technical problems were found. It is considered in some quarters that, in order to lower the cost of methanol and to achieve a smooth initial introduction, large-output power generation with the modified gas turbine is the most effective.

9-4-2 Utilization Technology of Fuel Alcohol in Vehicle Engines

The major conditions required for alternative energy in vehicles use are given below.

1) Must have high energy density and must be easily movable as energy for moving vehicle.
2) Must provide excellent vehicle performance and must be easy to use.
3) Must provide lower exhaust gas emission.
4) Must be lower fuel price and system cost.
5) Must show no problems with safety and maintainability.
6) Must provide a long-term stable supply and be widely distributable.

Against this background, car makers in Western Europe, U.S.A. and Japan compared various kinds of energy on their cars, and judged that alcohol fuels were promising for spark ignition type engines.

(1) Characteristics of Alcohol Fuels and Their Problems

Table 9-4-1 shows comparisons between characteristic values of metanol, ethanol and petroleum-based fuels, and indicates the following features of the each fuels.

1) Advantages of Alcohol

i) In spite of a low calorific value per unit volume (liquid) of alcohol, the calorific value of mixture of alcohol gas and air is nearly the same as that of petroleum-based fuels. Also the cooling action of inlet air due to the large latent heat of alcohol improves its engine's volumetric efficiency. These two factors increase its engine output.

ii) The high octane number of alcohol permits a high compression ratio and also a boosted pressure rise by a supercharger in gasoline base engines.

iii) Its broad combustion lean limits permit lean combustion, and owing to its fast combustion rate, an improvement in the thermal efficiency and a decrease in NOx can be expected.

iv) Its combustion product contains only a small amount of deposits, and it discharges no soot, sulfur products and lead.

v) Its exhaust gas contains less products which react photochemically and gives only a low emission of multiple aromatic hydrocarbon.

Table 9-4-1 Physical Preperties of Oxygen-containing Compounds

		Gasoline	Methanol	Ethanol	MTBE	10% mehtanol blending	10% ethanol blending	7% MTBE blending	Light oil
Chemical formula		$C_4 \sim C_{14}$ mixture	CH_3OH	C_2H_5OH	$C_5H_{12}O$				C_4–C_{14}
Molecular weight		100 ~ 105	32.0	46.1	88.1				—
Composition	Carbon	85 ~ 88	37.5	52.1	68.1				
	Hydrogen	12 ~ 15	12.6	13.1	13.7				
	Oxygen	~ 0	49.9	34.7	18.2				
	C/H ratio	5.6 ~ 7.4	3.0	4.0	5.0				
Specific gravity	15/4 ℃	0.70 ~ 0.78	0.793	0.789	0.747				0.830
Reid vapor pressure	37.8 ℃ lb/in²	7 ~ 15	4.6	2.5	7.8				—
Boiling point	℃	27 ~ 227	64.4	78.5	55.2				90% point <350
Dissolving quantity to water		240 ppm	≈ ∞	≈ ∞	6.9 %				—
Dissolving quantity of moisture		88 ppm	∞	≈ ∞	1.4 %				—
Kinetic viscosity	37.8 ℃ cSt	0.57	0.47	0.85	~ 0.31				
Lower calorific value	Kcal/kg	≈ 10,500	4,770	6,880	8,390	9,890	10,060	10,040	10,300
	Kcal/ℓ	≈ 7,720	3,770	5,040	6,270	7,330	7,450	7,620	8541
Carburetion latent heat	Kcal/kg	≈ 83	280	220	77	104	98	83	Abt. 60
	Kcal/ℓ	≈ 60	220	175	57	76	76	62	
Theoretical air/fuel ratio	(kg/kg)	14.5 ~ 14.8	6.4	9.0	11.7	13.7	14.0	14.4	14.8
Air/fuel mixture lower calorific value	Kcal/kg	660 ~ 690	645	638	660				652
Air/fuel mixture carburetion latent heat	Kcal/kg	≈ 5.4	37.8	22.0	6.1				Abt. 3.8
Octane number	Research method	90 ~ 92	107 ~ 109	107 ~ 109	117	≈ 95.5	≈ 95	≈ 93	—
	Motor method	82 ~ 84	89	90	102	≈ 86	84.5 ~ 86	84.5 ~ 85	—
Cetane value		≈ 12	3	8	—				45~50
Ignition point		≈ -45	11.1	12.8	- 27.8				>50
Automatic firing temperature		≈ 260	467	424	460				
Combustion limit (in air: vol. %)		1.4 ~ 7.6	6.7 ~ 36.0	4.3 ~ 19.0	1.6 ~ 8.4				1.0~6.0
Laminar-flow combustion speed	cm/s	≈ 38	52						—

Note: Gasoline mixed in regular gasoline; specific gravity: 0.736; RON: 90 to 92; MON: 82 to 84; lower calorific value: 7,729 kcal/ℓ.

(Source) Report of the Institute of Energy Economics, Japan IEE-SR181

2) Disadvantages of Alcohol

i) Since alcohol has a low calorific value per unit volume (liquid), it makes the size of the fuel tank and fuel pump larger.

ii) Large latent heat makes it difficult for the gasoline base engines to start in cold temperature.

iii) Since its cetane number is lower than that of diesel oil, technical measures for promoting ignition is necessary when it is used for a diesel engine.

iv) It discharges much formaldehyde, but this can be coped with by an oxidation catalyst.

v) Wear may be caused by its low viscosity at portions where lubrication by the fuel itself is required. It also corrodes certain kinds of metal and rubber.

vi) It absorbs moisture and causes layer separation.

vii) Since it gives out nonluminous flames, it may pose a problem in detecting a fire.

To cope with the above-mentioned characteristics and problems of alcohol fuels, research facilities and enterprises in many countries are carrying out research and development on gasoline and diesel engines. Table 9-4-2 shows the situation of technology for developments, the gasoline-alternative use and diesel oil-alternative use respectively. For the former, large-scale running tests have been conducted, the required engine modification is not so extensive, and degree of technological maturity is considerably higher.
In the diesel engine basis of the latter case, degree of technological maturity is lower than that of gasoline engine basis and the development will proceed more extensively for several types of diesel engine basis. In the following, these technologies will be described by dividing them broadly into a gasoline basis and diesel basis.

(2) Utilization Technology on a Gasoline Engine Basis

Utilization technology of fuel alcohol in the category of spark ignition engines has virtually been established regarding both the low blend alcohol fuel (M3 or low) and the neat or higher blend (M85 or above) alcohol fuel.

The utilization of oxygen-containing fuels in major countries suggests that the 3 to 5% alcohol-fuel mixture has no significant oil-alternation effects and exercises no faborable effect on engine performance, that is, improvement in thermal efficiency and lowering of exhaust emission, and only the lead-removing or lead-decreasing effect can be slightly expected. For improving the octane number, MTBE (compound of methanol and isobutylene) seems to have a higher possibility than the alcohol-fuel mixture.

The neat alcohol fuel gives higher thermal efficiency per calorific value than the gasoline fuel, which may be due to the following.

1) It has a higher octane number and permits an increase in the compression ratio.

2) Combustion speed is high and lean-burn combustion is possible.

3) The combustion gas temperature is low and heat loss is minimal.

Fig. 9-4-1 shows the possibility of raising the thermal efficiency of the alcohol fuel to 25%. In the commercial car test using a Mazda test engine running at 1,500 rpm and with a mean effective pressure of 3 kg/cm^2, the alcohol fuel improved in thermal efficiency by about 10% over the gasoline fuel, including the effect of raising the compression ratio from 9 to 11.8, as shown in Fig. 9-4-2.

Table 9-4-2 Technological Aspects of Utilizing Fuel Alcohol in Internal Combustion Engine

Utilization	Technologies	Development Stage	1 Basic Study (Single Cylinder Engine Test) Studies on such basic characteristics as combustion, emission and lubrication.	2 Applied Study (Multi-Cylinder Engine Test) Overall engine performance when applied to multi-cylinder engine.	3 Vehicle Application Study (Vehicle Test on Chassis Dynamo) Applicability and practicobility as vehicle system from the point of drivability and performance	4 Feasibility Study (vehicle Fleet Test on Road) Drivability and durability, safety and environmental effect.	5 Commercialization Study Sophistication of the system to meet the requirement of the commercial market.
Gasoline Substitute	Neat/ near-neat utilization	Carburation Fuel Injection	Univ. of Wisconsin Santa Clara Univ.			GM, Ford, VW Porsche, Toyota Mitsubishi Nissan, Matsuda	
		Stratified Charge	JARI				
	Neat utilization	Reforming	SERI, JARI, NISSAN, GM Univ. of Wisconsin				
Diesel Oil Substitute	Neat Utilization	Fumigation					
	Near-Neat Utilization / Dual Fuel	Dual-Pump and Dual-Nozzle	Hokkaido Univ.	SWRI, EPA Mitsubishi	JARI	Volvo, KHD	
		Dual-Pump Single-Nozzle	Isuzu				
	Neat Utilization / Assisted Ignition	Spark Assist			JARI	KOMATSU MAN	
		Glow Plug Assist			KHD, Caterpillar	GM	
	Neat Utilization / reforming	Fumigation	Komatsu	JARI			
	Others	Ignition Improver		Cummins			

(Source) The Institute of Applied Energy, Japan, 5th Energy Ind. Symposium, July 1985

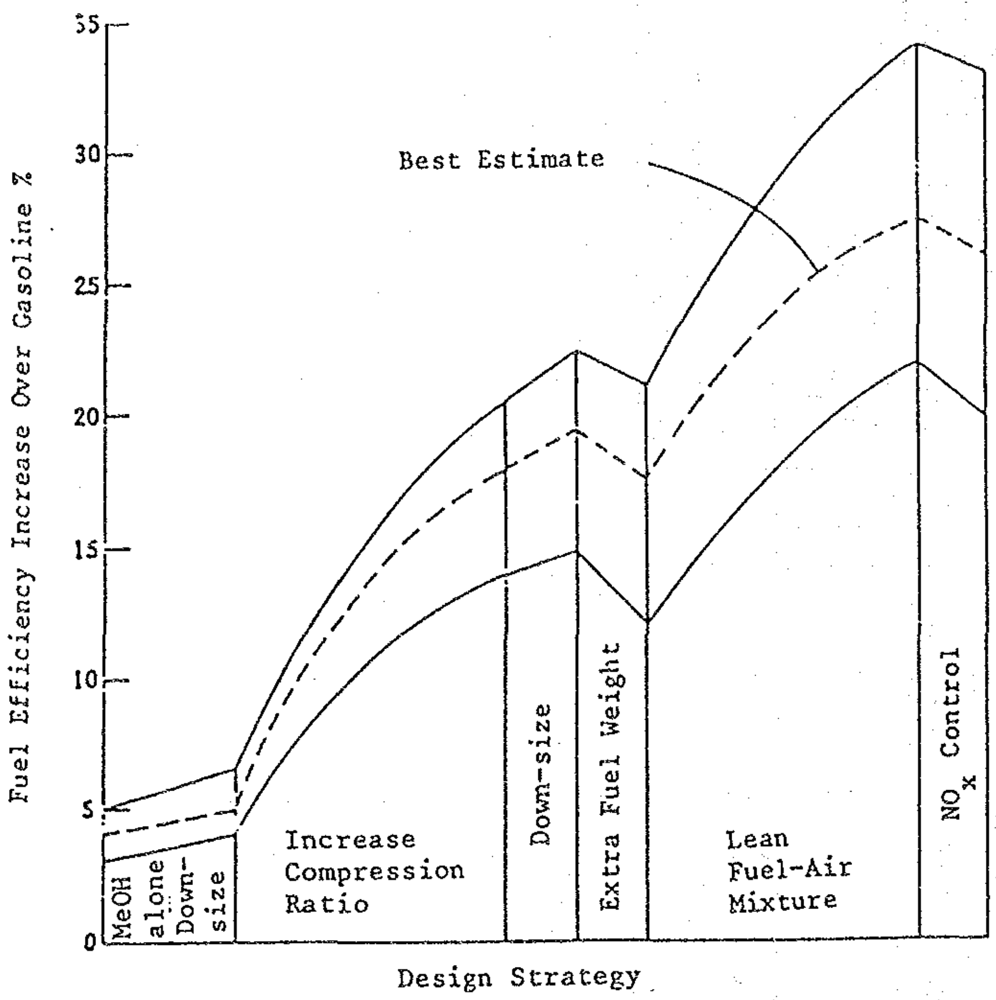


Fig. 9-4-1 Fuel Efficiency Increase Over Gasoline

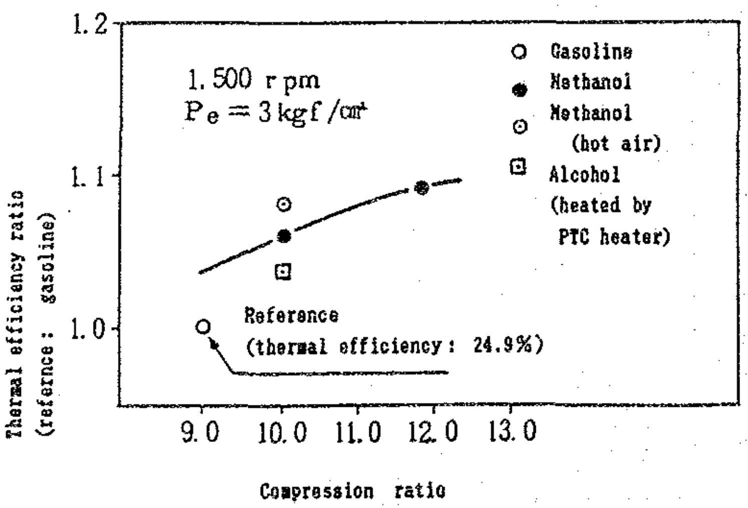


Fig. 9-4-2 Thermal Efficiency

(Source) Mazda Technical Review, No. 3 (1985)

Prior to the fleet test by the Ministry of Transport, a 30,000-km test on Mitsubishi Delica-van was carried out by the Bureau of Environmental Preservation, the state of Tokyo. The test on the vehicle shown in Fig. 9-4-3 was conducted using the current engine and parts, except a newly designed and installed gasoline tank, which was to be used for starting only, and a carburetor. The results of the 30,000-km test during three months from January to March 1986 are summarized as follows. NOx is about one-third, and considerable reductions in HC and CO can be seen. Aldehyde emission from the test car shows a 50% increase at the initial period of running and a 3- to 4-fold increase at the termination of running, over those figures of a gasoline vehicle, but is far lower than the aldehyde emission of a diesel vehicle. Fuel consumption per liter was 5.7 km, which was 1.8-fold compared with 10.3 km for the gasoline vehicle, but fuel consumption per calorific value for methanol was 1.5 km/1,000 kcal, which was 13% better than the value for gasoline, that is, 1.33 km/1,000 kcal.

Toyota has converted its electronically controlled engine into a lean combustion engine, and its Calina recorded a 10 mode fuel consumption of 17.7 km/l (gasoline equivalent), and Calina's NOx emission cleared 1986 regulations. In city and highway travelling modes, Calina also showed excellent fuel consumption and exhaust gas characteristics.

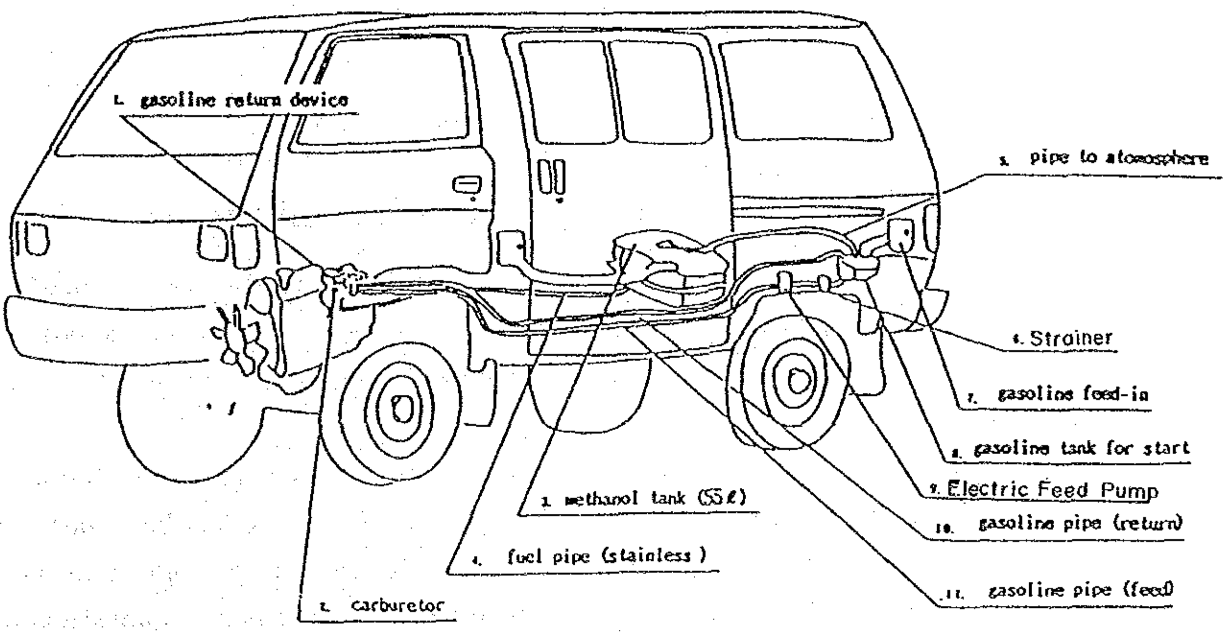


Fig. 9-4-3 Vehicle Fueled with 100% Methanol Used in Road Test

One of the most significant problems in using alcohol fuels on gasoline engine basis was low temperature startability, therefore, large-scale fleet tests were carried out in cold regions in the U.S. and Europe.

In the use of neat or high-concentration methanol and ethanol as gasoline alternatives, there have been problems, but they may be considered, as mentioned above, to have been solved by state-of-the-art technology. Many fleet tests have proved that fuel alcohol shows low exhaust-gas emission, and no serious problem in operation will occur. In the practical use of alcohol fuels, however, fuel supply poses a problem, and in order to solve this problem, FFV (Flexible Fuel Vehicle) has been developed.

The above vehicle permits the use of pure methanol, pure gasoline, and a mixture of both by a single vehicle. The attention of the development was focussed, in particular, on the TNO sensor developed in the Netherland, which optically detects the ratio of methanol and gasoline in the fuel mixture through the help of the color difference. A carburetor was developed which permitted the use of any of methanol, gasoline or gaseous fuel and was put to a fleet test.

An attempt is being made in which methanol is reformed into CO and H_2, using the exhaust heat of the engine, and the CO and H_2 were supplied to the engine, thereby significantly improving thermal efficiency including the recovery of the exhaust energy. The decomposition reaction in this case and the resultant decomposition gas generation increment are as follows:

$$CH_3OH \xrightarrow{\text{Endothermic}} 2H_2 + CO \quad \text{Cal. increase 22\%}$$

$$CH_3OH + H_2O \xrightarrow{\text{Endothermic}} 3H_2 + CO_2 \quad \text{Cal. increase 15\%}$$

The system is shown in Fig. 9-4-4. The combustible range of the hydrogen gas contained in the reformed gas is wide, and lean-burn combustion is possible. However, during a full load operation, an abnormal combustion such as back fire is liable to occur.

VW has developed a system for heating the reactor with a methanol burner to improve low-temperature startability. Its thermal efficiency has been improved by 20-30% compared with gasoline and by 5 to 10% compared with liquid methanol. NOx has been significantly reduced owing to lean-burn combustion, and the discharge quantity of the incompletely burnt fraction has dropped compared with that of liquid methanol.

However, on the other hand, the development of exhaust-heat reforming equipment which is mountable on a vehicle and improvement in the performance of the heat exchanger is further necessary.

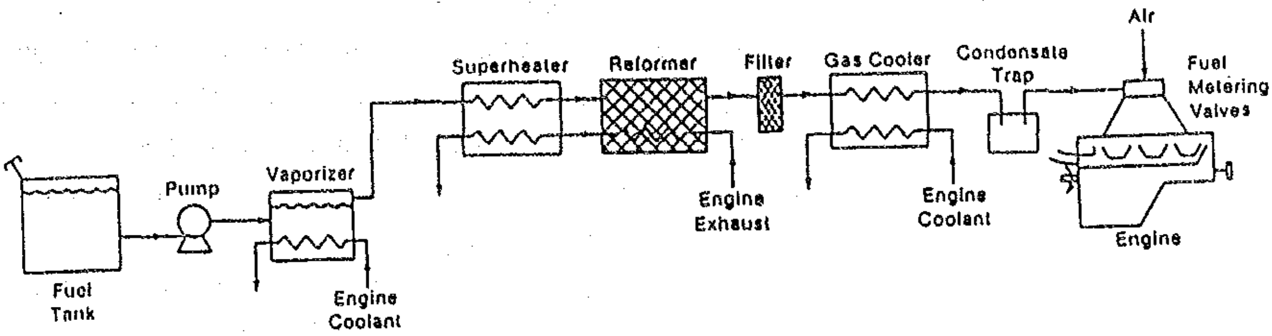


Fig 9-4-4 Reformed Methanol Fuel System
(Source) Automotive Technology, No. 1, 1986

(3) Utilization Technology on a Diesel Engine Basis

Various methods have been developed to improve the very low ignition capability due to the low cetane number of alcohol. These methods are broadly divided into the following three kinds:

o Mixed fuel system (mixing of diesel oil and ignition improving additive)
o Dual-kind fuel injection method (pilot system)
o Assisted ignition system (use of spark plug or glow plug)

1) Mixed Fuel System

The mixed fuel system is aimed at improving the ignition capability by mixing alcohol with highly-ignitable light oil or a nitrate-based firing-ignition improver. These two mixing systems are desirable, because they do not demand modification of the diesel engine which becomes the basis, but the limit of mixing due to layer separation and the cost of the additives pose problems in the respective methods.

The ignition improving additive is used in Brazil for sugar trucks using ethanol fuel. As this improving agent, 4.5% (vol %) TEGDN (Triethyl glycol dinitrate) is mixed, and further, 1% caster oil is mixed to supplement the lubricability of the fuel.

With this method, Benz engines of 5.7 and 9.7 amounting to 1,700 units were used early 1986. Their performance, indicates that the maximum torque was improved by 10% compared with the diesel engine at lower speed by 20% thereby contributing to an improvement in operability. Fuel consumption by a 22-ton truck showed about 15% improvement compared with a 100% ethanol-burning engine provided with a spark plug.

The cost of the ignition improving additive poses a problem, but in the past five years, the price of the improving additive dropped from 18 to 6 times the price of ethanol fuel (ethanol price also dropped from 45 ¢/l to 22 ¢/l).

Eventually, the price of the ethanol fuel mixed with the improving additive will be about 24% higher than straight ethanol.

Development for producing the ignition improving additive has progressed as a by-product of ethanol fuel production at sugar cane factories.

A cold starting test was conducted in Finland, using two turbo-equipped direct injection diesel engines and the fuel containing an ignition improving additive (17% DII-3" (Ethyl Co.)) showed better startability, though only a little, over the diesel oil, and far exceeded the startability of the other mixed fuel type engines.

2) Duel Fuel System

In the injection system, highly ignitable diesel oil and low ignitable alcohol have their own respective fuel and injection systems, and alcohol ignition is ensured by injecting a slight amount of diesel oil just prior to alcohol injection.

The F8L413F engine of KHD has the feature that a fixed amount of diesel oil is supplied to its entire operation area. Beside the KHD engines of West Germany, the dual fuel systems of Volvo in Sweden and of MWM in West Germany are used for fleet tests on buses and trucks. Depending on the load, 20 to 90% of the diesel oil is being replaced by methanol fuel. The drawback of the dual fuel system is that since two systems, each for injection and fuel supply, are required, the systems have become complicated and more expensive.

3) Assisted-Ignition Method

Completion of a assisted-ignition for neat methanol, using the spark-ignition plug or glow plug, is eagerly expected, because of much volume of diesel oil replaced. The development of this system is vigorously being performed in many companies and laboratories.

In the combustion chamber of MAN shown in Fig. 9-4-5, methanol is injected through an injection-hole nozzle into the combustion chamber above the piston, and the vapor mixture flowing along the combustion chamber wall or the spray mixture of the jet flow from the nozzle is ignited by the spark plug. The spark plug position is an important parameter and exercises various effects upon the engine performance. Low-temperature startability of this system, down to -2°C, is the same as that for diesel oil.

As can be seen from the total-load torque performance shown in Fig. 9-4-6, this methanol engine with an excellent smoke characteristics gives a very great low speed torque, compared with the diesel engine restricted by smoke at low revolution speed. This MAN's D2566FMUH engine was trial-used in the commercial test on buses in San Francisco, and a travel distance of 72,000 km was accumulated.

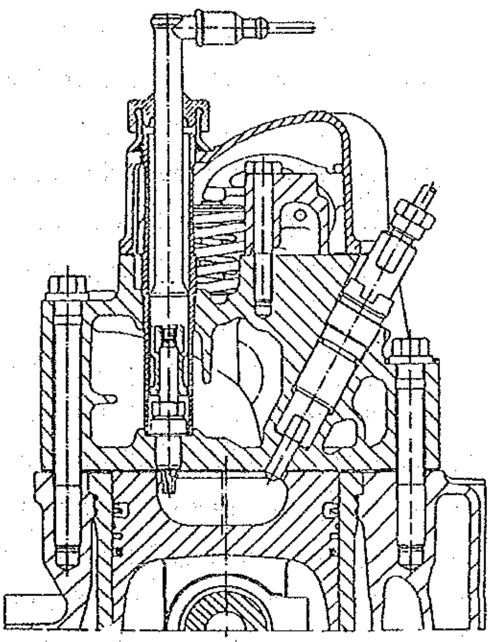


Fig. 9-4-5 M.A.N. D2566FMUH Engine (Development status 01/1984)
(Source) AFT Symposium, 1984

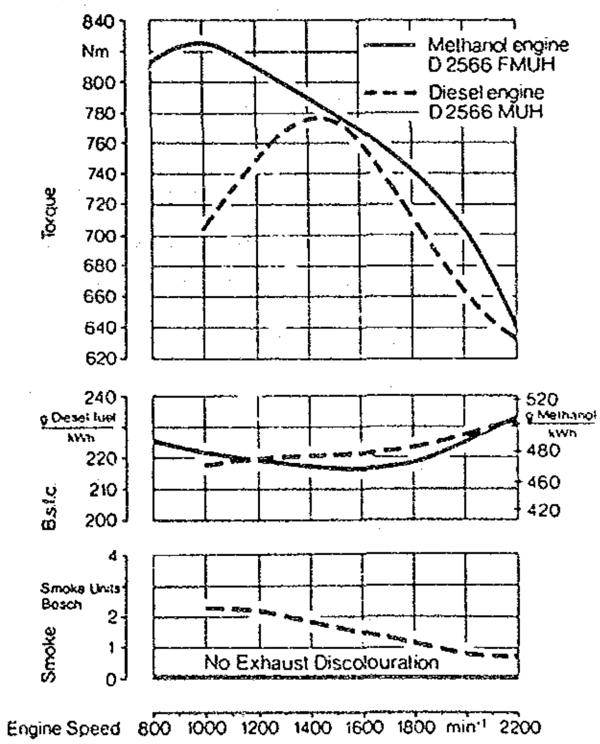


Fig. 9-4-6 Full-load curves of D2566FMUH methanol engine and D2566MUH Diesel version.
(Source) AFT Symposium, 1984

However there have been serious problems based on the facts that durability of the spark plug was less than 8,000 km and the deterioration of the plug leads to a catalyst deteriorations.

