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PROSPECTS OF DEVELOPING POWER ALCOHOL INDUSTRY IN THAILAND*

by

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1) Introduction

In the year 1977, Thailand spent about 810 million U.S. dollars for 9,700 million litres of imported petroleum crude and another 150 million U.S.dollars for 1,600 million litres of finished products. The import bills for petroleum-based energy, which shares more than 80 per cent of total energy consumption, accounted for 21 per cent of total import values. Tables 6 and 7 in the Annex have shown the pattern for petroleum utilization in Thailand.

As a result of exorbitantly increasing price and a tendency in shortage of supply of imported oil, together with rapid industrial and social development which have taken place in recent years, Thailand is on the threshold of an energy crisis and must do everything possible to exploit all available energy resources along with the necessity to improve efficiency of energy systems within the Kingdom. Until now, very little effort has been devoted to the provision of alternative supplies of liquid fuels.

Thailand is an agricultural country and still has more area available for cultivation. Various kinds of food crops such as sugar and cassava are good feedstocks for production of fermentation alcohol which can be utilized as complementing fuel. Such feedstocks may be obtainable both by absorption of surplus crop products, and by plantation in specific area for energy development. Developing power alcohol industry as an indigenous source of fuel supply can thus be acheived by making use of these renewable energy resources. The prospects for Thailand will be discussed in this paper.

2) Present Structure of Ethyl Alcohol Production and Utilization

In Thailand, there are at present 48 distrilleries. Of these, 45 are small government-owned distilleries which are operated by private companies under permission and regulation of the Government. These small distilleries produce potable alcohol for local consumption only. Therefore, the potable alcohol industry is currently the main exit for alcohol utilization in this country. Only 3 distilleries will produce industrial alcohol (95 % value by volume), two are privately owned while the other one, which also produces potable alcohol mainly, belongs to the Government. Eastern Chemicals Company and Thai Alcohol Company are the two private sector distilleries of recent origin which have industrial alcohol production rights exclusively for export markets. The Eastern Chemicals factory with the current installed capacity of about [illegible] million litres per year has started its production since the end of the year 1976 while the Thai Alcohol factory with an initial installed capacity of 60 million litres per year, only 1/4 of its ultimate distilling capacity, has not started operation.

In terms of 95% V/V ethanol equivalent, the approximate production of industrial alcohol in the year 1977 was totally 96.5 million litres of which 90.6 percent or 87.4 million litres was consumed in the form of spirituous liquors, 6.3 per cent or 6.1 million litres was for export and 3.1 percent or 3.0 million litres we for inland industria use, mainly for chemical purposes. The breakdown of ethanol production and utilization, including the use of raw materials, since 1973 is shown in Table 1 in the Annex.

The industrially domestic use of ethyl alcohol (total 3 million litres in 1977) can be categorized as :

55 per cent of total for medical products

30 per cent of total for cosmetic products

12 per cent of total for painting purposes

2 per cent of total for others

Table 1 implicitly shows that molasses has been used as main feedstock for producing fermentation alcohol in Thailand and the consumption has been dominated by potable alcohol industry. The use of glutinuous rice (5-10 %) blended with molasses for specific taste and aroma has a long historical background in the fermentation industry in Thailand for human consumption. The actual production capacity of 95 % V/V alcohol consists of :

Thai Alcohol Factory (to be completed soon)	60 million litres/year
Eastern Chemical Factory	8 million litres/year
Government-owned Factory	24 million litres/year
Total	92 million litres/year

3) **Availabili and Suitability of w Materials**

Molasses can be considered as conventional raw material for producing fermentation alcohol in the past history. Thailand is an agricultural country holding more than 100 million rais (1 rai = 1,600 sq.meters) of crop area which yield mostly starchy products such as rice, cassava and maize. Reducing sugar can be obtained by saccharification of starch. Therefore, in aiming at availability of raw materials for planning of ethanol production, we cannot omit these resources. Two factors that must be taken into account, i.e., productivity of planted area for alcohol from different crops and cost of raw materials for alcohol production from different feedstocks, will be discussed as follows :

