3.2.2 Blending of alcohol with gas oil or heavy oil-A (distillate fuel)

When alcohol is blended with gas oil or heavy oil-A (distillate fuel) and the mixture is used as fuel for existing diesel engines or small boilers, it is necessary to handle the mixture after making it into a homogeneous solution.

At normal temperature, alcohol and gas oil or heavy oil-A show an extremely poor solubility to each other. Because of this poor solubility, various blending methods are being considered including phase solution by solubilizer, emulsification with the use of an emulsifier, and blending by mechanically giving strong shearing force to two phases and producing fine particles.

Some experiments and studies using these methods have already been conducted in Japan. However, this report will not cover results of these efforts because these are too technical and require much description in detail.

II. Sales Policy

Each country uses either a monopoly system or taxation system for sales of ethyl alcohol to secure a liquor tax as an important source of revenue. Classification of major countries by the system adopted is as follows:

- Countries which use the monopoly system
  Denmark, Finland, Sweden, Norway, Switzerland, Austria, Federal Republic of Germany, France and Japan
- Countries which use taxation systems
  the United Kingdom, Italy, the Netherlands, Belgium, Canada, the United States and Brazil

For using ethyl alcohol as fuel or as basic raw material for the chemical industry, each country has sales promotion policy of its own as described below.

Regarding sales of ethyl alcohol for fuel use, Brazil, the United States and the Philippines implement a preferential policy benefiting consumers. Details of the preferential policy of each country are as follows:

1. Brazil

What the Survey Mission from Japan in October 1980 learned from hearings with respect to the preferential measures for sales were as follows.

(1) Assistance for ethyl alcohol sales

a. A certain profit margin is guaranteed to the service station marketers.
b. The market selling price of ethyl alcohol is to be 65-70% of the gasoline price. This market price was further reduced to 59% of the gasoline price in 1982.

(2) Incentives for vehicles fueled by ethyl alcohol

a. The installment sales period of gasoline vehicles is stipulated to be not longer than 12 months, but the period for ethyl alcohol vehicles is 24 months.
b. The single road tax on gasoline vehicles is 7% of the car price, but on ethyl alcohol vehicles, this tax is 3%.

2. The United States

Under the Federal Energy Act, there is a tax exemption of ¢4 per gallon from the federal energy tax. Decision has been made that this exemption will be increased to ¢5 per gallon by adding another ¢1, effective April 1983.

Depending on states, a state tax exemption is given in addition to that of the federal gasoline tax. The amount of the state tax exemption varies greatly from state to state, ranging from no exemption at all in some states to as much as ¢10.8 per gallon in Washington. For the amount of tax exemption in each state, refer to Appendix Table 7.

3. The Philippines

Information on the sales policy in the Philippines, obtained from PNAC in January 1983 is as follows:

- Difference in sales price between premium gasoline and ethyl alcohol blended gasoline (alcogas) is set at about US¢5/ℓ ($1 = 9.2 pesos) to sell alcogas at a lower price.
- For ethyl alcohol as fuel, the Government grants a subsidy of about US¢18/ℓ.

III. Consumption

1. Trends in Ethyl Alcohol Consumption

No appropriate statistics on total world consumption of ethyl alcohol have yet been reported.

Generally, the difference between production and consumption is considered to be the change in the inventory level of foreign trade is negligible. In case of ethyl alcohol, the variation in inventory in relation to production is considered negligible. Thus, total world production described in section B may be deemed as nearly equal to the total consumption.

Growth rate of production from 1965 to 1978 was:

- Industrial use 0.9%
- Fuel use (Brazil only) 16.5%

From the growth rate of production for industrial use, it may be concluded that the market for industrial use is already mature. The market for fuel use shows a considerable growth over the same period because of a sharp rise in oil prices, and the market for it may be considered to be a still growing one. However, it is necessary to make further study from a longer range perspective because the current market is affected by the temporary drop in oil prices.

Meanwhile, changes consumption by country will be fully discussed under section D on international trade. However, total international trade of ethyl alcohol on average accounts for only 4% of total world production. In fact, ethyl alcohol does not lend itself as an internationally traded commodity (for reasons to be discussed later).

Consequently, trends in consumption by country may safely be considered being virtually equivalent to trends in production in each country.

2. Trends in Consumption by End-use

As for classification by end-use, classification scheme varies from country to country. This makes it difficult to discuss the trends in consumption by end-use as a problem common to all countries.

As an example, changes in demand by the five major end-uses over the recent 10 years in Japan are shown in Table C-4.

Table C-4 Demand by Five Major End-uses over Recent Ten Years in Japan

(kl)

	1970 Production	1975 Production	Index (1970=100)	1980 Production	Index (1970=100)
Liquid Detergents	11,527	10,491	(91)	9,984	(87)
Cosmetics	20,986	23,158	(110)	16,657	(79)
Medicines	6,969	6,249	(90)	10,266	(147)
Vinegar	9,226	12,425	(135)	14,841	(161)
Food Preservatives	1,254	10,284	(820)	18,787	(1,498)

Source: Fermentation and Industry, Vol.39, p. 492

From Table C-4, it will be noted that demand for food preservatives has sharply grown. This is because in Japan chemical food additives have been reexamined from the safety standpoint in recent years and ethyl alcohol whose safety has been established has been increasingly used as food preservatives.

As for the other categories of demand, the demand for medicines and vinegar increased about 1.5 times over the 10 years (at an annual growth of about 5%) while the demand for liquid detergents and cosmetics showed slight decreases.

For reference, changes in demand for each end-use in the United States, Federal Republic of Germany and France are given in Appendix Table 8.

3. Factors Affecting Consumption

Ethyl alcohol is mainly used for the following three purposes;

Industrial Use:

- For chemical industry
- For beverage and food
- For hygiene and medicine

} (1) Utilizing the chemical and physical properties of ethyl alcohol

- For basic material of chemical industry

} (2) Utilizing ethyl alcohol as raw material for ethylene, etc.

Fuel Use: } (3) Utilizing ethyl alcohol as one of the energy sources

Since the size, character, etc. of each end-use market for ethyl alcohol are quite different that, we will analyze and describe the factors that affect the consumption of ethyl alcohol for each of the end-uses.

3.1 Ethyl Alcohol for Application in Chemical Industry, in Beverage and Food, and in Hygiene and Medicine

This use takes advantage of the dissolving, reacting, germicidal and other properties of ethyl alcohol and constitutes the main portion of industrial use of ethyl alcohol.

The uses of ethyl alcohol as solvent (which forms the biggest portion of chemical industry use), in beverage and food, and for hygienics and medicine all utilize the low toxicity of ethyl alcohol to the human body. These may be considered as ethyl alcohol's exclusive uses that allow no substitute to take its place.

Among the chemical industry uses of ethyl alcohol, ethyl acrylate and ester which are used for producing high grade paints and textile chemicals can be replaced by methyl alcohol and isopropyl alcohol, but the quantity of ethyl alcohol used in ethyl acrylate and esters is only 10% of the yearly ethyl alcohol consumption of Japan.

Under the circumstances, we can conclude that ethyl alcohol for chemical industry use, beverage and food use, and hygiene and medicine use (which altogether form major portion of industrial use ethyl alcohol) are special applications which can not be easily replaced by any substitute, since the replaceable portion is only 10%.

Two production processes of ethyl alcohol are known for said uses, i.e. synthesis and fermentation. Since the product by the synthesis process usually has some limitations in its use as mentioned in the foregoing part of this report, the synthesis process will be gradually replaced by the fermentation process when the fermentation process becomes more competitive than the synthesis process in terms of production cost.

3.2 Ethyl Alcohol as the Basic Material for Chemical Industry

Ethyl alcohol is used in order to obtain basic materials for the chemical industry such as ethylene through a chemical reaction which is a reversal of the synthesis process. This use of ethyl alcohol is industrialized only in such countries as Brazil, India, etc. where ethyl alcohol can be produced economically by using the fermentation process.

The petrochemical ethylene production process by thermal cracking of naphtha and natural gas is the most prevalent process in the world and recently the oil producing countries are planning to construct ethylene plants by the petrochemical process utilizing associated gas as feedstock.

Since there is no difference in quality between ethylenes produced from ethyl alcohol and by the petrochemical process, it will be the cost of production that will decide which of the two processes is more competitive. The petrochemical process utilizing naphtha produces a large quantity of by-products such as propylene, aromatics, etc. in addition to ethylene and it is to fully utilize these fractions that so-called petrochemical complexes have been formed. Therefore we should be aware that it is difficult to change the ethylene production by naphtha-based petrochemical process to ethyl alcohol-based production process even if the latter should become more favorable in terms of ethylene production cost.

3.3 Ethyl Alcohol for Fuel

Generally speaking, the selling price of gasoline is the production cost of gasoline plus gasoline tax and the government of each country counts on the gasoline tax as an important source of revenue.

Production cost of ethyl alcohol in the fuel use ethyl alcohol producing countries is estimated to be somewhere between the production cost and selling price of gasoline. Although introduction of fuel use ethyl alcohol may decrease the tax revenue from gasoline, it will surely contribute to the improvement of the foreign currency balance due to decrease in oil consumption, to the effective utilization of surplus farm products, to the increase in employment opportunities, etc. We may say that the consumption of fuel use ethyl alcohol will be affected by the future trends in oil price and the ethyl alcohol production cost.

D. INTERNATIONAL TRADE

In Table D-1, we compare the production (see Table B-13) and the import and export for each year.

We can see from Table D-1 that the ratio of the international trade to the production is low at approximately 4% on average and that ethyl alcohol is not an internationally traded commodity.

Table D-2 shows the international trade in ethyl alcohol for industrial use and fuel use combined in the years 1977-1979.

Since international organizations do not publish any reliable statistical report on international trade in ethyl alcohol, we prepared Table D-2 using the data collected by Chemical Marketing Center Co., Ltd., Japan.

Table D-1 Share of International Trade in Ethyl Alcohol to Production

	Import			Export		
	1977	1978	1979	1977	1978	1979
Quantity (1,000 MT)	392	467	177	200	247	276
Percentage to Production (%)	5.1	5.6	2.1	2.6	2.9	3.3

We might point out the following as some of the reasons why the international trade of ethyl alcohol is not so big:

- Because many governments regulate ethyl alcohol in some way or another, such as by adopting the monopoly system or special taxation system to secure liquor tax revenue, ethyl alcohol is precluded from becoming a free merchandise;
- Ethyl alcohol can be produced from various kinds of material by using the fermentation process and/or the synthesis process in every country of the world;
- Many governments aim to promote domestic production of ethyl alcohol from the viewpoint of agricultural policy because ethyl alcohol production by the fermentation process consumes a lot of farm products and expands the end-use application for farm products;

Table D-2 International Trade in Ethyl Alcohol

(1,000 MT)

	Import			Export		
	1977	1978	1979	1977	1978	1979
Austria	-	-	-	-	-	-
Belgium/Luxemburg	8.8	9.4	16.0	6.2	3.5	4.4
Bulgaria	13.3	13.2	12.7	-	-	-
Canada	0.1	-	-	---	---	---
Cyprus	0.1	0.1	---	-	-	-
Czechoslovakia	23.1	2.6	2.6	-	-	-
Denmark	16.4	16.1	---	1.5	0.8	---
Finland	6.3	12.3	2.3	0.9	0.6	0.7
France	1.4	0.9	27.6	55.0	79.6	96.2
Germany, Fed. Rep.	---	---	---	---	---	---
German Dem. Rep.	21.5	19.7	16.5	3.9	3.5	4.4
Greece	2.5	0.4	---	-	-	-
Hungary	-	-	-	-	-	-
Iceland	0.3	0.3	---	-	-	-
Ireland	1.7	2.8	---	-	0.2	-
Italy	9.7	12.7	30.3	26.0	16.9	4.2
Malta	---	---	---	---	---	---
Netherlands	5.7	---	---	5.6	---	---
Norway	1.4	0.7	0.4	9.6	8.0	8.5
Poland	---	---	---	---	---	---
Portugal	1.8	2.5	2.6	-	-	-
Romania	8.6	-	-	-	-	-
Spain	3.7	65.6	---	-	-	-
Sweden	19.0	17.0	19.3	2.0	11.0	-
Switzerland	14.2	21.5	8.0	-	-	-
Turkey	-	-	-	-	-	-
USSR	---	---	---	21.5	21.4	21.1
UK	11.2	11.9	25.5	47.9	79.6	75.2
USA	59.4	71.0	12.7	20.1	21.8	60.9
Yugoslavia	---	-	-	---	---	---
Japan	162.1	186.6	---	0.1	---	---
Total	392.3	467.3	176.5	200.3	246.9	275.6

Source: Chemical Marketing Center Co., Ltd., partly revised by the Study Team.

- Ethyl alcohol production plant does not require big amount of investment (it is said that the investment cost of the standard capacity plant of 120 kl per day is around US$10 to 18 million).

However, we expect that the international ethyl alcohol trade may become active due to the following reasons:

- Cost increase of the synthesis process due to oil price hikes may enlarge the cost difference between the fermentation process and the synthesis process so that the international trade may increase to some extent on account of this cost difference.
- Ethyl alcohol production by the synthesis process using associated gas as feedstock which is now planned by the oil producing countries is expected to be low priced and the developed countries are being counted on to become the market outlets.

E. SUPPLY AND DEMAND PROJECTIONS

I. Factors Affecting Supply and Demand Projections

We will analyze the outlook for trends in raw material market, production technology, production cost and consumption market which are factors that will affect the future supply and demand of ethyl alcohol.

1. Raw Material Market Trends

As mentioned before, industrial use ethyl alcohol is produced by the fermentation process and the synthesis process, while fuel use ethyl alcohol is produced only by the fermentation process.

Since raw materials used for the fermentation process are common to both industrial use ethyl alcohol and fuel use ethyl alcohol, we will first describe the raw material market trends of the fermentation process and later on the raw material market trends of the synthesis process.

1.1 Raw Materials for the Fermentation Process

1.1.1 Quantitative outlook of raw materials

We will describe hereunder the outlook of molasses and sugar cane which are used as raw materials for the fermentation process ethyl alcohol production, and also the outlook for cassava which is expected to become one of the important raw materials.

(1) Sugar cane and molasses

Since sugar cane is the raw material for sugar production and molasses is the by-product of sugar production, the quantitative outlook of these two materials will depend much on the supply and demand of sugar.

According to the World Bank estimate, world sugar demand is expected to increase annually by 2.7% up to 1995 (Table E-1). In this estimate, the World Bank developed the estimated values independently for supply side and demand side by using their forecasting model, and then figured out a reasonable price level to close the expected supply-demand gap. We judge their estimated annual growth rate of 2.7% to be reasonable.

We prepared on the other hand Tables E-2 and E-3 showing the cultivated area, the yield per unit area and growth rate of production for sugar cane and sugar beet during the past ten years on the basis of FAO statistics.

The average annual growth rates of sugar cane and sugar beet production are calculated to be 2.9% and 2.1% respectively, and thus, we may say that the sugar demand can be met in so far as the raw material supplies are concerned.