Komatsu in Japan has also developed the similar kind of the spark assisted engines in three different sizes, one of which is installed in the light truck and now twenty vehicles are under the fleet test. Fig. 9-4-7 shows the schematic view of their system.

GM/DDA converted its 2-cycle, 6-cylinder, V-type engine with a compression ratio of 19 into a methanol engine with glow plugs and made it possible to self-ignite methanol at heavy load condition by adjusting the scavenging effect and residual gas quantity.

This success is due to the contribution of an active substance contained in the residual gas. In operating conditions under which self-ignition deteriorated during a light load operation and during engine start, a glow plug has been switched on for assisting ignition. The retrofitted engine has been mounted on a bus in San Francisco and is undergoing a commercial test. According to the company operating the bus, the test result shows basically there is no difference from diesel engines, except that fuel consumption is inferior to that for the diesel engine during light load or idling. Acceleration shows no significant difference. According to a recent report, the travel distance of 58,000 km has been accumulated, and the problem lies in the 30,000 km life of the injection nozzle. Slight wear on the injection plug has also been reported.

The glow plug method in four cycle engines has been studied by several companies and organizations, among them Caterpillar's system is unique in a way. CAT's combustion chamber is caused, as shown in Fig. 9-4-8 (a) and (b), to collide a centre spray with the protrusion at the piston head, and the flame caused by the glow plug propagates not only circumferentially but also transversely, thereby promoting flame propagation. The emission of NOx is about one third of diesel engine although fuel consumption and HC slightly deteriorate at light load.

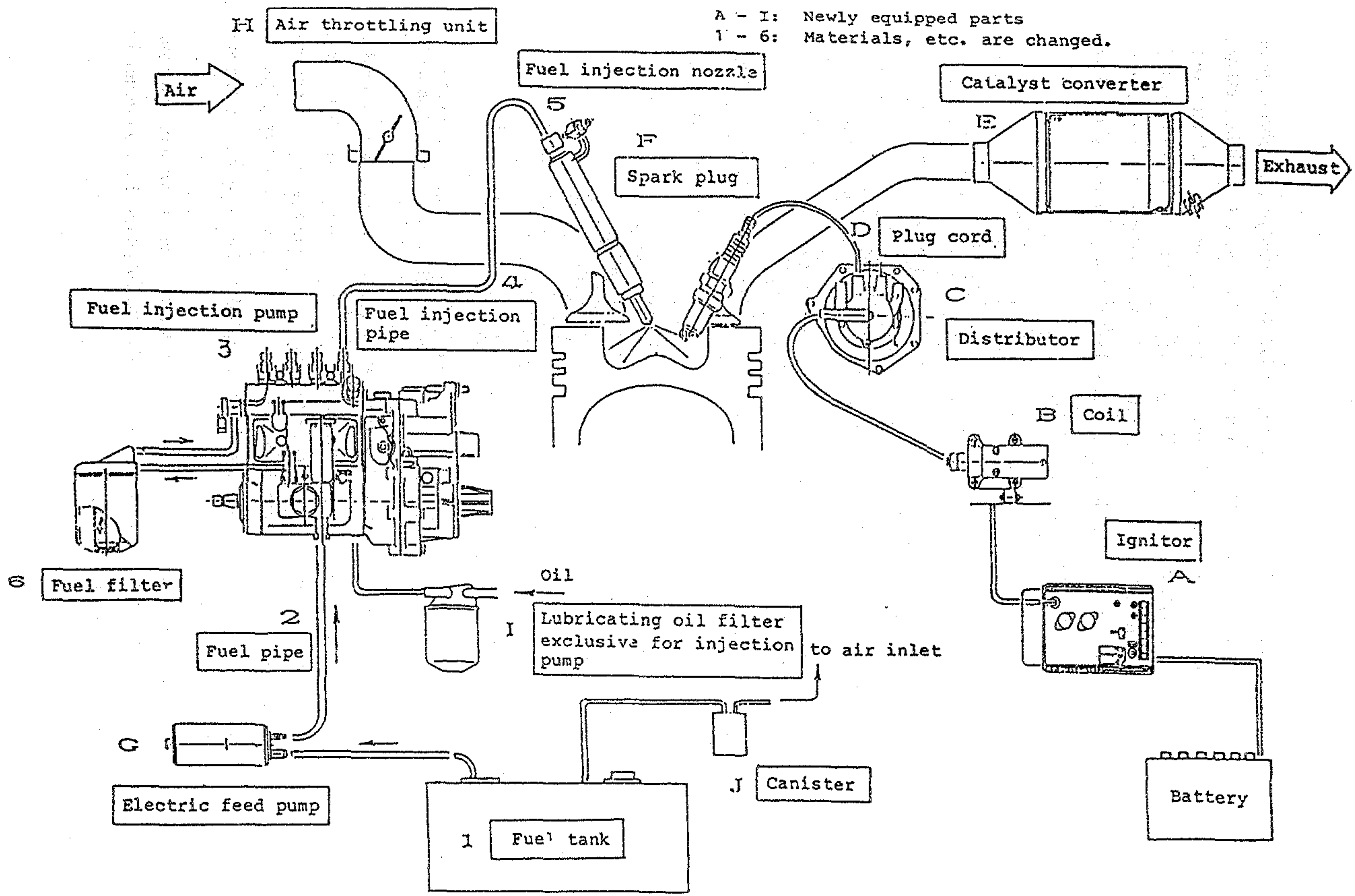


Fig. 9-4-7 Modification Items for Methanol Engine
(Source) International Symposium on Introduction of Methanol Powered Vehicles

The Japan Automobile Research Institute (JARI) is studying a hybrid system in which a reformed gas is supplied through the in-take tube, while methanol is directly injected into the cylinder. A test result has been obtained which shows that the operating method of injecting reformed gas into the cylinder at a medium load or above and of sucking in a reformed gas at a low load has shown better thermal efficiency and exhaust cleaning than only the intra-cylinder injection system.

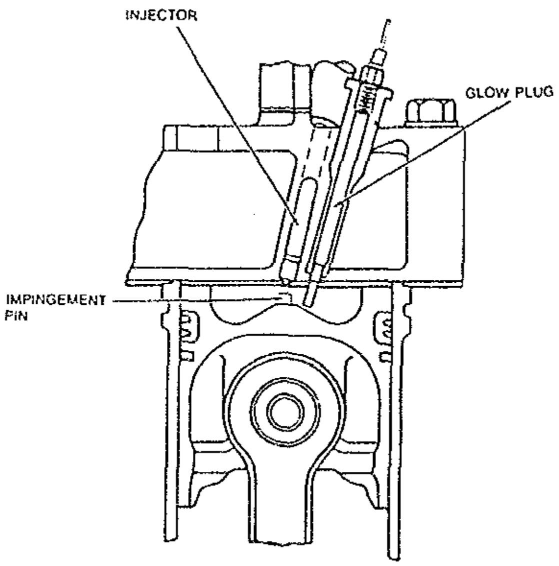


Fig. 9-4-8 (a) Cross Section of Combustion Chamber Modified for Methanol
(Source) SAE Paper 861169 ('86/9)

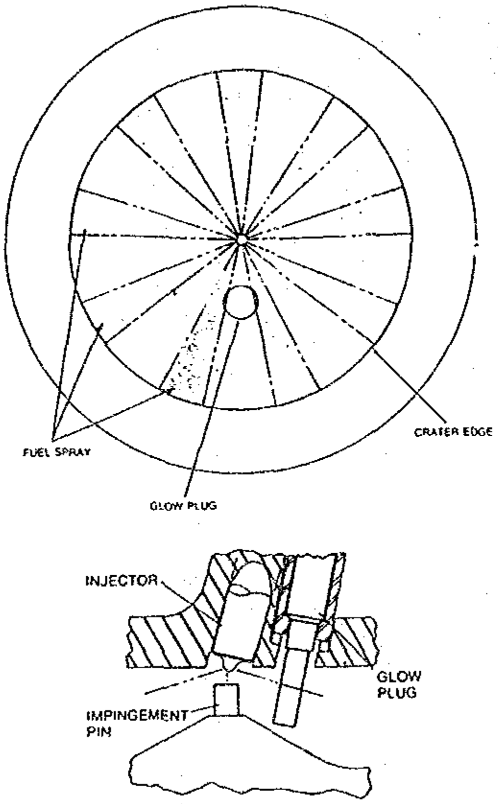


Fig. 9-4-8 (b) Glow Plug Location in the Combustion Chamber - Top View

A gas engine system developed by Mercedes-Benz use a fuel gasified by engine cooling water from which exhaust-heat energy has been recovered. Therefore thermal efficiency is recovered by recovering cooling loss energy and by decreasing the injection work. During low-temperature starting, preheating by an electric heater is used. These engines were mounted on buses in West Germany and put to running tests.

Fig. 9-4-9 shows the comparison of exhaust characteristics of various systems, when the exhaust gas level is assumed to be 100, and suggests the excellence of the alcohol fuel system in this respect.

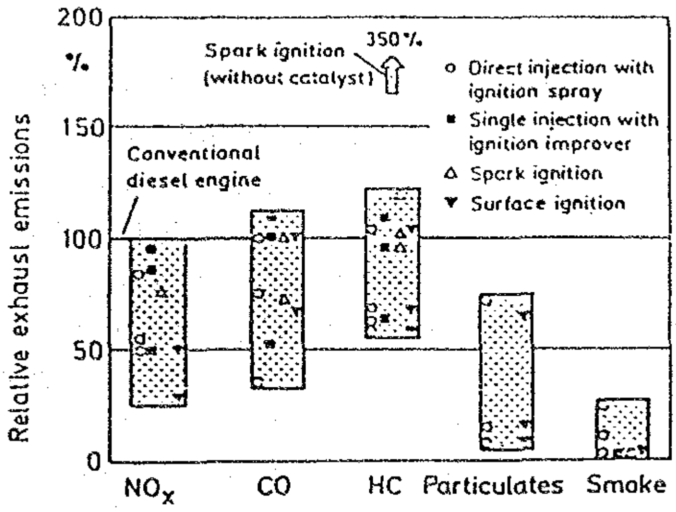


Fig 9-4-9 Relative Exhaust Emissions for Alcohol-Diesel and Diesel Derived Engines (Source) AFT Symposium, 1984

(4) Developments in Various Countries

1) Sweden

In Sweden, which has no oil, gas and coal resources, similar to Japan, large-scale tests on alcohol fuels have been conducted, and particular attention is given to low temperature startability and wear during the low temperature season. Fleet tests on 1,000 units M15 fuel have already been completed. Following these tests, running tests on 22 cars, trucks and buses using M100 fuel were started. Two buses travelled 16,000 km in 1980 to 1982. They used Volvo's dual fuel-injection system, and the alternation ratio by methanol was 75%. The performance and durability of these bus engines were similar to those of conventional diesel vehicles; and a decrease in exhaust emission, particularly NOx, and a decrease in the particle sizes of NOx were reported. The 22-car test commenced in 1984, with the participation of 10 Volvos, 7 Saabs and one each of Ford, Toyota, Mitsubishi and Mazda. The test continued until 1986. Twelve cars (2 pairs of Saab and 4 pairs of Volvo) were tested on M100 gasoline, and it was confirmed that energy consumption for M100 was less.

2) West Germany

West Germany was eager to study methanol and a hydrogen fuel as alternative fuels on a private-sector initiative basis.

In tests on methanol vehicles equipped with gasoline-based engines from 1979 to 1983, M100 was used, which consisted of 93% methanol with an addition of 7% hydrocarbon of C_4/C_5. This additive was used to avoid a combustible atmosphere in the fuel tank and to improve cold-region startability.

For heavy-duty vehicles, MAN, KHD and Benz developed methanol engines of independent types and participated in fleet tests on buses, trucks. MAN's spark assit type FR engines were mounted on buses, and have accumulated a record of 420,000 km since 1981. A supercharging system is also the object of study. At Aachen Institute of Technology and KHD, studies continue on direct-injection engines ignited by a hot surfce (glow plug).

Dual-fuel-type engines of KHD were mounted on five trucks in Berlin and accumulated a travelling distance of 800,000 km, and the longest distance per vehicle was 120,000 km. In Koln, buses accumulated 240,000 km during 1981 to 1985.

Three Mercedes-Benz gas engines were mounted on three buses and accumulated an operation record of 500,000 km.

3) Canada

Canada, the major producer of methanol, is vigorously pursuing studies on the possibility and, in particular, the practical use of methanol fuel, in view of the huge resources of natural gas and coal.

Recently, six Ford Escorts in three pairs were tested, and the FFV (Flexible Fuel Vehicle) test using M85, gasoline or their mixture was carried out with the aim of testing low-temperature startability in winter.

The MILE (methanol in large engines) program, covering the years from 1985 to 1989, commenced in the spring of 1985, and tests of a 7-pair bus fleet are in the planning.

For underground mining, a methanol engine, obtained by modifying a KHD engine into a glow assist type was trial-used.

4) U.S.A.

Since gasohol, which is made by mixing lead-free gasoline and 10% ethanol, was introduced in 1979, a billion gallons of ethanol have been used every year mainly as an extender. The demand for ethanol and methanol will increase further if they prove to be economical as an octane booster.

Ninety-nine cars have participated in the CEC program held in California since 1981, and out of them, forty Fords have run for five years and covered ten million miles. Of them, thirty-seven cars have run the whole distance for four years.

In 1983, more than five hundred Ford Escorts were mass-produced and their test in the CEC program has entered into the third year. In particular, to check the low-temperature startability with M85 fuel, it is now planned to give startability tests to five cars each of the three types. Commercial operation tests have been made in San Francisco by using two buses (methanol-fueled and diesel fueled) each from GM and MAN, under the CEC plan. The result of these buses indicates the only possibility for the vehicles to pass the stringent 1991 regulation on the particulate matter is to use the methanol engines.

Over four years from 1987, five thousand cars owned by the Federal Government, which are to be used as methanol-fueled cars, will be subjected to road tests every year, totaling twenty thousand cars. The objects include large-sized engine vehicles such as buses and eighteen long-distance trucks.

Nowadays, emission regulations have been intensified. Although methanol fuel is expensive, its exhaust emission characteristics are excellent.

This fact has given rise to the idea that methanol-fueled cars are cost effective, compared to diesel-engine vehicles for which emission measures have already been taken.

5) Japan

In Japan, measures to introduce fuel methanol as a countermeasure for NOx pollution and a substitute energy for petroleum in the field of transportation have been taken, especially in big cities where traffic is heavy. These measures have been taken because it is difficult to clear air pollution regulations, above all, the environmental standard of NOx, and also because the transportation sector in Japan depends almost 100% on petroleum-based fuel.

The Ministry of Transport started a 3-year fleet test since January 1987 in Tokyo on the light duty collection and delivery trucks. These includes twenty diesel based methanol engines supplied by Komatsu mounted on 2-ton trucks and ten gasoline based engines by Mitsubishi on 1-ton trucks.

The Japan Automobile Research Institute (JARI) has been performing basic research since 1973. They have been conducting researches to utilize both neat and high-concentration alcohol for various types of engines, and executed in-house tests on the buses mounted with these engines.

In June 1985, the Agency for Natural Resources and Energy declared the new energy introduction vision, which is summarized below.

i) To develop a technology for fuel M85-95 for gasoline engine-based vehicles from middle and long-term points of view

ii) To arrange the necessary system to introduce fuel methanol

iii) To execute required tests for introducing fuel methanol

Based upon above mentioned visions, the Agency for Natural Resources and Energy is making a concrete plan to execute road tests on methanol engine vehicles in 1988.

6) Others

In Indonesia methanol utilization has been studied in Pertamina and Lemigas for blending into gasoline with/without an additive. This study is understood to have two backgrounds. One is the international trend of reducing or eliminating TEL in gasoline and the other one is the consideration how to find out the outlet for methanol from Bunyu. As to fuel ethanol the survey team had some documents and comments on gasoline fleet test done by BPPT.

In New Zealand, a new carburetor has been developed.

A road test of 80,000 km has been executed over two years, using a Toyota Corolla mounted with the newly developed caburetor. This caburetor is used for an FFV, designed for using gasoline, methanol and gas fuel. It has already been tested in Norway. Since there is no manufacturing plant for automobiles and engines in New Zealand, they find the gasoline based alcohol engine vehicle to be promising because a large-scale modification of the vehicle body is not required, and various kinds of fuel can be used. On the other hand, it is doubtful whether diesel based vehicles will be economical.

9-4-3 Utilization for Purpose Other Than Vehicle Use

(1) Large Scale Power Generation Plant

Among the usage of methanol for purpose other than vehicle fuel, the largest one will be for power generation.
To examine the use of methanol fuel for power generation, methanol combustion tests in boilers or gas turbines have been executed in Japan and the U.S.

1) Boiler

The combustion tests of methanol in boilers have been executed in Japan and the U.S., and the results have proved the following facts:

i) Exhaust Gas Characteristics

a) NOx discharged by methanol fuel is kept down to about less than 50%, compared with NOx discharged by crude oil and heavy fuel oil.

b) No SOx is generated because methanol dosen't contain sulphur.

c) The CO content in methanol is almost the same as that in other fuel oils or slightly more, but HC content in incompletely burnt methanol is nearly the same or less than that in other fuel oil.

d) No soot is generated.

In all, methanol is considered to be an excellent fuel from the viewpoint of environmental protection.

ii) Combustion Characteristics

When using methanol in the existing boiler, it is sometimes necessary to change the size of the heat transfer area, because the flame emissivity of methanol is less than 50%, compared with that of fuel oil.

iii) Boiler Performance

Since methanol generates more moisture during burning than other fuel oil, this loss of moisture content results in a boiler efficiency drop by a few percentage.

iv) Modification of Boiler

There is no technical problem in modifying the oil-fired boiler to a methanol-fired one, although it requires newly established supply system of fuel methanol or enlarged capacity of existing supply system.

2) Conventional Gas Turbine

Combustion test of methanol in gas turbines has been executed in commercial gas turbines and combustion chambers in the U.S. and in Japan using combustion chambers. The results of the tests demonstrate the following facts.

i) Exhaust Gas Characteristics

a) About 45 ppm of NOx is detected, which is 25% less than that of jet fuel.

b) The concentration of CO emission is 70 ppm, while it is 50 ppm by jet fuel and 175 ppm by natural gas.

c) Hydrocarbon emitted from methanol is less than 10 ppm which is slightly higher than that of jet fuel, but other data indicate it is four to five times more than that of jet fuel.

d) Emission of aldehyde from methanol lies somewhere between the order of 10 ppb for jet fuel and 10 ppm for natural gas.

e) No SO_2 is detected from methanol, while from jet fuel, about 10 ppm of SO_2 is emitted. The quantity of particulates from methanol is a third to a quarter of that from jet fuel.

ii) Gas Turbine Performance

a) General performances of methanol such as starting and output-increasing speeds of the gas turbine are the same as those of the other fuels.

b) Methanol requires no water injection as an NOx countermeasure, and its thermal efficiency is about 3% higher than jet fuel with water injection.

iii) Modification of Gas Turbine

To modify the existing gas turbine into a methanol-fired one, it is necessary to newly install a fuel supply system or enlarge capacity due to an increase in the fuel flow. A gas turbine itself, however, needs only a partial and easy modification.
Table 9-4-3 shows the advantages of using methanol as a fuel for the gas turbine and the necessary matters of precaution.

3) Methanol Reforming Type Gas Turbine

Methanol can be reformed (steam reforming) or decomposed at a relatively lower temperature. A new system of gas turbine, which is designed to improve thermal efficiency by reforming and decomposing methanol by using the exhaust heat of the gas turbine, is now attracting attention.
The system fully utilizes the characteristics of alcohol, and it is expected that the efficiency will be widely improve by nearly 10% (the absolute value). This value is a theoretical calculation. It is desired to make detailed studies on this matter in the future. Fig. 9-4-10 shows that of a methanol reforming type gas turbine. The methanol reforming gas turbine causes a heating reaction of methanol by an exhaust gas heat of about 500°C and a reforming reaction at rather low temperatures of 250 to 350°C to decompose the methanol into H_2 and CO, and reforms the methanol into H_2 and CO_2 in the water-vapor reforming process, and then uses the reformed gas as its fuel.
The constituent elemental technologies are not novel but just a combination of existing technologies, and the methanol-reforming-type gas turbine will be ready for practical use without any major technical barriers. In Indonesia, many conventional gas turbines have been installed and, therefore, fuel switching to methanol using this method seems to be promising.

i) Features and Problems of a Power Generation System using Methanol-Reforming-Type Gas Turbine.

(Features)

a) The exhaust gas is clean and causes less pollution problems.

b) Package production of machinery and equipment can be easily attained at factories, and the reduction of costs and the construction period can be expected.

Table 9-4-3 Merits of Methanol as Gas Turbine Fuel and Matters to be attended to

Features	Merits and Matters to be Attended to
• No impurities such as N, S are contained.	• SOx, Fuel NOx, and smoke dust do not occur. • Combustion gas has little high-temperature corrosion behavior.
• Calorific power is small.	• The combustion of methanol, about twice as much as petroleum-based fuel or natural gas, increases the turbine operation fluid and improves the output.
• Latent heat of vaporization is large. • It is dissolved and reformed endothermically at 250 to 350°C.	• Thermal efficiency can be improved by exhaust heat recovery.
• Combustion temperature is low.	• Little thermal NOx occurs.
• Calorific power is small.	• The capacity of the tank, piping, etc., must be increased.
• Lubricity is non-existent.	• Attention must be paid in selecting a pump.
• It is incompatible with some materials.	• It has corrosion behavior against Mg, Al, Zn, and Cu. • With about 10% water contained, methanol corrodes carbon steel at 40 to 50°C or above. • It may swell or deteriorate rubbers and plastics.
• It can be mixed freely with water.	• Once Na and K, which cause high-temperature corrosion of a turbine, blend in methanol, they cannot be removed by flushing.
• It selectively dissolves light-weight ingredient of oil.	• Piping cannot be used in common with petroleum-based fuel.
• Vapor pressure is high.	• Attention must be paid to pump cavitation. • Actuating method requires contrivance.
• Flame is non-luminous. • Ignition point is low. (11°C).	• Attention must be paid to leakage and ignition.

c) Maintenance of the system will be simple.

d) Cooling sea water will be dispensed with, and inland application is possible.

(Problems)

A large quantity of demineralized water will be necessary for reforming methanol and for water injection.

(About 0.8 kg/h for a 100,000-ton class sytem: 4 to 5 times the quantity required for an ordinary thermal power generating system)

ii) Elements for developing a methanol-reforming-type gas turbine and problems with technology development conceivable elements of the technology development for the system are catalyst, heat recovery/ reaction system, and configuration of power generating system etc.

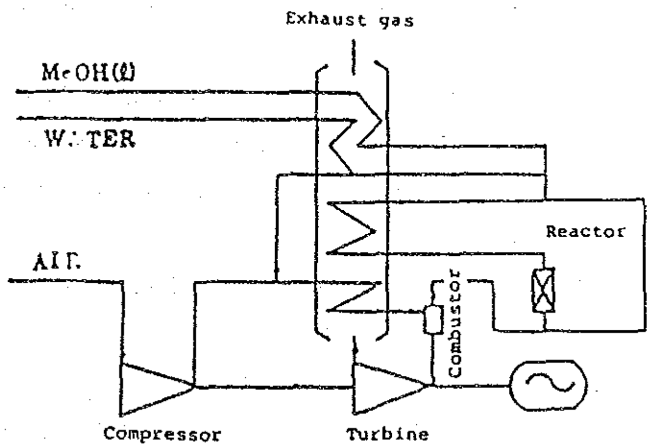


Fig. 9-4-10 Conceptual Drawing of Methanol-Reforming Type Gas Turbine

(2) Power Generation on Diesel Engine Basis

Indonesia consists of 13,667 islands scattered over an immense area measuring 1,888 km in the north-south direction and 5,110 km in the east-west direction across the equator. Of these islands about 3,500 islands are inhabited. In view of the fact that even typical islands like Sumatra and Kalimantan do not have well-developed power transmission and distribution networks, diesel engine generators of 100 to 5,000 kW are widely used at various locations in Indonesia, and their future expansion is also in the planning. Most of these diesel generators have been converted from diesel engines for vehicle use, in the case of small-capacity engines, and from marine or railway diesel engines, in the case of large-capacity engines. The features of these diesel engine generators are that their thermal efficiency is higher than that of gas turbine generators and their equipment costs are cheaper.

In view of these special situations, there is a possibility in Indonesia of using methanol as fuel for these power generators.

The methanol direct-injection-type diesel engines for generating purposes, using methanol as fuel, are, in principle, technically the same as the diesel engines for automobile use.

(3) Fuel cell

Fuel cells oxidize the fuel via electrochemical reaction, and obtain the chemical energy emitted at that time directly as electric energy. Typical example are shown in Table 9-4-4.

Although the molten carbonate type and solid electrolyte type are still in their research and development stage, the alkali type has already been applied to such special conditions as the space shuttle, and the phosphoric type is still in its demonstrative test stage.

For power generation, the phosphoric type is alleged to be the first for practical application.

As shown in Fig. 9-4-11, the unit cell of the fuel cell is composed of an ion conducting electrode layer, which is placed in the center, sandwitched by a porous fuel pole (anode) and an oxidizer pole (cathode).

The phosphoric type fuel cell uses hydrogen as its fuel, and this hydrogen is produced by steam reforming natural gas, methanol, etc. Fig. 9-4-12 shows the fuel reforming process for the phosphoric type fuel cell. A comparison between natural gas and methanol reveals that methanol has the merit of a simpler production process.

As the reforming process of methanol is simpler than that of natural gas, the realization of a compact system and reduction of construction costs are expected. Since the reforming reaction of methanol progresses at a low temperature, a reduction of heat loss and an improvement of power generation efficiency are also expected.