3-a) Productivity of Planted Area

Four different crops, namely, sugar cane, cassava, maize and rice will be considered. Table 2 in the Annex shows that planted area for surgar cane has highest productivity, both in terms of mass and income per unit area, while rice crop yields lowest productivity. However, according to experimental results and based on potential fermentable contents per unit weight, rice gives highest yield of alcohol, approximately 5.8 times as much as sugar cane does. Putting these factors together, it appears that sugar cane crop holds highest potential of alcohol yield per unit area of land used (564.2 litres/rai), the second highest yield is cassava crop (558.1 litres/rai), the third is rice crop (112.9 litres/rai) and the lowest is maize crop (78.6 litres/rai).

Cassava seems to be competitive with sugar cane in view of alcohol output but it gives lower income for the farmer in the same area. In the aspect of making use of land, it might be, therefore, said at this moment that sugar cane crop should probably be the most suitable feedstock for alcohol production.

3-b) Cost of Raw Materials

Cost of raw materials for alcohol production from five different substrates namely, blackstrap molasses, sugar cane, cassava, maize and broken rice are studied. Evaluation and comparison are shown in Table 3 (Annex). It is apparent that prices of starchy grains of maize and broken rice are relatively high when compared with sugar cane, molasses and cassava. For broken rice, its price is about 1.5, 2 and 3.5 times those of sugar cane, molasses and cassava respectively.

Although cassava is the cheapest raw material for alcohol production, its conversion cost is found to be very high. For example, it is learnt that CALMIG distillery in Curvelo, Brazil would produce ethanol at a cost of 3.50 Baht/litre yielding 180 litres from 1 ton of cassava and the cassava price is 240 Baht per ton (1 Thai Baht is equivalent to 0.05 US dollars). Using the same conversion ratio and cassava price in Thailand (460 Baht per ton), the cost of raw material would be 2.56 Baht and production cost would reach 4.73 Baht per 1 litre of ethanol while export price (F.O.B.Bangkok) of ethanol using molasses as feedstock is only 4.59 Baht/litre.

Suitability of the two materials, molasses and cassava seems to be competitive but varies from case to case. Availability of molasses depends on three factors; the sugar production, the sweetness of the used sugar cane and the efficiency of the sugar mill. About 70 % of molasses produced in Thailand has been exported. The export volume is growing every year. Table 4 shows the structure of molasses production and its utilisation during 1973-1977. For cassava, it is well known that cassava is an important food crop in Thailand. According to the demand of the market and considering the fact that cassava can grow easily, the production volume is fast growing year by year. Most of the cassava is made to pellets and exported. The price of cassava thus depends on foreign market situation.

Exported molasses could be available as feedstock for future alcohol plants. However, there is some limitation in the availability since the amount of molasses production is based on the capacity of the sugar mills which, due to world sugar market, cannot be easily increased . On the contrary, if cassava is chosen as raw material, it will be much easier to produce cassava in greater amount than to produce molasses.

Looking into these points of view, alternative use of molasses and cassava as raw material for development of alcohol production in Thailand will be subjected to the following conditions :

1) The availability of molasses is limited by the output of the sugar mill

2) More cassava needs more area and, to some extent, the economy in making use of land must be introduced.

3) The prices which are relevant to foreign market

4) Using molasses is cheaper only when the demand is less than the output.

4) Potential of Utilizing Alcohol as Fuel Supplement

The spectrum of the so-called "energy crisis" and fuel shortages have drawn attention from many many countries in exploiting every possible energy resource, rather than to put much reliance on petroleum-based energy. Fermentation alcohol has some attractive features being a renewable energy source and usable as alternatives for oil derivatives. The potential demand for alcohol developed in this country can be accounted as :

(1) Export

(2) Feedstock for domestic chemical industry

(3) Domestic fuel supplement

I: the 1977 export of 953,000 tc s of molasses were fermented in the country, Thailand would have had an excess 260 million litres of alcohol available. To make use of this large amount of alcohol as an export. the Government needs to develop international trade policy for alcohol and the price must be competitive to the world market. In terms of feedstock for domestic chemical industry, the existing demand in this category is only 3 million litres. This would involve substantially high investment of new large-scale chemical industries and possibly the world market space for export volume is needed. The potential demand for domestic fuel supplement seems to be the easiest channel to make use of available alcohol. However, in the light of overall national economy, an integrated feasibility study should be made among the three accounts of potential demand as mentioned. <u>This paper will deal only with the aspects of utilizing power alcohol, in fuel technology itsel</u>

