FEASIBILITY STUDY REPORT
ON
UTILIZATION OF SMALL-SCALE NATURAL GAS
IN
JAMBI PROVINCE
THE REPUBLIC OF INDONESIA
(SUMMARY)

NOVEMBER, 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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1. OUTLINE OF STUDY

1-1 Background of Study

The government of the Republic of Indonesia has been executing its national policy by issuing five-year national development programs, in order to develop and enhance the overall economy of the country.
The current five-year plan has placed stress on, among others;

(1) Balanced economic development, focusing on development of rural regions for increasing food products for coping with increase of population.

(2) Fair distribution of wealth by creating employment opportunities.

(3) National stability through promotion of economic growth, especially in regions where development is below the average of the Republic, by means of transmigration from highly populated areas.

Jambi Province, located in the central part of the Island of Sumatra, is one of the regions where social and industrial infrastructures are still to be developed, in comparison with other parts of the Republic. About 30% of its economy is dependent on agriculture including forestry and fisheries. However, Jambi Province is gifted with unused natural resources such as oil, natural gas and coal and its population is growing by a rapid rate, partially attributed to transmigration from the Island of Java. Taking these promising factors into consideration and by effective utilization of natural and human resources, Jambi Province is expected to develop greatly in the future.

Under these circumstances, the government of the Republic of Indonesia requested the government of Japan to conduct a feasibility study on the subject of promoting regional development by utilization of unused small-scale natural gas in Jambi Province.

In response to this official request from the government, Japan International Cooperation Agency dispatched Preliminary Survey Team consisted of JICA officials and experts of each field to the Republic of Indonesia in September, 1987. The Team had a series of discussions about details for the implementation of the Feasibility Study with the Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknologi; BPPT), the Counterpart of the Indonesian Government. The team agreed upon and signed with the Indonesian Counterpart the Scope of Work which defined the contents and conditions of implementation of the Feasibility Study.
This Feasibility Study has been prepared in accordance with the Scope of Work.
The objectives of the Feasibility Study are the following two projects.

(1) To improve electrification rate of Jambi City and surrounding areas, 50% at present, by constructing a power plant using natural gas as fuel.

(2) To supply LPG to the adjacent areas for household use and industrial and commercial use by separating LPG fraction contained in the natural gas.

1-2 Purpose of Study

The purpose of the study is to investigate technical, financial and economic feasibility of the project for power generation and LPG recovery, by utilizing small-scale natural gas to be produced in Sengeti gas field, the vicinity of Jambi City and to consolidate all results of findings and the assessment into the Feasibility Study Report.
If the project is proved viable, it can be applied as a development model for the utilization of gas produced from small-scale natural gas fields in various other regions of the Indonesian Archipelago where similar small-scale gas fields have been confirmed.

1-3 Scope of Study

The Feasibility Study will study and analyze the following subjects:

(1) Background Study of Project

- (A) Study of the social and economic circumstances of Jambi Province.
- (B) Study of the regional development plan of Jambi Province.

(2) Market Study

- (A) Study and forecast of supply and demand of electricity and LPG in Jambi Province.
- (B) Study of prices, sales and distribution system of electricity and LPG.

(3) Technical Study

- (A) Confirmation of volume of reservoirs and compositions of gas.
- (B) Technical study of power generation system using natural gas.
- (C) Study of LPG recovery process.
- (D) Technical study of the treatment and transportation of natural gas.
- (E) Survey of the candidate site for plant construction.

(4) Conceptual Design of Project

- (A) Determination of the generation method, the specification and the candidate site for the power plant.
- (B) Determination of the process, the specification and the candidate site for LPG Recovery Plant.
- (C) Determination of the route of the natural gas transmission pipeline and the specification of the pretreating facilities.

(D) Determination of the specification for the power transmission and distribution facilities.

(E) Determination of the specification for the necessary auxiliary facilities.

(5) Implementation Plan

(A) Preparation of implementation program of construction.

(B) Preparation of implementation program of operation.