Table 9-4-4 Typical Fuel Cell

	1st Generation	2nd Generation	3rd Generation	—
Electrolyte	Aqueous solution of phosphoric	Fused carbonate	Solid electrolyte	Alkali aqueous solution
Electric Charge Carrier in Electrolyte	H^+	CO_3^{--}	O^{--}	OH^-
Operating Temperature (°C)	170 ~ 220	~ 650	~ 1,000	Normal temperature ~ 100
Usable Reactant	H_2 (A small amout of CO is contained.)	H_2 . CO	H_2 . CO Hydrocarbon	Pure hydrogen
Usable Fossil Fuel and Synthetic Fuel	Natural gas Light oil up to naphtha Methanol	Petroleum Natural gas Coal Methanol	Petroleum Natural gas Coal Methanol	—
Expected Time for Practical Use	1980's	Around 1990	Around 1995	Hydrogen Energy Age
Power Generation Thermal Efficiency (%) when Fossil Fuel is used	About 40 (natural gas)	60 (Natural gas Interior reforming method) 45 (Coal gas)	50 (Coal)	—

(Source) Technical report of Electrical Society: "Prospect of Fuel-cell Power Generation Technology" (December, 1982)

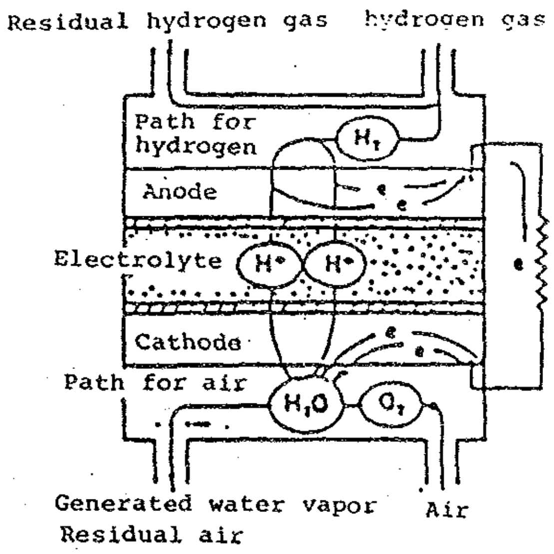


Fig. 9-4-11 Principle Diagram of Fuel-Cell Power Generation

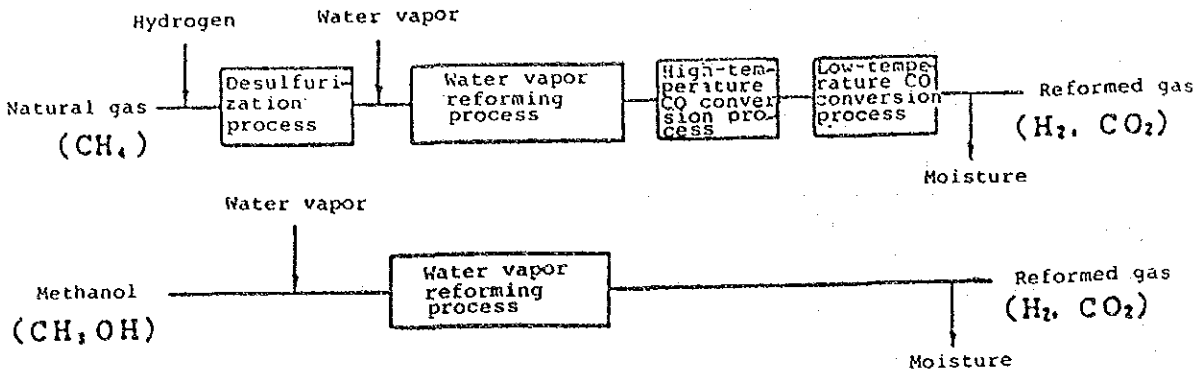


Fig. 9-4-12 Fuel-Reforming Process for Phosphoric-Acid Type Fuel Cell

(4) MTBE

MTBE (Methyl Tertiary Butyl Ether) is a kind of octane enhancer obtained by composing methanol and i-butylene.

$$CH_3OH + (CH_3)_2C = CH_2 \longrightarrow CH_3O\,(CH_3)$$

Methanol i-butylene MTBE

MTBE possesses very excellent properties as an octane booster because MTBE has a high octane value, being soluble in gasoline while being just slightly soluble in water, a higher calorific value and a lower latent heat than methanol and ethanol.

(5) City Gas

Mitsubishi Petrochemical Engineering Co., Ltd. and Seibu Gas Co., Ltd. are collaborating in technological development to produce city gas (a substitute for natural gas) from methanol. In this process, methanol is to be dissolved to form a mixture of methane and hydrogen with the aid of a catalyst. Proper selection of a catalyst and reaction conditions permit the generation of hydrogen rich low calorie gas out of methane rich high calorie gas.

The gas currently supplied by local city gas companies in Japan has, in general, a low heating value, and the conversion into high calorie gas is being planned. When imported LNG is to be used, large-scale harbor facilities and stockpiling bases will become indispensable, so the above mentioned process is drawing the attention of local city gas companies.

When fuel methanol is directly used for domestic or commercial use, the toxicity of methanol and its complicated supply system will pose problems, but if methanol is converted into a synthetic natural gas, these problems will be solved, and the convenience of using the gas will be remarkably improved.

For local city gas companies that find difficulties, technically and economically, in introducing natural gas and LNG and the using naphtha and LPG, keen attention is focused on this process as a petroleum-alternative energy (raw material) and also as a conversion measure for use as a high-calorie gas.

9-4-4 Required Qualities of Fuel Alcohol

As an automotive fuel, the qualities of neat or high blend alcohol fuels were examined in each country, and what attracted special attention was a proposal of required qualities prepared in June 1985 by a work shop, which was comprised of researchers from various countries, set up in the research section of VWs, West Germany. Items required for fuel methanol are as follows:

1) Ignition limits
(no inflammable atmosphere in tank)

2) Cold start and warm-up for S.I. engines

3) Low evaporating rate in vehicles

4) Long-term storability

5) Denaturant

6) Odor component

7) Luminosity of the flame during the whole burning process

8) Detergent for intake system

9) Corrosion inhibitor

10) Low variation in density and calorific value
(stoichiometric air-fuel ratio)

The most important requirement is to raise the inflammable limit value high enough to avoid combustion in the fuel tank, second is to improve the low temperature startability of spark ignition engines, and third is to ensure a cleaner environment and better human health. It is difficult to determine, a fuel that will meet all the requirements from the various studies in this field being carried out around the world, nor we decide on a particular fuel compound or test method at this stage. Definitions made by using the existing test methods are shown in Table 9-4-5.

It must be explained that a certain percentage of hydrocarbon (HC) is required to confine the calorific value within a desired range. A butane is necessary to keep the fuel for a long time without losing its vaporizing characteristics. By keeping the minimum methanol quantity at an 82-wt percentage level, a space for hydrocarbon and higher alcohol is provided.

Table 9-4-5 Methanol Fuel Standards Proposed by Volkswagen

		summer		winter	Test method
Methanol	wt-%		min. 82		GC
Hydrocarbons HC total*)	wt-%	min. 10	-	max. 13	GC
Butane C_4	wt-%	max. 1.5		max. 2.5	GC
Density d_{15}	kg/m³	700	-	790	DIN 51 757, ASTM D 941
Vapor pressure RVP (Dry)	mbar	550-700 **)		750-900**)	DIN 51 754, PREN12, ASTM D 323
Water	ppm	min. 2000	-	max. 5000***)	DIN 51 777, ASTM D 1744
Higher alcohols	wt-%		max. 5		GC
Formic acid	ppm		max. 5		
Acidity	ppm		max. 20		ASTM D 1613
Existent gum	mg/kg		max. 5		DIN EN5, washed with MEOH
Chlorine	ppm		max. 2		DIN 51408, Teil 1 ASTM D 3120, mod. & ASTM D 2988
Lead	ppm		max. 30		ASTM D 3237
Phosphorus	ppm		max. 10		ASTM D 3231
Sulfur	ppm		max. 100		ASTM D 3120
Additives	%		max. 1		

*) *Species, boiling range and quantity of HC depending on cold-start and safety requirements.*

**) Data for Central Europe shown here as an example, although different values are possible depending on the gasoline *available locally.*

***) With corrosion inhibitor.

The low temperature startability is related to the quality and quantity of HC to be blended and the Reid Vapor Pressure, but the kind of HC has not been specified. Namely, it does not matter whether the gasoline to be used is a full-range type or highly volatile type. Gasoline with a boiling point up to 110°C is known to cause no problem in the low temperature startability or operability.

Fuel methanol, having a Reid Vapor Pressure identical to that of the gasoline used in the area in question, is considered to be sufficient. The values shown in Table 9-4-5 are applicable in Central Europe and most states in the U.S. and Japan.

The quality of the fuel mentioned above must be equal to that fouond at gas stations, and careful attention must be paid to the change of gasoline quality during its transportation from refineries to gasoline stations.

The ideas mentioned so far are tentative, and the final decision will be made in accordance with the fleet tests or other tests being conducted in various places and according to the method for producing methanol most economically. In Indonesia, the problem of low temperature startability seems to be non-existent. Accordingly, when no attention is paid to export, the specifications for fuel methanol most economical to Indonesia will be the same with Table 9-4-5.

Finally as to the fuel ethanol specification, hydrous ethanol of 94-95% purity is generally used for industrial use. However, when it is mixed with gasoline, water content will be separated. Therefore hydrous ethanol cannot be used and anhydrous ethanol is required.

According to examples in Brazil, where much fuel ethanol is used, the specification of ethanol to be mixed in gasoline is as given below.

Purity: 99.3%

Acidity as acetic acid: 3.0 max.

On the other hand, where fuel ethanol 100% (neat) is used, hydrous ethanol would be used. In Indonesia, the specifications for fuel ethanol will be the same with the above mentioned specifications.

10. RESULTS OF SURVEY ON MARKETS

10-1 SURVEY ON BACKGROUND OF THE PROJECT

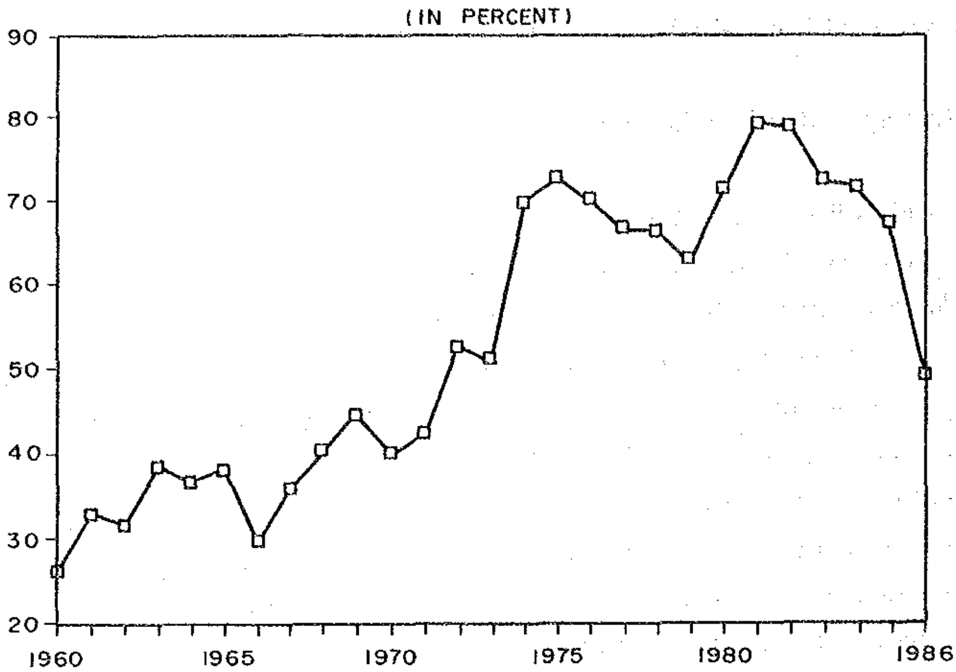
10-1-1 Energy Policy in Indonesia

Crude oil has been the keystone of Indonesia's energy policy but it is fast losing this preeminence to natural gas and other alternative energy resources. Notwithstanding efforts to move into alternative energy sources, about three quarter of electrical generation, however, still comes from steam and diesel generators in 1984/85.

Most importantly, oil provided and still provides the financial wherewithal for economic development. Until recently, Indonesia's energy policy and petroleum policy were synonymous. Oil had the dual role of being the nation's prime source of commerical energy and of providing both foreign exchange and government revenue to finance economic development. By the late 1970's, however, domestic consumption, growing by an annual rate as high as 15 percent, began to divert oil from exports into the domestic market.

Through the 1970's and into the early part of the 1980's oil and gas revenues became a primary source of Indonesia's foreign exchange. Oil revenues were the impetus behind the economy's remarkable growth rates during this period. Fig. 10-1-1 shows the importance of oil and gas revenues to the economy's external account position.

Fig. 10-1-1 Hydrocarbon Exports/Total Exports (In Percent)



Source: The Petroleum Report Indonesia, July 1987, Embassy of the U.S.A. Jakarta

Under above mentioned economic situation, present energy policy in Indonesia can be summarized as follows.

1) Intensification

To accelerate and intensify the survey and exploration of all energy resources, as an effort for a better identification of their potentials for an economical development program.

2) Diversification

To reduce the dependence on oil in the overall domestic energy consumption and replace it with other available energy recourses. Priorities were set to develop non-exportable and renewable sources of energy, first hydropower and geothermal, followed by coal.

3) Conservation

To economize the energy use as well as to ensure its more efficient and wise use. This conservation program is implemented through the following steps:

a) Sectoral identification of wasteful energy use

b) Providing information and educational programmes

c) Implementation through legislation and directives

4) Indexation

To apply the best and most efficient energy source for each particular energy demand.

This policy is then elaborated as follows:

1) The domestic energy supply

To guarantee the domestic energy supply in amount and quality according to the demand and with a price affordable to the public, with the objective of improving the welfare of the Indonesian people and providing the necessary support for rapid socio-economic growth.

2) The export of energy

To secure the supply of energy, not only for domestic use but also for export, to provide foreign exchange which can be used also for the development of new energy sources.

3) The development of alternate energy sources

To develop alternate energy source which are renewable but not exportable in order to lessens the consumption growth rate of exportable energies and ultimately replace the non-renewable energy sources.

4) Conservation of Oil

Oil should be used as economically as possible, and possibly only for those application where the use of other forms of energy is not possible.

5) The protection of the environment

In the development of energy resources, the protection of the environment should be maintained, to accomplish an improvement in the quality of life of the Indonesian people.

6) National resilience

The overall effort of providing energy and the management of the energy resources should bring an increase of national resilience which will enable the Indonesian people to face the future with more skill and confidence.

Depite a number of programs and policies introduced since 1983 to reduce the economy's overwhelming dependence upon the petroleum industry, they did not contribute to attain that goal. However, as a matter of fact, the collapse of oil prices has led to a reduction in the percentage contribution of oil and gas to the Budget and Balance of Payments.

In FY1986/1987, hydrocarbon revenues contributed 49.7 percent to Indonesia's export earnings and 39 percent of the government's internal revenues. For FY1987/1988, the Indonesian government forecast hydrocarbon revenues will contribute 50 percent to Indonesia's export earnings and 40 percent of the government's internal revenues.

The Budget and Balance of Payments forecasts for FY1987/1988 are based on crude oil production of 1.192 million barrels per day and an average price of $15 per barrel. While the production rate assumption has marginally eroded because of a more restrictive OPEC production quota of 1.133 million bbls/day, the price assumption has thus far proven conservative in an energy market of over $18.00 per barrel oil.

Because of the pressure from decreased hydrocarbon earnings, the government enacted a number of significant economic reforms in order to improve efficiency and promote exports. Several measures involving trade deregulation and economic liberalization were introduced in 1986 to overcome the "high-cost" economy label which Indonesia has borne in recent years.

While there is little question Indonesia's long-term future lies beyond complete reliance on oil and gas exports, there is equally little question the nation will rely on oil and gas for over half of its foreign exchange earnings for the immediate future. Therefore, it is very important for Indonesia how to take off in the future, taking advantage of abundant hydrocarbon export revenues, which should be the main target in Repelita VI (April 1994 - March 1999).

10-1-2 Industrialization Policy

(1) *Past trend of industrial growth and GDP*

Industrial development from REPELITA-I to REPELITA-III has contributed significantly especially to improvement of national economic force. (See Table 10-1-1) This can be understood from the fact that industrial production has been kept increasing even in world-wide economic recession. Furthermore, this made it possible to supply necessary goods for people's life & production activity, and also made it possible to export several industrial goods.

As a whole, high level of industrial growth has been attained in this period. That is, higher rate of industrial growth has been recorded such as 12.98% in REPELITA-I, 13.70% in REPELITA-II and 11.40% in REPELITA-III.

The growth of GDP as a measure for economic growth in Indonesia beginning from 1984 is presented using new series data based on 1983 constant market prices. There are some improvements in the coverage of each sector and the methodology compared to the old one. By using the new series data, the GDP in 1983 was recorded at 73,697.6 billion rupiahs. While in 1984, the GDP at current market prices was 87,535.5 billion rupiahs and 78,213.8 billion rupiahs at 1983 constant market prices. This implied a real economic growth of 6.1 (6.0 in revised figure) percent in the first year of PELITA IV, and 1.9 (2.3 in revised figure) percent, in the second year of Pelita IV.

This drastic reduction in GDP growth rate was one of impacts on Indonesian economy from such drastically changed international economy as crude oil collapse, big evaluation in Japanese yen and big devaluation in U.S.$. In the third year of PELITA IV, 1986, Indonesia recorded increased GDP growth rate of 3.2% (preliminary).

Among sectoral shares in GDP, agriculture still has the dominant share of 24 percent in 1985 but it is in the declining trend. Mining sector is in the trend of decrease last few years. On the other hand, manufacturing sector is steadily in the upward trend, showing 11 percent annum growth rate in 1985/1983.

More detailed figures can be found in Table 10-1-2 and Table 10-1-3.

Table 10-1-1 Past 5-Year Development Plan and Economy

F.Y. / Items	1969/70 - 1973/74	1974/75 - 1978/79	1979/80 - 1983/84
Main Targets of Development Plan	(Urgent Stabilization of People's Life) (1) Expansion of Agricultural Production (esp. Food Production) (2) Expansion of Textile Production, Building up of Infra-structure, Raising up of Agriculture-related Industries (3) Restraint of Infration (4) GDP Growth Rate Target : 5% annum Actual : 7.7% annum	(Building Up of Foundation for Economic Growth and Balanced Development) (1) Meeting Indispensable Goods for Peoples' Life, Building up of Infra-structure (2) Social Welfare and Equity in Income Distribution (3) Increase of Job Opportunity (4) Building up f Foundation of Economy (ex. Raising up of Natural Resources Processing Industries) (5) GDP Growth Rate Target : 7.5% annum Actual : 6.9% annum	(Economic Development and Equitable Distribution of Development Fruits) (1) Realisation of Economic Growth (2) Stabilization of Sound Society with Dynamism (3) Promotion of Non-Oil Exports (4) Raising Up of Labor Intensive Industries and Their Core Firms (5) Promotion of Private Sector Activities (6) Self-Reliance of Foods (7) GDP Growth Rate Target : 6.5% annum Actual : 6.1% annum
Main Features of Economy	(1) Expansion of Natural Resources Production (2) Increase of Investment from Abroad (3) Stabilization of Economy	(1) Transition to Era of High-Priced Natural Resources (2) No Substantial Growth of Investment from Abroad (3) Expansion of Manufacturing Industries and Increase of Self-Reliance in Fertilizer and Cement Industries (4) Improvement in Balance of Payment and Management Crisis in Pertamina.	(1) Improvement in Balance of Payments (2) Favorable Rice Crop in 3 Consecutive Years (20 million ton) and Self-Reliance in Rice Crop (3) Expansion of Industrial Production (Textile, Electric Appliances, Automobile)

Source: Indonesia Handbook, 1985, Japan Club of Jakarta

Table 10-1-2 Sectoral Growth Rate in GDP (Real Term)

Unit: Percent annum

	1978	1979	1980	1981 1)	1982 2)	1983 2)	(1983/1977)	1984 1)	1985 2)	(1985/1983)
Agriculture Forestry Fishery	5.1	3.9	5.2	4.9	2.1	4.8	4.3	4.4	3.4	4.4
Mining	△2.0	△0.2	△1.2	3.3	△12.1	1.2	△1.9	5.9	△5.6	△0.02
Manufacturing	16.8	12.9	22.2	10.2	1.2	2.2	10.7	15.6	5.9	10.6
Construction	14.0	6.4	13.6	12.7	5.2	6.2	9.6	△2.8	1.7	△0.6
Transport & Communication	20.3	8.9	8.9	11.1	5.9	5.0	9.9	8.9	6.1	7.5
Other Sectors	8.1	7.7	10.7	30.7	△10.3	4.6	7.9	4.8	2.9	3.8
Total	7.8	6.3	9.9	7.9	2.2	4.2	6.4	6.1	1.9	4.0

NOTE: 1) : Revised figure

2) : Preliminary figure

3) There is statistical discrepancy before and after 1983.

Source: Pendapatan National Indonesia 1983 - 85.

Table 10-1-3 Sectoral Share in GDP

	1977	78	79	80	81	82	1983	84	85
Agriculture Forestry Fishery	33.6	32.8	32.0	30.7	29.8	29.8	24.0	23.9	24.2
Mining	12.1	11.0	10.3	9.3	8.9	7.6	19.0	18.9	17.5
Manufacturing	11.9	12.9	13.7	15.3	15.6	15.4	11.0	12.1	12.6
Construction	5.2	5.5	5.5	5.7	6.0	6.1	6.2	5.7	5.7
Transport & Communication	4.8	5.4	5.5	5.5	5.6	5.8	5.4	5.5	5.8
Other Sectors	32.4	32.4	33.0	33.5	34.1	35.3	34.4	33.9	34.2
Total	100	100	100	100	100	100	100	100	100

Note: There is statistical discrepancy before and after 1983.

Source: Pendapatan Nasional Indonesia, 1983 - 1985.

Table 10-1-4 (1) Production of Selected Industrial Products

Manufacturing (10^3t/CY)	1980	1981	1982	1983	1984	(1984/1980) % annum	(1984/1972) % annum
Cement	5,259.4	5,599.4	5,998.0	6,588.5	6,607.4	5.9	22.2
Fertilizer	2,745.9	2,813.8	2,809.1	3,201.5	4,005.4	9.9	31.6
Paper	78.2	78.4	77.6	70.2	84.6	2.0	7.8

Table 10-1-4 Growth Rate of Production Index

		Percent annum
Agriculture	4.1	(1985/82)
Manufacturing	6.5	(1984/75)

Source: Key Indicators of Developing Member Countries of ADB (July 1986)

(2) Industrial development policy

Such factors as change in economic structure, expansion of employment opportunities, equalization in venture opportunities, reduction in import dependence, expansion in export of industrial goods, local industrialization and effective utilization of natural resources, energy resources and human resources are included in term of industrial development.

Industrial development policy which is to be pursued in REPELITA-IV will include following guidelines.

1) Industrial development should be toward improving national economic structure by developing harmonized program among industrial sectors and other sectors.

2) Industrial development should be toward strengthening industrial structure itself. In order to do so, close relationship among industrial sectors should be assured. And also, domestic industry protection policy and pricing & tax policy should be pursued in order to develop small scale industry furthermore.

3) The development of small scale industry should be continuously promoted not only for increasing employment opportunities but also for increasing its contribution in forming added value.

4) Contribution by Indonesian people to industrial development should be increased through improvement of designing capability, business management capability, production management methodology and development capability. The program for speeding up in technology transfer and increasing the capability in software should be continuously promoted.

5) Expanding export of industrial goods might be a national venture. Such efforts are to be pursued toward strengthening international competitiveness as improvement in price, quality and services in the field of diversification of industrial goods and its export expansion.

6) As a whole, industrial development program, which is based upon the Main State Policies and pursue shift from agriculture weighted economic pattern to industry weighted one, should realize autonomous progress, prosperity and fair society.

Based on above-mentioned guidelines, each annual growth rate in each industrial sector was envisaged as shown in Table 10-1-5.

Remarkably high growth rate of 9.5%/yr. is envisaged in manufacturing industries and, as a result, significant shift in economic structure was expected even compared with other south-east Asian countries.

Through this industrial development, the following targets were to be achieved during five years of Repelita IV.

- to increase opportunity for employment
- to promote export
- to save foreign currency
- to assist regional development
- to utilize natural resources, energy resources and human resources
- to prepare equitable environment for business opportunities

In growth rates in export, which are shown in Table 10-1-6, manufacturing industry has big increase rate in its export.

Average growth rate of 9.5%/yr. in manufacturing industries, envisaged in REPELITA-IV can be broken down as follows.

- machinery industry 17%/yr.
- basic chemicals industry 17.2%/yr.
- small-scale industry 6%/yr.
- miscellaneous industry 6%/yr.

Table 10-1-5 Sectoral Growth Rates and Structural Change

Sector	Estimated share in GDP, 1983/84	Average annual growth rate, Repelita IV	Projected share in GDP 1988/89
1. Agricuture	29.3%	3.0%	26.5%
2. Mining	7.0%	2.4%	6.1%
3. Industry	15.8%	9.5%	19.4%
4. Construction	6.7%	5.0%	6.7%
5. Transport and Communication	6.0%	5.2%	6.1%
6. Other sectors	35.2%	5.0%	35.2%

Table 10-1-6 Gross Value of Exports (F.O.B.), 1983/84 - 1988/89

(US$ million, current prices)

Item	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	Average Rate of Growth (%)
Oil and LNG (Gross)	14,140	13,825	15,424	17,317	19,008	20,363	7.6
1. Crude Oil and Oil Products	11,861	10,644	11,873	13,463	14,664	15,766	5.9
2. Liqu fied Natural Gas	2,279	3,181	3,551	3,854	4,344	4,597	15.1
Non-oil and non-LNG	5,170	6,050	7,009	8,015	9,215	10,753	15.8
1. Agricultural Products	2,597	2,859	3,123	3,395	3,717	4,160	9.9
2. Mining Products	652	740	841	963	1,066	1,166	12.3
3. Manufactured Products	1,921	2,451	3,045	3,657	4,432	5,427	23.1
TOTAL EXPORTS	19,310	19,875	22,433	25,332	28,223	31,116	10.0

10-1-3 Transmigration Policy

Indonesia has big population of more than 165 million people (estimate), of which 61% live in Java island in 1985 which occupies less than 7% of total land. Java island has 759 men/km^2 of population density compared with 86 men/km^2 in Indonesia as a whole. Growth rate of population during 1980/1971 in Java island was 2.3%/annum compared with 2.1%/annum during 1971/1961 and this growth rate was rather small compared with 3.3%/annum in Sumatra, 3.0%/annum in Kalimantan and 2.8%/annum in Maluku and Irian Jaya.