4-a) <u>Technical Aspects</u>

Consideration in the use of ethyl alcohol as an engine fuel is that it has anti-knock rating and could operate at a high compression ratio. Ethanol is an efficient non-corrosive fuel and can generally be mixed 20 : 80 with conventional gasoline providing fuel for normal car engines which requires no adjustment to the caburettor. 100 % ethanol can also be used with a modification of the carburettor. To be mixed 50 : 50 with diesel oil, an efficient fuel is produced which requires little adjustment to the injection system of the diesel engine. Tetra-ethyl lead is now the most popular anti-knock compound, but the dangers of excessive lead in the environment are now well known. Special attention is being given to ethanol as an additive to gasoline in place of lead, since it would help reducing pollutants, improving octane and possibly increasing mileage.

In the case of Thailand, it had been proved that it was technically feasible to use 15 % of alcohol (95 % ethanol) blended with lead-free gasoline in the internal combustion engine without any modifications of the engines. Utilization of blending percentage of lower than 15 % will cause cars of some models to knock. There were not any usual engine wear or mechamical problems in these engines. Utilization of power alcohol, at least 15 % blending with 85 % lead-free gasoline, in internal combustion engine is thus ready for normal vehicles in this country.

However, in utilizing ethanol as supplemental energy, a technical benefit in view of total energy gain must be pointed out. Actual operating data, from an existing distillery with a capacity of 22,000 litre/day and using molasses as feedstock, indicates that the production of 1 litre of ethanol would require an average of 0.416 litres of fuel oil and 0.227 kwh of electrical energy. This implies that we would need 4,236 kcal of heat equivalent to obtain heat of 5368 Kcal from 1 litre of ethanol. The energy conversion ratio (output/imput) is only about 1.27 and it looks like a transfer of energy consumption modes with a little gain of energy (1132 kcal per litre of ethanol) In volumetrical point of view, however, to use 1 litre of acohol fuel would approximately reduce 0.6 litres of petro-fuel consumption.

4-b) Economic Aspects

If 15 % alcohol blended with lead-free gasoline is acceptable for use, The selling of this new blending fuel at the same price as or less than that of leaded gasoline is a good persuasion. Current price of regular gasoline is 5.12 Baht while that of leaded or super gasoline is 5.60 Baht per litre (January 1979 prices in Bangkok gas stations). The selling price of blending fuel should, therefore, be 5.60 Baht per litre or less, and the price of blending alcohol can be calculated as follows :

regular gasoline price (1-0.15)+X(0.15) = super gasoline price

$$5.12(0.85)+0.15X = 5.60$$

$$X = \text{blending alcohol price} = 8.32 \text{ Baht/litre}$$

Current ex-factory price of 95 % ethanol is about 4.60 Baht per litre (F.O.B.Bangkok). The marginal profit per litre of power alcohol utilization (15 % blended) is therefore

8.32-4.60 or 3.72 Bahts and this marginal profit can be provided for government fuel taxes, distributor and gas station services. Blending in higher proportion of alcohol to gasoline is possible but the blending alcohol price must be lowered and the marginal profit is reduced.

However, the economy of utilizing power alcohol must also be considered in terms of loss and gain in foreign currency. If molasses and fuel oil are used for power alcohol production and if the alcohol substitution in blending fuel is volumetrically applicable to gasoline to be substituted, then consideration can be made by determining the outflow of foreign currency incurred by importing an amount of fuel oil and non-exporting an amount of molasses, and by determining the inflow of foreign currency incurred by the reduction of imported gasoline.

Based on current prices (c.i.f) of imported gasoline and fuel oil, Table 5 reveals the followings :

(1) Production of alcohol as supplemental fuel will not serve the purpose of gaining in foreign currency as long as the price of molasses is higher than 526 Baht/ton. The minimum price (averaged annually) of molasses within the past six years is 638 Baht/ton in the crop year 1975/76 (Table 4). This would indicate that domestic use of alcohol fuel would cause a loss in foreign currency.

