend on international economic situations but also very much on the circumstances in each country. In countries where natural conditions favor abundant vegetal resources, there are possibilities that such replacements could become feasible at a relatively early time. It is advisable that fermentation alcohol will be studied from various points of view as the forerunner of biomass utilization.

In conclusion, it should be emphasized that for the successful realization of such projects, it will be essential to make use of a reliable organization that is able to conduct not only feasibility studies that fully reflect local conditions based on market and technical analyses from an international point of view, but also effective and economic design, construction and operating services for actual commercial manufacturing plants of fermentation alcohol and derivative chemicals and, if necessary, own technological research and development services for optimal realization of the project.

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