The transmigration program is construed to be a multi-objective program. It is intended to provide land for the landless on Java, Bali and Lombok, to improve the distribution of population and at the same time provide manpower for the labor-scarce areas outside Java, Bali and Lombok so that the latter areas can develop as new centers of production, particularly agricultural production. The program is also seen as a vehicle to promote national stability and integration.

According to the results of general transmigration in 1984, 16% of total 28,000 families flowed to Jambi, 15% to Lampung, 14% to Riau and 13% to South Sumatera.

After 1982, the number of general transmigration was so drastically decreased to 40 percent and 50 percent of previous year in 1983 and in 1984 respectively. And also region of destination has been more heavily focused to Sumatera and Kalimantan than before. As to the region of origin, main regions are such areas as west Java, central Java and east Java, which together have 87 percent of total in 1984.

During the period of REPELITA-IV, at the end of Repelita III the Government expected 750 thousand families to transmigrate. As to this transmigration plan, voluntary transmigration program, called Swakarsa is to be encouraged due to budgetary limit, and reach 250 thousand families of achieved level during REPELITA-IV.

During the period of REPELITA-III, there were 527 thousand families of transmigration, which surpassed the target of 500 thousand families. On the other hand there are still cases of abandoning the newly established settlement by many families.

There are several patterns as to transmigration. There are 1) food crop 2) fishery 3) plain estate 4) cattle breeding 5) industry and mining 6) transmigration for defense manpower or retired army 7) agro-forestry.

There are concrete programs under way as to 1) and 3) and concrete programs will be implemented during REPELITA-IV as to 2) and 4). Furthermore 5) and 6) will be implemented beyond REPELITA-VI. As to 7), there is no concrete program but just in the stage of idea.

As to the project of effective utilization of Banko coal, transmigration might be in the category of 5) industry and mining. This will be different from present pattern of being settled in land based on agricultural activity. Furthermore, in this case there will be the necessity of skilled labor force. Therefore, the pattern of the category of 5) industry and mining must be studied based on basic transmigration policy as well as industrialization policy.

It is considered that this Project is a model case to examine the probability of implementing new transmigration plan concerning 5) industry and mine. As to the necessary number of labour force, about one thousand labour is expected including the plant and coal mining sector. And also, one thousand labour force will be needed including relevant service sector. Therefore total number of people concerning to this Project will be five thousand to ten thousand assuming five person in one family.

Table 10-1-7 Implementation of General Transmigration by Region of Destination 1980 - 1984

Daerah Tujuan Region of Destination	1980	1981	1982	1983	1984
1. Daerah Istimewa Aceh					
2. Sumatera Utara					
3. Riau	② 13.1	② 14.1	③ 8.9		③ 14.2
4. Jambi	③ 8.2			⑤ 8.3	① 16.4
5. Sumatera Barat					
6. Bengkulu					
7. Sumatera Selatan	① 39.7	① 28.6	① 20.2	④ 8.4	④ 13.4
8. Lampung			② 16.2	① 31.7	② 15.2
9. Kalimantan Barat		⑤ 6.7	④ 7.2	② 11.3	⑤ 7.8
10. Kalimantan Tengah	④ 7.3			③ 10.6	
11. Kalimantan Selatan		③ 7.8			
12. Kalimantan Timur					
13. Sulawesi Utara					
14. Sulawesi Tengah					
15. Sulawesi Selatan					
16. Sulawesi Tenggara	⑤ 4.7	④ 6.9			
17. Maluku					
18. Irian Jaya			⑤ 5.7		
19. Nusa Tenggara Barat					
20. Timor Timur					
Total	73/100	64.1/100	58.2/100	70.3/100	67/100

NOTE: Those figures in the bottom shows the accumulated figures of top five regions in total transmigrations including local transmigration.

Source: Statistik Indonesia, 1985

Table 10-1-8 Implementation of General Transmigration by Region of Origin 1980 - 1984

Daerah Asal Region of Origin	1980	1981	1982	1983	1984
D.K.I Jakarta	1.5	0.8	0.8	1.3	1.5
Jawa Barat	15.9	16.8	22.5	23.9	35.2
Jawa Tengah KK / Families	31.6	34.9	34.9	30.0	23.9
D.I. Yogyakarta	9.3	5.5	5.8	6.8	7.8
Jawa Timur	33.1	34.0	28.9	32.6	27.5
Bali	5.2	5.1	3.7	4.0	0.7
Nusa Tenggara	3.4	2.8	3.4	1.4	3.4
Total	100	100 (+57.6)	100 (+1.4)	100 (Δ59.9)	100 (Δ50.4)

NOTE: Figures in parenthesis are growth rates compared with previous year.

Source: Statistik Indonesia, 1985

10-2 DEMAND FOR PETROLEUM PRODUCTS

10-2-1 Supply and Demand for Energy

(1) Past trend of primary energy demand

In 1969 Indonesia initiated the first five year plan (REPELITA-1) and in 1984 the country finished REPELITA-III. In the 1970's the Indonesian economy expanded and its average growth rate per annum reached 7.6%.

In accordance with this rapid economic growth, energy consumption in the country sharply increased. Commerical energy consumption, in particular, has increased five times in the last 16 years, admittedly though it started from a low base. During the 1974-84 period average energy growth was 11.6%. This remarkable energy growth was not only caused by the population growth (2.34% p.a.), but could also be traced to growing demand from Industry, transportation, and the wider distribution of electricity in the country.

In the late 1970's, the government embarked on an ambitious program to move domestic energy consumption away from crude oil to maximize the percentage of oil production available for export. The most tangible result of this diversification effort is the construction of electrical generating facilities which utilize coal or hydro-energy. Diversification has also led to increased use of Liquefied Petroleum Gas by households. There are also plans for increased utilization of natural gas to domestic industry and for electricity generation. Not only the diversification effort, but also the increase of domestic retail prices of oil products gave big impact on crude oil consumption in Indonesia.

Pertamina is responsible for production, processing, and marketing refined oil products to the domestic market. It is obligated to supply sufficient quantities of eight fuel products (Bahan Bakar Minyak or BBM) to meet demand. The government sets the prices for these products. If the income from the sale of BBM does not meet costs (including crude, refining, storage, transportation and marketing), the government makes direct payment to Pertamina to cover the difference.

Beginning in the early 1970's domestic fuel consumption grew rapidly.

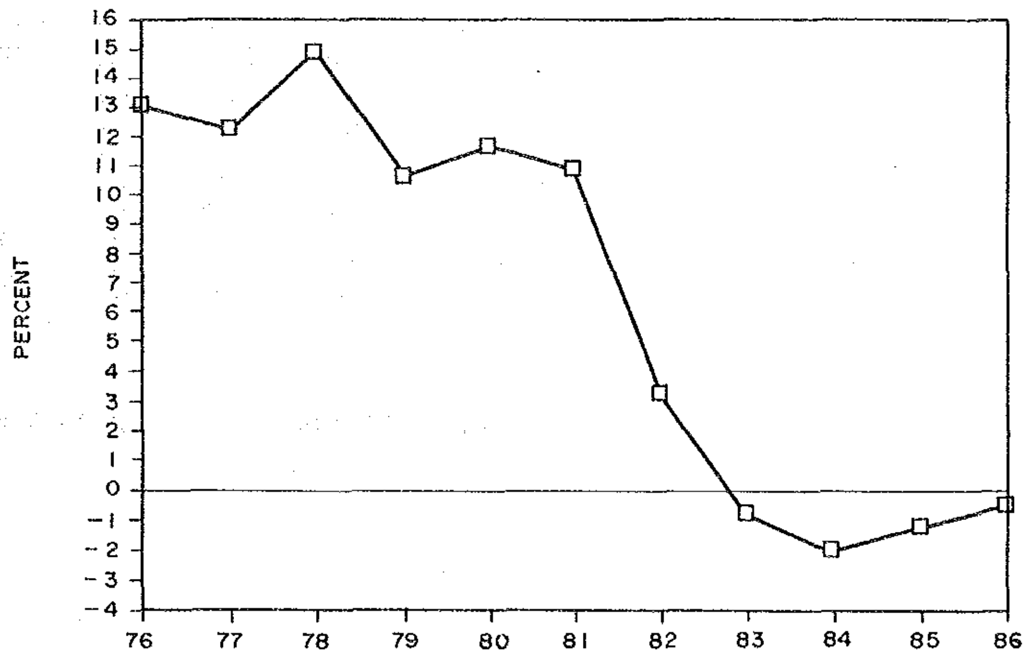
Following the run-up in crude prices starting in 1973, Pertamina's estimate of the cost of providing these products began to outstrip income from sales. In FY1977/1978, the government provided the U.S. dollar equivalent of $77 million to Pertamina to offset unrecovered costs. By FY1981/82, the subsidy had surpassed the U.S. dollar equivalent of $2 billion, 10.8 percent of the Budget.

In an effort to gain control of the situation, domestic retail prices were increased in January 1982 (by 58 percent on a weighted average basis), January 1983 (by 53 percent), and yet again in January 1984 (by 16 percent). Although the ten percent VAT, introduced on April 1, 1985, was conceived for general tax revenue purposes, it will also have the effect of raising prices for petroleum much the same as the previous petroleum specific price rises.

The decline of the domestic fuel subsidy is not the result of a one-time policy decision. As those tables 10-2-1 and 10-2-2 indicate, prices have increased steadily for the past from 1980 through 1985. In 1986, the government lowered the domestic price of refined product to reflect the drop in international oil prices. Nonetheless, Indonesian public did not receive the full benefit of the fall in energy prices. Compared to the over 60 percent drop in international oil prices from 1985 to 1986, the price of gasoline and kerosene were unchanged in Indonesia. Only the price of automotive diesel oil, off 17 percent, and industrial diesel oil, off 10 percent, and fuel oil, also off 10 percent, declined.

Fig. 10-2-1 depicts the percentage change in domestic consumption of crude oil from 1976 to 1986 in Indonesia.

Fig. 10-2-1 Percent Change in Crude Oil Consumption



Source: The Petroleum Report Indonesia, July 1987 (Embassy of the U.S.A., Jakarta)

Table 10-2-1 BBM Consumption and Subsidies

Financial Year	BBM Consumption (000 kl)	Subsidy Billion Rp	Subsidy Million US$
1978/79	NA	197.0	394.0
1979/80	NA	535.0	853.3
1980/81	NA	1,021.7	1,629.5
1981/82	25,270	1,316.4	2,056.2
1982/83	28,168	961.5	1,413.9
1983/84	26,300	928.1	938.7
1984/85	27,000	1,147[1]/506.7[2]	480.3
1985/86	26,200	532.3[1]/374.2[2]	598.8
1986/87	25,800	Nil	Nil
1987/88	24,920	Nil	Nil

1) Original budget estimate

2) Revised budget estimate

Source: The Petroleum Report Indonesia, July 1987 (Embassy of the U.S.A., Jakarta)

Table 10-2-2 Development of Domestic Fuel Oil Prices (Rp/Liter)

Products	May 3 1979	May 1 1980	Jan 4 1982	Jan 7 1983	Jan 12 1984	Apr 1 1985	Jul 10 1986
Avgas	100	150	240	300	300	330	250
Avtur	100	150	240	300	300	330	250
Super Gasoline	140	220	360	400	400	440	440
Premium Gasoline	*100*	*150*	240	320	350	385	385
Kerosene	25	37.50	60	100	150	165	165
Automotive diesel oil	35	52.50	85	145	220	242	200
Industrial diesel oil	30	52.50	85	145	200	220	200
Fuel Oil	30	45	75	125	200	220	200

Source: The Petroleum Report Indonesia, July 1987 (Embassy of the U.S.A., Jakarta)

Table 10-2-3 shows commercial energy supply by energy sources for last 16 years. The share of oil decreased to 66 percent in 1986 from 89 percent in 1970 but is still dominant, leading natural gas which has been expanding its share very rapidly. And also, the very high growth rate of hydro as high as coal is remarkable.

The growth rate of total energy supply decreased very much from 11%/yr (1986/70) to 4%/yr. (1986/81), to which a rapid decrease in oil demand contributes substantially.

Table 10-2-4 shows the primary energy supply at the end of Repelita II, III and IV. The share of oil will be reduced to 66% by the end of Repelita IV (1988/89). Natural gas, hydro and coal will make up the gap.

(2) Energy demand by sectors

Table 10-2-5 shows energy consumption by consuming sectors.

In 1986, the industrial, transportation, power generation and household sectors had 38.4%, 24.7%, 18.6% and 18.3% respectively. The transportation and household sectors are losing their shares and the industrial and power generation sectors are gaining in their trend.

However, the household sector also consumes much non-commercial energy such as wood and agricultural waste and therefore, consumed more than 60% of total energy in 1985.

Table 10-2-3 Primary Energy Consumption 1970 - 1986

Unit: 10^6 BOE

Year	Coal	Natual Gas	Hydro	Geo-thermal	Oil	Total
1970	0.803 [1.6]	3.670 [7.5]	0.768 [1.6]	-	44.017 [89.4]	49.259 [100]
1971	0.836 [1.5]	5.957 [10.4]	2.876 [5.0]	-	47.781 [83.2]	57.449 [100]
1972	0.805 [1.3]	3.655 [5.8]	2.578 [4.1]	-	55.528 [88.7]	62.567 [100]
1973	0.636 [0.9]	6.131 [8.2]	3.139 [4.2]	-	64.770 [86.7]	74.676 [100]
1974	0.797 [1.0]	4.507 [5.4]	3.648 [4.4]	-	73.932 [89.2]	82.884 [100]
1975	0.819 [0.9]	6.659 [7.0]	3.961 [3.9]		83.206 [87.9]	94.645 [100]
1976	0.659 [0.6]	7.740 [7.3]	3.640 [3.5]		93.308 [88.6]	105.346 [100]
1977	0.783 [0.6]	11.535 [9.5]	3.800 [3.1]	-	105.426 [86.7]	121.545 [100]
1978	0.706 [0.5]	21.350 [14.3]	5.273 [3.5]	-	122.438 [81.8]	149.766 [100]
1979	0.717 [0.4]	25.732 [15.4]	5.743 [3.4]	-	134.973 [80.7]	167.165 [100]
1980	0.951 [0.5]	30.283 [16.6]	5.552 [3.0]	-	145.964 [79.9]	182.750 [100]
1981	1.041 [0.5]	36.683 [17.5]	6.387 [3.1]	-	158.904 [78.3]	203.015 [100]
1982	0.995 [0.5]	35.524 [17.1]	6.735 [3.2]	0.063 [0.03]	164.031 [79.1]	207.347 [100]
1983	1.060 [0.5]	39.850 [18.5]	10.139 [4.7]	0.384 [0.2]	163.722 [76.1]	215.154 [100]
1984	1.816 [0.8]	45.672 [20.1]	14.712 [6.5]	0.447 [0.2]	164.144 [72.4]	226.791 [100]
1985	5.007 [2.1]	51.010 [21.5]	16.194 [6.8]	0.437 [0.2]	164.810 [69.4]	237.458 [100]
1986	8.099 [3.3]	53.755 [21.9]	20.979 [8.6]	0.467 [0.2]	161.909 [66.0]	245.209 [100]
Average growth Rate (%/yr)	15.5	18.3	23.0	65.2	8.5	10.6

Source: MIGAS (Aug. 1987)

Table 10-2-4 Commerical Energy Supply at the End of Pelita II, III and IV

Unit; 10^6 BOE

SOURCES	End of PELITA II (1978/197)	End of PELITA III (1983/1984)	End of REPE-PELITA IV (1988/1999, projection)
Natural Gas Coal Hydro Geo-thermal Oil	24.5 (15.3%) 0.65 (0.4%) 3.85 (2.4%) - 131 (81.9%)	43.41 (17.7%) 1.14 (0.5%) 11.64 (3.7%) 0.42 (0.2%) 167 (74.7%)	55.2 (19.6%) 14.7 (5.2%) 24.3 (8.6%) 1.96 (0.7%) 186.0 (65.9%)
Total	160.0 (100.0%)	223.61 (100.0%)	282.2 (100.0%)
Growth Rate (per cent/Y)		6.92	4.76

Table 10-2-5 Consumption of Commercial Energy by Demand Sector
(In Million BBL Oil Equivalent)

Year	Industry MBOE	%	Transportation MBOE	%	Electricity MBOE	%	Houshold MBOE	%	Total MBOE	%
1968	15.25	35.2	11.90	27.4	2.45	5.7	13.76	31.7	43.35	100
1969	12.91	28.9	13.28	29.8	2.22	5.0	16.21	36.3	44.62	100
1970	14.18	28.8	14.97	30.4	2.80	5.7	17.30	35.1	49.26	100
1971	16.97	29.5	16.34	28.4	5.14	8.9	18.99	33.1	57.45	100
1972	17.43	27.9	19.19	30.7	5.03	8.0	20.92	33.4	62.57	100
1973	22.11	29.6	23.61	31.6	5.48	7.3	23.49	31.5	74.68	100
1974	21.86	26.4	27.25	32.9	6.09	7.3	27.69	33.4	82.88	100
1975	26.18	27.7	28.61	30.2	7.95	8.4	31.91	33.7	94.65	100
1976	28.78	27.3	32.68	31.0	9.17	8.7	34.72	33.0	105.35	100
1977	36.56	30.1	36.04	29.7	10.50	8.6	38.45	31.6	121.55	100
1978	51.97	34.7	40.09	26.8	14.60	9.7	43.10	28.8	149.77	100
1979	59.29	35.5	44.75	26.8	15.82	9.5	47.30	28.3	167.16	100
1980	65.39	35.8	49.22	26.9	17.37	9.5	50.76	27.8	182.75	100
1981	74.55	36.8	52.53	25.9	21.56	10.6	54.27	26.7	203.01	100
1982	73.36	35.4	55.64	26.8	24.41	11.8	53.95	26.0	207.36	100
1983	82.11	38.2	53.71	25.0	30.65	14.2	48.69	22.6	215.16	100
1984	88.58	39.1	55.47	24.5	36.79	16.2	45.95	20.3	226.79	100
1985	92.95	39.1	57.38	24.2	42.30	17.8	44.83	18.9	237.46	100
1986	94.14	38.4	60.56	24.7	45.71	18.6	44.80	18.3	245.21	100

Source: From 1968 to 1969: Dept. of Mines & Energy (P.T.E.)
From 1970 to 1986: MIGAS

(3) Prospects of alternative energy

1) Coal

Prior to the collapse of oil prices in 1986, coal was fast becoming one of Indonesia's most important mineral resources and a key element of the government energy diversification program. According to Perum Tambang Batubara, in terms of calorific value, Indonesia has more potential energy reserves in coal than in oil and gas. The 23.2 billion tons of coal reserves are estimated to be equivalent to 18 billion Tons of Coal Equivalent (TCE). Combined oil and gas reserves are estimated to equal 5 billion TCE. Because of limited systematic exploration, less than 15 percent out of the total amount of coal resources could be categorized and proven. Proven reserves known to date amount to only about 1.5 billion tons.

The current world energy prices and problems in the domestic economy have forced Indonesia to modify its ambitious plans to develop the coal industry. Plans which originally envisaged an expansion of annual coal production to 15 million tons by 1990, with some 14 million tons for domestic use, have been set aside. The government now predicts Indonesia will have an annual production of 12.8 million tons of coal by 1990 with only two thirds (8.1 million tons) to be absorbed by the domestic market. Total coal production amounted to 2.4 million tons in 1986 compared to 1.813 million tons in 1985 and 1.085 million tons of coal output in 1984.

Before budget cutbacks took hold, the government's National Planning Board (Bappenas) forecast construction of over 1,800 MW of coal-fired electric generating capacity during the next five years. The Suralaya central power station in West Java is already operational and coal-fired. The Paiton station in East Java is planned to be coal-fired but the construction of this plant has been subject to lengthy delays.

The cement sector, currently a major consumer of both oil and gas in the form of generated electricity, is the second largest prospective consumer of coal. Prior to the dramatic drop in oil prices, the government was putting increasing pressure on firms in the cement industry to speed up their plans for conversion from oil burning generators to coal. With the current price of oil, the economics of conversion from oil to coal, become less favorable.

2) Hydropower

In Kalimantan, Sumatra and Java, there are significant opportunities for the development of hydropower. There are currently 1,428 megawatts of hydropower installed and plans for construction of an additional 1,475 megawatts during Repelita IV. Fifty megawatts of new construction will be in small hydro units.

Because of Budget stringency, hydropower schemes are increasingly difficult to fund. The incidence of cost is the primary problem with hydroelectric plants, i.e., most of the expense of hydropower is "up front;" the savings and efficiency occurs during the life of the plant. This cost/benefit pattern is reversed from government's current bias to defer costs as much as possible in order to bridge current financial conditions where liquidity is tight. The government must have a convincing argument for savings to devote scarce capital development funds to this energy sector but this very argument is less striking with $18 per barrel oil than it was with $30 per barrel oil.

3) Geothermal

Indonesia has geothermal potential in excess of 10,000 MW, or some 250,000 barrels/day oil equivalent, scattered throughout the archipelago. In contrast to natural gas deposits, geothermal potential is found in regions where there is a substantial demand for electricity, i.e. Java and Sulawesi.

Pertamina is developing some of the steam resources itself, some work is being done in cooperation with the New Zealand government, and other areas are contracted out to production sharing contractors.

Areas being developed or being considered for development are:

- Kamojang (W. Java) - Operated with development assistance from the New Zealand government. A 30 megawatt geothermal unit is in operation.
  Potential for the area is estimated as sufficient to support two additional 55 MW units.
- Gunung Salak (W. Java) - Operated by Union Oil.
- Darajat (W. Java) - Operated by Amoseas.
- Wayang Windhu (W. Java) - open
- Dieng Plateau (W. Java) - Operated by Pertamina. One 2 MW unit is in operation.
- Lahendong (Bali) - Operated by Pertamina.

- Banten (W. Java) - Operated by Pertamina.
- Lahendong, North Sulawesi - Operated by Pertamina. Area expected to produce 85 MW.

10-2-2 Long-term Supply and Demand Prospects for Energy

(1) Long-term supply and demand prospects for energy

Repelita IV is still a formal energy supply and demand projection, which began in 1984. (See Table 10-2-4) Though it is reported that preparatory work has been done for Repelita V, no official information has been disclosed yet. Therefore, informal information is discussed in this section.

Table 10-2-6 shows projection of each share of consuming sectors in total commercial energy.

Table 10-2-7 shows the shares of commercial-and non-commerical energy at the end of Repelita IV and their future trend. Total energy consumption including commerical-and non-commerical energy is projected to increase by about 3% p.a. or more. Of this, non-commerical energy is to grow by less than 2% p.a. and commercial energy by 4-5% p.a. As a result, the share of commercial energy is to increase to 67% by the year 2000 from 60% projected at the end of Repelita IV.

Government officials predict that total energy demand for the nation will exceed 900,000 barrels of oil equivalent per day (BOE) by 1990 and more than double to 1.9 million BOE per day by the end of the century. Whereas oil currently satisfies 75 percent of energy demand, if this dependence were to remain unchanged, more than 630,000 b/d of crude would be consumed domestically by 1990 and 1.43 million b/d by the end of the century. Within ten years, Indonesia would be consuming all of the oil that it produced.

In the long run, the government remains committed to development of alternative energy. The largest projects are focused on the coal industry followed by hydroelectric plants. Geothermal, though promising, involves uncharted waters for Indonesia. In the near term, however, the weak world oil prices have led to decreased government revenues which in turn limits the government's ability to invest in these capital intensive projects.

Table 10-2-6 Projection of Energy Share by Sector

	1990	1995	2000	2005
Industry, Agriculture Construction, Mining	45.7	48.1	50.5	52.7
Transportation	27.3	26.5	26.0	25.6
Household/Service	27.0	25.4	23.5	21.7

Source: Paper presented at the Second Meeting, Indonesia - Japan Joint Energy Committee (January 86, Tokyo)

Table 10-2-7 Projection of Total Energy Consumption at the End of Repelita IV (1988/1989) and Future Trends

	Repelita IV (1988/89)	Unit: 10^6 BOE			Growth Rate of Energy Consumption (%/yr)		
		1995	2000	2005	95/88	2000/95	2005/2000
Commerical Energy	282.2 (60%)	366.5	462.9	572.0	3.8	4.8	4.3
Non-Commerical Energy	183.3 (40%)	208.6	226.3	245.7	1.9	1.6	1.7
Total	465.5 (100%)	575.1	689.1	817.7	3.1	3.7	3.5

10-2-3 Demand for Petroleum Products

Table 10-2-8 shows BBM consumption form 1975 to 1985.

In the last 10 years, fuel oil recorded high growth rate of 10% p.a. and ADO and IDO show a growth rate of a 8-9% p.a. Kerosene consumption, which occupied 27% of total BBM demand in 1985, shows a relatively low growth rate of 3.5% p.a.

The above tendency was further strengthened between 1981 and 1985. BBM consumption almost leveled off and ADO and IDO was forced to grow by such a limited rate as 0.2% p.a. and 1.6% p.a. respectively. Kerosene recorded a minus growth rate of 5% p.a. On the other hand, fuel oil had a very high growth rate of 9% p.a. And also, mogas recorded a slightly minus growth rate.

Such factors as decreased growth of the economy and increased petroleum products prices contributed to this tendency.

As to decreasing demand for kerosene, such structural changes as rural electrification and substitution by LPG in urban areas seemed to contribute to this trend.

Table 10-2-8 BBM Consumption in Indonesia

(10^3kl/yr.)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Growth Rate 85/75	85/81
Avgas	20.1	19.9	17.8	20.5	20.4	18.8	16.7	15.0	12.7	11.4	10.4	△6.4	△11.2
Avtur	287.4	322.1	347.9	401.2	500.6	540.7	606.4	618.2	587.9	608.3	622.9	8.0	0.7
Mogas	2409.8	2630.0	2909.9	3290.0	3729.6	3856.4	4216.0	4077.1	3954.4	4114.2	4157.6	5.6	△0.3
Kerosene	4885.0	5301.0	5875.8	6999.1	7349.0	7891.0	8436.7	8027.3	7597.6	7212.5	6914.8	3.5	△4.9
ADO	3043.0	3817.0	4457.0	5204.0	5869.8	6768.4	7510.1	7999.8	8096.3	7920.4	7576.5	9.6	0.2
IDO	758.0	893.0	1024.0	1261.0	1310.6	1319.4	1580.8	1498.4	1715.0	1709.8	1686.0	8.3	1.6
Fuel oil	1828.0	1853.0	2130.0	2693.0	3066.6	3152.8	3399.5	3699.4	4607.2	4821.4	4832.7	10.2	9.2
Total	13231.3	14836.0	16762.4	19868.8	21846.6	23547.5	25766.3	25935.2	26571.1	26398.1	25800.9	6.9	0.03

Source: MIGAS

Table 10-2-9 shows oil products consumption by such consuming sectors as transportation, industry, power generation and households from 1975 to 1985. In the four years from 1981 to 1985, kerosene in the household and industrial sectors recorded minus growth of 4.4% p.a. and 3.7% p.a. respectively. The power generation sector recorded as high a growth rate as 9% p.a. and the transportation sector recorded only 1.2% p.a.