(C) Estimation of the total investment cost.

(6) Financial and economic analysis

2. THE CURRENT CONDITIONS OF JAMBI PROVINCE

2-1 Outline of Jambi Province

Jambi Province is located near the middle of the Island of Sumatra and has an area of approximately 53,400 square km. The total population is approximately 1.8 million as of 1986.

Since Jambi Province is designated as a preferential province for transmigration from overpopulated areas, the population increase rate was 3.7% per year, compared to the Indonesian average of 2.3% per year. The climate is tropical and humid. The annual rainfall is 2,000 to 2,800 mm. The dry season is from May through October and the rainy season is November through April.

2-2 The Economy of Jambi Province

As shown in Table 2-1, Configuration of Jambi Province's GRDP (Gross Regional Development Products) by sector, the economy of Jambi Province is heavily dependent on agriculture (including forestry and fisheries), accounting for a high GRDP percentage of 30%. But its dependent ratio is declining gradually.

On the other hand, manufacturing in this region is restricted to things made from agricultural products such as gum processing and plywood board and thus the contribution ratio of manufacturing to GRDP, 10.7%, is lower than the national average (12.6%). However, its increase rate is as high as the average of 15.1% per year for the period from 1983 to 1986.

Table 2-1 Configuration of Jambi Province GRDP by Sector

Industrial Sector	1983	1984	1985	1986
1. Agriculture	32.14%	31.85%	30.51%	29.96%
2. Mining & Quarrying	13.48	13.41	13.70	13.50
3. Manufacturing	9.38	10.18	10.73	11.98
4. Electricity & Water Supply	0.50	0.50	0.54	0.57
5. Construction	2.46	2.38	2.25	2.18
6. Trade, Restaurant & Hotel	16.41	16.80	16.44	16.17
7. Transport & Communication	8.27	7.78	7.44	7.67
8. Banking & Financial Service	6.38	6.35	6.39	5.86
9. Others	10.98	10.70	12.00	12.11
Total	100.00	100.00	100.00	100.00

(Source: Statistical Office Jambi Province)

2-3 Regional Development Plan of Jambi Province

Jambi Province's development goals are:

(A) The improvement of the standard of living for residents.
(B) The transformation of the economy from the traditional structure into a modernized structure. The development of various industries is especially prioritized. In order to aid these industry-promotion programs, societal resources such as roads, harbors, bridges, communications and electricity are being improved.

2-4 The Energy Situation of Jambi Province

The primary energy being consumed in Jambi Province is 55% for petroleum-related energy and 45% for wood-related energy. The ratio of the petroleum-related energy is gradually increasing.
The government of Indonesia launched a policy to save petroleum-related energy which is the major source of acquisition of foreign currencies. In response to the policy, the provincial government of Jambi commences investigating the possibility of use of hydro-power and geothermal energy as alternative energy in addition to the effective use of coal and natural gas.

3. MARKET STUDY

3-1 Study of Electricity Supply and Demand

A study was made for the electricity supply and demand of the entire Jambi Province and also of Jambi City and surrounding areas for which this project is aimed.
The following are summaries of findings from the study.

(1) Electricity supply and demand of Jambi Province

- Electricity for Jambi Province is supplied by the Jambi branch office of PLN, Indonesia's National Utility Corporation.

- One power transmission and distribution system does not cover the entire Jambi Province, instead several independent diesel power plants are installed to supply electricity to isolated areas.

- Jambi Province has 380,000 households in the fiscal year of 1986 and only 9% of these households are electrified.

- 85% of the electricity supply and demand of Jambi Province are concentrated in Jambi City and surrounding areas.

(2) Electricity Supply and Demand of Jambi City and Surrounding Area

- 49% of 55,000 households in Jambi City and surrounding areas are electrified.

- Three power plants, Pasar, Kasang, Payo Selincah, are installed in Jambi City. Since Pasar, the oldest of these plants, is out of operation, the total installed capacity of the two Kasang and Payo Selincah plants was 41 MW in 1987 and the total available capacity deducting capacity decrease due to age deterioration was 37 MW.