As we see in Table E-2, sugar cane yield per unit area in Asia is lower than the world average of 52 tons/ha by about 5 tons/ha (i.e. approximately 10% lower) and is capable of being improved considerably in spite of unfavorable climates and soil conditions of that region. Therefore we can conclude that aside from its use for producing sugar, some portion of world sugar cane production may be used as one of the raw materials for ethyl alcohol.

Since molasses is a by-product of sugar production, if sugar production increases annually at 2.7% as aforesaid, molasses production is anticipated to increase at the same growth rate as that of sugar production.

World molasses production amounted to 30.8 million tons in 1979/1980 as given in Table B-1, so we can expect about 830,000 tons of annual increase in molasses production. According to the World Bank Report entitled Alcohol Production from Biomass in the Developing Countries, September 1980, wasted molasses amounts to 5 million tons in the world now and we can therefore expect that a fairly large quantity of molasses can be used as raw material for ethyl alcohol when we take the expected increase in molasses production into consideration.

(2) Cassava

It is said that cassava originated in South America but nowadays cassava is cultivated all over the world, mainly in the developing countries and is consumed as food and animal feed.

Cassava is internationally traded mainly between EC member countries and Thailand as animal feed, which accounts for almost 90% of world trade. According to FAO statistics, world trade is around 1.5 million tons, which is only a little over 1% of the world production of cassava, about 127 million tons.

Table E-1 Sugar - Summary of World Production, Consumption and Trade by Economic Regions

	Actual						Estimated	Projected			Growth Rates				
	1960	1963	1970	1975	1977	1978	1979	1980	1985	1990	1960-77	1977-80	1980-85	1985-90	1977-90
	(1,000 MT)										(% per annum)				
Production															
Developed Countries	15,145	17,137	18,773	21,010	23,425	22,015	22,000	22,025	25,719	28,505	2.6	-2.0	3.2	2.1	1.5
Developing Countries	19,990	25,808	31,204	37,465	44,023	44,444	43,000	43,949	53,190	63,539	4.8	-0.1	3.9	3.6	2.9
Planned Economy Countries	16,957	22,101	22,927	23,070	24,377	25,849	25,000	25,265	26,799	29,964	2.2	1.2	1.2	2.3	1.6
World Total	52,092	65,046	72,904	81,545	91,825	92,308	90,000	91,239	105,708	122,008	3.4	-0.2	3.0	2.9	2.2
Consumption															
Developed Countries	21,513	24,089	27,908	25,308	27,101	26,804	28,500	30,309	31,042	33,000	1.4	3.8	0.5	1.2	1.5
Developing Countries	15,675	19,851	25,449	31,508	34,344	37,859	38,500	39,118	47,160	57,479	4.7	4.4	3.8	4.0	4.0
Planned Economy Countries	11,227	16,280	18,735	20,518	22,869	23,270	24,000	24,384	26,597	29,306	4.3	2.2	1.8	2.0	1.9
World Total	48,415	60,220	72,092	77,334	84,314	87,933	91,000	93,811	104,799	119,785	3.3	3.6	2.2	2.7	2.7
Exports															
Developed Countries	2,159	3,227	2,933	3,210	5,937	5,831	5,600	5,415	6,292	7,519	4.6	-3.0	3.1	3.6	1.8
Developing Countries	7,977	8,473	9,048	10,935	15,213	10,743	18,000	14,426	14,256	16,843	3.9	-1.8	-0.2	3.4	0.8
Planned Economy Countries	6,926	7,784	9,493	6,302	7,066	8,223	2,400	6,002	7,750	8,764	0.1	-5.3	5.2	2.5	1.7
World Total	17,062	19,484	21,474	20,447	28,216	24,797	26,000	25,843	28,298	33,126	2.8	-2.9	1.8	3.2	1.2
Imports															
Developed Countries	10,986	10,333	11,560	10,083	11,892	10,072	11,500	12,208	12,160	13,098	0.5	0.9	-0.1	1.5	0.8
Developing Countries	3,962	4,966	4,188	5,820	7,540	8,550	8,000	7,106	8,404	11,467	3.9	-2.0	3.4	6.4	3.3
Planned Economy Countries	2,557	3,460	5,461	4,759	7,807	6,346	6,500	6,526	7,734	8,561	6.8	-5.8	3.4	2.1	0.7
World Total	17,505	18,759	21,209	20,662	27,239	24,968	26,000	25,840	28,298	33,126	2.6	-1.7	1.8	3.2	1.5

Source: International Sugar Organization (actual); World Bank, Economic Analysis and Projections Department (projected).

Table E-2 Sugar Cane Production by Regions

	Cultivated Area (1,000 ha)			Yield per Unit Area (kg/ha)			Production (1,000 MT)		
	1969/71	1979	1981	1969/71	1979	1981	1969/71	1979	1981
World	10,747	13,584	13,819	52,833	55,547	56,102	567,817	754,536	775,285
Africa	698	864	930	67,394	70,744	69,582	47,036	61,095	64,687
North/Central America	2,698	2,920	3,036	57,088	61,236	56,535	154,022	178,785	171,625
South America	2,477	3,530	3,831	51,735	58,028	57,230	128,123	204,853	219,249
(Brazil)	(1,708)	(2,537)	(2,803)	(45,926)	(54,750)	(54,888)	(78,460)	(138,899)	(153,858)
(Brazil's percentage share in world total)	(15.89)	(18.68)	(20.28)	(86.93)	(98.57)	(97.84)	(13.82)	(18.41)	(19.85)
Asia	4,599	5,935	5,633	47,389	47,886	51,548	217,931	284,207	290,357
Europe	7	6	6	72,132	63,910	64,000	486	374	384
Oceania	269	329	384	75,065	76,570	75,437	20,220	25,222	28,983

Source: FAO

Table E-3 Sugar Beet Production by Regions

	Cultivated Area (1,000 ha)			Yield per Unit Area (kg/ha)			Production (1,000 MT)		
	1969/71	1979	1981	1969/71	1979	1981	1969/71	1979	1981
World	7,621	8,847	9,345	29,304	29,794	30,120	223,322	263,618	281,485
Africa	42	69	71	31,546	33,924	34,952	1,324	2,324	2,464
North/Central America	610	477	527	41,825	43,627	49,274	25,528	20,809	25,951
South America	49	32	47	36,070	31,798	38,329	1,772	1,027	1,808
Asia	579	901	1,176	23,114	23,477	20,986	13,394	21,145	24,675
Planned Economy Countries	4,674	5,408	5,554	23,070	22,226	19,806	167,816	120,198	109,999
Europe	2,982	3,639	3,892	35,949	39,045	42,644	107,209	142,095	165,987

Source: FAO

We will first review this self-supporting type of supply and demand pattern before we discuss the potential of its becoming a raw material for producing ethyl alcohol.

According to FAO Food Balance Sheets, it is estimated that animal feed accounts for one-third and food including processed products for two-thirds of cassava consumption. Table E-4 shows the world average daily food intake per capita and the share of root-crops including cassava in it to show the position of cassava as food.

According to Table E-4, the world average daily food intake per capita is rising while the share of root-crops is decreasing both in the developed countries and developing countries. We understand from this fact that cassava is losing its importance as food.

As for production, Table E-5 shows changes in production, yield per unit area and cultivated area for cassava during the past ten years based on the FAO statistics. The table shows that the expansion of hectarage at an average annual rate of 2.2% was responsible for a 1.9% average annual growth of cassava production during the past ten years. Cassava cultivation is usually carried out on non-fertile soil in an extensive way. According to the World Bank, the prevailing yield of 9 - 12 tons/ha can be improved up to 20 tons/ha by cultivating improved varieties and adopting advanced cultivation methods and fertilizer administration.

Since we expect that the food consumption of cassava which accounts for two-thirds of world cassava consumption will decrease and that the cassava yield per hectare can be raised considerably by improving cultivation methods, we consider that cassava can be counted on as a major raw material for ethyl alcohol productions in terms of quantity.

1.1.2 Outlook for raw material prices

(1) Sugar cane

Since no international organization has ever made a reliable price projection for sugar cane, we used the projected sugar prices to derive the future sugar cane price trends.

The World Bank Report entitled Price Prospect for Major Primary Commodities suggests that the average sugar price will be US$372/ton for the period 1985-1995. The World Bank derived this price by separately projecting the supply and demand for sugar using their own forecasting model to seek the price which will close the gap between supply and

Table E-4 Daily Food Intake per Capita and the Share of Root-crops in It

(cal/day)

		1961-65	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Food Intake		2,438	2,435	2,481	2,474	2,505	2,526	2,505	2,499	2,549	2,523	2,570	2,571
Share of Root-crops	World	191	180	187	182	176	171	168	169	169	162	164	161
	Developed countries	189	178	179	176	173	171	166	165	162	160	156	159
	Developing countries	192	181	191	184	177	170	169	171	172	163	167	162
	(Brazil)	(292)	(329)	(340)	(339)	(324)	(323)	(312)	(266)	(248)	(250)	(237)	(241)

Table E-5 Cassava

	Cultivated Area (1,000 ha)			Yield per Unit Area (kg/ha)			Production (1,000 MT)		
	1969/71	1978	1979	1969/71	1978	1979	1979/71	1978	1979
World	10,794	13,615	13,397	8,958	8,863	8,748	96,692	120,670	117,201

Source: FAO

demand as mentioned before, and we judge that the expected sugar price of US$372/ton is reasonable.

Fig. E-1 shows the trends in sugar price over the 1961 - 1982 period by the International Sugar Council. From this data we find that the sugar price was approximately US$282/ton in 1982. When we adopt the World Bank price forecast of US$372/ton for the sugar price in 1990, average annual price increase is about 3.3% for the 1982 - 1990 period.

Therefore we judged that the price of sugar cane will also rise at a rate of 3.3% per annum in the coming years.

(2) Molasses

According to the World Bank Report entitled Alcohol Production from Biomass in the Developing Countries, molasses is utilized for:

- Animal feed, raw material for ethyl alcohol by fermentation in producting countries: approximately 66%;
- Internationally traded as animal feed: approximately 20%;
- The remaining 14% of molasses is abandoned without being utilized.

Due to temporary stagnation of oil price and the special character of ethyl alcohol market, we cannot anticipate any remarkable change in the molasses demand.

Regarding supply of molasses, an annual growth rate of about 2.7% (i.e. about 830,000 ton increase annually) is anticipated in parallel with the increase of sugar production as mentioned before.

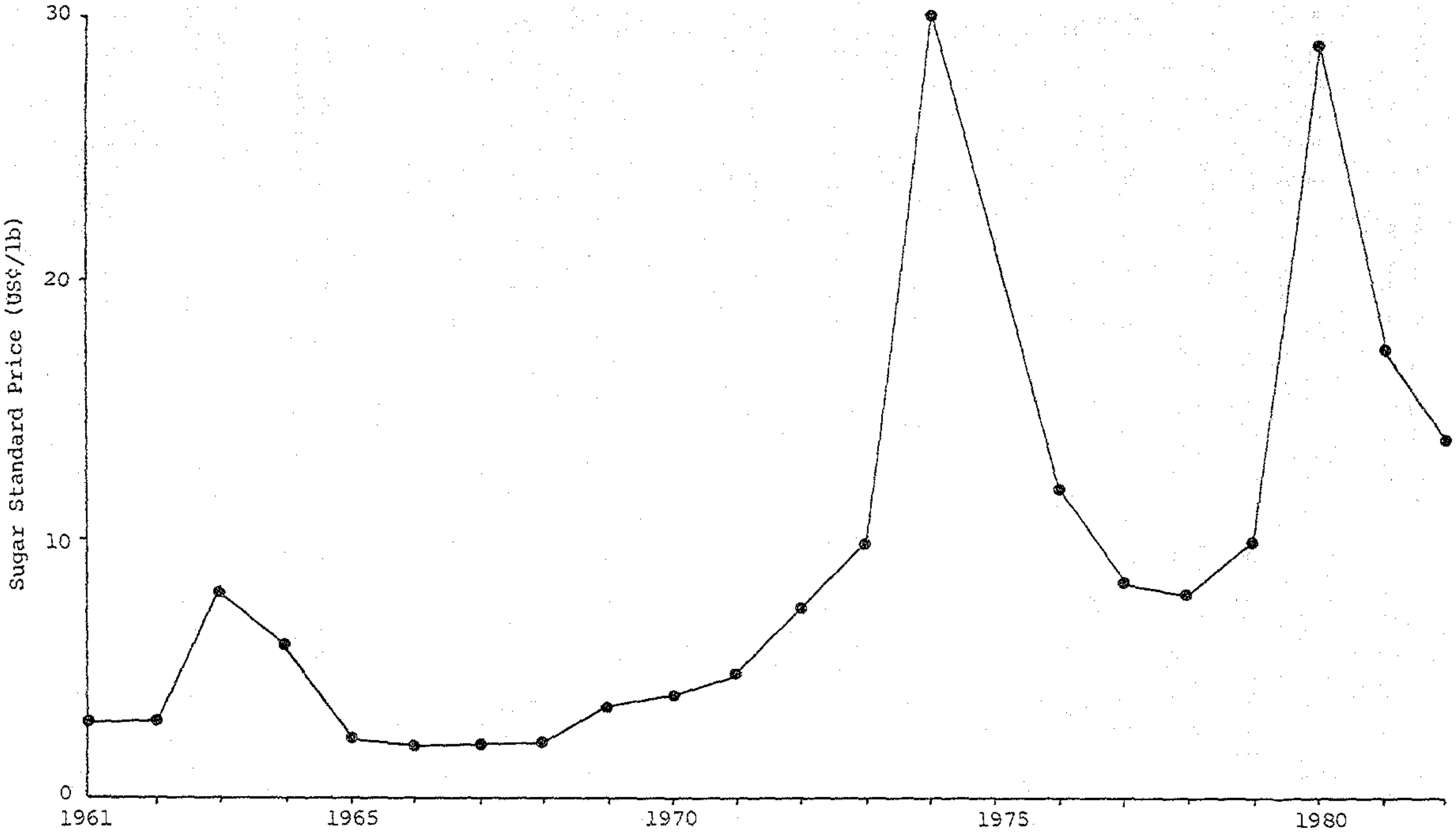
As any substantial change is unlikely to occur in the future molasses supply-demand, we estimated the future molasses prices on the basis of the past price trends.

The average price increase rate is estimated at about 1.6% per annum by the least square method from the past price trend of molasses shown in Fig. E-1, and we expect that this annual price increase is also applicable in future.

(3) Cassava

Since the internationally traded quantity of cassava accounts for only about 1% of the world total production as mentioned before, there is very little price data on cassava. When we consider the characteristics of cassava market and competi-

Fig. E-1 World Market Price of Sugar



Source: International Sugar Council

tion with other feedcrops, cassava demand is unlikely to rise sharply. Hence cassava price is also unlikely to rise sharply.

Though appropriate price data for cassava is not available, we show in Fig. E-2 the farm shipping prices of cassava in Thailand for the past twelve years.

Regression analysis gives us an average annual rise of 3.9% of cassava price from Fig. E-2.

Since any remarkable change is not anticipated in the future supply-demand situation of cassava, the cassava price is considered to increase at an annual rate of 3.9% in future.