Table 10-2-10 shows each share of oil consumption by each consuming sector from 1979 to 1986. Only transportation sector showed an expanding trend to 38.2% and power generation sector showed clear downward trend to 10.9% in 1986. On the other hand, household and industrial sectors showed almost a levelling-off or slightly decreasing trend.

Table 10-2-11 shows the sales volume of each oil product by supply region of Pertamina in 1985.

Tables 10-2-12, 10-2-13 show oil products demand by each region for 1995 based upon actual data as of 1985. In this study, we assumed the Repelita IV-based case as a high demand case, where the growth rate of each BBM in Repelita IV was adopted to estimate demand for 1995. And also Ascope figures were adopted as a low demand case. For the study on "Prospects of Long-term Demand for Fuel Methanol (See Section 10-3-1), we employed Ascope estimates as a "more likely" case based upon interviews in Jakarta in 1986. (See Table 10-2-14.)

Table 10-2-9 Oil Products Consumption by Sectors

(Unit: 10³BBL)

YEAR	Transportation							Industry				Power Generation				Household
	Avgas	Avtur	Gas.	ADO	IDO	F.O.	Total	ADO	IDO	F.O.	Total	ADO	IDO	F.O.	Total	Kerosene
1975	126.1	1807.2	15155.3	8249.0	710.3	2509.5	28557.4	9034.4	3653.9	7448.4	20136.7	1854.8	401.1	1537.5	3793.4	30723.2
1976	125.1	2025.7	16540.3	11050.1	1001.9	1892.0	32635.1	9811.5	4309.7	7839.9	21961.1	3142.1	307.4	1924.4	5373.9	33337.7
1977	111.9	2187.9	18300.2	12161.4	1040.2	2177.8	35985.3	11713.6	5121.3	9138.9	25973.7	4154.5	279.0	2081.2	6514.7	36952.8
1978	128.7	2523.2	20691.1	13699.1	1070.7	1932.8	40045.5	13844.1	5712.9	12169.5	31726.5	5187.2	1144.1	2832.6	9163.9	41501.8
1979	126.9	2999.8	22963.2	15654.6	1030.5	1929.9	44704.8	15857.5	6602.0	12335.0	34794.5	4484.1	605.0	4820.6	9909.7	45564.1
1980	126.7	3266.3	24029.6	18330.7	1139.5	2239.5	49131.7	18427.6	6797.0	11030.1	36254.8	4876.0	169.8	6477.3	11523.1	49054.0
1981	103.8	3725.7	26235.2	20229.4	1099.5	1053.1	52446.7	19892.9	8331.3	10767.7	38991.9	5712.7	270.9	8897.0	14880.5	52584.3
1982	98.1	3888.7	26075.6	23098.9	1079.9	1333.9	55575.0	20312.0	8236.0	10608.8	39516.8	6609.8	207.3	10589.5	17406.6	51892.3
1983	83.6	3686.0	24694.5	23017.0	1010.0	1168.8	53660.7	20997.0	8924.0	12067.1	41988.0	6712.5	272.9	12917.6	19903.0	48169.8
1984	72.0	3829.6	25472.1	22965.9	1460.3	1653.7	55453.7	20561.6	8924.3	13672.8	43158.7	5863.2	290.5	14121.0	20274.8	45256.5
1985	65.1	3893.4	25877.8	22695.9	1265.0	1205.9	55003.1	18666.4	8653.1	6256.2	33575.7	5757.4	222.7	14682.8	20662.9	43923.5
Growth Rate (%/Yr.)																
85/75	△6.4	8.0	5.50	10.7	5.94	△7.1	6.8	7.53	9.0	△1.73	5.23	12.0	△5.71	25.3	18.5	3.54
85/81	△11.0	1.1	△0.3	2.9	3.6	3.4	1.2	△1.6	1.0	△12.7	△3.7	0.2	△4.8	13.3	8.6	△4.4

Source: KIGAS

Table 10-2-10 Share of Oil Consumption by Sector

	Transportation	Industry	Electricity	Household	Total
1979	32.4	23.4	7.6	36.5	100
1980	32.7	23.7	8.3	35.3	100
1981	32.8	23.3	9.7	34.2	100
1982	33.7	22.5	11.0	32.8	100
1983	32.5	24.0	12.7	30.7	100
1984	34.1	23.4	13.1	29.4	100
1985	35.4	22.2	13.6	28.8	100
1986	38.2	21.7	10.9	29.1	100

Source: MIGAS ("Petroleum and Gas Industry of Indonesia")

Table 10-2-11 Domestic Sales Volume of Oil Products 1985 (C.Y.)

Oil Products	Sales Volume 10^3 KL	Pertamina Supply Region								
		I	II	III	IV	V	VI	VII	VIII	
Avgas	10.3 [100]	0.988 [9.6]	0.099 [1.0]	3.944 [38.1]	0.180 [1.7]	3.812 [36.9]	0.148 [1.4]	0.233 [2.3]	0.939 [9.1]	
Avtur	619.0 [100]	61.515 [9.9]	21.637 [3.5]	204.048 [33.0]	21.055 [3.4]	206.359 [33.3]	56.851 [9.2]	23.669 [3.8]	23.870 [3.9]	
Premium Gas	116.9 [100]	3.654 [3.1]	0.217 [0.2]	89.397 [76.4]	10.368 [8.9]	13.279 [11.4]	0.023 [0.02]	-	-	
Regular Gas	3997.3 [100]	447.89 [11.2]	292.302 [7.3]	1551.898 [38.8]	478.127 [12.0]	898.207 [22.5]	182.649 [4.6]	114.939 [2.9]	31.304 [0.8]	
Kerosene	6983.3 [100]	774.378 [11.1]	439.209 [6.3]	2538.363 [36.3]	1002.824 [14.4]	1738.017 [24.9]	256.350 [3.7]	201.906 [2.9]	32.250 [0.5]	
ADO	7491.5 [100]	1171.905 [15.6]	897.560 [12.0]	2416.445 [32.3]	836.783 [11.2]	1565.744 [20.9]	299.072 [4.0]	216.314 [2.9]	87.629 [1.2]	
IDO	1612.3 [100]	54.418 [3.4]	131.296 [8.1]	960.336 [59.6]	140.696 [8.7]	308.725 [19.1]	16.782 [1.0]	-	-	
Fuel Oil	3361.8 [100]	159.218 [4.7]	39.694 [1.2]	1512.146 [45.0]	425.104 [12.6]	1053.966 [31.4]	171.653 [5.1]	-	-	
BBM Total	24192.4 [100]	2673.966 [11.1]	1822.014 [7.5]	9276.577 [38.3]	2915.137 [12.0]	5788.109 [23.9]	983.528 [4.1]	557.061 [2.3]	175.992 [0.7]	

(Note): Regions
I : Medan
II : Palembang
III : Jakarta
IV : Semarang
V : Surabaya
VI : U. Pandang
VII : Menado
VIII : Jayapura

Table 10-2-12 Domestic Sales Volume of Oil Products 1995 (C.Y.) [Ascope case]

Oil Products	Sales Volume 10^3 KL	Pertamina Supply Region								
		I	II	III	IV	V	VI	VII	VIII	
Avgas	14.8	1.4	0.2	5.6	0.3	5.5	0.3	0.3	1.4	
Avtur	620.5	61.4	21.7	204.8	21.1	206.6	57.1	23.6	24.2	
Premium Gas	167.8	5.2	0.3	128.2	14.9	19.1	0.03	-	-	
Regular Gas	5720.3	640.7	417.6	2219.5	686.4	1287.1	263.1	165.9	45.8	
Kerosene	7040.1	781.5	443.5	2555.6	1013.8	1753.0	260.5	204.2	35.2	
ADO	7163.3	1117.5	859.6	2313.7	802.3	1497.1	286.5	207.7	86.0	
IDO	1541.7	52.4	124.9	918.9	134.1	294.5	15.4	-	-	
Fuel Oil	3250	152.8	39.0	1462.5	409.5	1020.5	165.8	-	-	
BBM Total	25518.5	2812.9	1906.8	9808.8	3082.4	6083.4	1048.6	601.7	192.6	

(Note): Regions I : Medan, II : Palembang, III : Jakarta, IV : Semarang, V : Surabaya, VI : U. Pandang, VII : Menado, VIII : Jayapura

Demand figures are taken from ASCOPE document (Dec. 1985).

Sales volumes in each supply region were calculated based upon shares in 1985 (C.Y.)

Table 10-2-13 Domestic Sales Volume of Oil Products 1995 (C.Y.) [Pelita IV Based Case]

Oil Products	Sales Volume 10^3 KL	Pertamina Supply Region								
		I	II	III	IV	V	VI	VII	VIII	
Avgas	12.3	1.2	0.1	4.7	0.2	4.5	0.2	0.3	1.1	
Avtur	604.7	59.87	21.16	199.55	20.56	201.37	55.63	22.98	23.58	
Premium Gas	139.6	4.33	0.28	106.65	12.42	15.91	0.028	-	-	
Regular Gas	4757.7	532.86	347.31	1845.99	570.92	1070.48	218.85	137.97	38.06	
Kerosene	11751.5	1304.4	740.34	4625.79	1692.22	2926.12	434.81	340.79	58.76	
ADO	11824.1	1844.56	1418.89	3819.18	1324.30	2471.24	472.96	342.90	141.89	
IDO	1968.5	66.93	159.45	1173.23	171.26	375.98	19.69	-	-	
Fuel Oil	5489.5	258.01	65.87	2470.28	691.68	1723.70	279.96	-	-	
BBM Total	36547.9	4072.2	2753.4	14245.4	4483.6	8789.3	1482.1	844.9	263.4	

(Note): Regions
I : Medan
II : Palembang
III : Jakarta
IV : Semarang
V : Surabaya
VI : U. Pandang
VII : Menado
VIII : Jayapura

Demand figures are calculated based upon the growth rate in Pelita IV.
Sales volumes in each supply region were calculated based upon shares in 1985 (C.Y.)

Table 10-2-14 Estimates of Oil Products Demand in 1995

10^3 Kl/yr

	Sales Volume		Actual Data 1985
	Pelita IV Base	Ascope	
Avgas	12.3 (0.03)	14.8 (0.06)	10.3 (0.04)
Avtur	604.7 (1.7)	620.5 (2.4)	619.0 (2.6)
Premium Gas	139.6 (0.4)	167.8 (0.7)	116.9 (0.5)
Regular Gas	4757.7 (13.0)	5720.3 (22.4)	3997.3 (16.5)
Kerosene	11751.5 (32.2)	7040.1 (27.6)	6983.3 (28.9)
ADO	11824.1 (32.4)	7163.3 (28.1)	7491.5 (31.0)
IDO	1968.5 (5.4)	1541.7 (6.0)	1612.3 (6.7)
Fuel Oil	5489.5 (15.0)	3250.0 (12.7)	3361.8 (13.9)
BBM Total	36547.9 (100)	25518.5 (100)	24192.4 (100)

NOTE: Ascope figures are taken from the document in the 3rd Conference of ASCOPE, Dec. 1985, the title of which is "Long Range Outlook of Petroleum Product Supply and Demand and Utilization of Refining Capacity in the ASEAN Region"

10-3 POTENTIAL DEMAND FOR FUEL METHANOL

10-3-1 Prospects of Long-term Demand for Fuel Methanol

Long-term demand for fuel methanol largely depends upon such factors as 1) the future restriction of environmental emissions like SOx, NOx 2) long-term price changes of oil and 3) availability of domestic crude oil in Indonesia.

In this section, some economic boundary conditions were specified in order to evaluate the possibility of introduction of methanol for fuel use in Indonesia. Details of the LP model bruilding are shown in Interim Report of F.Y. 1986. Here are shown some main results of the study.

(1) Objective of Survey

This survey is aimed at quantitative evaluating and analysing, in the "Effective Utilization of Banko Coal," the impacts by introducing fuel methanol into Indonesia as a substitute fuel for various oil products, namely, the production costs of methanol, oil prices and introduceable quantity of fuel methanol, on the basis of oil refining capacities in the country, crude oil costs, export prices of oil and prospect of demands for various oil products.

In the survey, a LP model (linear programming model), which represents the crude oil and oil-product flows in Indonesia, has been prepared and used.

The presence or absence of economic benefits obtained by introducing fuel methanol into Indonesia may be determined by the difference in magnitude between the cost for introduction (namely, methanol price) and the increase in profits obtainable from the increase in the export of crude oil and oil products, etc.

Therefore, it has been decided in the present survey to obtain the critical conditions where the increased cost by methanol introduction becomes equal to the increased profits obtained by the decrease in consumption (namely, increase in export) of crude oil and oil products as well as the increase in profits due to a decrease in the production cost in the oil refining sector. Then the economic requirements for fuel methanol introduction, namely, the equilibrium between the methanol price and the crude oil price, are calculated.

Table 10-3-1 Main Matrix of LP Model

Equation \ Structural Variables	Crude Oil: Production	Crude Oil: Export	Crude Oil: Domestic Transportation	Refineries: Crude Oil Input	Refineries: Refining Unit	Refineries: Refining Unit	Refineries: Blending	Refineries: Oil Products	Refineries: Oil Products Export	Products Transportation	Domestic Demand	Fuel Alcohol Transportation	Fuel Alcohol Production	(Type)
Objective function(Profit)	− Production Cost	+ Export Price	− Transportation Cost		− Refining Cost	− Refining Cost			+ Export Price	− Transportation Cost	+ Sales Price	− Transportation Cost	− Production Cost	= MAX
<Crude Oil Volume Balance>														
Crude Oil Volume	+	−	−											= 0
<Material Balance in Refineries>														
Material Balance 1				+	−									= 0
Material Balance 2					+	−								= 0
Unfinished Products						+	−							= 0
Oil Product Production							+	−						= 0
Oil Product Delivered								+	−	−				= 0
<Refining Unit>														
Processed Volume					+	+								< Capa.
Own Use					−	−								= 0
<Product Spesification>														
MAX							+	−						< 0
MIN							+	−						> 0
<Balance of Transported Volume>														
Crude Oil			+	−										= 0
Oil Products										+	−			= 0
Fuel Alcohol											−	+		= 0
<Balance of Alcohol>														
Alcohol Production												−	+	= 0
Constraint Conditions	Production Level	Exports Level			Processing Capacity	Processing Capacity		Product Specification			Demand Level		Production Level	

Fig. 10-3-1 Flow of LP Model in Indonesia (Existing capacity case)

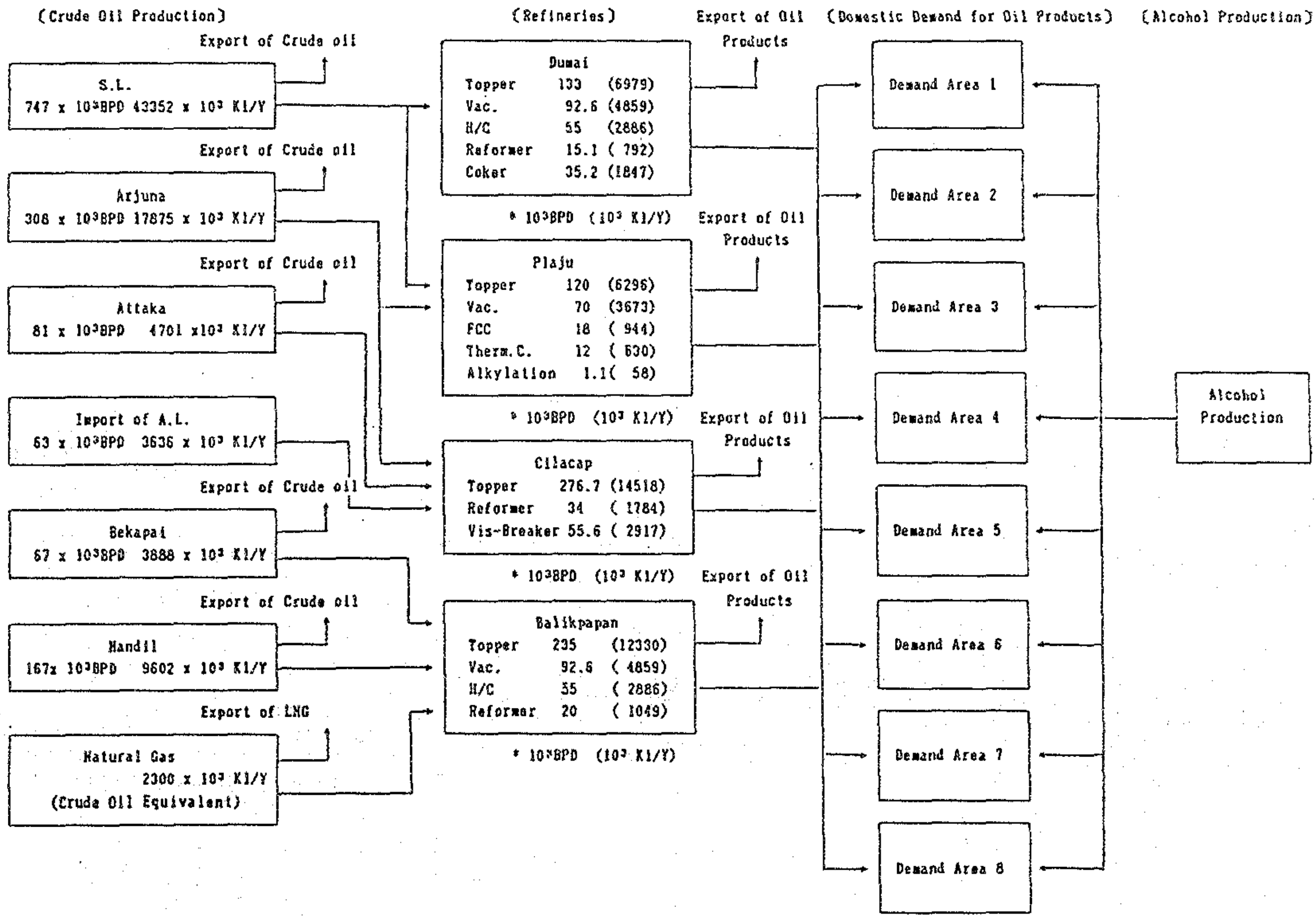
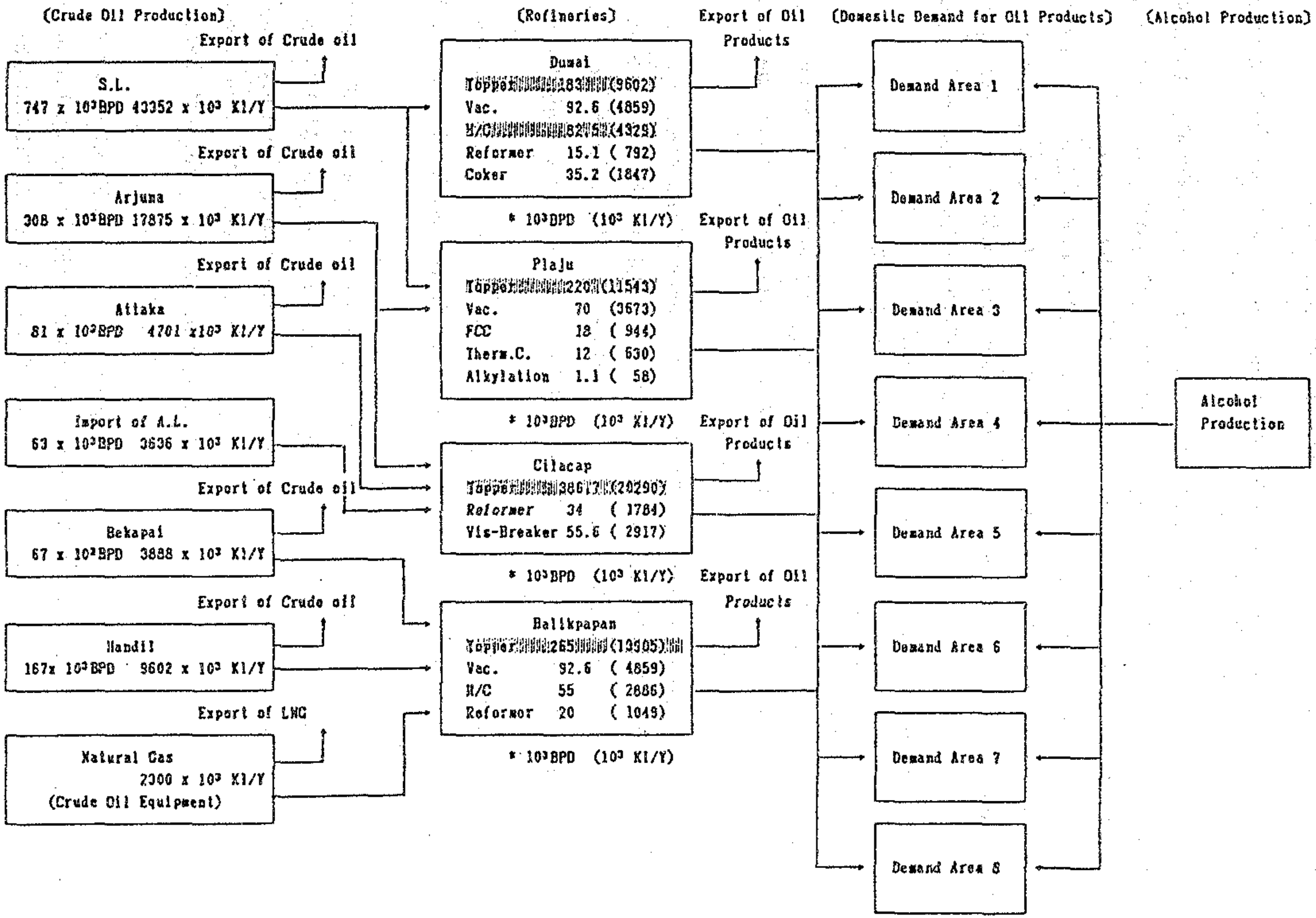


Fig. 10-3-2 Flow of LP Model in Indonesia (Expended capacity case)



NOTE: Refining capacity were expanded in dotted part (▒▒).

(2) Results of LP Model Study Concerning Fuel Methanol

As to introduction of fuel methanol, such three cases are examined as case-AC, case-AM and case-AM20 - AM37.

In case-AC, maximum allowable price of methanol was calculated to introduce full volume of 1.6 million T/Y under the condition of 30 $/BBL of crude oil, which is the estimated production volume of methanol from Banko coal.

In case-AM, minimum price of crude oil was calculated under the condition of 139$/Kl of methanol price, which corresponde to IRR 13.5% in the methanol production project. And also in those cases from AM20 to AM37, methanol volume of introduction was calculated under 139$/Kl of methanol price in relation to crude oil price range from 20$/BBL to 38$/BBL.

1) Concluding Remarks

From the study results of the LP model, the long-term demand for fuel methanol is projected as follows from the relation between the crude oil price and production cost of methanol:

i) At a crude oil price of $30/BBL, the economic merit of fuel methanol introduction cannot be expected. Fuel methanol introduction is governed by how to evaluate the effects other than economic factors such as preservation of oil resources, increase in employment opportunities due to industrialization, etc.

Therefore, it is considered in the present study that no long-term demand for fuel methanol will occur, if the crude oil price is below $30/BBL.

ii) At a crude oil price of $30/BBL, a long-term demand of 1.6 million t/yr for fuel methanol exists, if it is supplied at a cost of $111/kl or below. When methanol is to be produced from Banko coal, a methanol supply at $111/kl has only a low economic benefit (IRR: about 9.5%) in view of the investment risk, and thus the present project will not become an attractive one.

iii) Changes in the introduceable quantity of methanol, when the crude oil price is fixed at $30/BBL and the methanol price is changed from $111/kl (when IRR is about 9.5% in case of Banko coal) to $139/kl (IRR: about 13.5%), have not been investigated in the present survey due to time restrictions. After executing an additional study in the future, the long-term demand for methanol (methanol supply capacity viewed from economic benefit) at a crude oil price of $30/BBL should be judged.

2) Equilibrium between Methanol Price and Crude Oil Price

The results are shown in Case A-C and Case A-M of Table 10-3-3.

i) Case A

This case is a reference for comparison with other cases, and presupposes no methanol introduction for the prospects of oil product demands. The case shows a refining pattern based on ASCOPE demand as a reference for a more likely case.

Since gasoline demand is great, according to the above demand prospect, the refining pattern has become the "maximum gasoline yield." As a result, a shortage of naphtha, which is the fuel and feedstock of hydrogen for hydrocrackers, has occurred in Dumai and Balikpapan refineries. In spite of achieving a higher degree of hydrocracker operations, which can obtain higher profits, in actuality, the hydrocrackers have such a relatively low rate of operation (Dumai 69%; Balikpapan 66%).

ii) Case A-C

This case is aimed at examining the necessary conditions for introducing a total quantity of 1.6 million tons of methanol, with respect to Case A. If the crude oil price is fixed at $30/BBL, the equilibrium price (the maximum allowable price) of methanol introduction will be $111/kl. In such a case, methanol of 810 x 10^3 kl and 222 x 10^3 kl (oil product equivalent) will be introduced as substitutes for gasoline and kerosene, respectively. The impact to the refining pattern in this case is that hydrocrackers can be put to more effective use, resulting in a decrease in unprofitable fuel oil exports of about 2.1 million kl and, conversely, in an increase of about 2.6 million kl in export of highly value added products mainly consisting of kerosene and reformate. On the other hand, although the maximum allowable price of methanol, $111/kl, in this case is higher than the lower limit value of $102/kl (price corresponding to IRR : 8.0%) of the cost for producing methanol from Banko coal, this case is not necessarily profitable, considering the risk of investment in methanol production facilities.

iii) Case A-M

In this case, the equilibrium crude-oil price for introducing methanol is calculated, when the methanol price is fixed at $139/kl (which corresponds to IRR 13.5% in the methanol production project). The crude oil price, which permits the introduction of the total 1.6 million tons of methanol at a price of $139/kl, is $38/BBL. In this case, as in the A-C Case, methanol has been introduced as gasoline and kerosene substitutes. The impact to the refining pattern has resulted in increases in kerosene and reformate exports through a higher rate of operation of hydrocrackers.