(2) Production of alcohol for export will gain in foreign currency if the price of molasses is less than 1,068

Baht/ton. The maximum price of molasses was 1,016 Baht/ton in the crop year 1973/74. However, fo: such a high price of molasses, the price of alcohol must be higher than 4.60 Baht/litre and the foreign currency gain shall be maintained. The problem is left to demand and price of alcohol in the foreign market.

(3) In the case of cassava, if value-added in processing cassava roots to exporting-pellets is counted, there is a big loss in foreign currency for utilizing alcohol derived from it, either for domestic fuel or for export. On the contrary, if there are some specific crop areas to grow cassava as an alcohol feedstock, not for exporting pellets, it would be more economical in this aspect.

5) Outline for Development Program of Power Alcohol Industry in Thailand

It has been discussed in the previous sections that molasses is likely to be the most suitable raw material as long as it is locally available for production of ethyl alcohol. However, utilization of ethanol for gasoline additive would not save foreign exchange unless for export. Establishment of power alcohol industry in Thailand would, therefore, serve only the following objectives :

(1) To be less dependent on foreign energy source and increase the firmness of domestic energy supply, a policy for national energy development plan.

(2) To increase value-added of agricutural products by such agro-industry

(3) To increase employment opportunities which would help reduce social problems

(4) To reduce the severity of the environmental lead poisoning caused by present gasoline additive (tetra-ethyl lead)

(5) To solve the problems of surplus sugar, cassava or other starchy crops, which would arise in the future. (It should be noted that saving in foreign exchang is attainable in this objective since the surplus cannot be converted to export values).

Total gasoline consumption in 1977 was more than 2,200 million litres. The rate of consumption is increased about 8-10 % annually and it is expected that the total demand for gasoline in this country will be about 2,800 million litres by the year 1980. To determine how much power alcohol could be produced would involve too many factors, such as existing potential productivity, the availability and suitability of raw material, time required for construction of new distilleries and the blending ratio. The power alcohol development program will be bound to the following assumptions :

a) Molasses is the most suitable feedstock in as much as it is available.

b) Availabity of molasses for power alcohol production shall be from the present export volume and be not more than

1 million ton/year due to the constraint of the sugar industry

c. Existing distilleries (except the Thai Alcohol factory which is not yet in operation) shall not serve the purpose of this program.

d) It shall take at least 3 years for construction and/or expansion of new distilling units

e) The ratio of ethanol blended with gasoline shall be fixed at 15 : 85 volumetrically.

According to the above statement, the first 5-year development program beginning in 1980 can be outlined as follows :

5-a) <u>Schedule I</u> Utilizing 60 million litres of ethanol blended with gasoline in 1980, whereas 400 million litres of new blending fuel is available for serving 14 % of the total demand for gasoline of which 2.1 % will be substituted by ethanol.

This schedule is based on existing installed capacity of the Thai Alcohol factory (1st unit) and thereby it is necessary to install new distilleries. Schedule I is appropriate for the first stage of power alcohol utilization, beginning on a small scale as an implementation program to introduce and entrust this new blend of fuel to the people. The program can be implemented by coordinating the use of government-owned vehicles with the supply of fuel from the Oil Fuel Organization, also a government enterprise. The governmental gasoline consumption is in this small scale and if it is found to satisfactory, another program of bigger scales can follow. Schedule I would require approximately 220,000 ton of molasses, 22 % of its maximum possible export volume.

5-b) Schedule II Utilizing 240 million litres of ethanol blended with gasoline in 1983, whereas 1,600 million litres of new blending fuel is available for serving 43 % of the total demand for gasoline of which 6.5 % will be substituted by ethanol.