1.2 Synthesis Process

1.2.1 Prospect of raw materials supply

Ethylene is the raw material for the synthesis process ethyl alcohol production and about 36 million tons was produced in 1980 as shown in Table B-7.

According to the survey conducted by Shell, ethyl alcohol produced by the synthesis process amounted to about 1.6 million kl in 1980, and about 600,000 tons of ethylene was used for ethyl alcohol production.

As above, ethylene consumed as the raw material for the synthetic production of ethyl alcohol accounts for only 1.6% of the total ethylene production. In view of the ethylene production projects using associated gas in oil producing countries and the current world-wide low operation rate of ethylene plants, we can expect that enough quantity of ethylene will be available for the synthetic production of ethyl alcohol.

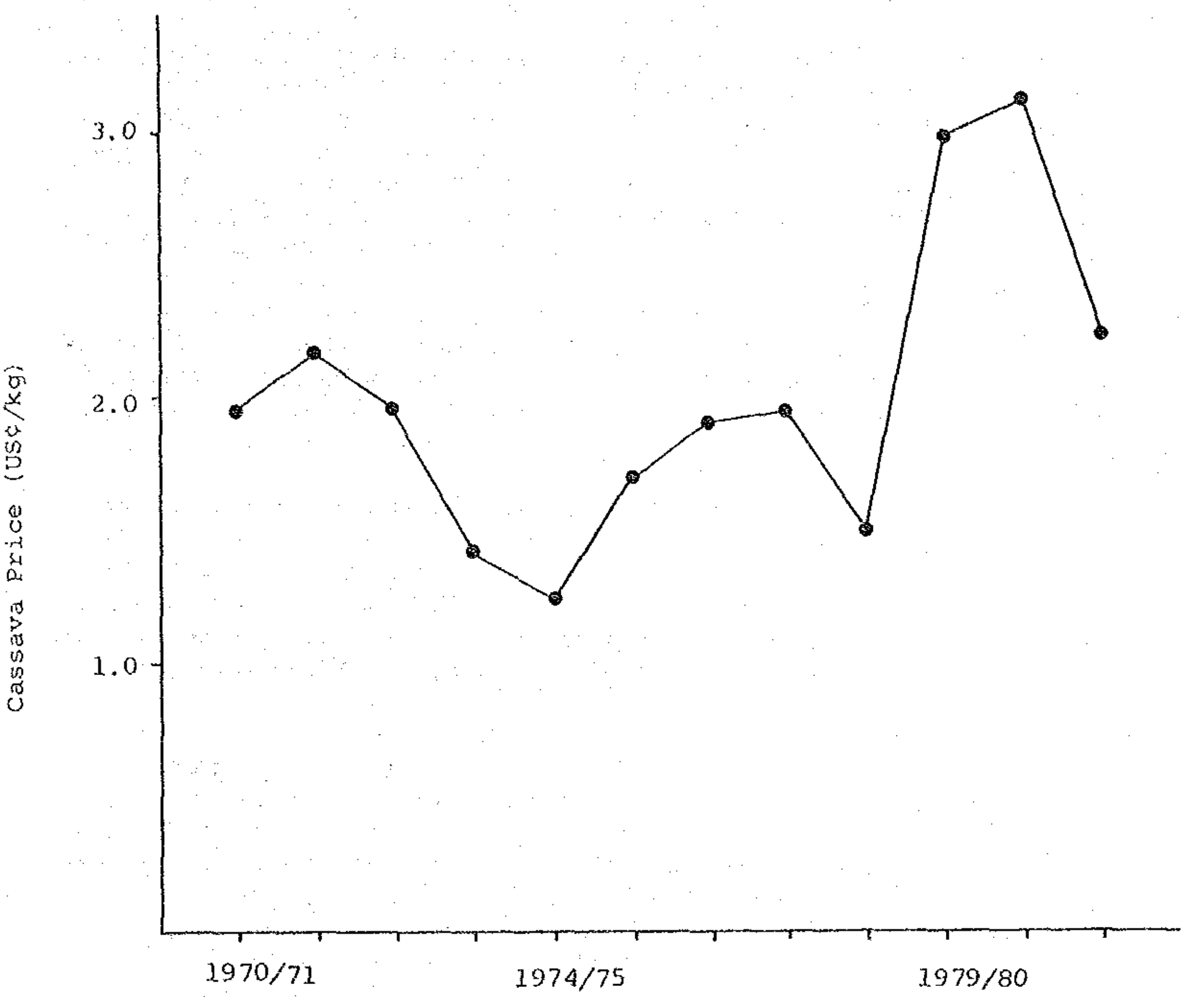
1.2.2 Price trends of materials

Ethylene, which is the raw material of the synthesis process ethyl alcohol, is produced by thermal cracking of naphtha, natural gas and associated gas.

According to the industry, feedstock costs account for about 80% of the ethylene cost due to be soaring oil price in recent years.

Thus, in estimating the future ethylene price, the rising price of ethylene material was given an 80% weight.

Fig. E-2 Changes in Farm Shipping Price of Cassava in Thailand



Note: Applied conversion rate US¢1 = 4.17 Baht

The price of naphtha may be considered as closely linked with the crude oil price since naphtha is one of its fractions. Among many forecasts of crude oil price by various international organizations, the forecast announced in the World Bank Report entitled Emerging Energy and Chemical Applications of Methanol was adopted for this report as it envisages an average rise of 2.5% which is considered reasonable in view of forecasts by IEA, and others.

The rate of price rise for naphtha-based ethylene was assumed to be 2.0% a year.

The natural gas price in the United State is controlled to a lower level than the potential market up to 1985 under the price control on energy, but reportedly it will rise to the price level equivalent to low-sulphur heavy oil-C when converted to an equal calorific value and become almost equal to the price of the natural gas-based ethylene in absolute terms in and after 1986. The 1980 price of the natural gas-based ethylene was US$490/ton, which was considerably lower than the naphtha-based ehtylene price (US$750 - 800/ton) as stated previously. In this report, the natural gas-based ethylene price is assumed to rise at an annual rate of 2% up to 1985, then rise sharply to become equal to the naphtha-based ethylene price in 1986; after that, it will continue rising at an average annual rate of 2.0% again.

As for associated gas, Shell plans to construct a 350,000 kl/year capacity synthetic ethyl alcohol production plant in Saudi Arabia for on-stream in 1986. Associated gas will be used as the material for ethylene in this project. The cost of associated gas is reported to be US$0.5 per MMBTU, and the associated gas-based ethylene price is estimated at approximately US$400/ton.

It is reported that the price of the associated gas-based ethylene will be maintained at a same level for a long period as a matter of policy. Thus, ethylene from this project is considered to be the most competitive among various materials for the synthetic ethyl alcohol production. From this, it was anticipated that the price of the associated gas-based ethylene will remain at US$400/ton after 1986 without any price rise.

2. Trends in Production Technology

Technological innovations have been described in the section on production. In this section, the effects of technological innovations on the production cost will be reviewed.

We may consider the following as the major technological innovations leading to the production cost reduction:

- Increase in the yield per unit area of raw materials (only on farm products used materials for the fermentation process ethyl alcohol production)
- Savings in raw material cost and utility cost
- Reduced investment cost of production plant
- Economies resulting from larger production scale

We will see the potential magnitude of cost reduction attainable by the technological innovations on each of the fermentation process and synthesis process using the latest average production costs stated in the section on production as a basis. For this cost study, a newly constructed production plant was assumed.

2.1 Fermentation Process

Cost study is made for each of the major raw materials; molasses, sugar cane and cassava.

Among the latest technological innovations as mentioned in the section on production, only those items that are considered to have been carried to a relatively high degree of technical completion will be taken up in evaluating their effects on cost reduction.

2.1.1 Molasses

(1) Increase in the raw material yield per unit area

Since molasses is not a farm product but a by-product of sugar production, this item is not applicable.

(2) Saving in raw material and utilities costs

The most modern process using molasses as raw material was assumed to incorporate the most modern technologies that have been carried to a high degree of technical completion, such as the continuous fermentation process using immobilized yeast and the pressurized distillation. Thus, the production process of ethyl alcohol from molasses is assumed to be as follows:

Molasses
↓
Fermentation (continuous fermentation process using immobilized yeast)
↓
Distillation (pressurized distillation)
↓
Ethyl alcohol

We do not expect any cost reduction due to raw material saving even when the immobilized yeast process is adopted for the fermentation process.

On the other hand, we can expect utility cost saving by adopting the pressurized distillation, since the pressurized distillation is said to be capable of saving about 30% of utilities consumed in the distillation unit. Generally, it is said that the distillation process consumes about 85% of the total utilities requirements. It is therefore possible to save about 26% of the total utilities consumption by adopting the pressurized distillation.

(3) Reduced construction cost of production plant

The immobilized yeasts process in the fermentation process makes it possible to reduce the investment cost of the fermentation unit by about 20 - 30% by comparison with the conventional process. The fermentation unit accounts for about 25% of the total investment cost. Thus, the total investment cost can be reduced by 5 - 7.5% by adopting the immobilized yeast process. In this report we assumed a 6% saving as an average.

The pressurized distillation process also affects the investment cost because it requires larger wall thickness for the distillation column but makes the diameter of the column smaller. All in all, it is said that the pressurized distillation column is somewhat cheaper than the conventional unit, but this has not been taken into account because its effect on the total plant investment cost is insignificant.

(4) Economies resulting from larger production scale

In the sugar producing countries, ethyl alcohol plants using molasses as raw material are usually located near sugar plants to facilitate collection of molasses.

This means that the capacity of ethyl alcohol plant is restricted by the availability of molasses that can be economically transported. Thus, we have not considered economies of scale by the capacity expansion.

In summary, when molasses is used as raw material, the technological innovations will bring about:

- 26% reduction in utilities cost
- 6% reduction in plant investment cost

2.1.2 Sugar cane

(1) Increase in the raw material yield per unit area

The ten year average annual growth rates of sugar cane yield over the 1968-1978 period according to the FAO statistics are given in Table E-6. During the said ten years, the yield of Brazil, India and Cuba had grown annually on an average by 18.8%, 3.7% and 12.1% respectively. We expect that the yield will increase at approximately the same rate as used to be and assumed 10% annual growth of the sugar cane yield per unit area is for this report. This 10% growth rate is attainable in view of the past ten year performance in Brazil and Cuba.

(2) Saving in raw material cost and utility cost

The latest sugar cane-based ethyl alcohol production process will be the same as the molasses-based production process as follows:

Sugar cane
↓
Fermentation (continuous fermentation process using immobilized yeast)
↓
Distilation (pressurized distillation)
↓
Ethyl alcohol

We do not expect any quantitative saving in material by adopting the immobilized yeast process for the fermentation unit. On the other hand, we can expect about 30% manpower saving in utilities by adopting the pressurized distillation process in the distillation unit. Generally, the utilities consumed in the distillation unit amounts to about 70% of the total utilities consumed in the sugar cane-based ethyl alcohol production. Thus, about 21% of the total utilities consumed can be saved by adopting the pressurized distillation.

(3) Reduced investment cost of production plant

The immobilized yeast process in the fermentation unit makes it possible to reduce the investment cost of the fermentation unit by about 20 - 30% in comparison with the conventional process. The fermentation unit accounts for about 15% of the total investment cost of sugar cane-based ethyl alcohol production plant. Accordingly, the total investment cost can be reduced by 3 - 4.5% by adopting the immobilized yeast

Table E-6 Growth of Farm Products

	Production	Yield	Cultivated Hectarage	Average Annual Growth Rate for the Last 10 Years
	(1,000 MT)	(kg/ha)	(1,000 ha)	(%)
(Rice)				
China	143,400	3,717	38,575	14.6
India	69,000	1,792	38,500	8.8
Indonesia	26,350	2,977	8,850	25.3
(Wheat)				
China	60,003	1,444	40,001	32.0
USA	58,289	2,301	25,333	7.2
India	34,982	1,574	22,220	24.6
(Cassava)				
Brazil	24,935	11,844	2,105	-28.6
Indonesia	13,100	9,371	1,398	24.1
Thailand	12,500	12,500	1,000	-25.5
(Sweet Potato)				
China	92,600	8,527	10,860	4.6
Viet Nam	2,400	6,316	380	26.0
Indonesia	2,350	7,605	309	23.0
(Sugar Cane)				
Brazil	138,325	54,906	2,519	18.8
India	156,450	50,160	3,119	3.7
Cuba	70,000	53,030	1,320	12.1
(Corn)				
USA	197,208	6,330	28,726	10.0
China	40,620	3,113	13,050	9.0
Brazil	16,309	1,442	11,314	11.0
(Potato)				
Poland	49,582	20,312	2,441	20.7
USA	15,769	30,456	518	17.2
China	14,040	9,154	1,543	15.5

Source: FAO

process. In this Study, an average of 4% saving in total investment cost was assumed.

(4) Economies resulting from larger production scale

The capacity of sugar cane-based ethyl alcohol production plant is restricted by the availability of economically transportable sugar cane. In the section on production, we mentioned a 120 kl/day capacity as being the latest average, and this production scale of 120 kl/day is considered reasonable.

Summarizing, for sugar cane-based ethyl alcohol production, technological innovations are expected to bring about:

- 10% reduction in raw material cost (due to increased yield)
- 18% reduction in utilities cost
- 4% reduction in plant investment cost

2.1.3 Cassava

(1) Increase in the raw material yield per unit area

Growth rates of cassava yield according to FAO statistics are given in Table E-6. According to this table, the cassava yield in Brazil and Thailand during the last ten years declined at an average annual rate of 28.6% and 25.5% respectively while in Indonesia cassava yield rose at an annual average rate of 24.1%.

When we try to forecast the cassava yield we should take into account that it is only very recent that cassava has come to be recognized as one of the raw materials for ethyl alcohol and that various efforts have been and are being made in improving varieties and cultivation method and also in realizing all-year harvesting under a planned cultivation, etc.

Since the World Bank Report predicts a considerable increase in yield (from prevailing level of 9 - 12 tons/ha to 20 tons/ha) and Indonesia with the world average cassava yield has attained 24% annual growth rate, we may anticipate a 20% annual growth rate in yield.

(2) Saving in raw material cost and utilities cost

In the latest cassava-based ethyl alcohol production process, the non-cooking process was assumed for liquefaction/saccharification process, and also the continuous fermentation process using immobilized yeast and the pressurized distillation for the fermentation and the distillation process respectively as in the case of molasses-based and sugar cane-based ethyl alcohol production.

Cassava
↓
Liquefaction/saccharification (non-cooking process)
↓
Fermentation (continuous fermentation process using immobilized yeast)
↓
Distillation (pressurized distillation process)
↓
Ethyl alcohol

We do not expect any quantitative saving in material by adopting the immobilized yeast process for the fermentation unit.

On the other hand, we can expect about 60% utilities saving by adopting the non-cooking process in the liquefaction/saccharification process and about 30% utilities saving by adopting the pressurized distillation process in the distillation unit.