3) Relation between Crude Oil Price and Introduceable Quantity of Methanol

When the methanol price was fixed at $139/kl (price corresponding to IRR: 13.5%), the crude oil price for allowing the introduction of the total methanol amount of 1.6 million tons per year was $38/BBL (A-M Case). Here, the methanol price is fixed at $139/kl regardless of the introduced quantity of methanol, and changes in the amount of the introduced quantity of methanol are obtained, when the crude oil price is changed from $30 to $38/BBL. Results are shown in Table 10-3-3 and Fig. 10-3-3.
Changes in the introduceable quantity of methanol, when the crude oil price is fixed at $30/BBL and the methanol price is changed from $111 to $139/kl, have not been investigated at this time, owing to restrictions in time. This investigation must be conducted in the future.

i) Case A-M30

At a crude oil price of $30/BBL, methanol of 119 x 10^3 kl is introduced as a gasoline substitute. As a result, the shortage in naphtha in Case A is filled up, and hydrocrackers operate at a higher rate. The resultant increase in export of the middle distillate is to make up for the methanol introduction cost.

ii) Case A-M31

As the crude oil price is increased to $31/BBL, methanol of 252 x 10^3 kl is introduced as a gasoline substitute (gasoline equivalent of 131,000 kl).

As a result, gasoline production facilities, i.e., reformers, experience a lower operation rate, and this appears, in the overall balance, mainly as an increase in the kerosene export. Incidentally, in the Case A-M30, the swing portion amounting to 84 x 10^3 kl between naphtha and kerosene was directed to naphtha, namely gasoline production, whereas in Case A-M31, the swing portion is directed to kerosene production due to the difference in the export price between kerosene and gasoline.

iii) Case A-M34

As the crude oil price is increased to $34/BBL, methanol of 656 x 10^3 kl (gasoline equivalent of 341 x 10^3 kl) is introduced as a gasoline substitute. Since excess naphtha is now put to reformers, reformate, which is the blending stock for gasoline, is increased in production for export.

iv) Case A-M35

The gasoline substitute by methanol rises to 671 x 10^3 kl (gasoline equivalent of 349 x 10^3 kl), resulting in an increased production of reformate and in an increased rate of operation by hydrocrackers (for the same reasons as in Case A-M30).

v) Case A-M37

When the crude oil price reaches $37/BBL, methanol is introduced to the amount of 671 x 10^3 kl as a gasoline substitute (gasoline equivalent of 349 x 10^3 kl and to the amount of 453 x 10^3 substitute (kerosene equivalent of 222 x 10^3 kl). The refining pattern is the same as in Case A-M35, resulting in a further increase in kerosene export.

vi) Case A-M38 (= Case A-M)

Only when the crude oil price rises to $38/BBL, the introduction volume of methanol rises for the first time to 1.6 million tons (2.01 million kl).

Table 10-3-2 Cases for Methanol Introduction

Case	Crude Oil Price	Methanol Price	Domestic Oil Demand	Remarks
(Case A) A	30$/BBL	No Introduction of Methanol	ASCOPE	Reference case (No Introduction of Methanol)
A C	30$/BBL →	? $/kL	ASCOPE	Maximum price of methanol for introducing full volume of 1.6 million T/Y
A M	? $/BBL ←	139$/kl	ASCOPE	Minimum price of crude oil for introducing full volume of 1.6 million T/Y
AM20-AM37		139$/kl	ASCOPE	Methanol volume of introduction in relation to crude oil price (20$/BBL～38$/BBL) with fixed methanol price of 139$/kl

NOTE: 1.6 million T/Y of Methanol is assumed to be produced in South Sumatra and to be introduced in domestic oil products market.

Methanol introduction depends upon both crude oil price and methanol price. Here boundary condition of each price was calculated with fixed price of the other.

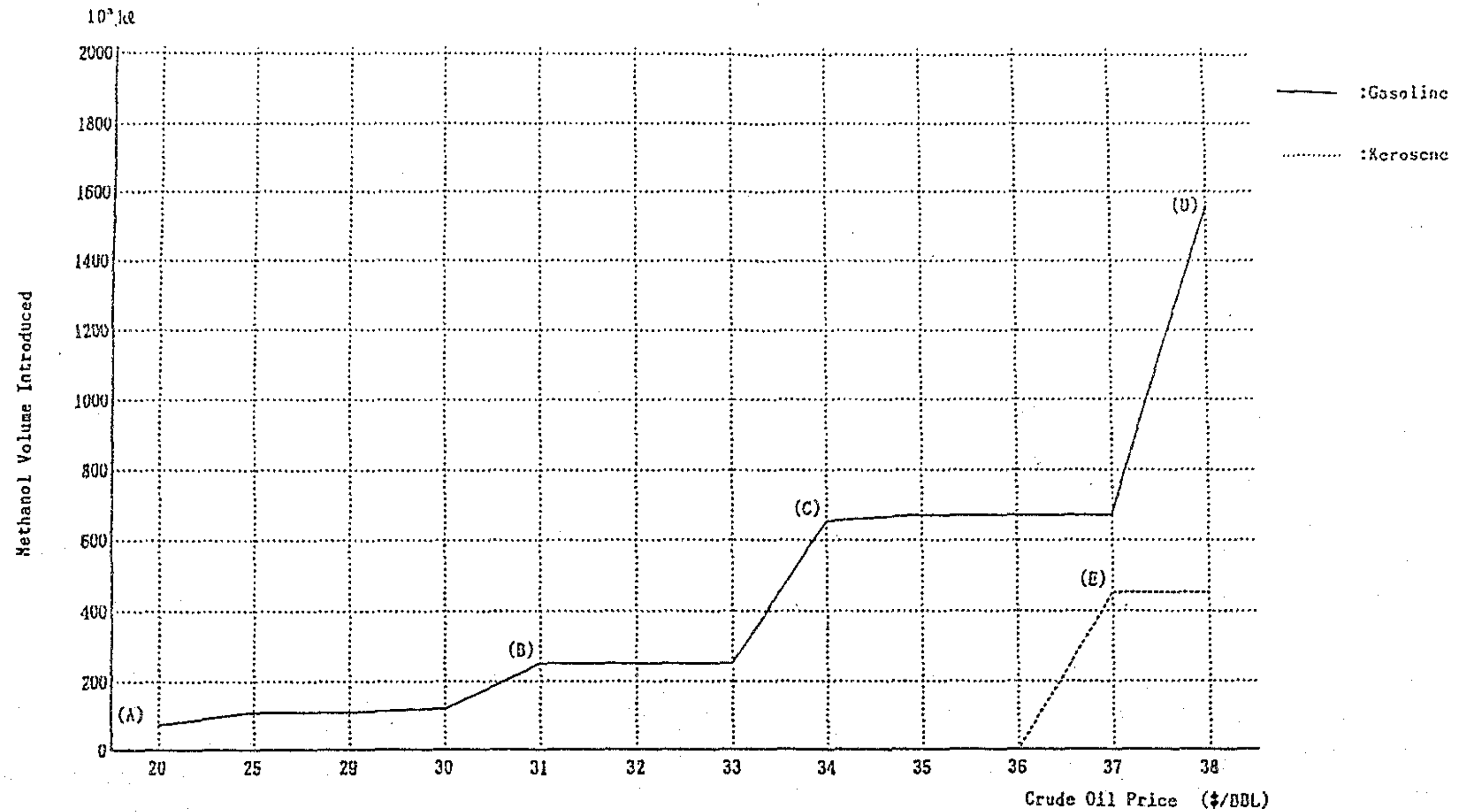
As to domestic oil demand, two cases were assumed. For Pelita IV - based case, both added refining capacity case and kerosene import case were set to respond to bigger kerosene demand.

Table 10-3-3 Results of Cases for Methanol Introduction

Items \ Cases	A	A－C	A－M	A-M20	A-M25	A-M26	A-M27	A-M28	A-M29	A-M30	A-M31	A-M32	A-M33	A-M34	A-M35	A-M36	A-M37
(1) Crude oil Price($/BBL)	30	30 ↓	38 ↑	20	25	26	27	28	29	30	31	32	33	34	35	36	37
Methanol Price($/kℓ)		111	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139
(2) Methanol volume																	
To Demand Area 2 Kerosene market(10^3 kℓ)		453	453														453
To Demand Area 3 Gas. market (10^3 kℓ)		1557	1557	74	110	110	110	110	110	119	252	252	252	656	671	671	671
Kerosene market(10^3 kℓ)																	
Total (10^3 kℓ)		2010	2010	74	110	110	110	110	110	119	252	252	252	656	671	671	1124
(3) Oil Products Replaced																	
Gas. (10^3 kℓ)		810	810	38	57	57	57	57	57	62	131	131	131	341	349	349	349
Kerosene (10^3 kℓ)		222	222														222
(4) Relative relation between Methanol price and Crude oil price		1.18	1.16	2.21	1.77	1.70	1.64	1.58	1.52	1.47	1.43	1.38	1.34	1.30	1.26	1.23	1.19

Note: Case A is the reference case with no introduction of fuel methanol.

Fig. 10-3-3 Methanol Volume Introduced (v.s. Crude Oil Price)



Note: 1 Assumptions; Methanol Price 139$/kl
Domestic Oil Product Demand ASCOPE Case

2 Through methanol introduction, gasoline delivery for demand area 3 from Cilacap is reduced at such points as (A)(B)(C)(D).

At points (A)(B)(C), gasoline delivery for demand area 4 from Cilacap is increased and that from Dumai is decreased, leaving gasoline production in Dumai reduced.

At point(C), reformate export from Dumai is to start. At point(D), gasoline delivery for Area 5 from Cilacap is increased and gasoline production in Balikpapan is decreased, starting reformate export from that refinery.

At point(E), kerosene delivery for Area 2 from Plaju is to be replaced by methanol. This causes delivery for Area 3 from Plaju increased, that for Area 3 from Cilacap decreased, that for Area 4 from Cilacap increased and finally, that for Area 4 from Balikpapan decreased.

And as a result, kerosene production from Balikpapan is to be decreased.

10-3-2 Potential Demand by Sector

The purpose of this section is to try rough demand projection for methanol in Indonesia, based upon some assumptions by consuming sector.

(1) Transportation Sector

i) Low level methanol blending in gasoline

In the future, this use may be the most important demand for increasing methanol use. However, the uncertainties of substituting methanol for gasoline are substantial. Implementing the widespread use of neat methanol in the transportation sector means the rapid expansion of the down-stream distribution system before the car manufacturer is willing to produce and sell neat methanol-fueled cars. The existing distribution network is not compatible with methanol use. And installing an additional parallel distribution system would mean significant investment costs. For car manufacturers at present, there is no significant impetus to large-scale production of large quantities of methanol-fueled cars.

For that reason low level methanol blending seems to be the preferred solution to introducing methanol in the medium term. The use of methanol as a direct blending component in transportation fuels has been limited to a max. 3% of gasoline mixture. If one assumes methanol will be blended in gasoline consumed in Indonesia, the demand could amount to somewhere around 140 x 10^3 kl/yr.

If one assume that supply of low level methanol blend will be started in major cities, the methanol demand could amount to 48 x 10^3 kl/yr. in the Jakarta area and 28 x 10^3 kl/yr. in the Surabaya area.

ii) Neat methanol for gasoline substitution

Introducing neat methanol (M100) to replace gasoline hits on quite severe infrastructure obstacles which have to be solved among car producers, methanol producers and consumers themselves as discussed earlier.

The frequent evaluations of recent years on the potential use of M100 in the gasoline sector are now considered to have been too optimistic. They do not appear to be realistic during this century. This situation could change radically in the case of interruptions in the supply of crude oil. It must be considered that 99% of transportation fuel is produced from oil, and also the R/P - ratio in Indonesia was 18 at the end of 1985.

Natural gas and coal must be substituted for gasoline to avoid a decrease of oil exports.

iii) Neat methanol for diesel oil substitution

Introducing neat methanol to replace diesel oil does not also appear realistic for the time being in Indonesia. However, diesel oil substitution must be done over the long term for the same reasons mentioned above. The consumption of diesel oil in 1995 in Indonesia is estimated to be 11.8×10^6 kl/yr. During the penetration stage, the demand for neat methanol as a diesel oil substitute will be in major cities for use by city buses and trucks and will improve the einvironment. If one assumes that 10% of diese oil consumption in the year 2000, and 30% in the year 2020 are substituted by neat methanol (100%), then the potential demand for fuel methanol in this sector is expected to be 1360×10^3 kl/yr. in 2000 and 4080×10^3 kl/yr. in 2020.

iv) Total potential methanol in transportation sector

Above estimated demands are summarized as follows:

(10^3 kl/yr.)

	Penetration stage	Year 2000	Ultimate stage
* Low level blend	48 - 76	140	140
* Gasoline substitution	-	240	1430
* Diesel oil substitution	-	1360	4080
Total	48 - 76	1740	5650

(2) Power Generation Sector

Methanol can be applied for large power stations of steam and gas turbines, or 1 - 5 MW class diesel engines or 100 KW - 1000 KW class small and medium diesel engines.

Although the interconnection of the electric grid has been extended, there are still many isolated small power stations of 100 KW class needed in Indonesia. The total number of unelectrified villages was over 53,000 at the end of 84/85. As for rural areas such as PLN region X, V and IX, the electrification rate is a low 2.7%, 2.7% and 5.8% respectively. The rate in Jakarta Raya and Tangerang is the highest, 54%.

Package type generator sets of 100 KW class diesel type alcohol engine seem to have a big potential for using fuel methanol. Assuming the fuel consumption rate is 0.27 - 0.28 l of ADO.IDO/kWh or 0.6 l of methanol/Kwh in about 10% of total unelectrified villages, total monthly methanol consumption is 180 x 10^3 kl/month.* However, this demand for fuel methanol (2200 x 10^3 kl./yr.) has only max. potential for rural electrification.

Note: 5000 units x 0.5 x 100 kW x 24 hrs. x 30 days x 0.6 = 180 Ml/month

(0.5: load factor; 0.6: l/Kwh)

A long term potential demand study using the LP model mentioned in Section 10-3-1 shows that the consumption of kerosene will be substituted by fuel methanol in a specific demand pattern and assumed prices of oil and methanol.

This means kerosene used in the household sector can be decreased by electricity use in the household sector and methanol consumption will be increased in the power generation sector.

In Indonesia, typical boiler type power generators are not expected to have a bigger market share for fuel menthanol because natural gas and coal are produced in Indonesia and the economics for power generation use in a boiler is superior than that of fuel methanol.

However, the result of the LP model study is reasonable if one assumes that some percentage of increased electricity consumption will be generated through gas-turbine power generators and diesel engine power generators using fuel methanol.

Table 10-3-4 shows the power generating capacity of PLN gas turbine power generators were around 950 MW total and that of diesel type was around 650 MW in 1985/86. The diesel type will be increased to 1280 - 1725 MW but gas turbines will be decreased to 267 - 627 MW in 1993/94.

However, if fuel methanol through a reforming system is applied for gas turbine power generators by making modifications, existing gas tubine power generators will be kept operating because the modification cost is expected to be cheaper than other new power generators and thermal efficiency will be greatly improved. Diesel type power generators will also be the fuel methanol reformer type.

To show potential methanol demand in the power generation sector, it was assumed that existing gas turbine capacity will not be scrapped but modified to fuel methanol use through a reformer.

The fuel consumption (HSD/IDO) of gas turbine power generators in 1985/86 was estimated around 450 x 10^3 kl/yr. If one assumes that all gas turbine will be modified to consume fuel methanol through a reformer in the long term, the potential demand for fuel methanol could amount to

around 870 x 10^3 kl/yr. $(478 \times \frac{9100}{3800} \times \frac{0.28}{0.37} = 868)$

If 20% of new additional diesel type power generation is fuel methanol type through a reformer, the potential demand for fuel methanol will be around 76 x 10^3 kl/yr.

(3) Industrial Sector

Diesel oil consumption (ADO, IDO) in industry in 1995 is estimated to be 13800 x 10^3 kl/yr. Detailed usage and volume of ADO and IDO in industry is not clear but is estimated to be for power generation by diesel or gas turbines and for process heating purposes.
Therefore, in this study, the potential demand in industry is estimated based on the following assumptions:

i) 30% of ADO and IDO is power generation use and 30% of consumption could be converted to fuel methanol if the price of methanol is competitive.

ii) 70% of ADO and IDO is process heating and other use and cannot be converted to fuel methanol because of technical reasons.

Then, the potential demand in industry is estimated to be 1400 x 10^3 kl/yr.

(4) Household Sector

Methanol is toxic and therefore, its direct use in households cannot be expected in the future. The long-term prospects using the LP model shows that the kerosene consumed in households will be substituted by fuel methanol through power generation.
Therefore, in this study, the potential demand in the household sector was estimated to be negligibly small.

(5) Summary of Potential Demand for Fuel Methanol

Potential demand for fuel methanol can be summarized as follows by penetration stage (or earlier stage) and ultimate stage (or commerical introduction stage).

		(10^3 kl/yr)
	Penetration stage	Ultimate state
Fuel Methanol	48 - 76	8150

Table 10-3-4 (1) Power Generating Capacity in PLN (up to 93/94) (MW)

JAVA

	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94
Hydro-P	535	535	885	1235	1241	1770	1884	2064	2564	2564	2739
		-	-	-	(1235)	(1824)	(1946)	-	-	-	(2564)
Oil	1506	1506	1506	1506	1456	1856	1806	1806	1806	1806	1806
		-	-	-	-	-	-	-	-	-	-
Coal	0	400	800	800	800	1200	1600	2000	2400	2800	3200
		-	-	-	-	-	-	(1600)	(1600)	(2400)	(2800)
Geotherm	30	30	30	30	140	140	140	140	250	470	470
		-	-	-	-	-	-	-	-	-	-
Gas T.	645	645	645	645	645	645	645	570	520	100	100
		-	-	-	-	-	-	(520)	(480)	(480)	(460)
Total	2716	3116	3866	4216	4282	5611	6075	6580	7540	7740	8315
		-	-	-	(4276)	(5665)	(6137)	(6130)	(6700)	(7720)	(8100)

Table 10-3-4 (2) Power Generating Capacity in PLN (up to 93/94) (MW)

Outside JAVA

	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94
Hydro-P	129	179	179	185	202	219	260	386	437	579	734
		-	-	-	-	(203)	-	-	(385)	(385)	(525)
Oil	50	115	180	180	180	180	310	310	310	310	310
		-	-	-	-	-	-	-	-	-	-
Coal				130	130	130	130	180	230	280	430
				(0)	-	-	-	(130)	(180)	(230)	(330)
Diesel	518	567	647	950	1181	1279	1266	1264	1266	1303	1280
		(631)	(740)	(1139)	(1444)	(1570)	(1500)	(1655)	(1667)	(1722)	(1725)
Gas T.	217	280	300	300	300	300	300	300	285	221	167
		-	-	-	-	-	-	-	-	-	-
Total	914	1140	1305	1744	1992	2107	2266	2440	2528	2693	2921
		(1205)	(1399)	(1804)	(2256)	(2383)	(2588)	(2781)	(2827)	(2868)	(3057)

Note: Figures are from the document of PLN' as of June 30,'85.
Figures in parentheses are from the document of PLN as of April, 1986.

Table 10-3-5 Total Fuel Consumption by PLN (Unit: 10^3 kl)

	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94
1. Diesel P. (HSD/IDO)	492	487	550	636	697	740	748	709	815	829	760
2. Gas.T.P (HSD/IDO)	501	691	478	435	431	433	392	304	240	37	37
3. Oil (MFO)	2403	2690	1883	2038	2675	3004	2833	3034	2953	2996	3350

10-4 PRELIMINARY ESTIMATION ON MARKET OF CHEMICALS

10-4-1 Methanol

Methanol is the one of important chemicals to be directly synthesized from synthetic gas, and is used as raw materials for other chemicals and as solvent without further processing as shown in Table 10-4-1 "Break down of Demand for Methanol in 1987".

World methanol balance between production capacity and consumption is illustrated in Fig. 10-4-1. Also the world demand forecast is shown in Table 10-4-2. As seen from the above tables, methanol is mostly used for chemicals at present time. However, various research efforts are exerted to use neat-or blend-methanol as fuel for automobiles and electric power generators. When such efforts are commericalized, the situation of demand is to be drastically changed.

The demand and supply forecast for methanol in Asian countries are listed in Table 10-4-3, which shows the production of methanol in Asian block will be lower than the consumption. So if the production cost of methanol in this project is well competitive to it in Middle east, Oceania, etc., there will be a chance to export.

World price trend of methanol is shown in Table 10-4-4.

Table 10-4-1 Breakdown of Demand for Methanol in 1987

	U.S.A.	W. Europe	Japan
Formaline	33.0 %	42.3 %	46.7 %
Chloreometnane	8.1	6.8	4.6
DMT	3.3	3.2	2.9
Methylamine	3.0	3.7	4.1
MMA	3.6	3.0	7.5
Acetic acid	9.9	5.2	8.7
Solvent	8.1	3.5	3.4
MTBE	17.0	5.8	-
Gasoline blend	0.2	10.2	-
Others	13.7	16.4	22.1
Total	100.0	100.0	100.0
Demand (10^3 Ton/Y)	4,540	4,368	1,400

Fig. 10-4-1 World Methanol Balance

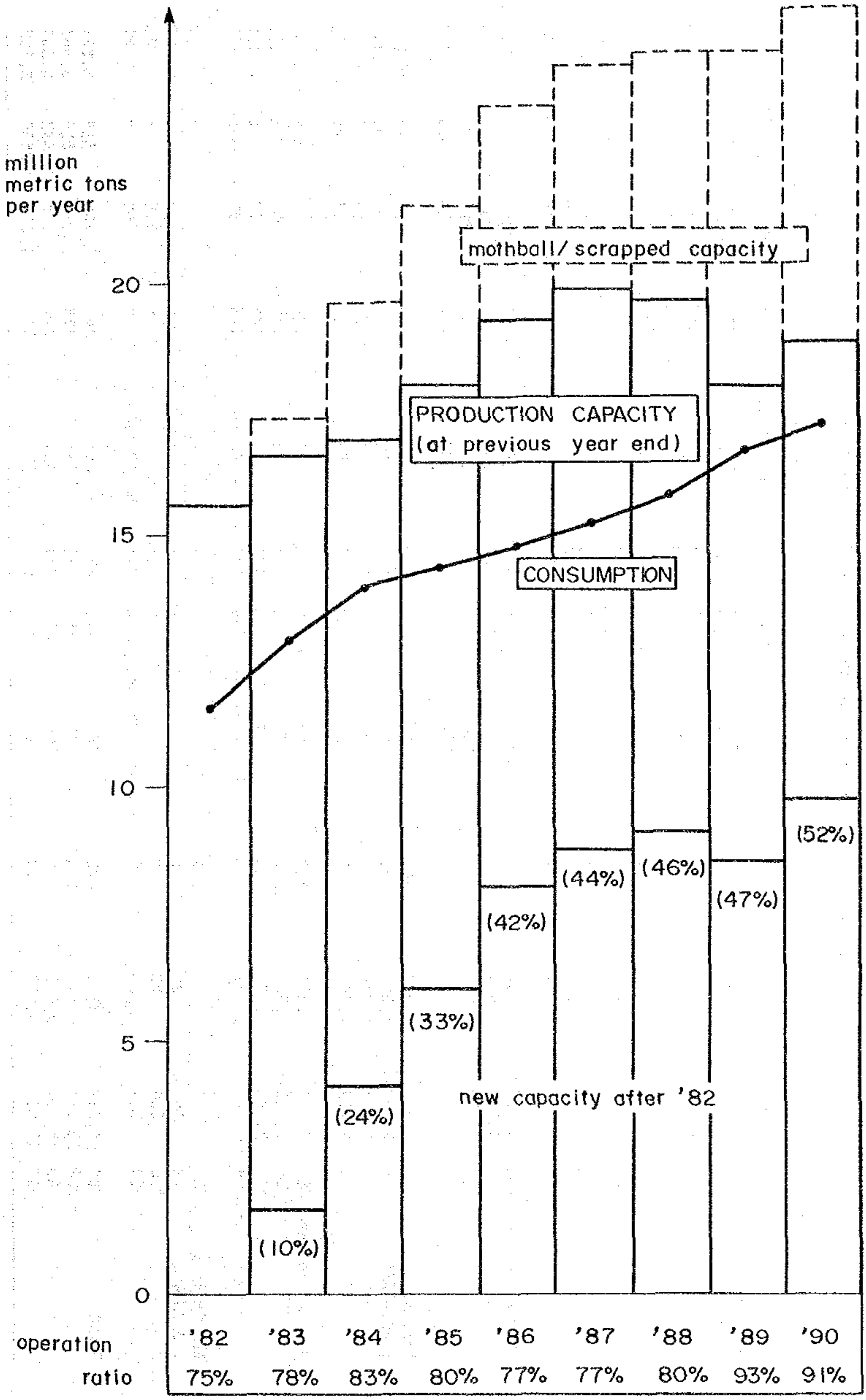


Table 10-4-2 World Demand Forecast For Methanol

(Unit: 10^3 tons)

		Total	Formaldehyde	Solvents	Chloromethanes	MMA	DMT	Methylamines	Aceticacid	MTBE	Gasoline Blending	Others
North America	'87	4,975	1,678	427	370	170	198	152	450	770	20	740
	'88	5,164	1,712	434	374	175	204	156	455	880	6	768
	'89	5,424	1,748	443	377	180	211	161	460	1,050	-	795
	'90	5,657	1,782	451	381	185	227	166	465	1,190	-	821
South America	'87	282	160	25	-	4	25	11	-	30	-	27
	'88	307	167	25	5	4	25	11	-	42	-	28
	'89	321	175	25	6	4	25	11	-	46	-	29
	'90	339	183	25	7	4	30	11	-	49	-	30
West Europe	'87	4,368	1,848	155	297	130	140	161	225	252	445	715
	'88	4,510	1,877	157	306	134	141	171	233	294	465	732
	'89	4,689	1,909	160	314	137	143	181	247	362	487	749
	'90	4,862	1,941	162	323	141	144	190	273	404	521	763
East Europe (incl. USSR)	'87	3,225	1,320	150	20	20	167	50	20	35	40	1,403
	'88	3,313	1,350	153	21	21	175	52	41	43	40	1,417
	'89	3,413	1,375	156	22	22	184	53	57	68	40	1,436
	'90	3,488	1,400	159	23	23	193	55	63	77	40	1,455
Asia & Oceania	'87	2,471	1,339	118	70	117	100	70	146	40	5	466
	'88	2,560	1,381	119	71	125	104	74	147	50	5	484
	'89	2,642	1,422	123	71	135	107	78	147	56	5	498
	'90	2,728	1,457	124	72	144	111	79	148	67	5	511
Middle East & Africa	'87	65	30	3	-	-	-	-	-	-	-	32
	'88	147	32	3	-	-	-	-	-	80	-	32
	'89	208	33	3	-	-	-	-	-	140	-	32
	'90	214	34	3	-	-	-	-	-	145	-	32
Total	'87	15,386	6,375	878	757	441	630	444	841	1,127	510	3,383
	'88	16,001	6,519	891	777	459	649	464	876	1,389	516	3,461
	'89	16,697	6,662	910	790	478	669	484	911	1,722	532	3,539
	'90	17,288	6,797	924	806	497	694	501	949	1,932	566	3,622

Table 10-4-3 Methanol Demand and Supply in Asian Countries

(MT)

		JAPAN	KOREA	TAIWAN	PHILIPPINES	THAILAND	MALAYSIA	SINGAPORE	INDONESIA	INDIA	CHINA	BURMA	OTHERS	TOTAL
1986	Consumption	1,280	120	170	15	18	30	15	130	110	255	0	16	2,159
	Production	219	0	55	0	8	400	0	29	65	259	0	0	1,035
	Import	1,061	120	115	15	10	0	115	125	45	0	0	16	1,622
	Export	0	0	0	0	0	370	100	24	0	4	0	0	498
1987	Consumption	1,400	150	200	18	18	30	10	140	115	265	0	16	2,362
	Production	150	0	50	0	8	500	0	220	70	280	10	0	1,288
	Import	1,250	150	150	18	10	0	30	70	45	0	0	16	1,739
	Export	0	0	0	0	0	470	20	150	0	15	10	0	665
1988	Consumption	1,430	160	214	20	19	31	10	150	117	275	0	16	2,442
	Production	80	0	55	0	8	500	0	300	75	290	70	0	1,378
	Import	1,350	160	159	20	11	0	10	0	42	0	0	16	1,768
	Export	0	0	0	0	0	469	0	150	0	15	70	0	704
1989	Consumption	1,461	165	227	21	19	31	10	155	121	285	0	16	2,511
	Production	0	0	60	0	8	500	0	300	80	300	120	0	1,368
	Import	1,461	165	167	21	11	0	10	0	41	0	0	16	1,892
	Export	0	0	0	0	0	469	0	145	0	15	120	0	749
1990	Consumption	1,493	170	244	21	20	32	10	160	124	295	0	16	2,585
	Production	0	0	60	0	8	530	0	300	85	320	125	0	1,428
	Import	1,493	170	184	21	12	0	10	0	39	0	0	16	1,945
	Export	0	0	0	0	0	498	0	140	0	25	125	0	788

Table 10-4-4 Methanol Price Trend

(/MT)

Month		FOB USGULF	CIF R'DAM T1	CIF JAPAN
'83	1	$152	$167	$211
	2	$145	$163	$196
	3	$143	$161	$188
	4	$142	$156	$186
	5	$140	$154	$181
	6	$140	$157	$177
	7	$141	$154	$162
	8	$138	$150	$154
	9	$135	$144	$166
	10	$139	$141	$172
	11	$137	$144	$188
	12	$137	$145	$168
'84	1	$132	$146	$155
	2	$132	$144	$153
	3	$132	$154	$154
	4	$132	$155	$156
	5	$145	$150	$153
	6	$154	$143	$150
	7	$142	$134	$151
	8	$137	$134	$149
	9	$133	$132	$149
	10	$130	$132	$147
	11	$127	$126	$148
	12	$125	$120	$146
'85	1	$127	$124	$147
	2	$129	$124	$146
	3	$129	$133	$143
	4	$140	$137	$143
	5	$157	$139	$145
	6	$157	$136	$147
	7	$145	$139	$150
	8	$134	$140	$151
	9	$134	$132	$153
	10	$129	$124	$158
	11	$125	$125	$150
	12	$132	$122	$145
'86	1	$126	$123	$147
	2	$131	$123	$143
	3	$121	$110	$139
	4	$120	$92	$140
	5	$110	$88	$136
	6	$103	$85	$126
	7	$100	$78	$127
	8	$95	$76	$114
	9	$91	$78	$104
	10	$85	$73	$99
	11	$85	$70	$97
	12	$81	$66	$91
'87	1	$78	$78	$87
	2	$90	$92	$84
	3	$91	$92	$84
	4	$98	$94	$88
	5	$98	$98	$94
	6	$100	$106	$98
	7	$111	$108	$100
	8	$111	$108	
	9			
	10			
	11			
	12			

10-4-2 Fertilizer

Urea fertilizer consumption in Indonesia is shown in Table 10-4-5.