This schedule is based on the ultimate potential productivity of the Thai Alcohol factory and the availability of molasses. The Thai Alcohol factory could positively develop its second, third and fourth distilling units (200,000 l/day for one unit) prior to the year 1983, depending upon the demand in the foreign market and/or upon the Government's policy in this matter. However, due to economy of scale, lower production cost is possible. About 380,000 tons of molasses will be consumed, the amount of which is close to its maximum availability. The rest of molasses should be served for the domestic growing demand in spirituous liquors and chemical industry. The main objectives of the decision making to use schedule II will be the reduction of environmental lead and of dependence on imported oil. Pricing adjustment might, therefore, be an attractive persuasion to this new type of blending fuel.

5-c) Schedule III (final stage) Utilizing 480 million litres of ethanol blended with gasoline in 1985, whereas 3,200 million litres of new blending fuel is available for serving 75 % of the total demand for gasoline of which 1.25 % will be substituted by ethanol.

This schedule is based on the proposal that super gasoline will be entirely replaced by the new blending fuel, leaving only the regular type to be consumed in the same manner. Since all molasses is consumed in Schedule II, other substrates must be introduced for the production of additional 240 million litres of power alcohol. Sufficient substrates must be provided by two means, which would need a firm policy on the part of the national alcohol program, i. e.

(1) To obsorb surplus crop products and use them for alcohol production in an amount which would partially fullfil the total requirement of 240 million litres.

(2) To develop extra land area for planting raw material that will be used only as a feedstock for power alcohol production. This means there must be a specific land for energy development or, in more simple words, the energy plantation.

The larger area of land for energy development will be required after 1985 along with the growing demand for power alcohol in the country. The sources of substrates will mainly come from this type of land and partially from the surplus of food crops. The number of distilleries, size and type of each unit and their location would need careful economic study before any justification can be made, and is not within the scope of this paper. However, it should be noted that the decision making to use the Schedule III will comply with all objectives as mentioned in this section.

6) **Conclusion**

Present utilization of fermentation alcohol in Thailand is mainly devoted to alcoholic beverages with only a small percentage of demand in chemical industries. Molasses has long been used as conventional raw material for alcohol production. Figures from existing factories show that alcohol production cost is heavily affected by raw material, whatever it is, generally sharing more than 50 % of the total cost.

Sugar cane crop has shown highest potential of both quantity of alcohol yield and income per unit of planted area. However, the use of sugar cane as raw material for alcohol production is still more expensive than cassava and molasses. Cassava was found to be the cheapest substrate but the total product cost of alcohol is still high due to the high cost of conversion process. Molasses seems to be the most suitable feedstock for distilleries as long as it is available. Thailand is now exporting about 7[illegible] % of total molasses production. This export volume can be diversified for domestic alcohol industry. However, the availability of molasses will be limited by the sugar industry which is now facing an unsatisfactory situation in the world market. The limited amount would induce a higher price. This makes other raw materials more competitive to molasses.

Fermentation alcohol has some attractive features since it represents a renewable energy resource and can be used as alternatives for oil derivatives. It was proved in Thailand that it is technically feasible to use 95 % V/V ethanol blended with lead-free gasoline, at a volumetric proportion of 15 : 85, in the internal combustion engine without any modifications. The use of this new blending fuel as substitue for super gasoline is economical in view of gasoline's price in the market. However, alcohol blended fuel would not at present serve the purpose of saving in foreign exchange, since the cost of molasses itself in one litre of alcohol produced is higher than the c.i.f. value of gasoline.

The program of power alcohol industry in Thailand should be stepwise developed, possibly commencing in 1 0. The first step shall be done on a small scale implementation while the second step is based on utilization of all available molasses. The final step shall replace all the use of super gasoline by alcohol-blended gasoline. This step will require other forms of substrates, and to a certain extent, will need extra land for energy development.

This paper tells that power alcohol industry in this country is a sound possibility, However, it must be understood that the optimization of production and utilization of fermentation alcohol is a different matter of which an integrated feasibility study is needed before any action shall be taken.