Generally, utilities consumed in the liquefaction/saccharification process and the distillation process respectively account for about 30% and 60% of the total utilities consumed in the cassava-based ethyl alcohol production, so we can expect utilities saving of about 36% in total, i.e. 18% each in the liquefactin/saccharification process and the distillation process.

(3) Reduced investment cost of production plant

The ratio of possible cost reduction (20 - 30%) in the investment cost of the fermentation unit by adopting the immobilized yeast process times the portion accounted for by the fermentation unit (about 20%) in the total investment cost of the cassava-based ethyl alcohol production plant makes it possible to reduce the total investment cost by about 4 - 6%. In this Study, an average of 5% saving in total investment cost was assumed.

(4) Economies resulting from larger production scale

As with the sugar cane-based ethyl alcohol production plant, the capacity of the cassava-based ethyl alcohol plant is restricted by the economies of raw material collection, and a standard capacity of 120 kl/day was assumed to be appropriate.

Summarizing, for cassava-based ethyl alcohol production, technological innovations are expected to bring about:

- 20% reduction in raw material cost (due to increased yield)
- 36% reduction in utilities cost
- 5% reduction in plant investment cost

2.2 Synthesis Process

As the latest process under the synthesis process, the following processes, including pressurization in the distillation process, have been assumed:

Ethylene
↓
Reaction process
↓
Distillation process (pressurized process)
↓
Ethyl alcohol

2.2.1 Saving in raw material cost and utilities cost

In the case of the synthesis process, saving in the cost of raw materials is possible by using improved catalyst in the reaction unit. However, since research and development efforts in the field of catalysts are reportedly far from vigorous lately, as stated in the section on technological innovations, the cost of raw materials was assumed to remain unchanged.

With respect to curtailment in the amount of utilities, reduction of production cost would be possible by the use of the pressurized process in the distillation unit.

As the distillation process accounts for about 85% of the total utilities consumed under the synthesis process, 30% saving resulting from the use of the pressurized process leads to a reduction of total utilities cost by 26% on the whole.

2.2.2 Reduced investment cost of production plant

As stated in the section on the fermentation process using molasses, some cost reduction by the use of the pressurized process can be expected, but it was not taken into account as with the fermentation process.

2.2.3 Economies resulting from larger production scale

Table E-7 presents major manufacturers using the synthesis process.

In Table E-7, raw material for ethylene consists of associated gas only for the planned SABIC/Shell project in Saudi Arabia; naphtha or natural gas is used as raw material by all other manufacturers.

It is evident from Table E-7 that the capacity of the plants recently built or under planning is oriented toward ever larger scale.

The average production capacity of the plants built since 1970 and those in the planning stage using naphtha, natural gas or associated gas as feedstock is about 170,000 kl/year (135,000 tons/year). In the section on production, the capacity of the synthesis process plant was assumed to be about 40,000 kl/year. But the capacity of syntehsis plants yet to be built is bound to become larger in scale, as it has been since 1970, and the average production capacity may be assumed to be 170,000 kl/year. Under this assumption, economies of scale arising from larger production scale is calculated by applying the empirical exponential rule of raising to the power of 0.7. Under this calculation, the investment cost of the plant for producing 170,000 kl/year increases by about 2.75 times in spite of the fact that the plant capacity increases by 4.25 times.

If, as a consequence, the future production capacity under the synthesis process is assumed to be 170,000 kl/year, reduction of about 36% in fixed cost associated with the plant investment cost can be expected.

From the foregoing, technological innovations in the area of the synthesis process may be expected to bring about:

- Utilities cost reduction of 26% and
- Investment cost reduction of 36% (by economies of scale)

3. Production Cost Trends

Average cost of production under the existing fermentation and synthesis processes has been estimated in the section on production on the assumption that the plant would be of a newly constructed type. But in order to grasp the effects of:

- Raw material market trends and
- Production technology trends

Table E-7 Synthetic Ethyl Alcohol Manufacturers of the World

Country	Manufacture	Plant	Process	Start of Opera- tion (Year)	Production Capacity (1,000 MT/y)
USA	Union Carbide Corp.	Texas City, Texas	Direct method - Technology proprietary process	1969	370
	Shell Chemical Co.	Houston, Texas	" - Shell process	1948	120 (Stopped in 1979)
	Publicker Industries Inc.	Philadelphia, Pa.	" - VEBA process	1968	185
	US Industrial Chemicals Co. (National Distillers)	Tuscola, Ill.	" - Technology proprietary process	1972	200
	Texas Eastman	Longview, Texas	" - "	1956	77 [952-832]
UK	B.P. Chemicals	Cragenouth Scoi.	Direct method - Shell process	1951/56	35
			" - VEBA process	Under Construction	(155)
		Baglan Bay S. Wales	" - "	1973	155
	British Celanese	Spondon		1930	40
			Schweitlsäure		[230-(350)]
Germany, Fed. Rep.	Eraölchemie GmbH	Köln-Worringen	Direct method - Shell process	1960/63	60
	Chemische Werke Hüls AG	Herne	" - VEBA process	1972	130 [190]
France	Soc d'Ethanol de Synthese (SODES)	Lillebonne	Schweitlsäure	1968	100
Canada	Chemical Alcohols	Yarennes Que.	Direct method - VEBA process	1971	60
Japan	Japan Synthesis Alcohol	Kawasaki	Direct method - Shell process	1965	40
	Japan Ethanol	Yokkaichi	" - "	1972	40 [90]
Korea, Rep. of	Chung Fu Fertilizer	Ulsan	Direct method - Shell process	1974	30 (Stopping)
China	CNTIC	Kirin	Direct method - VEBA process	1978	100
		Taching	" - "	1981	200 [300]
Saudi Arabia	SABIC/Shell Oil (SPPC)	Al Jubail	Direct method - Shell process	1984 Under Construction	280
Eastern Europe	Chemopetrol	Zaluzi (Czechoslovakia)	Direct method - Technology proprietary process	1963	60
	VEB Chem. Werke Buna	Schkopau (German Dem. Rep.)			25
	Rumania				40
	USSR				650 [775]

Source; Fermentation and Industry, Vol. 39, No. 8, 1981.

on the production cost, estimation of the production cost has been attempted for the year 2000. As the purpose of this attempt has been to probe into the relative levels of production costs between the fermentation and synthesis processes, when various types of raw materials are used, general rise in cost, including plant investment cost and labor cost, has not been incorporated.

3.1 Setting of Cases

Cases for tentative calculations included the following:

A. Average production cost of the world, in case molasses is used as raw material in the fermentation process.

B. Average production cost of the world, in case sugar cane is used as raw material in the fermentation process.

C. The production cost in Brazil, when sugar cane is used as raw material in the fermentation process.

D. Average production cost of the world, when cassava is used as raw material in the fermentation process.

E. Average production cost of Europe and Japan, when naphtha is used as raw material for ethylene in the synthesis process.

F. Production cost in the United States, when natural gas is used as raw material for ethylene in the synthesis process.

G. Production cost in Saudi Arabia, when associated gas is used as raw material for ethylene in the synthesis process.

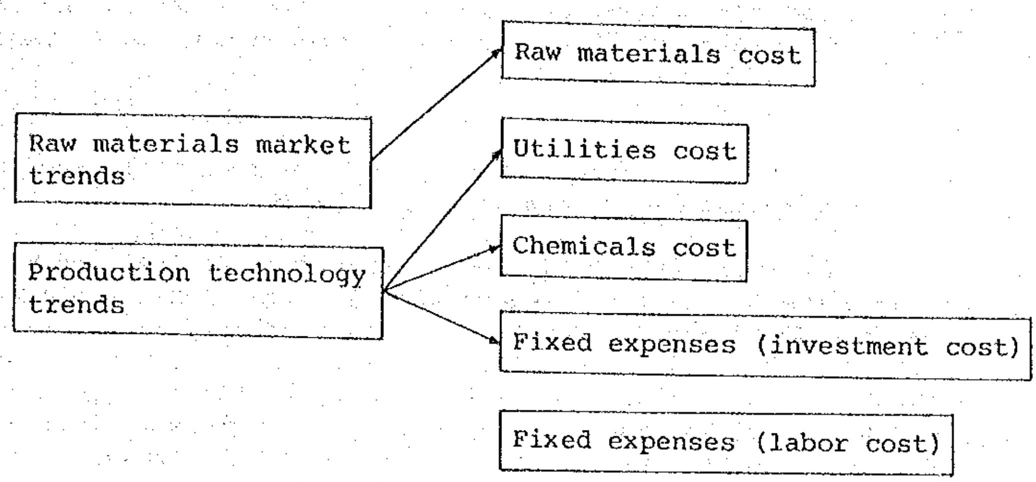
3.2 Reflection of Raw Material Market Trends and Production Technology Trends on Ethyl Alcohol Production Cost

Ethyl alcohol production cost factors roughly consist of:

- Raw material cost
- Utilities cost
- Chemicals cost
- Fixed expenses (depreciation, etc.) related to investment cost
- Fixed expenses related to labor cost

The relations among the respective production cost factors, raw material market trends and production technology trends have been conceived as shown below.

Production Cost Factors



Strictly speaking, production technology trends do affect the chemicals cost and fixed expenses (related to labor cost), but it has been excluded from the scope of this study as these effects would be insignificant.

3.3 Tentative Calculations of Production Cost for the Year 2000 by Case

The average production cost of ethyl alcohol by the fermentation and synthesis processes at the present time has been discussed in the section on production and summarized in Table B-11. Tentative calculations of production costs, from the present time till the year 2000, will now be made by treating market trends of raw material and production technology as factors in cost fluctuations.

3.3.1 Case A (The average world production cost utilizing the molasses-based fermentation process)

The current cost of ethyl alcohol is estimated at $407 per kl, an average cost based on the $412 per kl production cost of industrial ethyl alcohol and the $402 per kl production cost of fuel ethyl alcohol shown in Table B-11.

As stated in the reference to market trends of raw material, the price of raw molasses is expected to rise annually by 1.6%, but as estimated in the section on trends in production technology, it can be expected that future technological innovations will reduce labor cost by 26% and construction cost by 6% by the year 2000. Accordingly, the production cost in Case A is likely to rise from the present $407 per kl to $469 per kl in the year 2000. The results of this calculation are summarized in Table E-8.

3.3.2 Case B (The average world production cost utilizing the sugar-cane-based fermentation process)

As shown in Table B-11, the current cost is $429 per kl. Although the price of raw sugar cane is expected to rise annually by 3.3% in the future, future technological innovations can be expected to reduce raw material cost, labor cost and construction cost by 10%, 18% and 6%, respectively. As such, the production cost in Case B is expected to rise from the present $429 per kl to $628 per kl by the year 2000. The results of this calculation are summarized in Table E-9.

3.3.3 Case C (Production cost in Brazil utilizing the sugar-cane-based fermentation process)

As shown in Table B-11, the current cost is $279 per kl. Although the price of raw sugar cane is expected to rise annually by 3.3% in the future, future technological innovations can be expected to reduce raw material cost, labor cost and construction cost by 10%, 18% and 6%, respectively. Accordingly, the production cost is expected to rise from the present $279 per kl to $386 per kl in the year 2000. The result of this calculation is summarized in Table E-10.

3.3.4 Case D (The average world production cost utilizing the cassava-based fermentation process)

As shown in Table B-11, the current cost is $427 per kl. Although the price of material cassava is expected to rise annually by 3.9% in the future, future technological innovations can be expected to reduce raw material cost, labor cost and construction cost by 20%, 36% and 5%, respectively. As such, the production cost is expected to rise from the present $427 per kl to $502 per kl in the year 2000. The result of this calculation is summarized in Table E-11.

3.3.5 Case E (The average production cost in Europe and Japan utilizing the naphtha-ethylene-based synthesis production process)

The current average international cost using the synthesis

Table E-8 Ethyl Alcohol Production Cost Estimate

A. Fermentation Process (World Average), Raw Material: Molasses

(US$/kℓ)

		Current Production	Factors Affecting Production Cost		Production Cost
		Cost	Raw Material Price	Technological** Progress	in 2000
Variable costs	Raw Material cost	259	1.6%/year	⟶	344
	Utilities costs	74		-26%	55
	Chemical cost	2		⟶	2
Fixed costs	Construction cost	66		-6%	62
	Labor cost	6		⟶	6
Total		407*			469

* Average production cost of industrial and fuel ethyl alcohol.

** ⟶ indicates no technological progress.

Table E-9 Ethyl Alcohol Production Cost Estimate

B. Fermentation Process (World Average), Raw Material: Sugar Cane

(US$/kℓ)

		Current Production Cost	Factors Affecting Production Cost: Raw Material Price	Factors Affecting Production Cost: Technological Progress	Production Cost in 2000
Variable costs	Raw Material cost	330	3.3%/year	-10%	533
	Utilities costs	2		-18%	2
	Chemical cost	2		→	2
Fixed costs	Construction cost	89		-4%	85
	Labor cost	6		→	6
Total		429			628

Table E-10 Ethyl Alcohol Production Cost Estimate

C. Fermentation Process (Brazil), Raw Material: Sugar cane

(US$/kℓ)

		Current Production	Factors Affecting Production Cost		Production Cost
		Cost	Raw Material Price	Technological Progress	in 2000
Variable costs	Raw Material cost	180	3.3%/year	-10%	291
	Utilities costs	2		-18%	2
	Chemical cost	2		→	2
Fixed costs	Construction cost	89		-4%	85
	Labor cost	6		→	6
Total		279			386

Table E-11 Ethyl Alcohol Production Cost Estimate

D. Fermentation Process (World Average), Raw Material: Cassava

(US$/kℓ)

		Current Production Cost	Factors Affecting Production Cost: Raw Material Price	Factors Affecting Production Cost: Technological Progress	Production Cost in 2000
Variable costs	Raw Material cost	208	3.9%/year	-20%	331
	Utilities costs	123		-36%	79
	Chemical cost	18		→	18
Fixed costs	Construction cost	72		-5%	68
	Labor cost	6		→	6
Total		427			502

process in which, unlike fermentation process, ethylene is used as a raw material in the production of ethyl alcohol, is shown in Table C-3. Since the price of ethylene varies according to the raw material used, e.g., naphtha, natural gas or associated gas, the production cost in the year 2000 is based on the assumption that naphtha, which is used mainly in Europe and Japan, will be used as a raw material for ethylene.

Since the price of ethylene in Europe and Japan is $775 per ton and 0.48 tons of ethylene is required for 1 kl of alcohol, the current raw material cost is estimated at $372 per kl by multiplying $775 by 0.48 tons. The price of ethylene is expected to rise annually by 2%, calculated by multiplying 2.5% by 80% since the proportion of naphtha used as raw material in the production of ethylene, in terms of the cost price of ethylene is 80%, though the price of naphtha as well as that of crude oil rises annually by 2.5%. On the other hand, it can be expected that by the year 2000 technological innovations will reduce labor cost by 26%, and the use of larger scale equipment will reduce construction cost by 36%. Accordingly, the production cost is expected to rise from the present $564 per kl to $665 per kl in the year 2000. The result of this calculation is summarized in Table E-12.