Oven the past 8 years the average growth rate in demand has been 19.4%. If the growth rate averages 5 - 10% over the next 5 years, urea consumption in 1990 will reach 4,366 - 5,509 thousand tons on the basis of 1985 demand of 3,421,309 tons.

Production capacity of urea is listed in Table 9-4-6.

There will be need to make a plan for new urea plants after 1990. As seen from Table 10-4-6, an adequate location of a new plant will be eastern part of Indonesia, such as Sulawesi, for domestic supply. Also the north Sumatra will be adequate for a new plant for export. The natural gas supply for PUSRI will be enough for twenty years, since a new gas reservoir was found recently in Musi area. So we cannot find out a reason why the production of fertilizer in Banko area is advantageous. And a viability of fertilizer production within this project depends only on the production cost.

Table 10-4-5 Urea Fertilizer Consumption, 1978 - 1985

Year	Production	Imports	Exports	Total Consumption	Increase (%)
1978	1,437,000	8	343,952	1,093,056	-
1979	1,834,000	7	233,030	1,600,977	46.5
1980	1,914,000	9,013	230,526	1,692,487	5.7
1981	2,021,000	302,084	16,782	2,306,302	36.2
1982	2,060,000	292,349	45,033	2,307,316	-
1983	2,205,000	184,523	328,547	2,060,976	-10.6
1984	2,910,000	188,489	262,309	2,836,180	37.6
1985	3,762,000	92,665	433,356	3,421,309	20.6

Table 10-4-6 Number of Urea Fertilizer Plants and Installed Capacity in Indonesia, 1985

Name of Company	Commenced Production	Location	Capacity tons/year
PT. PUSRI I	1963	Palembang	100,000
II	1974	Palembang	380,000
III	1977	Palembang	570,000
IV	1978	Palembang	570,000
PT. PUPUK KUJANG	1978	Cikampek	570,000
PT. ACEH ASEAN FERTILIZER	1984	Aceh	570,000
PT. PUPUK KALTIM I	1984	East Kalimantan	570,000
II	1985	East Kalimantan	570,000
III	1986	East Kalimantan	570,000
PT. PUPUK ISKANDAR MUDA	1989	Aceh	570,000
Total Production Capacity			5,040,000

11. INTEGRATION STUDY AND REVIEW OF MASTER PLAN

11-1 EVALUATION OF COAL BASINS AS ENERGY RESOURCES

North-West Banko, Central Banko and North Suban Jeriji area were surveyed from FY1985/86 to FY1987/88 under the project, however, the purpose of the survey was to find the suitable places to obtain coal samples for coal gasification test at Serpong, therefore, the survey work was carried out putting emphasis on general geological survey to confirm the exposed locations of each coal seam on the surface (outcrops) and shallow hole drilling to check the thickeness of overburden over each coal seam within the said area.

The items taken up in the section shall be investigated in the feasibility study which will be carried out in FY1988/89, so that the matters will be examined preliminaly based on the existing reports subjoining a few observations which were taken out under the project.

11-1-1 Coal Reserves

Shell estimated minable coal reserves within the said area (North-West Banko, Central Banko and North Suban Jeriji) under some preconditions (for detail turn to 7-1-2), according to the report prepared by Kinhill-Otto Gold Joint Venture in May 1984.

Minable coal reserves estimated by Shell are shown in Table 11-1-1.

The Government of Indonesia was granted a loan by the World Bank and then undertook a programme to assess the coal reserve in South Sumatra coalfield taking over the investigation work carried by Shell as shown in 7.2.

The Government appointed Kihill-Otto Gold Joint Venture to be consulting company to carry out the above mentioned programme.

Kinhill-Otto Gold Joint Venture has been completed feasibility study on North-West Banko and some core drilling holes were driven in Central Banko, North Suban Jeriji and East Suban Jeriji, and they estimated minable coal reserves on North-West Banko area at 560 million tons, making the elevation of the deepest bench in the put deeper from 100 meters (from the surface) to 250 meters, though it is open to discussion, considering from tropical heavy rain and from geotechnical point of view.

Table 11-1-1 Minable Coal Reserves in the Said Area

Area	North-West Banko	Central Banko	North Suban Jeriji
Final pit slope	15°	15°	15°
Coal reserves (million t)	128.5*1	127.5*2	242.0
Waste volume (million M^3)	354.7	-	-
Stripping ratio	2.82 : 1	2.5 : 1*2	2.9 : 1*2

(note) for detail turn to 7-1

(note) *1 coal reserves after considering 85% of safety factor.

(note) *2 geological coal reserves and geological stripping ratio

Coal seams in North-West and Central Banko belong to M_2 (Mangus, Suban and Petai) and coal seam in North Suban Jeriji belongs to M_4 sub-division of Enim formation.

Coal reserves in North-West Banko were estimated based on about 170 of boreholes, therefore, reliability is on rather high level.

However, coal reserves in Central Banko was estimated based on about 70 boreholes, and only 7 boreholes were used to estimated coal reserves in case of North Suban Jeriji, therefore, their reliability is on low level (especially in case of North Suban Jeriji)

Although several boreholes were driven in Central Banko and North Suban Jeriji by the hands of D.O.C, no further progress has been made in the study.

Quite complicated geological conditions will be in the way of making a decision to do more detailed survey and/or exploration work in case of Central Banko, and rather low coal quality will be an obstacle in case of North Suban Jeriji to carry forward the programme (see the following paragraph).

11-1-2 Coal Quality and Heating Value

Proximate and ash component analyses results of each coal seam in the said area by the hands of Shell are shown in Table 7-1-1, Table 7-1-2, and, Table 7-1-3 and the table on page 22, respectively.

Coal samples for coal gasification test obtained in the said area under the project also were analysed by the hands of PPTM at Serpong or the laboratory of their headquarters in Bandung.

The analysis results are shown in Table 7-3-4, Table 7-3-5 and Table 7-3-6.

It may be given as a conclusion based on the above analysis results that coal in North West Banko is superior to coal in another area for steam coal, though sodium oxide contents in ash is rather high.

Discussion on merit and demerit of each coal from the viewpoint of moisture, ash and sulphur contents, calorific value and ash component (especially sodium oxide contents) is given below, though it may be open to the critisism of being too hasty to draw conclusions based on limited number of analysis results.

i) Moisture contents

Among the above mentioned three areas, the highest in moisture contents is North Suban Jeriji, Central Banko is next and North West Banko is the lowest.

Total moisture contents are 23 - 32% in North West Banko, 33 - 38% in Central Banko and 42 - 44% in North Suban Jeriji.

ii) Ash content

Ash contents (dried base) are 2 - 7% in North West Banko, 6 - 17% in Central Banko and 3 - 12% in North Suban Jeriji, North West Banko is the lowest in ash contents.

iii) Total sulphur contents (dried base)

There is not sharp difference in total sulphur contents among the above mentioned three areas, it will be less than 0.7%, expect a certain coal seam in all areas.

iv) Calorific value (net)

Calorific value measurement coal samples under the project also was carried out by the hands of PPTM. The results are as follows:

North West Banko	3027 - 5684 Kcal/kg
Central Banko	3754 - 4307 Kcal/kg
North Suban Jeriji	3502 - 4289 Kcal/kg

It should be estimated that North West Banko is far superior to another and Central Banko comes to North West Banko though so big difference between Central Banko and North Suban Jeriji can not be found.

v) Ash component analysis (especially sodium oxide contents in ash)

It is a common knowledge that high sodium oxide content in coal substance does severe harm to boiler and 7,000 PPM of sodium oxide content in coal is considered a yardstick of permissible limit.

Although high sodium oxide content in coal substance more than the above mentioned yardstick were not observed among the coal samples for coal gasification test (it might be caused by obtaining coal samples at rather shallow depth below the surface) Shell indicated that sodium oxide content in coal substance are quite within the bounds of possibility to cause a severe problems of boiler damage when the pit goes down below 40 meters from the surface in case of North West Banko.

11-1-3 Coal Mining Cost

Coal mining cost within the said areas shall be investigated in detail in the feasibility study which will be carried out in FY1988/89, however, it had been studyed in the interim report III (FY1986/87) preliminaly and estimated at $14.48/ton including depreciation allowance, interest, real estate tax and value added tax to expenses and/or payment generated in Indonesia in case of North-West Banko.

In case of Central Banko the mining cost will be forced to be a little bit higher by the reasons that

i) mining loss will be rather higher under the stress of quite complicated geological conditions

ii) strippling ratio also will be higher by the same reason.

2.9 m^3/ton of geological stripping ratio was estimated by Shell in case of North Suban Jeriji, however it is nothing but geological stripping ratio.

Stripping ratio has a possibility of being higher under more detailed mining planning and it will push mining cost up together with construction and maintenance cost of long distanced entrance road.

11-1-4 Environmental Impact

Influence on botany and animal ecosystem will be unavoidable when big coal surface mines (including Bkit Asam coal mine) develop withing the narrow limited areas around Muara Enim one after another.

Changing water-course of existing river and channel may be needed and careful consideration shall be taken for both mines and inhabitants within the exploited areas.

11-1-5 Overall Evaluation as Energy Resources

Directorate of Coal planned to prepare North West Banko area for coal supply source to Suralaya Power Generation plant No. 3 and No. 4 unit and invited foreign coal mining companies under contractor base for tender to develop and exploit the said area.

However, the matter including Sumatra mine mouth coal field steam power plant and relative transmission line system - including HVDC power transmission system (submarine cable) - was entrusted to the steering committee headed by Prof. Dr. Habibie, the chairman of BPPT, constituted of ministers or chairmans of

BAPENAS
Ministry of Mines and Energy
Ministry of Communication and Transportation
Ministry of Development of Domestic Product
Ministry of Trade

The above mentioned committee also will draw a final conclusion on exploitation of South Sumatra coal field and, East and South Kalimantan coal field which were entered into production sharing contract between PTB (state owned coal corporation) and foreign or indigineous capitals.

North West Banko is superative among the said areas as energy resources from the viewpoint of coal reserves, coal quality, mining cost and accuracy of exploration works.

11-2 EVALUATION OF COAL BASINS AS RAW MATERIAL FOR SYNTHESIS GAS PRODUCTION

11-2-1 Product Gas Amount

Effective components of product gas for synthesis gas are carbon monoxide gas (CO) and hydrogen gas (H_2).

Amount of these effective gas is varied with coal quality.

Fig. 11-2-1 shows the effect of coal quality on the amount of effective product gas.

Among three coals, gasification of N.W. Banko coal gives the biggest amount of effective gas because of the lowest total moisture, the lowest ash content and higher C content in the feed coal.

In case of North Suban Jeriji coal, effective gas volume is the smallest due to the lowest C content in the coal as mined.

11-2-2 Oxygen Consumption

Other important factor on the evaluation of coal basins is the consumption of blowing oxygen for gasifing the coal.

Some coal has higher content of oxygen in the coal and this oxygen reduces the oxygen consumption for gasification.

However, the coal with higher oxygen has usually lower carbon in it and so it produces smaller amount of effective gas.

Fig. 11-2-2 shows the effect of coal quality on the consumption of blowing oxygen.

North S.J. coal with higher oxygen consumes smaller amount of blowing oxygen, but produces smaller amount of effective gas.

On the other hand, N.W. Banko coal shows the opposite tendency to North S.J. coal.

Fig. 11-2-3 shows the blowing oxygen consumption per unit volume of effective gas.

It is indicated that these three coals are nearly same in the oxygen consumption required to produce unit volume of effective gas.

11-2-3 Evaluation of Coal Basins

In order to evaluate coal basins as raw material for synthesis gas production, gas production cost for three Banko coal were calculated basing on the following assumptions:

- Same coal cost as mined.
- Same coal processing capacity
- Same total equipment cost and labor cost
- Same utility consumption for operation
- Gas production cost for N.W. Banko coal is 100 as a basis.
- Material balance in table 8-4-8.

Table 11-2-1 shows the relative production cost per unit volume of effective gas.

The amount of effective gas produced for the gasification of N.W. Banko coal is 1.20 times as much as for C. Banko coal in the as mined coal basis and is 1.38 times as much as for North S.J. coal.

The difference in the amount of effective gas production affects significantly on the gas production cost.

Gas production cost is the cheapest in the gasification of N.W. Banko coal, so that N.W. Banko coal seems to be the most favorable for the synthesis gas production and C. Banko coal follows the next.

Table 11-2-1 Relative Production Cost of Effective Gas

	N.W. Banko	Central Banko	North S.J.
Coal cost	20.0	24.0	27.7
O_2 cost	28.0	27.6	26.7
Scrap cost	1.5	1.5	1.6
Lime cost	0.5	2.3	1.7
Fixed capital cost labor cost Utility cost Interest etc.	50.0	52.4	55.0
Total production cost	100.0	107.8	112.7

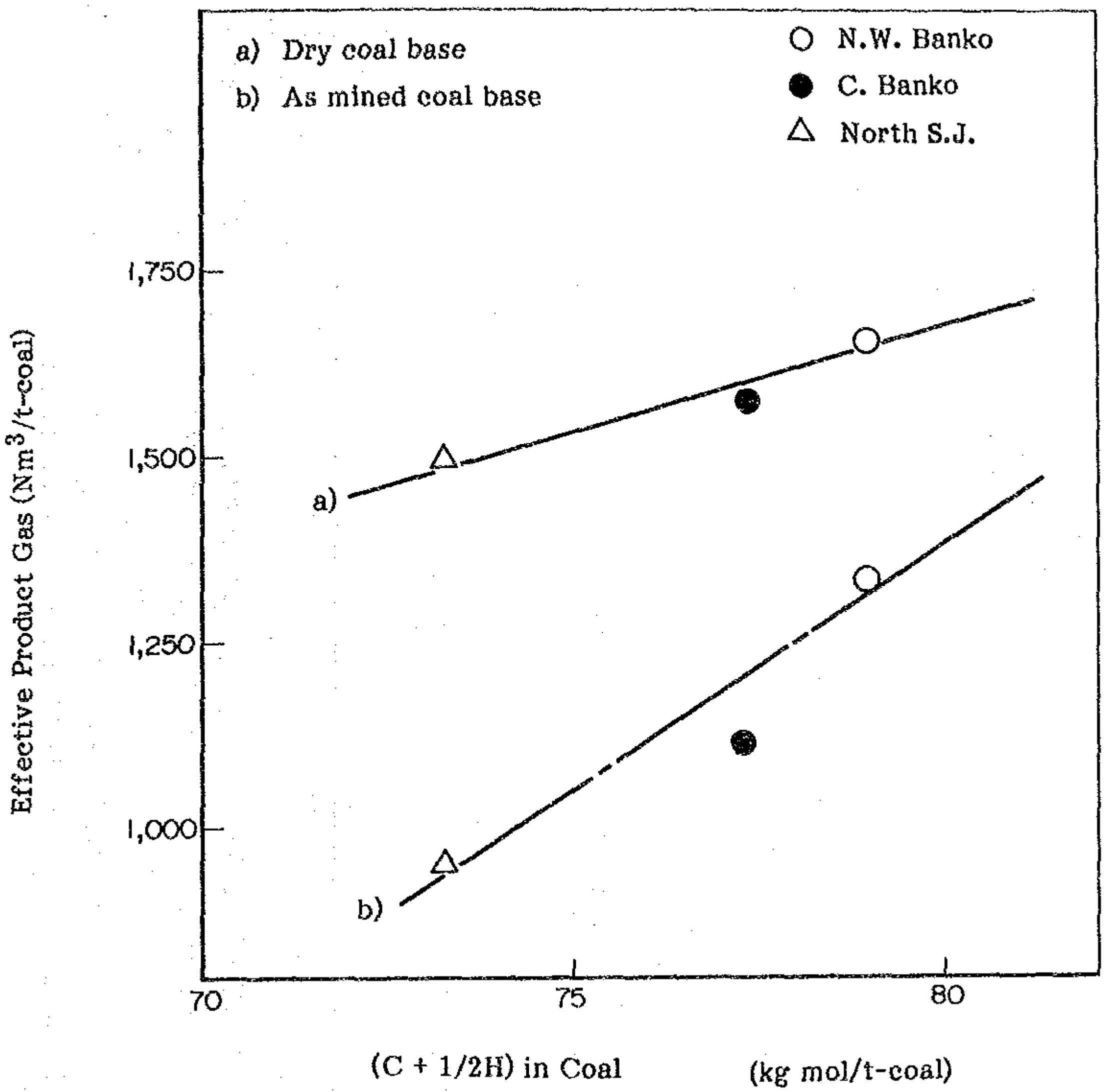


Fig. 11-2-1 Effect of Coal Quality on Effective Product Gas Volume

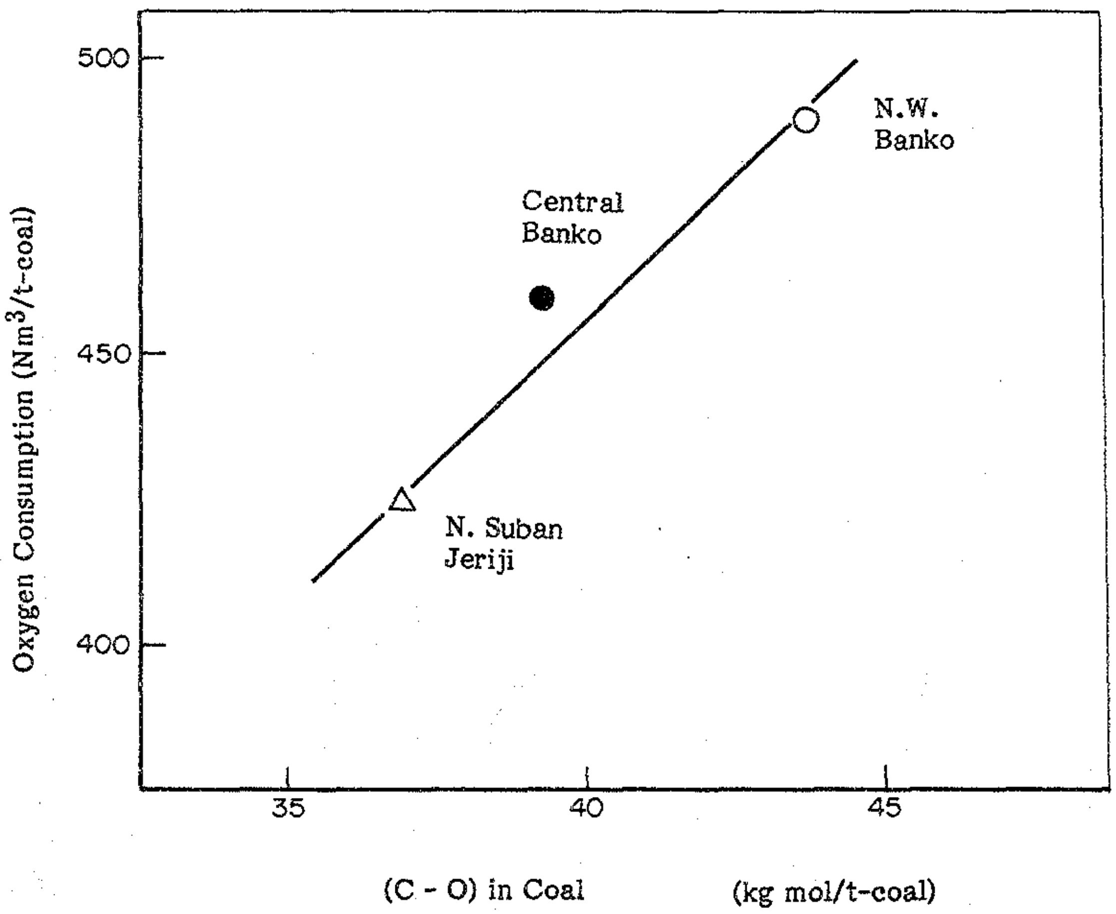


Fig. 11-2-2 Effect of Coal Quality on Oxygen Consumption

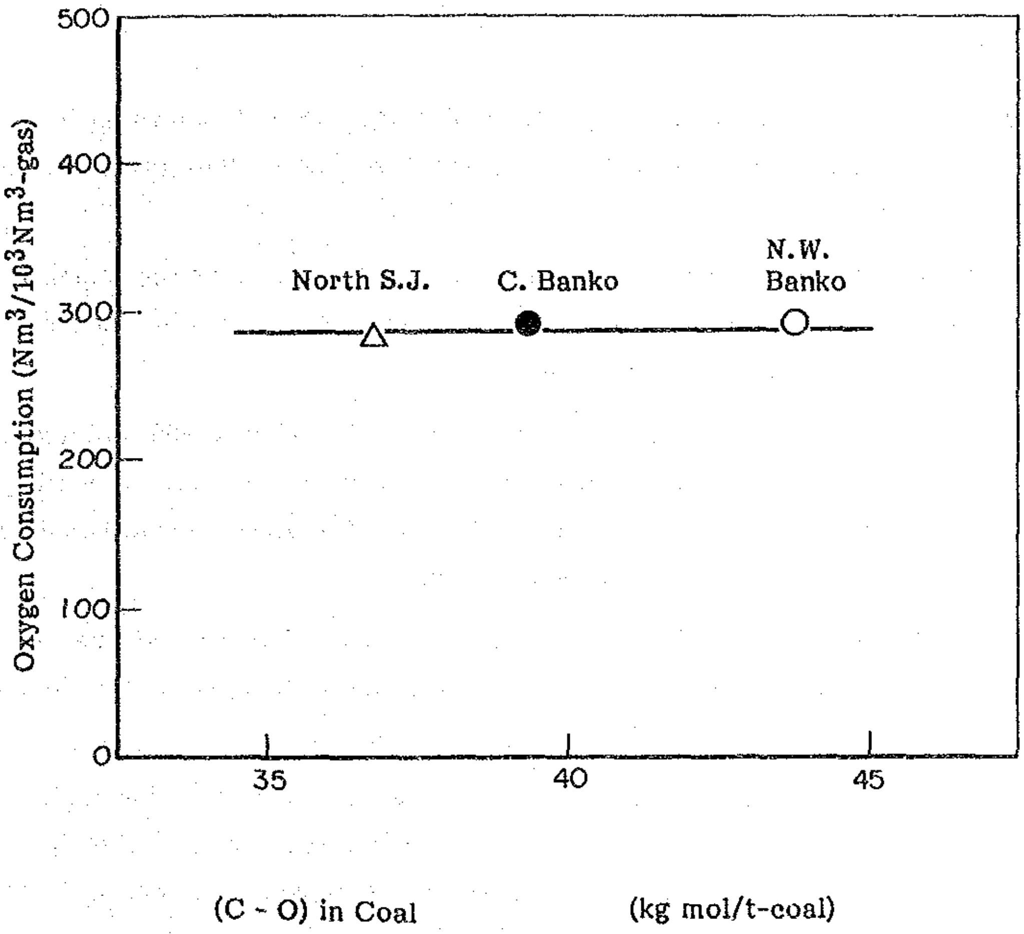


Fig. 11-2-3 Effect of Coal Quality on Oxygen Consumption per Unit Volume of Effective Gas

11-3 REVIEW OF MASTER PLAN

The preliminary Master Plan proposed in the Interim Report (1985), pp. 356-389 has been reviewed.