- The break-down by sector of the approximately 48.7 GWh of electricity consumed in 1986 is: residential sector, 49.8%; commercial sector, 12.6%; public and other sector, 11.9%; industrial sector, 25.6%. As it is clear from the past trends shown in Table 3-1, the electricity demand of the industrial sector displays remarkable growth.

- Factories located in areas, where the supply of electricity is not reliable have their own generating units. Many of them are expected to become PLN consumers as PLN electrification program is improved.

Table 3-1 Past Population and Electricity Consumption by Sector of Jambi City and Surrounding Areas

Fiscal Year	1982	1983	1984	1985	1986	Average*	Average**
Residential Sector							
Population	230,986	241,435	249,189	249,450	284,036	-	-
Growth Rate (%)	-1.63	4.52	3.21	0.10	13.86	5.30	4.01
No. of Household	N.A.	N.A.	N.A.	48,721	54,615	-	-
Household Size	N.A.	N.A.	N.A.	5.12	5.20	-	5.16
No. of Consumers	13,121	16,394	19,688	24,881	26,689	-	-
Growth Rate (%)	N.A.	24.94	20.09	26.38	7.27	19.42	19.67
Electr. Ratio (%)	N.A.	N.A.	N.A.	51.07	48.87	-	49.97
Unit Consump.(KWh)	1,242.2	1,178.6	1,024.7	936.6	908.6	-	-
Energy Consump.(GWh)	16.30	19.32	20.17	23.30	24.25	-	-
Growth Rate (%)	N.A.	18.55	4.41	15.52	4.05	10.44	10.63
Commercial Sector							
No. of Consumers	1,930	2,081	2,259	2,647	2,506	-	-
Growth Rate (%)	N.A.	7.82	8.55	17.18	-5.33	6.75	7.06
Energy Consump.(GWh)	4.86	5.74	5.91	6.24	6.15	-	-
Growth Rate (%)	N.A.	18.21	3.02	5.52	-1.48	6.07	6.32
Constituent Ratio	N.A.	0.98	0.68	0.36	-0.37	0.58	0.59
Public & Other Sector							
No. of Consumers	508	615	690	878	815	-	-
Growth Rate (%)	N.A.	21.06	12.20	27.25	-7.18	12.54	13.33
Energy Consump.(GWh)	4.34	4.48	5.06	6.04	5.79	-	-
Growth Rate (%)	N.A.	3.06	13.15	19.28	-4.13	7.46	7.84
Constituent Ratio	N.A.	0.16	2.98	1.24	-1.02	0.71	0.74
Industrial Sector							
No. of Consumers	120	127	104	111	102	-	-
Growth Rate (%)	N.A.	5.83	-18.11	6.73	-8.11	-3.98	-3.41
Energy Consump.(GWh)	3.59	3.67	5.77	9.84	12.48	-	-
Growth Rate (%)	N.A.	2.40	57.19	70.50	26.83	36.59	39.23
Total							
No. of Consumers	15,679	19,217	22,741	28,517	30,112	-	-
Growth Rate (%)	N.A.	22.57	18.34	25.40	5.59	17.72	17.97
Energy Consump.(GWh)	29.08	33.21	36.92	45.43	48.67	-	-
Growth Rate (%)	N.A.	14.19	11.18	23.03	7.14	13.74	13.88

Note : * Exponential average
** Arithmetical average

Source : PLN Wilayah IV Cabang Jambi
Kantor Statistik Propinsi Jambi

. PLN Head Office (Pusat) and Region IV (Wilayah IV) have their own electricity demand forecasts (peak load) of this area by accumulating the demand forecast values of each sector.

. In this study, the electricity demand forecast is made after various indices in two forecasts, one compiled by the head office and one by the region IV, are reviewed.
The results are shown in Figure 3-1.