3.3.6 Case F (Production cost in the United States utilizing the natural-gas-ethylene-based synthesis process)

Since the price of ethylene in the United States is $427 per ton, and 0.48 tons of ethylene is required for 1 kl of alcohol, the current raw material cost is estimated at $237 per kl by multiplying $427 by 0.48 tons.

Although the price of natural gas in the United States will be held at a level below the actual market price due to the policy of price control on all energy sources from now till 1985, the industry predicts that the price of ethylene will not vary whether natural gas or naphtha is used as the raw material, because the price of natural gas will rise to the same level as that of low-sulfur heavy oil-C after 1986, in terms of calorific value. Accordingly, it was expected that the raw material cost in the year 2000 would be $531 per kl, the same as in Case E.

On the other hand, it can be expected that technological innovations will reduce labor cost and construction cost by 26% and 36%, respectively, in the year 2000. As such, the production cost is expected to rise from the present $427 per kl to $665 per kl by the year 2000, the same price as in Europe and Japan. The result of this calculation is summarized in Table E-13.

Table E-12 Ethyl Alcohol Production Cost Estimate

E. Synthesis Process (Average of Europe and Japan), Raw Materials: Naphtha

(US$/kℓ)

		Current Production	Factors Affecting Production Cost		Production Cost
		Cost	Raw Material Price	Technological Progress	in 2000
Variable costs	Raw Material cost	372*	2.0%/year		531
	Utilities costs	83		-26%	61
	Chemical cost	2		→	2
Fixed costs	Construction cost	101		-36%	65
	Labor cost	6		→	6
Total		564			665

* Average ethylene production cost of Europe and Japan: US$775/MT x 0.48.

Table E-13 Ethyl Alcohol Production Cost Estimate

F. Synthsis Process (USA), Raw Material: Natural gas

(US$/kℓ)

		Current Production	Factors Affecting Production Cost		Production Cost
		Cost	Raw Material Price	Technological Progress	in 2000
Variable costs	Raw Material cost	235*			531**
	Utilities costs	83		-26%	61
	Chemical cost	2		→	2
Fixed costs	Construction cost	101		-36%	65
	Labor cost	6		→	6
Total		427			665

* Ethylene production cost in USA: US$490/MT x 0.48.
** Same as the average raw material cost of Europe and Japan shown in E.

3.3.7 Case G (Production cost in Saudi Arabia utilizing the associated gas-ethylene-based synthesis process)

Since industry expects the price of ethylene to be $400 per ton, determined as a matter of government policy, it was assumed that the raw material cost, out of all current costs would be $192 per kl in the year 2000, calculated by multiplying $400 by 0.48 ton.

On the other hand, technological innovations can be expected to reduce labor cost by 26% by the year 2000. Since the capacity of the ethyl alcohol plant now being planned in Saudi Arabia is to be as large as 350,000 kl per year, reductions in construction cost by installing larger equipment can no longer be expected. Calculated on this basis, the production cost is expected to rise from $384 per kl at the time of start-up of the ethyl alcohol plant (in 1986) to $362 per kl by the year 2000. The result of this calculation is summarized in Table E-14.

3.4 Result of Tentative Calculations

The result of tentative calculatons of ethyl alcohol production cost is given in Table E-15.

The following may be stated as trends gleaned from Table E-15.

- Excepting cases where low-cost ethylene from associated gas and the like as raw material is available, the synthesis process is likely to lose competitiveness.
- Consequently in the future, advantages in the production cost are likely to accrue in cases where low cost materials are available for the fermentation process, such as in the case of Brazil, and in cases where associated gas is available as ethylene material for use in the synthesis process.

4. End-use Market Trends

As stated in the section on the uses of ethyl alcohol, the end-uses are roughly divided into the following categories.

Table E-14 Ethyl Alcohol Production Cost Estimate

G. Synthesis Process (Saudi Arabia), Raw Material: Associated gas

(US$/kℓ)

		Current Production Cost	Factors Affecting Production Cost: Raw Material Price	Factors Affecting Production Cost: Technological Progress	Production Cost in 2000
Variable costs	Raw Material cost	192	→		192
	Utilities costs	83		-26%	61
	Chemical cost	2		→	2
Fixed costs	Construction cost	101		→	101
	Labor cost	6		→	6
Total		384			362

Table E-15 Ethyl Alcohol Production Cost Estimate for Year 2000

(US$/kl)

Process	Raw Material		Current Prod'n. Cost Est.	Year 2000 Prod'n. Cost Est.
A. Fermentation process	. molasses	. World average	407	409
B. "	. Sugar cane	. World average	429	628
C. "	. Sugar cane	. Brazil	279	386
D. "	. Cassava	. World average	427	502
E. Synthesis process	. Naphtha	. Europe, Japan	564	665
F. "	. Natural gas	. USA	427	665
G. "	. Associated gas	. Saudi Arabia	(384)	362

Figures in ( ) show estimated costs in 1986.

Industrial Use:

For chemical industry use For food and beverage For hygienics and medicine	(1) Uses that take advantage of chemical and physical properties of ethyl alcohol
For use as basic material for chemical industry	(2) Uses as raw material for making ethylene
Fuel Use:	(3) Use as energy

Consequently, as alternative substitutes differ according to use and also the nature of end-use market differs, the end-use market trends by applications will be presented for each of the three categories of use.

4.1 Uses for Application in Chemical Industry, for Food and Beverage and for Hygienics and Medicine within the Category of Industrial Use

These are uses that utilize the characteristics of ethyl alcohol. Substitutes available in these areas are methyl alcohol and isopropyl alcohol, but specific applications which can be replaced by these are very limited, for example, Japanese market, accounting for as low as 10% or so of the total. Thus, the effect of substitutes may be considered slight.

Past growth in consumption of ethyl alcohol for these uses has been low at 0.9% a year, showing that this is a fully matured market.

Estimation of future market growth can be worked out by the use of the elasticity to GNP, but since the result of analysis of the correlation between past consumption and GNP is not significant, it was assumed in this Study that the past growth rate will probably be carried over into the future as no basic change in the market structure is anticipated.

If consumption should grow at the rate of 0.9% a year, consumption in the world is anticipated to increase at the rate of about 80,000 kl a year, and the total consumption is estimated to increase from about 8.35 million kl in 1980 to 9.98 million kl in the year 2000.

4.2 Use as Basic Material for Chemical Industry within the Category of Industrial Use

In this use, the purpose is to obtain basic raw material, such as ethylene, for the chemical industry through chemical reaction that is the reversal of synthesis for obtaining ethyl alcohol. The growth of this market outlet may be considered as being dependent on the ability to compete against ethylene produced by the petrochemical process in terms of production cost.

Cost estimation under existing conditions has been cited on Table C-3 of this chapter. Comparison of estimated production cost of ethylene under the two processes is presented in Table E-16 for the year 2000 on the basis of the ethyl alcohol production cost in Table E-15 for the year 2000. However, the price of the raw material for the petrochemical process was assumed to rise by 2.5% a year, and since the raw material cost accounts for 80% of the total production cost, ethylene price was assumed to rise by 2% a year.

From Table E-16 these trends can be gleaned.

- The world average of the cost of production under the process of manufacturing ethylene from ethyl alcohol is higher than the existing petrochemical process. In countries like Brazil, where the ethyl alcohol production cost is low, however, the ethyl alcohol process shows a trend of bolstering its competitiveness against the petrochemical process in the aspect of ethylene production cost.

Table E-16 Comparison of Ethylene Production Costs (1)

(US$/MT)

	Existing State	2000
Ethyl Alcohol Process		
World Average	1,023	1,280
Brazil	724	960
Petrochemical Process		
Average for Japan and Europe	775	1,100
USA	490	1,100
Saudi Arabia	--	400

- However, ethylene produced by the petrochemical process in oil-producing countries like Saudi Arabia using associated gas as raw material is highly competitive in production cost. And as is evident from the existing situation, the trend towards switching from naphtha and natural gas to associated gas in the oil-producing countries is likely to intensify.

Since crude oil prices are politically determined, as we have witnessed on two occasions of sudden price raising in the past, prices have soared widely. And if, as an example, a price rise that will lead to doubling of price in 15 years is assumed the annual rate of rise will be 5%. The assumed case of 5% price increase every year in shown in Table E-17. In the petrochemical process, however, 5% annual rise in the price of raw material will result in 4% rise in the price of finished product, since the raw material cost accounts for 80% of the total.

Supposing the crude oil price is to rise by 5% a year, the world average cost of the production of ethylene from ethyl alcohol would become lower than the cost required for making ethylene from naphtha or natural gas as is done in Europe, Japan and the United States. And this is expected to lead to brisk production of ethylene from ethyl alcohol is various countries of the world.

4.3 Fuel Use

As ethyl alcohol is used as a substitute for gasoline, the consumer market in this area is greatly affected by the gasoline

Table E-17 Comparison of Ethylene Production Costs (2)

(US$/MT)

	Existing State	2000
Ethyl Alcohol Process		
World Average	1,023	1,280
Brazil	724	960
Petrochemical Process		
Average for Japan and Europe	775	1,570
USA	490	1,570
Saudi Arabia	---	400

price trends, which in turn is dependent on the crude oil price trends. With regard to the crude oil price trends, the World Bank report entitled Emerging Energy and Chemical Applications of Methanol estimates an annual rise in price of 2.5%. IEA, on the other hand, expects little change in the price of oil up to 1990, and it estimates an annual price rise of 3% between 1990 and 2000. The World Bank's projection of an annual rise of 2.5% is considered reasonable even when forecasts of IEA and other international organizations are taken into account.

With regard to the relation of the crude oil price to the gasoline production cost (ex-refinery price), details are found in the World Bank report entitled Alcohol Production from Biomass in the Developing Countries. And on the basis of this report, the future relation of crude oil price to the gasoline production cost in shown in Table E-18.

Table E-18 Crude Oil Price and Gasoline Production Cost

	Existing State (1983)	1990	1995	2000
Crude Oil Price (US$/barrel)	29.0*	34.5	39.0	44.0
Gasoline Production Cost (UC¢/ℓ)	0.25	0.30	0.34	0.38

* Arabian Gulf posted price

The results of tentative calculations of the ethyl alcohol production costs shown in Table B-11 and Table E-15 are converted into gasoline equivalent on the basis of calorific values (low calorific value of gasoline/low calorific value of alcohol = 7,700 kcal/ℓ/5,048/ℓ) and compared with gasoline in Table E-19. The table also shows the market price of gasoline by adding the gasoline tax to its production cost as a reference.

Table E-19 Gasoline and Ethyl Alcohol Production Costs (1)

(US¢/ℓ)

		Existing State	2000
	Gasoline production cost	0.25	0.38
	Gasoline market price	0.55 - 0.65	0.68 - 0.78
Ethyl Alcohol	World average molasses-based production cost	0.62	0.71
	World average sugar cane-based production cost	0.65	0.96
	Sugar cane-based production cost in Brazil	0.43	0.59
	World average cassava-based production cost	0.65	0.76

Note: The gasoline market prices represent the amount obtained by adding the gasoline tax of US¢0.30-0.40/ℓ to the gasoline production cost.

In case the crude oil price rises annually by 2.5%, the ethyl alcohol production cost would be higher than the gasoline production cost even in the year 2000, as can be seen from Table E-18. This appears to call for government incentives for ethyl alcohol production. The case for a presumed annual rise of 5% in crude oil price is given in Table E-20.

In the case of presumed annual rise of crude oil price by 5.0% shown in Table E-20, the ethyl alcohol production cost in countries like Brazil, where the ethyl alcohol production cost is low, would be about equal to the gasoline production cost. And since this makes the alcohol economically competitive, substitution of alcohol for gasoline is anticipated to take place rapidly.

Table E-20 Gasoline and Ethyl Alcohol Production Costs (2)

(US¢/ℓ)

		Existing State	2000
Gasoline production cost		0.25	0.57
Gasoline market price		0.55 - 0.87	0.87 - 0.76
Ethyl Alcohol	World average molasses-based production cost	0.62	0.71
	World average sugar cane-based production cost	0.65	0.96
	Sugar cane-based production cost in Brazil	0.43	0.59
	World average cassava-based production cost	0.65	0.76

II. Supply and Demand Projections

Supply and demand projections will be discussed separately for the short-term and the long-term outlook.

1. Short-term Projection

The supply and demand projection from the present to around 1986, when Saudi Arabia's synthesis process commences operation, will be presented for each of the three major uses of ethyl alcohol.

1.1 General Industrial Uses (Chemical Industry Use, Food and Beverage Use, Hygienic Products and Medicinal Use)

With respect to these uses, the situation at the demand side will be analyzed, and this will be followed by the supply side's response towards the demand.

1.1.1 Demand

As stated before, an annual growth of about 80,000 kl (0.9%) in the consumption of ethyl alcohol for the aforementioned uses can be expected. As a consequence, new demand of about 240,000 kl is anticipated between now (1983) and 1986.

Meanwhile, the production cost by the synthesis process using naphtha and natural gas as raw material is anticipated to be about US$665/kl in the year 2000. This will be too high and out of competition against the production cost of US$386/kl for alcohol produced by the fermentation process in countries like Brazil, where the raw materials are available at low cost, and against US$ 362/kl for alcohol produced by the synthesis process using associated gas as raw material for ethylene. In the circumstances, some move towards:

- Conversion of the manufacturing process to fermentation,
- Importation of ethyl alcohol produced under the fermentation process and
- Importation of ethyl alcohol made under the synthesis process using associated gas as raw material for producing ethylene is considered likely.

It is difficult to make a quantitative estimation of ehtyl alcohol by the change in production process or by the switch to imports on account of various policy problems attending shutdown of existing plants, the difference between the production cost and import cost, in case of home production, and of policies for protecting home-produced agricultural products. Nevertheless, the ratio of the idle capacity will be estimated form the existing output by the sysnthesis process and the quantity involved in the change of the manufacturing process or switching to imports will be estimated. According to the result of survey conducted by Shell, the 1980 production by the synthesis process is estimated at about 1.6 million kl. And if 10 to 30% of the total synthesis plants should be laid off in the future, about 160,000 to 480,000 kl may possibly be filled either by the fermentation process production or by imports. As a consequence, the following may be envisaged for the short-term outlook up to 1986:

- Demand increase:	240,000 kl
- Conversion from synthesis process or switch to imports:	160,000 to 480,000 kl
- Total incremental demand for the fermentation process:	400,000 to 720,000 kl

1.1.2 Supply

With respect to supply needed for meeting the increased demand, the incremental portion, as stated in the section on trade, has basically been filled by the country where the demand has grown. In other words, the self-sufficient characteristics of ethyl alcohol market has so far been followed, but international transactions are anticipated to become brisk in the future, on account of differences in the prices of farm products used as raw materials for the fermentation process and of widening differences in the prices of ethylene used as raw material in the synthesis process.