Annex

Table 1 Thailand's Production and Utilization of Alcohol

(million litres)

Year	Raw Materials		Production	Utilization		Export
	Glutinous Rice (ton)	Molasses (ton)	95% v/v	Potable	Industrial	
1973	25,372	220,950	61.1	59.6	1.5	-
1974	38,278	229,948	80.4	78.8	1.6	-
1975	8,798	179,201	63.9	61.7	2.2	-
1976	10,515	227,105	76.7	73.2	2.4	1.1
1977	15,656	287,650	96.5	87.4	3.0	6.1

Table 2 Productivity of Planted Area

Crop	Planted Area (1)	Production (1)	Average Yield (2)		Potential Yi[illegible] of Alcoho[illegible]	
	(1,000 rais)	(1,000 tons)	(ton/rai)	Value (Baht/rai)	(3) (litres/ton)	(litres [illegible] re[illegible]
Sugar Cane	2,804	22,564	8.06	2,400	70	564.2
Cassava	4,359	10,138	2.13	980	262	558.1
Maize	8,029	2,675	0.333	556	236	78.6
Rice	53,595	15,068	0.276	516	409	112.9

Remarks (1) 1976/1977 crop statistics

(2) averaged over 1973-19 7

(3) experimental results by Faculty of Environment and Resource Studies, Mahidol University, Bangkok

1 rai = 1,600 sq.meters = 0.395 acres

1 Baht (Thai currency) = 0.05 US dollars

Table 3 Cost of Raw Substrates Yielding 1 Litre of 95% Alcohol

Substrate	Yield of 95% Alcohol (litres/ton)	Unit Price (Baht/ton)	Cost of Raw substrates (Baht/litre)
Molasses	271 (1)	840 (3)	3.10
Sugar Cane	70 (2)	300	4.29
Cassava	262 (2)	460	1.76
Maize	236 (2)	1,670	7.08
Broken Rice	409 (2)	2,640	6.45

Remarks (1) average yield from existing distilleries in Thailand

(2) experimental results

(3) averaged over 1973-1977 F.O.B. Prices, Bangkok

Table 4 Molasses Production and Utilisation in Thailand

(1,000 tons)

Year	Production	Local Consumption	Export	Price(F.O.B.) Baht/ton
1972/73	526	119	407	766
1973/74	702	210	492	1,016
1974/75	678	178	500	954
1975/76	910	188	722	688
1976/77	1,223	270	953	782

Table 5 Inflow and Outflow of Foreign Currency in Developing Alcohol Industry

(Baht per litre of alcohol produced)

F.O.B. Price of Molasses (Baht/ton)	Currency Outflow			Currency Inflow (1979 Figures)		Loss or Gain in Foreign Currency		Remarks
	non-export-molasses	imported fuel oil	Total	(Case I) gasoline substituted	(Case II) alcohol exported	Case I	Case II	
526	1.94	0.66	2.60	2.60	4.60	0	+2.0	Loss = negative sign
688	2.54	0.66	3.20	2.60	4.60	-0.60	+1.40	Gain = positive sign
782	2.89	0.66	3.55	2.60	4.60	-0.95	+1.05	Gasoline's price is
954	3.52	0.66	4.18	2.60	4.60	-1.56	+0.42	c.i.f. value
1,016	3.75	0.66	4.41	2.60	4.60	-1.81	+0.19	
1,068	3.94	0.66	4.6	2.60	4.60	-2.0	0	
F.O.B. Price of Cassava Pellets	non-exporting pellets equivalent to cassava consumed (1)							(1) 1 litre of alcohol need 3.8 kg of cassava roots equivalent to 2.3 kg of pellets
1,670 Baht/ton	3.84	0.84 (2)	4.68	2.60	4.60	-2.08	-0.08	(2) need more steam if cassava is raw material

Table 6 Thailand's total consumption of petroleum products in 1977 was approximately 10,700 million litres. The pattern of utilization, product by product, in volume is as follows :

diesel oil	34 %
fuel oil	33 %
gasoline	21 %
kerozene, jet fuel and LPG	12 %

Table 7 The volumetric share of petroleum-based energy utilized by major economic sectors in Thailand, as averaged over the 1973-1977 period, can be shown by the following classifications :

Transportation & Communication	44.6 %
Manufacturing	17.8 %
Electricity & Water Supply	16.0 %
Agricuture (including fisheries)	11.4 %
Commercial Services and Others	10.2 %

B - 81

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