. Comparing the forecasted demand of electricity with the total capacity of power plants, adding a new plant capacity of 10 MW to be constructed in 1992 to those of the existing plants, the construction of a power plant of 20 MW output range will be necessary by the end of the fiscal 1994 (Figure 3-2).

. Even though this project is implemented, it would be necessary to construct another some 20 MW scale power plant around fiscal 1998.

3-2 Electricity Tariff

The electricity tariff is controlled by the Directorate of General Electricity and New Energy of Ministry of Mine and Energy, and a standardized electricity tariff policy is employed throughout Indonesia.

Tariff schedule of electricity of 1986 is shown Table 3-2.

. Sales revenue, amount of sold electricity and averaged unit prices for the last several years are shown in Table 3-3.

3-3 LPG Demand Study

. LPG in Indonesia is used as an alternative fuel of kerosene and its demand is rapidly increasing as a fuel for household use.

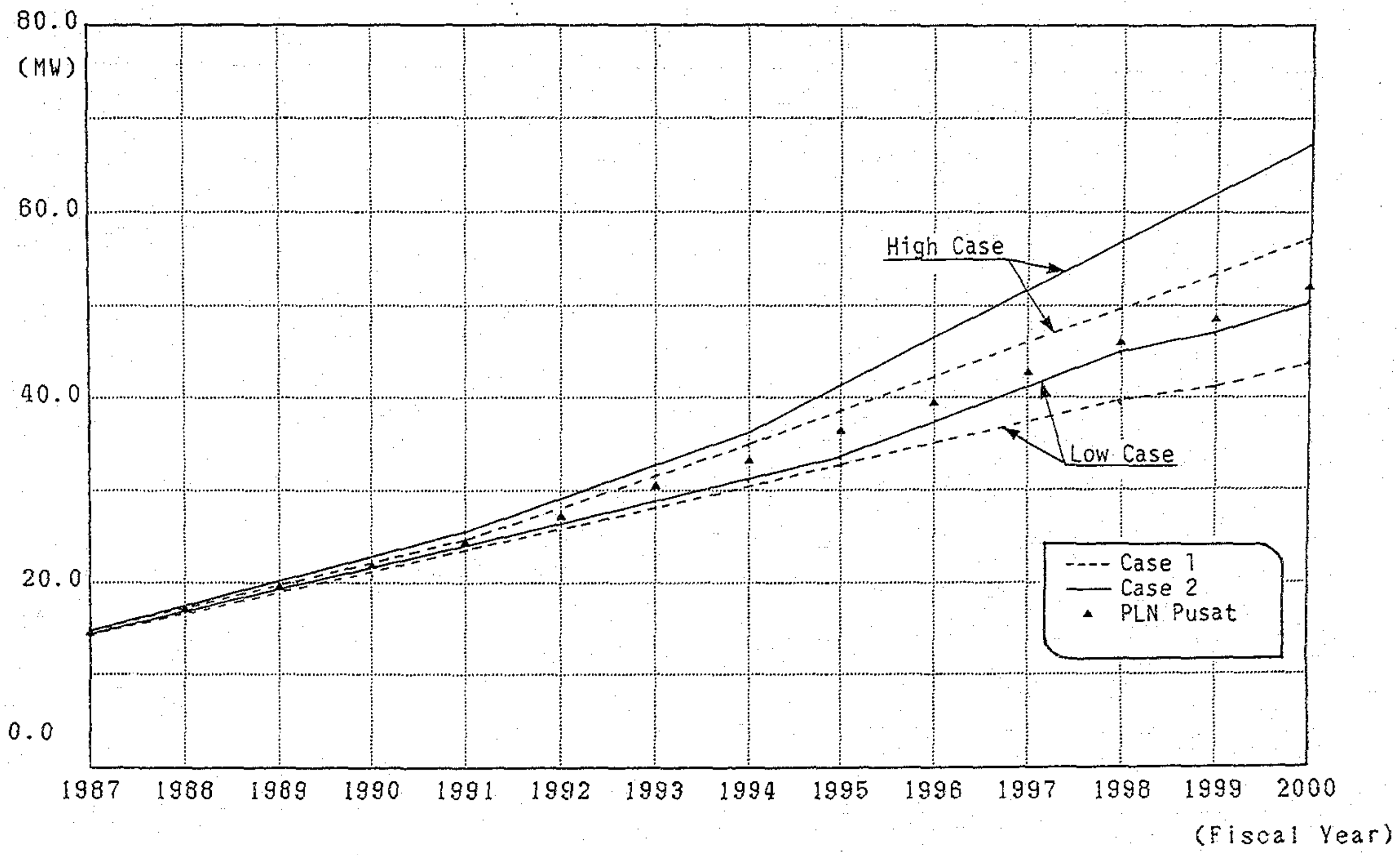


Figure 3-1 Electricity Demand (Peak Load) Forecast of Jambi City and Surrounding Area