The choice between domestic production and import by the country where demand growth has emerged will depend, besides policy considerations, on the difference between the production cost and the import cost. Factors affecting cost increase in the case of import include:

- Freight cost amounting to about US$60 - US$80/kl
- Refining cost (in case of differences in specifications) of about US$50/kl
- The tariff (α)

Consequently, the possibility of exporting ethyl alcohol depends on whether export can be made at a price lower than the price arrived at by subtracting US$110 - US$130/kl and the tariff portion from the prevailing market price in the importing country. And the countries with the possibility of exporting alcohol are, as stated before, those having low-cost raw materials available for the fermentation process (Brazil, etc.) and those in a position to use associated gas as raw material for ethylene production by the synthesis process, such as Saudi Arabia where the plant is scheduled to commence operation in 1986. The outcome will probably be a price competition between these two groups.

1.2 Use as Basic Material for Chemical Industry

This use is subject to the impact of the rise in crude oil prices to a great extent. In the section on the end-use market trends, therefore, estimates have been made for the case of 2.5% annual rise in the crude oil price and for the case of 5.0% annual rise. However, as the estimates worked out by the international organizations generally assume price stability up to 1986 or thereabouts, the crude oil price rise of 2.5% a year has been used in the short-term outlook.

In case annual crude oil price rise of 2.5% is assumed, the world average of the production cost of ethylene from ethyl alcohol, as has already been shown in Table E-16, compares unfavorably with the petrochemical process now and will remain so in the year 2000. However, countries like Brazil, where ethyl alcohol production cost is low, are and will be fully competitive in price now and up to 1986 against the petrochemical process used in Europe and Japan. Under the circumstances, the trend towards the use of ethyl alcohol as basic raw material for the chemical industry including ethylene production is anticipated to intensify.

1.3 Fuel Use

As in the case of use as basic raw material for the chemical industry, annual crude oil price rise of 2.5% is assumed in the short-term outlook.

As has already been shown in Table E-19, crude oil price rise of 2.5% a year puts the production cost of ethyl alcohol in terms of equivalent calorific value will be between the gasoline production and marketing costs even in the case of Brazil where ethyl alcohol production cost is low. This means the need for some government incentives for ethyl alcohol and a partial loss of gasoline tax revenue.

As a consequence, use as fuel is likely to be determined by a delicate balance between reduced gasoline tax revenues resulting from the government incentives for ethyl alcohol and other policy considerations, such as balance of payments and farm product fostering policy in each country. The short-term outlook, as a consequence, sees the situation as being an extension of the existing state of things, and the countries having policies on balance of payments and on fostering of farm products are expected to continue producing ethyl alcohol for fuel use.

2. Long-range Projection

Long-range supply and demand outlook up to the year 2000 will be presented for each end-use.

2.1 General Industrial Use

2.1.1 Demand projection

Assuming an annual demand increase of 0.9% continuing into the future, as stated before, the worldwide demand for industrial-use ethyl alcohol is projected to increase from about 8.35 million kl in 1980 to some 9.98 million kl in the year 2000. The increase in demand during the period will be about 1.63 million kl.

While it is difficult to quantitatively grasp the change in manufacturing process from the synthesis process to fermentation process and the switch from domestic production to imports, possibility of producing about 480,000 to 800,000 kl by the fermentation process or of importing similar amounts is conceivable, if the plants by the synthesis process equivalent to 30 to 50% of the 1980 production of about 1.6 million kl are to be shut down.

Accordingly, the long-range outlook up to the year 2000 may be summarized as follows:

- Demand increase:	1.63 million kl
- Change from sysnthesis process to fermentation process or switch to import:	480,000 - 800,000 kl
- Total incremental demand for the fermentation process:	about 2.11 - 2.43 million kl

2.1.2 Supply projection

As stated in the section on short-term outlook, the basic approach would be filling the incremental demand with the fermentation process production or with imports by the country where such increase has taken place. And as countries capable of competing in the export market, those with supply of low-cost materials for the fermentation process (Brazil, etc.) and the oil-producing countries that have associated gas available for use as raw material for producing ethylene by the synthesis process, are conceivable.

2.2 Basic Material for Chemical Industry Use

In case crude oil price rises by 2.5% each year, the following trends are conceivable.

- The world average of the cost of producing ethylene from ethyl alcohol would compare unfavorably with that of the petrochemical process.
- However, the countries like Brazil where ethyl alcohol production cost is low are likely to become more competitive against the petrochemical process in future, and are anticipated to intensify the trend towards using ethyl alcohol as basic material for the chemical industry.

In case the crude oil price rises by 5.0% a year, the world's average cost of producing ethylene from ethyl alcohol will become lower than the cost of producing ethylene by the petrochemical process using naphtha or natural gas, as is being done in Europe, Japan and the United States. And in the countries like Brazil, where ethyl alcohol production cost is low, the trend toward the use of ethyl alcohol as basic material for the chemical industry is anticipated to be intensified. With regard to the possibility of export, however, there is a tendency in Europe, Japan and the United States towards seeking ethylene material from the oil-producing countries. Moreover comparison of production costs, i.e. US$400/ton for oil-producing countries' ethylene production cost and about US$960/ton for producing ethylene from ethyl alcohol in Brazil, makes it difficult to place any hope on the export market.

2.3 Fuel Use

In case a crude oil price rise of 2.5% a year is assumed, the ethyl alcohol production cost in terms of equivalent calorific value would be in the year 2000 between the gasoline production cost and its market selling price. This would require some incentives for ethyl alcohol by the government. The use as fuel, as a consequence, is not likely to change much from the present level, since the use as fuel in the longer-range would be determined in consideration of the balance between reduced gasoline tax revenue due to incentives for ethyl alcohol and various other policy considerations such as the balance on the foreign currency accounts and fostering of farm products.

In case a crude oil price rise of 5.0% a year is assumed, the ethyl alcohol production cost in terms of equivalent calorific value in countries like Brazil where ethyl alcohol production cost is low, would be about on the par with the gasoline production cost. As this would make alcohol economically competitive against gasoline, rapid progress in the substitution of ethyl alcohol for gasoline is likely to be seen.

With regard to possibility of export, however, additional cost by freight and so forth is likely to make the ethyl alcohol importing price higher than the gasoline production cost in the countries contemplating import. And since problems related to the petroleum and auto industries of the prospective importing countries will have to be coped with, hopes for the export market cannot be entertained so easily.

III. Exporting Possibilities of Ethyl Alcohol Produced in Brazil

Considering the outlook for demand and supply, exporting possibilities of ethyl alcohol produced in Brazil may be said to be as follows.

1. General Industrial Use

World demand is expected to increase from 8.35 million kl in 1980 to 9.98 million kl in the year 2000 with an annual average growth of about 80,000 kl. If the synthesis process based on naphtha and natural gas loses cost competitiveness and the operation rate of synthesis process production goes down to 30-50% of capacity in the year 2000, the additional 480,000 to 800,000 kl demand will have to be met by either the fermentation process or imports. If this is the case, total demand will increase by 2.11 to 2.43 million kl.

Regarding supply, it is expected that there will be supply achieved using the fermentation process from countries producing low-cost agricultural products such as Brazil, and by synthesis from associated gases such as Saudi Arabia.

2. Basic Chemical Use

The cost of producing ethylene from alcohol may turn out to be cheaper compared to the cost of producing it from naphtha or natural gas. Therefore, in countries such as Brazil and India, where alcohol is produced from domestic agricultural product, considerable amounts of alcohol will be used for basic chemical use.

On the other hand, the ethylene production cost from associated gas in oil-producing countries is very low, and it is notable that Europe, Japan and the United States are trying to obtain ethylene from the oil-producing countries.

Further, in the industrial countries, the petrochemical process using naphtha produces large amounts of useful by-products such as propylene and aromatic, in addition to ethylene, so that operation of these petrochemical processes using naphatha is expected to continue in the future.

3. Fuel Use

Assuming that the price of crude oil increases at an average annual rate of 5%, the cost of producing alcohol in countries where agricultural raw materials are cheap, such as Brazil, would be about the same as the cost of producing gasoline, so that rapid progress in the substitution of alcohol for gasoline is likely to be seen in such countries.

On the other hand, it is also necessary for the purposes of export to keep in mind the additional cost of freight as well as problems in the petroleum and auto industries of the prospective importing countries.

From the above, it seems that Brazil has the potentiality of exporting alcohol for the following reasons.

Firstly, for general industrial use, the increase of world demand is expected to be over 2 million kl (corresponding to 30 million tons of sugar cane, that is, 600,000 ha of additional cultivating area) in the year 2000.

Regarding these increases in demand, Brazil will be one of the most likely exporters, and the possible competitors will be oil-producing countries like Saudi Arabia.

Secondly, for basic chemical use and for fuel use, domestic consumption will rapidly increase in countries like Brazil which can produce alcohol by the fermentation process using low-cost agricultural raw materials.

Moreover, if uncertain supply and/or more rapid increases in the price of crude oil should occur in the future, or if oil-importing countries should initiate policies to resort to alternative energy sources for national security, considerable amounts of alcohol might be released for exportation rather than consumed domestically.

Appendix Table 1 Properties of Ethyl Alcohol

1. Physical Properties

Appearance	Colorless and transparent liquid
Odor	Distinctive aromatic odor
Taste	Taste of burning sensation
Specific gravity	(d^{15}_{4}) 0.79360; (d^{20}_{4}) 0.78934
Boiling point	78.325°C (760 mmHg)
Melting point	-114.15°C
Refractive index	(n^{20}_{D}) 1.3614; (n^{25}_{D}) 1.35941
Critical temperature	243.1°C
Critical pressure	62.96 atm
Flash point	12.8°C
Ignition point	392°C
Explosion limit	(in atmosphere) lower limit 3.3 vol %, upper limit 19 vol %
Vapor pressure	40 mmHg (19°C)
Heat of combustion	326.66 kcal/mol
Heat of vaporization	10.337 kcal/mol (20°C) 9.304 kcal/mol (BP)
Heat of dissolution	-2.67 kcal/mol (water 200 mol 18°C)

2. Chemical Properties

Ethyl alcohol is a saturated monohydric alcohol having one hydoxyl group.

It is extremely soluble in water, alcohols, ether, and other organic solvents. It dissolves many metallic salts, alkali hydroxide, hydrocarbon, fatty acid, and other organic compounds, and also various gases more greatly than water does.

Sodium and potassium form ethoxide with ethyl alcohol and dissolve into ethyl alcohol.

Ethyl alcohol reacts with sulfuric acid to form acid ethyl sulfate and, if heated, produces ethylene or diethyl ether depending on conditions. It also forms carbil sulfate by action of sulfuric anhydride.

It forms halide ethyl C_2H_5X by action of trihalide phosphorous PX_3.

It produces acetaldehyde and acetic acid by oxidation with a sulfuric acid solution of chromic acid and potassium permanganate, or by oxidation by contact with platinum black.

It is oxidized by chlorine and bromine into aldehyde and becomes acetal in the presence of excess ethyl alcohol. As its chlorination further advances, it will become monochloacetal and dichloroacetal. Finally, it will become chloroalhexide $CCl_3CH(OC_2H_5)_2$.

It forms ethyl sulfate by nitric acid which contains no sulfurous acid. It produces mercury fulminate $(CNO)_2Hg$ when reacted with mercury and excess nitic acid. When subjected to thermal cracking at 800°C, it produces ethylene and water, or acetaldehyde and hydrogen.

3. Pharmacological Properties

Ethyl alcohol is a sedative and not a stimulant as generally believed.

When ehtyl alcohol is diluted and taken in a proper quantity, it will stimulate appetite, promote secretion of gastric juice and assist in food intake. However, if less diluted ethyl alcohol is repeatedly drunk, it will affect the mucous membrane of the stomach.

If ethyl alcohol is drunk in excess, it will paralize the respiratory center and particularly does harm to the nerve system, and may cause mental diseases. In terms of relations between the blood level of ethyl alcohol and toxic symptoms, the inhibitory nerve center will be paralized and judgement lost with an ethyl alcohol concentration of 0.05%, both motor nerve and sensory nerve will be paralized with 0,1%, entire motor nerve will be disturbed with 0.2%, comatose condition will occur with 0.4 to 0.5%, and death with 0.6 to 0.7%.

In industrial applications, ethyl alcohol is regarded as a solvent of relatively no harm. Ethyl alcohol vapor will act as an anesthetic if inhaled. Repeated exposure to ethyl alcohol vapor will cause irritation to mucous membranes, headache, trembling, sleepiness, nausea, loss of appetite, etc.

In case of exposure over 8 hours per day in production front, the maximum allowable concentration is 1,000 ppm. A concentration of 5,000 ppm will produce a pungent odor and induce drowsiness and loss of senses in a few hours time. With a concentration of 5,000 to 10,000 ppm, these symptoms will occur within 1 hour.

It is generally believed ethyl alcohol will not accumulate in the body as a toxic substance because it is completely burned in the body and reduced to carbon dioxide gas and water. However, if ethyl alcohol is taken in a large quantity at a time, damaged body tissues may remain in that condition without the impediments cured. Therefore, care must be taken to avoid continuous exposure to ethyl alcohol in high concentration.

If the skin is exposed to ethyl alcohol repeatedly or over a prolonged period, ethyl alcohol will be absorbed through the skin and cause toxicity.

Appendix Table 2 Ethyl Alcohol Standards of Various Countires

Japan Monopoly Ethyl Alcohol Standards

Test Items	Indicated Unit	Types of Monopoly Alcohol				
		Anhydrate 1st Class	Anhydrate Compounded Class	Hydrate Special Class	Hydrate 1st Class	Hydrate Compounded Class
Properties		Colorless, transparent, free of floating matters and noxious odor	Colorless, transparent and contains no floating matters	Colorless, transparent, free of floating matters and noxious odor	Colorless, transparent, free of floating matters and noxious odor	Colorless, transparent, containing no floating matters
Ethyl Alcohol Content	vol. %	99.5% or more	99.5% or more	95.0% or more	95.0% or more	95.0% or more
Residue on Evaporation	mg/100ml	2.5 or less	2.5 or less	2.0 or less	2.5 or less	2.5 or less
Free Acid	wt.% as acetic acid	0.002 or less	0.005 or less	0.002 or less	0.002 or less	0.005 or less
Aldehyde	mg/100ml as acetaldehyde	0.5 or less	1 or less	Trace or less	0.5 or less	1 or less
Methyl Alcohol Content	mg/ml	1 or less	1.5 or less	Not detected	1 or less	1.5 or less
Diacetyl	Detected or not	Not detected	--	Not detected	Not detected	--
Fusel Oil	wt.%	0.004 or less	--	Not detected	0.004 or less	--
Organic Impurities		No fading from standard color within 4 min.	No fading from standard color within 4 min.	No fading from standard color within 9 min.	No fading from standard color within 4 min.	No fading from standard color within 4 min.
Substances Colored by Sulfuric Acid	Detected or not	Not detected	Not detected	Not detected	Not detected	Not detected
Heavy Metals	Detected or not	Not detected	Not detected	Not detected	Not detected	Not detected
Chlorides	Detected or not	Not detected	Not detected	Not detected	Not detected	Not detected
Sulfates	Detected or not	Not detected	--	Not detected	Not detected	--
Substances Colored by Sodium Hydroxide	Detected or not	Not detected	Not detected	Not detected	Not detected	Not detected
Benzine	--	Less than standard solution color	Less than standard solution color	--	--	--
Trialcohols of Keton-isopropyl Alcohol Derivative	--	--	Less than standard solution color	--	--	Less than standard solution color
Ether	--	--	No ether odor	--	--	--

Note: For method of analysis, refer to Monopoly Alcohol Anlysis Methods.