11-3-1 Basis for Master Plan

(1) Product

Out of the possible chemical products for this project shown in Fig. 11-3-1, Methanol and Urea have been taken up for the Master Plan under the following circumstances.

i) Fuel methanol is the most prospective product in Indonesia, since it can be used as fuel in the form of neat and blending stock to other fuel oil, such as gasoline, kerosene and diesel oil.

ii) Although the previous study in the Interim Report III (1986) pointed out that the economics of urea production were inferior to those of methanol, the Master Plan in the 2nd stage is to hold the case of methanol/urea co-production for revaluation of economics.

iii) Single Cell Protein, Fuel oil by Fischer Tropsch Process and Fuel oil through methanol MTG Process are put aside for the same reasons mentioned in the Interim Report, May 1985, p. 362.

iv) Other products produced directly from synthesis gas or indirectly through methanol, such as ethanol, ethylene, acetic acid, ethylene glycol, or MTBE, are left out of consideration because of rather small demand in Indonesia or premature technologies for producing them.

As for electric power, two cases of the electric power generation method will be considered, i.e., one is so-called CGCC (Coal Gasification Combined Cycle) and the other is fluidized bed combustion boiler.

(2) Plant Capacity

Plant capacity of each unit is selected based on the following;

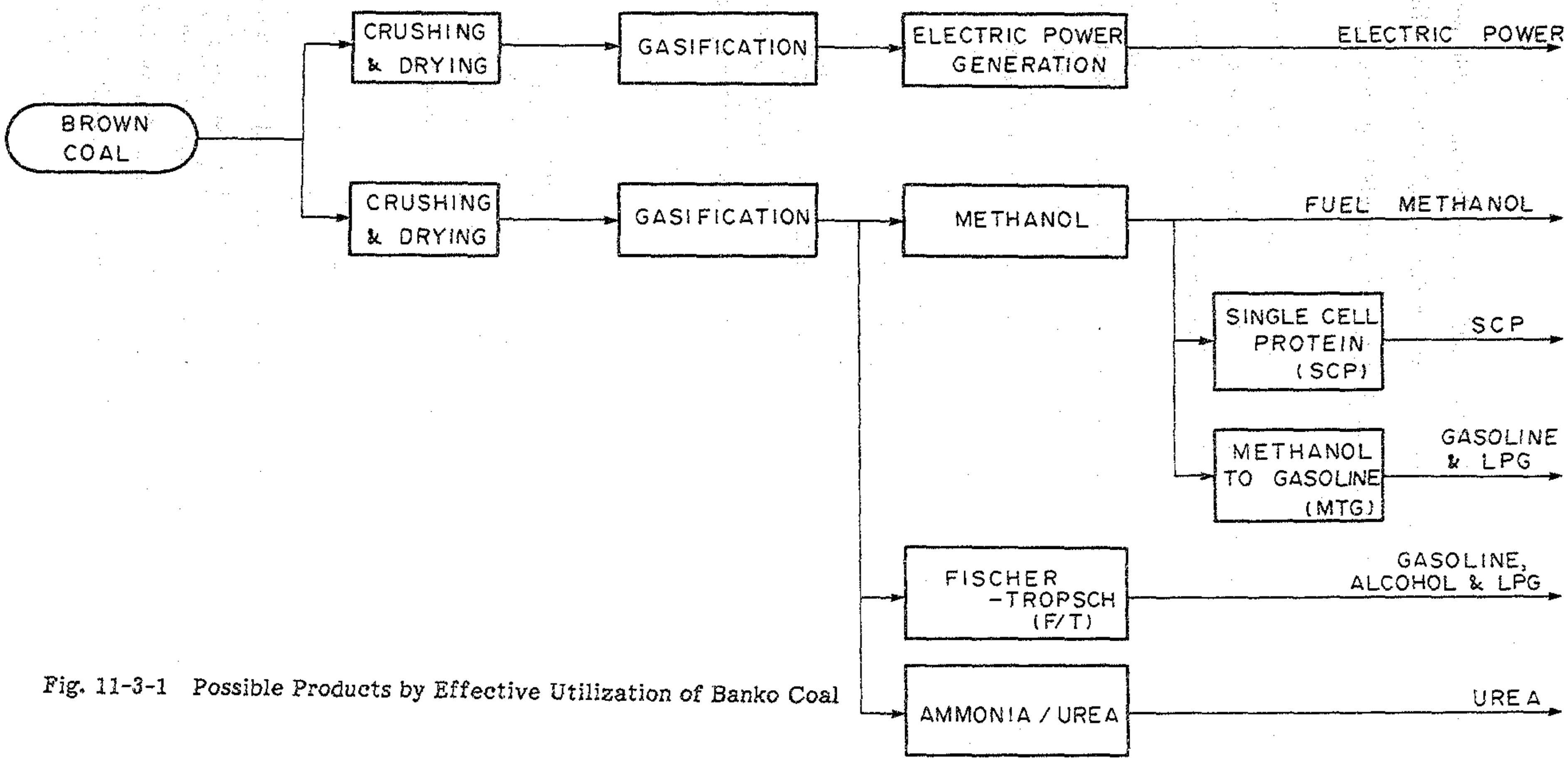


Fig. 11-3-1 Possible Products by Effective Utilization of Banko Coal

i) Coal mining capacity should be about three to six million tons per year, since it is economical capacity even at the earliest stage of the operation.

ii) Plant capacity of derivatives should be commercially proven and good enough for Indonesian Market.

iii) With regard to the capacity of electric power generation plant, only the case of supply to adjacent area to the plants should be considered based on the preliminary economic evaluation described in the Interim Report III (1986), pp. 138-177.

iv) Cooling water requirement should be low enough to be supplied from River Enim or River Lematang in the dry season.

These considerations have led to the plant capacities mentioned below which might be changed after further detailed studies;

i) Coal mining; 4.2 to 4.5 million ton/year
ii) Gasification Plant for derivatives; 537,600 Nm^3/Hr
iii) Fuel Methanol Plant; 5,000 ton/day
iv) Urea Plant; Synthesis gas requirement to be the same as for 5,000 ton/day Methanol Plant, i.e., Methanol 4,060 ton/day + Urea 1,750 ton/day.
v) Electric Power Generation Plant; To be in equal capacity to the power requirement in the plants (the gasification complex).

(3) Mining Area

Since the evaluation of coal basins is under way, the mining area isn't to be specified in this stage and selection should be made in the 3rd stage from N.W. Banko, Central Banko and North Suban Jeriji, although N.W. Banko, and West and Central Banko were proposed as the mining area in the original Master Plan based on old information by Shell.

(4) Design Coal

The coal quality for the Master Plan has been reviewed and is to be left as it is, as listed in Table 11-3-1 throughout the 2nd stage because, in the recent coal analyses, no significant difference from Table 11-3-1 has been seen in carbon to hydrogen ratio in dry basis although lower moisture than 35% has been suggested. For further details on coal analyses, refer to section 7-2.

This design coal will be reviewed and revised in the 3rd stage reflecting further detailed studies in the 2nd stage.

Table 11-3-1 Design Coal

	As received	After drying
Total Moisture	35.0 %	10.0 %
Ash Content	4.84 %	6.7 %
Volatile Matter	32.79 %	45.4 %
Fixed Carbon	27.37 %	37.9 %
Calorific Value-Gross	4,430 Kcal/Kg	6,820 Kcal/Kg
Carbon		70.06 %
Hydrogen		5.67 %
Nitrogen		1.10 %
Oxygen		22.95 %
Sulfur		0.22 %
SiO_2 in ash		33.65 %
CaO in ash		18.45 %
Na_2O in ash		12 %

(5) Plant Site

Three areas, i.e. Tanjung Priok, Desa Muara Enim and N.W. Banko were proposed as the plant site in the original Master Plan. The plant site, however, should be finalized in the 3rd stage with the selection of the mining area.

11-3-2 Case Study for Master Plan

In order to establish the Master Plan, four cases of the preliminary Master Plans have been prepared as per the following.

(1) Derivatives Plant

As discussed in subsection 11-3-1,

i) Fuel Methanol production

ii) Fuel Methanol and Urea production

are taken up out of possible products for the Proposed Project and the following two cases have been set up.

Case 1 is to produce only fuel methanol of which plant capacity is two trains of 2,500 ton per day and can be defined as a base case, since fuel methanol is expected as the most prospective derivatives of coal in Indonesia.

Case 2 is to produce 4,060 ton per day of methanol as well as 1,750 ton per day of urea through ammonia. Since a demand of urea in Indonesia will still grow up, this case is selected. However, a viability of this case will mainly depend on a sales price of urea after a decade and possibility of natural gas supply for a new project in Indonesia, since PUSRI has urea production facilities starting from natural gas in Palembang and there is enough amount of natural gas resources to produce urea but not enough for export.

(2) Electric Power Generation Plant

For the electric power generation plant, two cases are selected for the preliminary Master Plan.

Case A is to generate a required amount of electricity for the gasification complex utilizing CGCC (Coal Gasification Combined Cycle).

Case B covers the same capacity of electric power generation plant as Case A but by utilizing fluidized bed combustion boiler.

Since both of Case A and Case B handle the same capacity, an independent economic evaluation on the electric power generation method has been carried out before entering into the next step for material balance studies. Results for the case of supply to adjacent area are summerized in Table 11-3-2.

Table 11-3-2 Results of Financial Analysis on Power Genration Method (900 MW)

	Case A (CGCC)		Case B (Fluidized Bed Boiler)	
	E-4*	E-1*	E-9**	E-10**
Ex-plant Price of Electricity	64 Rp/kwH (11.55 ¥/kwH)	78 Rp/kwH (14.08 ¥/kwH)	64 Rp/kwH (11.55 ¥/kwH)	78 Rp/kwH (14.08 ¥/kwH)
IRR on Total Investment	13.5%	17.0%	14.0%	17.5%
First Year to Have Profit before Tax (Year from Operation Starts)	3rd	2nd	2nd	1st
Clear off of Accumulated Loss (Year from Operation Starts)	5th	2nd	3rd	1st
Pay off of All the Debts (Year from Loan Raised)	12th	12th	12th	12th
Minimum Sales Price (IRR = Interest Rate)	46 Rp/kwH (8.31 ¥/kwH)		44.7 Rp/kwH (8.08 ¥/kwH)	

Note * ; cited from Interim Report III
** ; cited from ATTACHMENT 11-3

It's turned out from the above mentioned economic evaluation that Case B is slightly advantageous compared with case A. Therefore, fluidized bed combustion boiler is to be selected for the Master Plan. See ATTACHMENT 11-3 for further details.

To summarize, following four cases have been set up and Cases 1-A and 2-A are to be left out of consideration.

Case 1-A	:	Methanol	5,000 T/D
		CGCC	
Case 1-B	:	Methanol	5,000 T/D
		Fluidized bed boiler	
Case 2-A	:	Methanol	4,060 T/D
		Urea	1,750 T/D
		CGCC	
Case 2-B	:	Methanol	4,060 T/D
		Urea	1,750 T/D
		Fluidized bed boiler	

(3) Coal Gasification Plant

Molten Iron Bath Process has been taken up taking the process evaluation made in the 2nd stage into consideration (see section 7-1).

Only one case of the capacity is to be studied on this plant since the required volume of synthesis gas is identical between the two cases.

(4) Material Balance

Material balances for Coal Gasification Complex of Case 1-B and Case 2-B covering Coal Gasification Plant, Derivatives Plant and Electric Power Generation Plant have been estimated and shown in Table 11-3-3 and Table 11-3-4.

Also over-all material balances for these two cases covering Coal Gasification Complex and its infrastructure have been estimated and shown in Table 11-3-5 and Table 11-3-6.

According to these over-all material balances,

a) the annual coal requirement is ranging from 4,230,000 tons to 4,540,000 tons

b) the raw water requirement is 1.0 tons per second at the maximum, against which the dry season discharge of River Enim is estimated at 22.5 tons per second.

Therefore, these two cases seem to be viable from a technical point of view.

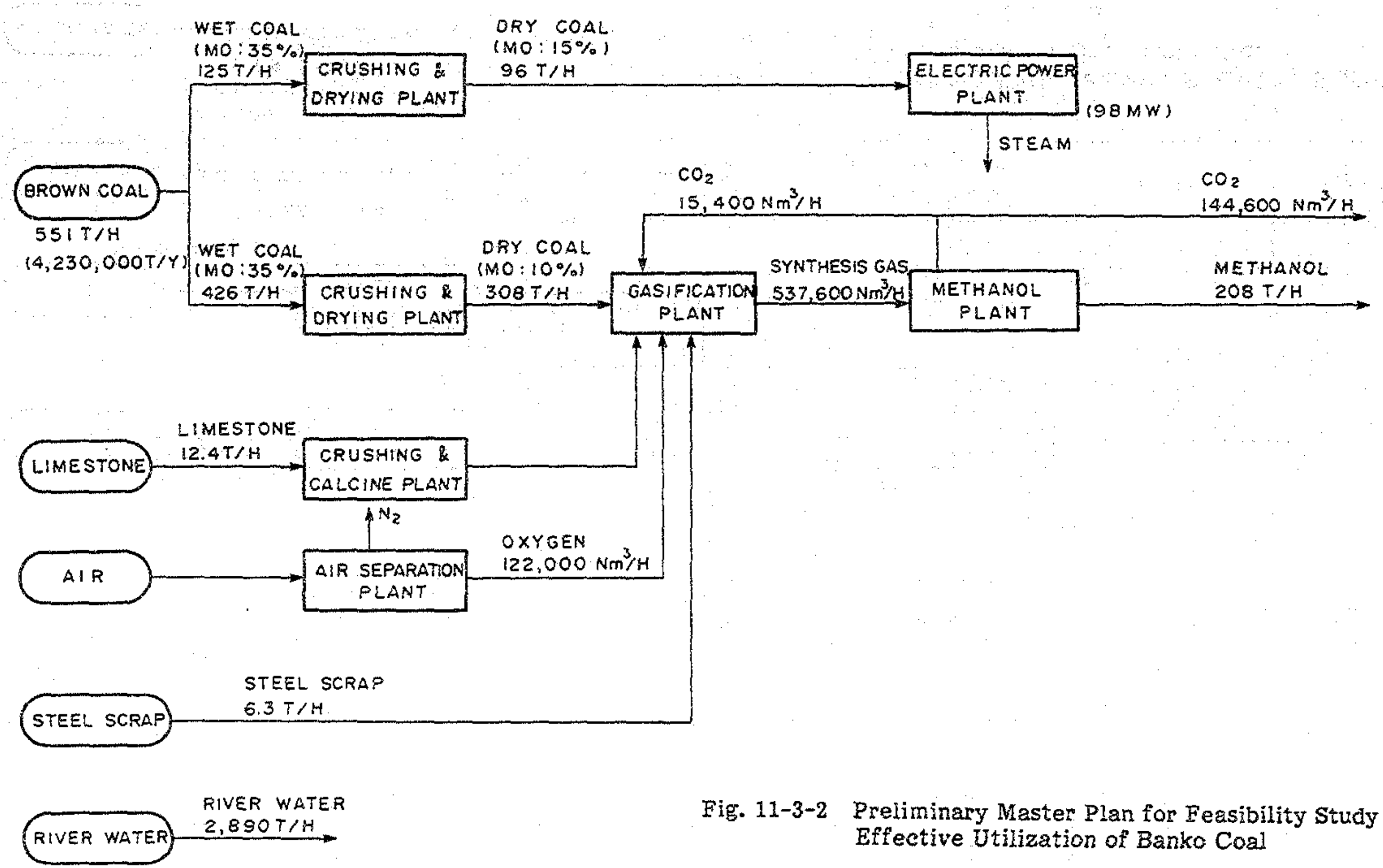


Fig. 11-3-2 Preliminary Master Plan for Feasibility Study on Effective Utilization of Banko Coal

Case 1-B

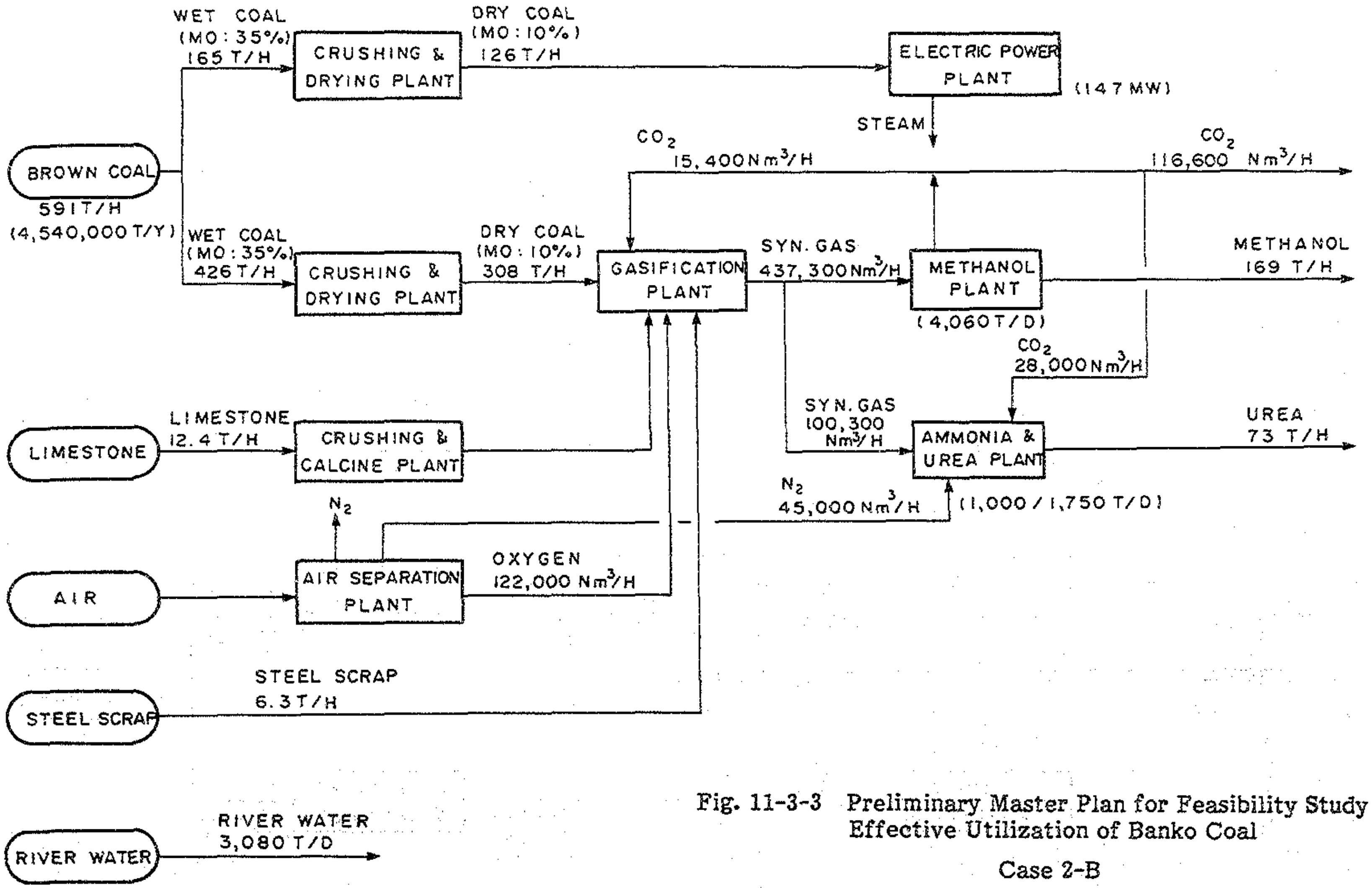


Fig. 11-3-3 Preliminary Master Plan for Feasibility Study on Effective Utilization of Banko Coal

Case 2-B

Table 11-3-3 Coal and Utility Requirement (Methanol Production Complex)

Case No. 1-B Methanol 5,000 T/D
Fluidized Bed Combustion

Coal & Utilities	Conditions	Coal Gasification (Molten Iron)	Methanol & Utility	Electric Power Generation	Total	Remarks
COAL	Moisture: 35%	426 T/H		125 T/H	551 T/H (4,230,000 T/Y)	
ELECTRICITY		9.9 MW	88.0 MW	-97.9 MW	0	
IW		220 T/H	2,620 T/H	50 T/H	2,890 T/H*	* INCL. BFW MAKE-UP 259 T/H CW MAKE-UP 2,070 T/H
CW	32 - 42°C	4,300 T/H	63,900 T/H	920 T/H	69,120 T/H	
BFW		360 T/H	375 T/H	525 T/H	1,260 T/H	
HP STEAM	480°C 65 kg/cm^2G		427 T/H	330 T/H	757 T/H	
MP STEAM	350°C 40 kg/cm^2G		199 T/H	-199 T/H	0	
MP STEAM	250°C 40 kg/cm^2G	-358 T/H	-327 T/H	685 T/H	0	
LP STEAM	156°C 3.5 kg/cm^2G	151 T/H	433 T/H	-584 T/H	0	
STEAM COND.		-151 T/H	-850 T/H	0	-1001 T/H	
FUEL GAS		15.6×10^6 Kcal/H	-30.3×10^6 Kcal/H	14.6×10^6 Kcal/H	0	
LIMESTONE		12.4 T/H		3.8 T/H	16.2 T/H	
IRON SCRAP		6.3 T/H			6.3 T/H	
WASTE WATER	DIRTY	0	-312 T/H	-30 T	-342 T/H	
WASTE WATER	CLEAN	0	-696 T/H	-44 T/H	-740 T/H	
ASH				-8.2 T/H	-8.2 T/H	
SLAG		-30 T/H			-30 T/H	

Table 11-3-4 Coal and Utility Requirement (Methanol and Urea Production Complex)

Case No. 2-B Methanol/Urea 4,060 T/D / 1,750 T/D
Fluidized Bed Combustion

Coal & Utilities	Conditions	Coal Gasification (Molten Iron)	Methanol/Urea & Utility	Electric Power Generation	Total	Remarks
COAL	Moisture: 35%	426 T/H		165 T/H	591 T/H (4,540,000 T/H)	
ELECTRICITY		9.9 MW	137.2 MW	-147.1 MW	0	
IW		220 T/H	2,810 T/H	50 T/H	3,080 T/H*	* INCL.
CW	32 - 42°C	4,300 T/H	59,930 T/H	6,350 T/H	70,580 T/H	BFW MAKE-UP
BFW		360 T/H	310 T/H	622 T/H	1,292 T/H	270 T/H
HP STEAM	480°C 65 kg/cm^2G		397 T/H	646 T/H	1,043 T/H	CW MAKE-UP
MP STEAM	350°C 40 kg/cm^2G		312	-312	0	2,120 T/H
MP STEAM	250°C 40 kg/cm^2G	-358 T/H	-265 T/H	623 T/H	0	
LP STEAM	156°C 3.5 kg/cm^2G	151 T/H	385 T/H	-536 T/H	0	
STEAM COND.		-151 T/H	-833 T/H		-984 T/H	
FUEL GAS		15.6×10^6 Kcal/H	-40×10^6 Kcal/H	24.4×10^6 Kcal/H	0	
LIMESTONE		12.4 T/H		5.0 T/H	17.4 T/H	
IRON SCRAP		6.3 T/H			6.3 T/H	
WASTE WATER	DIRTY		-293 T/H	-42 T/H	-335 T/H	
WASTE WATER	CLEAN		-715 T/H	-44 T/H	-759 T/H	
ASH				-10.8 T/H	-10.8 T/H	
SLAG		-30 T/H			-30 T/H	

Table 11-3-5 Coal and Utility Requirement (Over-all)

Case No. 1-B — Methanol 5,000 T/D, Fluidized Bed Combustion

Coal and Utilities	Conditions	Coal Mining	Gasification Complex	Infrastructure	Total	Remarks
COAL (WET)	Moisture: 35%	-551 T/H	551 T/H		0	(4,230,000 T/Y)
METHANOL		8 T/H	-208 T/H		-200 T/H	(1,600,000 T/Y)
ELECTRICITY		25 MW	0	20 MW	45 MW	
IW		500 T/H	2,890 T/H	90 T/H*	3,359 T/H	* FOR POTABLE WATER
CW	32 - 42°C				0	
BFW					0	
HP STEAM	480°C 65 kg/cm^2G				0	
MP STEAM	350°C 40 kg/cm^2G				0	
MP STEAM	250°C 40 kg/cm^2G				0	
LP STEAM	156°C 3.5 kg/cm^2G				0	
STEAM COND.					0	
FUEL GAS					0	
LIMESTONE			16.2 T/H		16.2 T/H	
IRON SCRAP			6.3 T/H		6.3 T/H	
WASTE WATER	DIRTY		-342 T/H		-342 T/H	
WASTE WATER	CLEAN		-740 T/H		-740 T/H	
ASH			-8.2 T/H		-8.2 T/H	
SLAG			-30 T/H		-30 T/H	
OVERBURDEN		-3,900 m^3/H			-3,900 m^3/H	(11.7 x 10^6 m^3/Y)

Table 11-3-6 Coal and Utility Requirement (Over-all)

Case No. 2-B Methanol/Urea 4,060 T/H / 1,750 T/D
Fluidized Bed Combustion

Coal and Utilities	Conditions	Coal Mining	Gasification Complex	Infrastructure	Total	Remarks
COAL (WET)	Moisture: 35%	-591 T/H	591 T/H		0	(4,540,000 T/Y)
UREA			-73 T/H		-73 T/H	(560,000 T/Y)
METHANOL		8 T/H	-169 T/H		-161 T/H	(1,300,000 T/Y)
ELECTRICITY		25 MW	0	20 MW	45 MW	
IW		500 T/H	3,080 T/H	90 T/H*	3,670 T/H	* FOR POTABLE WATER
CW	32 - 42°C				0	
BFW					0	
HP STEAM	480°C 65 kg/cm²G				0	
MP STEAM	350°C 40 kg/cm²G				0	
MP STEAM	250°C 40 kg/cm²G				0	
LP STEAM	156°C 3.5 kg/cm²G				0	
STEAM COND.					0	
FUEL GAS					0	
LIMESTONE			17.4 T/H		17.4 T/H	
IRON SCRAP			6.3 T/H		6.3 T/H	
WASTE WATER	DIRTY		-335 T/H		-335 T/H	
WASTE WATER	CLEAN		-759 T/H		-759 T/H	
ASH			-10.8 T/H		-10.8 T/H	
SLAG			-30 T/H		-30 T/H	
OVERBURDEN		-4,100 m^3/H			-4,100 m^3/H	(12.5 x 10^6 m^3/Y)