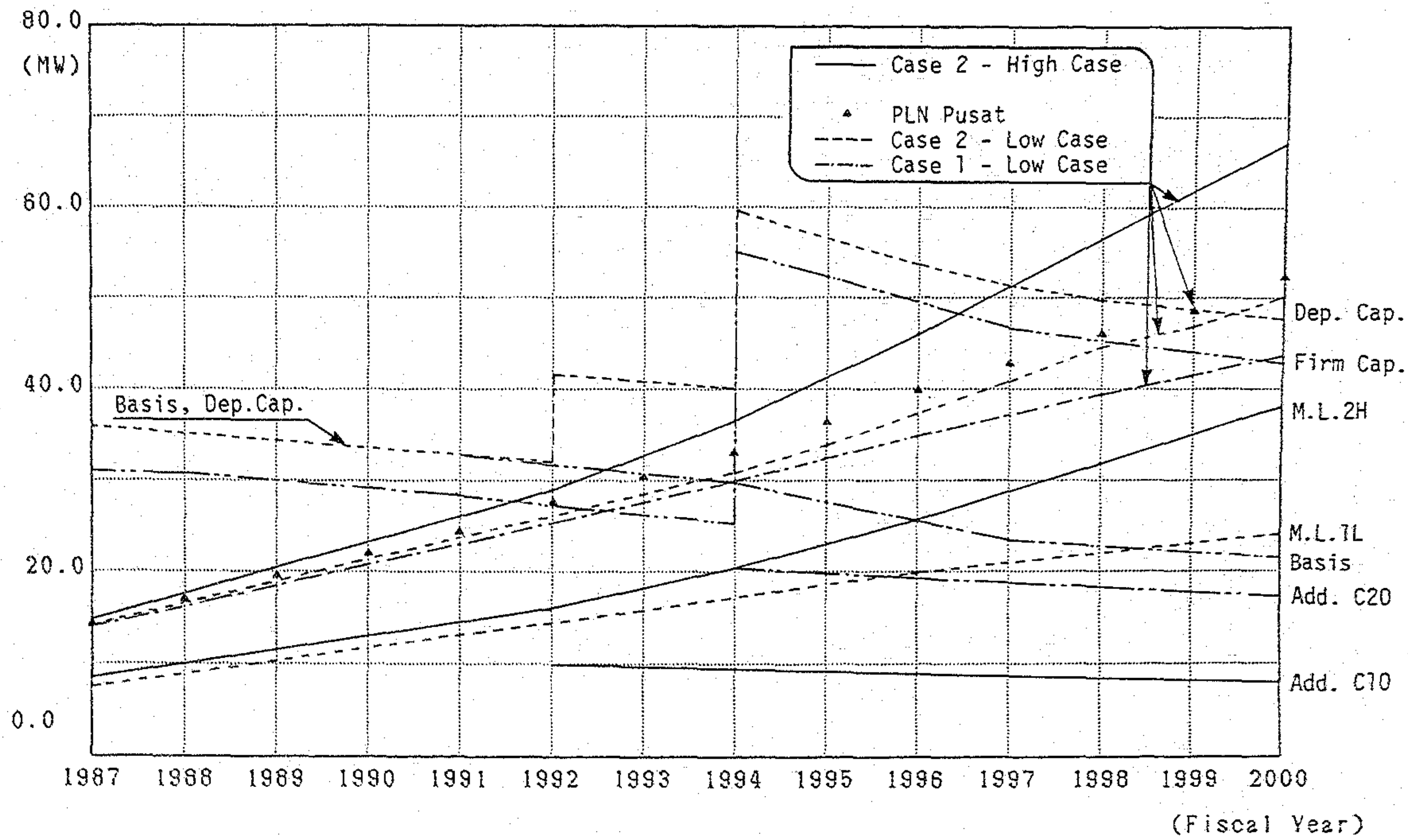


Figure 3-2 Electric Power Supply and Demand Balance Forecast of Jambi City and Surrounding Areas

Table 3-2 Tariff Schedule of Electricity (1986)

No.	Code of Tariff	Contracted Power	Demand Charge	Consumption Charge (Rp/kWh)	Additional Charge (Rp/kWh)
1	S_1	to 200 VA	*)	-	N.A.
2	S_2	250 VA to 200 kVA	2,100	43.50	N.A.
3	R_1	250 VA to 500 VA	2,100	70.50	N.A.
4	R_2	501 VA to 2,200 VA	2,100	84.50	N.A.
5	R_3	2,201 VA to 6,600 VA	3,680	126.50	N.A.
6	R_4	6,601 VA & Over	3,680	158.00	N.A.
7	U_1	250 VA to 2,200 VA	3,680	134.00	N.A.
8	U_2	2,201 VA to 200 kVA	3,680	150.00	N.A.
9	U_3	201 kVA & Over	2,300	WBP=158.00 LWBP= 99.00	N.A.
10	U_4	-	-	307.00	N.A.
11	I_1	Up to 99 kVA	2,300	WBP= 97.50 LWBP= 60.50	N.A.
12	I_2	100 kVA to 200 kVA	2,300	WBP= 92.50 LWBP= 57.50	N.A.
13	I_3	201 kVA & Over	2,100	WBP= 90.50 LWBP= 56.00	N.A.
14	I_4	5,000 kVA & Over	1,970	WBP= 77.00 LWBP= 48.50	N.A.
15	G_1	250 VA to 200 kVA	3,680	96.00	N.A.
16	G_2	201 kVA & Over	1,970	WBP= 99.00 LWBP= 65.00	N.A.
17	J	-	-	76.50	N.A.

Source: Directorate of General Electricity & New Energy