Appendix Table 2 (cont'd.)

Monopoly Alcohol Standards of Federal Republic of Germany

Class	Denatured Ethyl Alcohol for Special Use	Denatured Anhydrous Ethyl Alcohol for Special Use
No.	450	520
Appearance	Colorless and transparent	Colorless and transparent
Aroma and taste	No noxious odor	No noxious odor
Ethyl alcohol content (wt. %)	94.4	99.6
Potassium permanganate test	8 min. or more	8 min. or more
Aldehyde content (mg/100 mℓ) as acetaldehyde Fusel oil content (mg/100 mℓ)	} 6.0 or less	} 6.0 or less
Acid content (mg/100 mℓ) (as acetic acid)	1.0 or less	1.0 or less
Methyl alcohol content (mg/100 mℓ)	250 or less	10 or less
Volatile base content (mg/100 mℓ)	0.2 or less	0.2 or less
Evaporation residue (mg/100 mℓ)	2.0 or less	2.0 or less
Benzen content (mg/100 mℓ)	Not detected	0.2 or less

Source: Die Brammtweinwirtschaft, 110, 406 (1970)

Appendix Table 2 (cont'd.)

Federal Specifications (USA)

	Federal Spec. OE-760b Apr. 16, 1957			
	Grade 1		Grade 2	
	Class A	Class B	Class A	Class B
Specific gravity 15.56°C/15.56°C	0.7962 or less	0.8158 or less	0.7967 or less	0.8162 or less
Acidity (as Acetic Acid)	0.003% or less	0.003% or less	0.003% or less	0.003% or less
Evaporation residue (100 mℓ)	0.001 g or less	0.001 g or less	0.003 g or less	0.003 g oe less
Water soluble	Passing	Passing	Passing	Passing
Methyl alcohol 0.1% or less	"	"	"	"
Fusel oil	"	"	"	"
Potassium permanganate reduced substance	5 min. or more	5 min. or more	5 min. or more	5 min. or more
Trialcohols of keton-isopropyl tertiary butyl alcohols	Passing	Passing	Passing	Passing

Note: 1) Grade is equivalent to the reagent class of ACS (American Chemical Society Specification), Class A represents 99.5%, while Class B represents 95%.

2) Grade 2 Class A is equivalent to NF (The National Formulary) anhydrate alcohol and represents 99.4%.

3) Grade 2 Class B is equivalent to USP (The United States Pharmacopia) alcohol and represents 94.9%.

4) Grade 3 is denatured alcohol using alcohol compatible with Grade 2 as raw material.

5) Grade 4 is specially authorized standard solvent using Grade 3, No. 1 special denatured alcohol as raw material.

Appendix Table 2 (cont'd.)

Special Grade Ethyl Alcohol Standards of French Alcohol Monopoly

Alcohol percentage (15°C):	96°GL (96 vol. % or more)
Free acid (as acetic acid):	1.8 g or less in anhydrate 100 ℓ
Aldehyde (acetaldehyde):	1 g or less in anhydrate 100 ℓ
Esters (as ethyl acetate):	6 g or less in anhydrate 100 ℓ
Impurities (excluding methyl alcohol):	9 g or less in anhydrate 100 ℓ
Methyl alcohol:	Not detected
Higher alcohol (fusel oil):	"
Furfural:	"
Sulfides:	"
Other properties:	Colorless and transparent, and the transparency remains even when diluted with distilled water.

Note: The tests have been made under the analytical methods prescribed by the French Alcohol Bureau as official methods.

Source: Data arising from the Alcohol Specialists' Conference sponsored by OECD Development Center in 1977.

Appendix Table 2 (cont'd.)

Industrial Ethyl Alcohol Standards of India

Requirements for Absolute Alcohol

IS:321-1964

SL No.	Characteristic	Requirement for		
		Speical Grade	Grade 1	Grade 2
(1)	(2)	(3)	(4)	(5)
i)	Specific gravity at 15.6°/ 15.6°C, Max	0.796 1	0.796 1	0.796 1
ii)	Ethanol content, percent by volume at 15.6°C, Min	99.50	99.50	99.50
iii)	Miscibility with water	Miscible	Miscible	Miscible
iv)	Alkalinity	Nil	Nil	Nil
v)	Acidity (as acetic acid), percent by weight, Max	0.006	0.006	0.006
vi)	Residue on evaporation, percent by weight, Max	0.005	0.005	0.005
vii)	Aldehyde content (as CH_3CHO), g/100 mℓ, Max	0.10	0.006	0.10
viii)	Ester content (as $CH_3COOC_2H_5$), g/100 mℓ, Max	0.02	--	--
ix)	Copper (as Cu), g/100 mℓ, Max	--	0.000 4	--
x)	Lead (as Pb), g/100 mℓ, Max	--	0.000 1	--
xi)	Methyl alcohol content	--	To satisfy the requirement of the test	--
xii)	Fusel oil content	--	To satisfy the requirement of the test	--
xiii)	Ketones, isopropyl alcohol and tertiary butyl alcohol	--	do	--
xiv)	Total sulphur and compounds of sulphur (as S), percent by weight, Max	0.001	--	--
xv)	Sulphur dioxide (as SO_2), percent by weight, Max	0.000 05	--	--

Appendix Table 3-1 Details of Results of Cost Calculation by Raw Material

Ethyl Alcohol Production Cost

Plant capacity:	120 kℓ/day
Purity:	99.5 vol %
No. of operation days:	300 days/year
Raw Material:	Molasses
Use:	Fuel

	Cost Item	Unit Price	Volume	US$/kℓ
Variable Costs	Raw Material Cost	\$74/MT	3.5 MT/kℓ	259
	Utilities Costs			
	Power	¢8.5/kWh	64 kWh/kℓ	5
	Fuel	¢28/10^4 kcal	240 x 10^4 kcal/kℓ	67
	Water	¢20/MT	8 MT/kℓ	2
	Chemical Cost			2
	Subtotal			335
Fixed Costs	Labor Cost	\$2,000/y/man x 60 men = \$120,000/y		
	Maintenance Cost	9.8 x \$$10^6$ x 0.03 = \$294,000/y		
	Tax and Insurance	9.8 x \$$10^6$ x 0.02 = \$196,000/y		
	Depreciation Cost	9.8 x \$$10^6$ x 0.9 x 1/12 = \$735,000/y		
	Profit	9.8 x \$$10^6$ x 0.1 = \$980,000/y		
	Management Cost	Labor cost x 80% = \$96,000/y		
	Subtotal			67
	Total			402

Appendix Table 3-2

Ethyl Alcohol Production Cost

Plant capacity:	120 kℓ/day
Purity:	99.5 vol %
No. of operation days:	300 days/year
Raw Material:	Molasses
Use:	Industrial

	Cost Item	Unit Price	Volume	US$/kℓ
Variable Costs	Raw Material Cost	$74/MT	3.5 MT/kℓ	259
	Utilities Costs			
	Power	¢8.5/kWh	64 kWh/kℓ	5
	Fuel	¢28/10^4 kcal	240 x 10^4 kcal/kℓ	67
	Water	¢20/MT	8 MT/kℓ	2
	Chemical Cost			2
	Subtotal			335
Fixed Costs	Labor Cost	$2,000/y/man x 80 men =	$160,000/y	
	Maintenance Cost	11.0 x $\$10^6$ x 0.03 =	$330,000/y	
	Tax and Insurance	11.0 x $\$10^6$ x 0.02 =	$220,000/y	
	Depreciation Cost	11.0 x $\$10^6$ x 0.9 x 1/12 =	$825,000/y	
	Profit	11.0 x $\$10^6$ x 0.1 =	$1,100,000/y	
	Management Cost	Labor cost x 80% =	$128,000/y	
	Subtotal			77
	Total			412

Appendix Table 3-3

Ethyl Alcohol Production Cost

Plant capacity:	120 kℓ/day
Purity:	99.5 vol %
No. of operation days:	300 days/year
Raw Material:	Sugar cane
Use:	Fuel

	Cost Item	Unit Price	Volume	US$/kℓ
Variable Costs	Raw Material Cost	$22/MT	15 MT/kℓ	330
	Utilities Costs			
	Power	--	--	0
	Fuel	--	--	0
	Water	¢20/MT	10 MT/kℓ	2
	Chemical Cost			2
	Subtotal			334
Fixed Costs	Labor Cost	$2,000/y/man x 60 men = $120,000/y		
	Maintenance Cost	14.3 x $$10^6$ x 0.03 = $429,000/y		
	Tax and Insurance	14.3 x $$10^6$ x 0.02 = $286,000/y		
	Depreciation Cost	14.3 x $$10^6$ x 0.9 x 1/12 = $1,073,000/y		
	Profit	14.3 x $$10^6$ x 0.1 = $1,430,000/y		
	Management Cost	Labor cost x 80% = $96,000/y		
	Subtotal			95
	Total			429

Appendix Table 3-4

Ethyl Alcohol Production Cost

Plant capacity:	120 kℓ/day
Purity:	99.5 vol %
No. of operation days:	300 days/year
Raw Material:	Cassava
Use:	Fuel

	Cost Item	Unit Price	Volume	US$/kℓ
Variable Costs	Raw Material Cost	\$32/MT	6.5 MT/kℓ	208
	Utilities Costs			
	Power	¢8.5/kWh	107 kWh/kℓ	9
	Fuel	¢28/10^4 kcal	400 x 10^4 kcal/kℓ	112
	Water	¢20/MT	10 MT/kℓ	2
	Chemical Cost			18
	Subtotal			349
Fixed Costs	Labor Cost	\$2,000/y/man x 60 men =	\$120,000/y	
	Maintenance Cost	11.5 x \$$10^6$ x 0.03 =	\$345,000/y	
	Tax and Insurance	11.5 x \$$10^6$ x 0.02 =	\$230,000/y	
	Depreciation Cost	11.5 x \$$10^6$ x 0.9 x 1/12 =	\$863,000/y	
	Profit	11.5 x \$$10^6$ x 0.1 =	\$1,150,000/y	
	Mangement Cost	Labor cost x 80% =	\$96,000/y	
	Subtotal			78
Total				427

Appendix Table 3-5

Ehtyl Alcohol Production Cost

Plant capacity:	120 kℓ/day
Purity:	99.5 vol %
No. of operation days:	330 days/year
Raw Material:	Ethylene
Use:	Industrial

	Cost Item	Unit Price	Volume	US$/kℓ
Variable Costs	Raw Material Cost	$680/MT	0.48 MT/kℓ	326
	Utilities Costs			
	Power	¢85/kWh	82 kWh/kℓ	7
	Fuel	¢28/10^4 kcal	75 x 10^4 kcal/kℓ	21
	Water	¢20/MT	85 MT/kℓ	17
	Chemical Cost (incl. steam)			40
	Subtotal			411
Fixed Costs	Labor Cost	$2,000/y/man x 60 men =	$120,000/y	
	Maintenance Cost	17.8 x $$10^6$ x 0.03 =	$534,000/y	
	Tax and Insurance	17.8 x $$10^6$ x 0.02 =	$356,000/y	
	Depreciation Cost	17.8 x $$10^6$ x 0.9 x 1/12 =	$1,335,000/y	
	Profit	17.8 x $$10^6$ x 0.1 =	$1,780,000/y	
	Management Cost	Labor cost x 80% =	$96,000/y	
	Subtotal			107
Total				518

Appendix Table 4 Present Situation of Ethyl Alcohol Chemical Industry in Brazil

Product	Plant				Remarks
	Company	Capacity MT/y	Process	Use	
Ethylene	UNION CARBIDE DO BRAZIL S.A.	23,000	U.C.C.	LDPE	Operation 1958-69
	INDUSTRIAS QUIMICAS ELETRO CLORO S.A.	10,000	SCIENTIFIC DESIGN	HDPE	Operation started 1962
	COMPANHIA BRAZILEIRA DE ESTIRENO S.A.	4,000	KOPPERS	Ethyl benzene (styrene)	Operation 1959-70, closed 1978
	SALGEME INDUSTRIAS QUIMICAS S.A.	60,000	PETROBRÁS CENPES	Ethylene dichloride	Onstream scheduled for 1981
	COMPANHIA PERNAMBUCANA DE BORRACHA SINTETICACOPERBO	30,000	COPERBO	Vinyl acetate	Modification of existing butadiene plant, onstream scheduled for 1982
Acetaldehyde	PHODIA INDUSTRIAS QUIMICAS E TEXTEIS S.A.	40,000	PHONE POULENC	Acetic acid, solvents	In operation
	HOECHST DO BRAZIL QUIMICAS E FARMAC S.A.	4,200	HOECHST	Acetic acid, solvents	In operation
	USINA VICTOR SENCE S.A.	360	MELLE	Acetic acid, solvents	In operation
	COMPANHIA PERNAMBUCANA DE BORRACHA SINTETICACOPERBO	50,000	U.C.C.	Acetic acid, vinyl, acetate	Operation 1965-1971, now resumed
Octyl alcohol	EREKETROZ DO NE IND. QUIMICA S.A.	3,300	MELLE	Plasticizer	Now in operation, being expanded to 16,500 MT/y
	EREKETROZ DO NE IND. QUIMICA S.A.	150	MELLE	Solvents, plasticizer	By-product of octanol production, being expanded to 750 MT/y
Butyl alcohol	RHODIA INDUSTRIAS QUIMICAS E FARMAC S.A.	4,800	MELLE	Solvents	In operation
	HOECHST DO BRAZIL QUIMICA E FARMAC S.A.	1,530	HOECHST	Solvents	In operation
Butadiene	COMPANHIA PERNAMBUCANA DE BORRACHA SINTETICACOPERBO	33,000	U.C.C.	Polybutadiene	Operation 1965-1971, There is plan to expand plant for ethylene production
Ethyl ether	RHODIA INDUSTRIAS QUÍMICAS E TEXTEIS S.A.	1,400	PHONE POULENC	Chemicals, medicines	In operation, There is plan for expansion and renovation of equipment
	IBMEL-IND. DE MATERIAL BÉLICA DO EXERCITO	480		Explosives	In operation

Appendix Table 4 (cont'd.)

Product	Plant				Remarks
	Company	Capacity MT/y	Process	Use	
Ethylene glycol, Monoethyl ether	OXITENO S.A. INDUSTRIA E COMÉRCIO	1,300	HALCON	Acetate solvents	Operation started 1973
Diethylene glycol, Monoethyl ether	OXITENO S.A. INDUSTRIA E COMÉRCIO	1,900	HALCON	Acetate solvents	Operation started 1973
Ethyl chloride	COMPANHIA BRASILEIRA DE ESTIRENO S.A.	60	CRE	Catalyst for production of ethyl benzene	In operation (pilot plant)

Source: UNIDO sponsored "Joint Study Meeting on Use of Fermentation Alcohol as Fuel and Basic Raw Material in Chemical Industry in Developing Countries," Material Vol. II, Alcohol Council

Appendix Table 5 Present Situation of Ethyl Alcohol Chemical Industry in India

Ethyl Alcohol Base Chemical Products

Product	No. of Plant	Installed Capacity (MT)	Production in 1976 (MT)	Rate of Operation (%)
Acetic Acid	9	29,220	24,984	85.5
Acetic Anhydride	5	11,770	5,700	48.4
Butyl Acetate	4	8,730	3,781	43.3
Ethyl Acetate	8	6,390	4,915	76.9
Monochloroacetic Acid	4	6,900	3,652	52.9
Pentaerythritol	2	1,800	298	16.5
DDT	2	4,200	4,527	107.8
Styrene	3	33,000	21,061	63.8
Polyethylene	1	13,000	13,000	100.0
Acetone	1	1,500	30	2.0
Butyl Alcohol	3	8,250	3,522	42.6
Butadiene	1	25,200	10,462	41.5

Source: UNIDO sponsored "Joint Study of Alcohol", Material Vol. I, Alcohol Council

Appendix Table 6 Ethylene Production Cost

Plant capacity: 60,000 MT/year
Product purity: 99.95% in polymer grade

	Cost Item	Unit Price	Volume	US$/t
Variable Costs	Raw Material Cost	\$520/MT* (\$349/MT)**	1.75 MT/MT	910 (611)
	Utilities Costs			
	Power	¢8.5/kWh	235 kWh/MT	20
	Fuel	¢28/10^4 kcal	36 x 10^4 kcal/MT	10
	Water	¢20/MT	180 MT/MT	36
	Steam	\$12/MT	1.08 MT/MT	13
	Catalyst and Chemicals			2
	Subtotal			991
Fixed Costs	Labor Cost	\$2,000/y/man x 40 men = \$80,000/y		
	Maintenance Cost	8.0 x \$$10^6$ x 0.03 = \$240,000/y		
	Tax and Insurance	8.0 x \$$10^6$ x 0.02 = \$160,000/y		
	Depreciation Cost	8.0 x \$$10^6$ x 0.9 x 1/12 = \$600,000/y		
	Profit	8.0 x \$$10^6$ x 0.1 = \$800,000/y		
	Management Cost	Labor cost x 80% = \$64,000/y		
	Subtotal			32
	Total			1,023 (724)

* Material cost was obtained from average cost of fermentation ethyl alcohol, as follows:
\$416/kℓ ÷ 0.8 = \$520/MT

** In case of Brazil, material cost \$279/kℓ ÷ 0.8 = \$349/MT was used, and results of calculation were indicated with figures in parentheses. Except for material cost, all costs were assumed the same.

Appendix Table 7 State Gasoline and Gasohol Tax Rates*

(¢/gallon)

State	Gasoline Tax	Gasohol Tax with Exemption	Remarks
Alabama	11.0	8.0	Alcohol must be produced in Alabama from locally grown agricultural commodities.
Alaska	8.0	0.0	
Arkansas	9.5	0.0	Alcohol must be produced in Arkansas from locally grown agricultural commodities.
California	7.0	3.0	Exemption to be reduced to ¢3 per gallon in 1983 and eliminated on January 1, 1984.
Colorado	9.0	4.0	Alcohol must be produced in Colorado.
Connecticut	11.0	10.0	
Florida	8.0	3.0	Gasohol exemption is to be reduced to ¢4 per gallon in 1983, ¢2 per gallon in 1985 and eliminated in 1987.
Idaho	11.5	7.5	Alcohol must be produced in Idaho.
Iowa	13.0	6.0	Gasohol tax was raised to ¢8 per gallon on May 1, 1982 and will be raised to ¢10 per gallon on July 1, 1983; thereafter it will be raised by ¢1 per gallon annually until the tax is equalized with gasoline.
Kansas	8.0	5.0	Gasohol exemption is scheduled to decrease by ¢1 per gallon until it is phased out in 1985.
Louisiana	8.0	0.0	Alcohol must be produced in Louisiana.
Michigan	11.0	6.0	Gasohol tax will be raised to ¢8 per gallon in 1983, ¢9 per gallon in 1984 and phased out in 1985.

Appendix Table 7 (cont'd.)

(¢/gallon)

State	Gasoline Tax	Gasohol Tax with Exemption	Remarks
Minnesota	13.0	9.0	
Montana	9.0	2.0	Gasohol exemption to be reduced by ¢2 per gallon in 1985 and 1987, and phased out in 1989. Alcohol must be produced in Montana.
Nebraska	13.9	8.9	Alcohol must be produced in Nebraska.
Nevada	10.5	9.5	
New Hampshire	14.0	9.0	Alcohol must be produced in New Hampshire from locally grown agricultural commodities.
New Mexico	9.0	0.0	Alcohol must be produced in New Mexico.
North Carolina	12.0	9.0	Gasohol exemption will be reduced by ¢1 per gallon each year until it is phased out in 1985.
North Dakota	8.0	4.0	
Oklahoma	6.5	0.0	¢0.08 per gallon is collected on both fuels for inspection fees.
South Carolina	13.0	6.0	Gasohol tax will be raised to ¢7 per gallon in 1986 and again in 1987 to equal gasoline tax.
South Dakota	13.0	9.0	
Texas	5.0	0.0	Beginning in 1987, gasohol tax will be raised by ¢1 per gallon annually until it is equal to the gasoline tax.
Utah	11.0	6.0	
Virginia	11.0	3.0	Alcohol must be produced in Virginia from local raw materials; gasohol tax exemption will be phased out in 1990.
Washington	13.5	10.8	
Wyoming	8.0	4.0	

Appendix Table 7 (cont'd.)

* Does not include incentives not related to gasoline tax offered by the following states:

Hawaii - gasohol exempt from 4% state excite tax imposed on gross proceeds of retail sales.

Illinois - gasohol exempt from 80% of the states 5% sales tax; this exemption will be lowered to 60% on July 1, 1982 followed by additional 20% annual reductions until it is phased out in 1985.

Indiana - gasohol exempt from 4% sales tax.

Ohio - dealers are refunded ¢35 per gallon of qualified fuel (ethanol or methanol) that is reported as having been blended with unleaded gasoline.

Source: (A) Highway Taxes and Fees, 1982, U.S. Department of Transportation, Federal Highway Administration.

(B) Alcohol and Biomass Fuels Project Directory, Pasha Publications, Arlington, Virginia, 1982, pp. 7-35.

Appendix Table 8 Demand for Alcohol by End-use

The United States

(kℓ)

End-use \ Year		1973 Q'ty	1973 over previous year (%)	1974 Q'ty	1974 over previous year (%)	1975 Q'ty	1975 over previous year (%)	1976 Q'ty	1976 over previous year (%)
Solvents	Paint, ink, etc.	28,365	165	12,053	42	11,613	96	3,412	29
	Special solvents, etc.	114,590	105	132,257	115	91,356	69	91,326	100
	Cosmetics	178,437	100	167,083	94	119,424	71	134,113	112
	Medicines for external use	24,317	98	22,544	93	23,114	103	23,860	103
	Processing of food and medicines	46,276	107	57,723	125	48,553	84	47,962	99
	Detergents, fungicides, etc.	98,371	112	105,251	107	84,648	80	67,025	79
	Subtotal	490,356	106	496,911	101	378,708	76	367,698	97
Raw material for chemical industry	Acetaldehyde	78,967	63	99,564	126	87,149	88	49,226	56
	Other raw material for chemical industry	298,190	97	309,571	104	278,898	90	354,139	127
	Subtotal	377,157	87	409,135	108	366,047	89	403,365	110
Others	Fuel	4,004	99	3,177	79	3,381	106	4,070	83
	Test and research	12,983	384	8,266	64	6,223	75	7,556	121
	Others	3,179	112	2,719	86	1,413	52	8,943	633
	Subtotal	20,166	196	14,162	70	11,017	78	20,569	188
Total		887,679	98	920,208	104	755,772	82	791,632	105
Total (when acetaldehyde is excluded)		808,712	104	820,644	101	668,623	81	742,406	111

Appendix Table 8 (cont'd.)

Federal Republic of Germany

(kℓ)

Classification \ Year	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78
Beverages, perfumery	60,907	66,712	63,205	41,945	42,199	41,529
Medicines	4,276	4,524	4,712	4,481	4,476	4,630
Cosmetics, external use medicines	9,553	9,235	9,418	9,933	10,146	9,681
Vinegar	11,013	11,663	11,159	9,439	10,752	9,772
Raw material for chemical industry	130,170	143,547	115,958	129,153	130,602	55,776
Fuel	9,078	9,282	9,305	10,102	10,272	10,160
Exports	367	199	60	89	0	0
Others	868	0	0	0	0	0
Total	226,232	245,162	213,817	205,142	208,447	131,548
Delivery to Berlin Monopoly Bureau	11,707	14,089	13,677	11,688	10,799	12,158
Total	237,939	259,251	227,494	216,830	219,246	143,706

Appendix Table 8 (cont'd.)

France

(kℓ)

Classification \ Year	1972/73	1973/74	1974/75	1975/76	1976/77
Beverage (for processsing)	}75,080	}85,227	72,428	80,059	76,668
Beverage (for addition)			8,682	7,444	7,578
Strengthening of wine	22,998	27,686	17,503	19,534	23,737
Perfumery, cosmetics	27,163	27,755	25,151	27,420	27,797
Medicines	10,357	10,879	11,042	12,104	12,782
Vinegar	6,526	7,638	6,659	7,764	7,116
Production of export items	30,237	25,853	23,492	27,533	30,879
Chemical reaction	84,856	87,719	66,042	65,763	77,998
Solvents	44,609	52,444	42,052	42,507	43,568
Household use	22,944	23,686	22,344	22,782	21,639
Exports	73,435	33,844	16,573	25,071	57,651
Others	538	538	506	9,583	17,765
Total	398,743	383,269	512,474	347,564	405,178

Source: Ministry of International Trade and Industry, the Government of Japan

[4] INDUSTRIAL CROPS

[4] INDUSTRIAL CROPS

CONTENTS

[4-1] NATURAL RUBBER

A. OUTLINE

The most common species of natural rubber tree is Hevea brasiliensis, the original habitat of which is the Amazon basin. In the latter half of the nineteenth century, seeds of Hevea brasiliensis Mueli were transported to Southeast Asia, and the cultivation of these trees has grown by leaps and bounds due to the hot and humid climate and the fertile soil of the area.

The three major producing countries of natural rubber at present are Malaysia, Indonesia and Thailand, and their total production accounts for 80% of worldwide production. Natural rubber is also being produced in Asian countries such as India, Sri Lanka and Vietnam, and also in Africa.

It has been said that the area suitable for the cultivation of rubber trees is limited to the zone located between 15 degrees north and south latitudes, however improvements in cultivation techniques and other developments have enabled Hainan Island of China to also succeed in their cultivation.

I. Types and Grades of Natural Rubber

Natural rubber is roughly classified into two types: The conventional type and the technically specified type. In addition, the former is classified into sheets (the major type comprising RSS-Ribbed Smoked Sheets - with the subordinate type being Air Dried Sheets) and Crepes. These classifications depend on differences in grading methods, manufacturing methods and raw materials, but can be summarized as shown in the following Table.

		Processing	Drying	Raw materials	Product
Conventional grades:	Visual inspection				
RSS		Sheeting	Smoking	Field latex	RSS 1-5
ADS		Sheeting	Natural	Field latex	ADS
Crepes		Milling	Natural	Field latex, cup-lump and others	White crepe, Pale crepe, Brown crepe and others
Technically specified grades	Technical inspection	Cracking	Hot air	Field latex, cup-lump and others	CV, L, LV, 5, 10, 20, 50

There are five grades for RSS, from RSS-1 to RSS-5, and some 30 grades for Crepes.

The technically specified type is known as Technically Specified Rubber (TSR). The first grade is SMR (Standard Malaysian Rubber), which was introduced on the market by Malaysia in 1965. At the outset, TSR was marketed in grades of 5L, 5CV, 5, 10, 20 and 50, but new grades have been subsequently developed one after another, due to users' requirements for improvements in product features and processing conditions, and research efforts made by producers.

In addition, gradings of RSS, Crepes and TSR are mainly based on the following criteria:

1. RSS : Foreign matter and color
2. Crepes: Raw materials, foreign matter and color
3. TSR : Foreign matter, viscosity, vulcanization properties and color

The international criteria for grading natural rubber are defined in the International Standards for Quality and Packing for Grades of Natural Rubber, commonly known as the "Green Book", which has been prepared by the International Rubber Quality and Packing Conference. According to these criteria, natural rubber is classified into 35 standard grades. These classifications are however, applicable only to the conventional type, while TSR grading depends on the standards of each producing country.

II. Methods of Manufacturing Natural Rubber

As described above, although natural rubber falls broadly into three groups; RSS, Crepes and TSR, the initial raw material for all of them is field latex obtained from rubber trees. Latex can be obtained from rubber trees aged six to seven years after planting, and can be gathered over a period of 25 to 30 years thereafter on an average. The Dry Rubber Content (DRC) of field latex is approximately 30 to 40%. Latex is gathered by tapping, in which a thin slice of bark is cut from the rubber tree to extract the sap, which is then collected in a cup attached to the tree. The contents of these cups are then poured into large containers which are subsequently transported to a depot, from where the latex is transported to the next processing facility.

Raw materials other than latex are cuplump and tree lace which are commonly regarded as scrap. Cuplump is coagulated latex which has remained in the bottom of a cup or which has been left without being collected. Tree lace is coagulated latex covering the tapping cuts on the tree.

The methods for manufacturing each of the various kinds of natural rubber from these raw materials are described below.

1. RSS

RSS is produced from latex, and the process consists broadly of three treatment processes: coagulation, sheeting and smoking.

Field Latex	
(Filtration)	The latex is filtered through wire nets (about 60 mesh) to remove foreign materials such as small pieces of wood, soil, and so on.
(Dilution)	The latex is diluted with water to control DRC.
(Coagulation)	Using acid (formic or acetic acid are the most suitable). This process requires 10 to 20 hours.
Coagulum	
(Sheeting)	The coagulum is passed through ribbed rollers produce sheets.

(Drying in shade)	
Unsmoked Sheets (USS)	
(Smoking)	At about 70°C for three to seven days. (Thicker sheets require a longer period.)
Smoked Sheets (RSS)	
(Selection)	By visual inspection
(Baling)	
(Weighing)	
(Pressing)	
(Bale Coating)	To prevent adhesion between bales and for marking (use of calcium carbonate and talc)
(Marking)	
Finished Product	

Note: Estates perform all of the processes shown above continuously, while smallholders carry out the processes up to the USS stage, with packers performing the remaining processes, in which case water-washing is required prior to smoking.

2. Crepes

(Pale Crepes, Pale Crepes, etc.)	(Brown Crepes)	Remarks
Field Latex	**Scrap**	
Coagulum	(Immersion in water)	
(Milling)	(Water-Washing and Milling)	Passed between rollers about ten times while washing with water.
(Natural Drying)	(Natural Drying)	At room temperature, for 3 to 4 weeks.
(Baling)	(Baling)	