Note: *) Tariff Subscription

	(Rp/Month)
60 VA :	1,550
75 VA :	1,940
100 VA :	2,510
125 VA :	3,200
150 VA :	3,765
175 VA :	4,350
200 VA :	5,025

WBP : Peak Load Hours (18.00 - 22.00 Local time)
LWBP: Off Peak Load Hours (22.00 - 18.00 Local time)

- Petroleum and natural gas in Indonesia are developed, refined and sold solely by PERTAMINA and the supply of LPG in Jambi Province is controlled by the domestic sales department of PERTAMINA.

- Since an LPG production facility does not exist in Jambi Province at present, LPG filled in cylinders is transported there from PERTAMINA's LPG supply center of Palembang in South Sumatra Province. LPG cylinders are delivered to customers by LPG sales agents designated by PERTAMINA.

Table 3-3 Sales Revenue, Sold Electricity and Averaged Unit Price of Electricity of Jambi City and Surrounding Areas

Fiscal Year	Sales Revenue (Rp)	Sold Electricity (kWh)	Averaged Unit Price of Electricity (Rp/kWh)
1981	1,251,696,458	23,579,681	53.1
1982	1,879,796,694	27,153,211	69.2
1983	2,873,991,627	31,101,520	92.4
1984	4,083,777,680	34,666,024	117.8
1985	4,839,624,302	42,456,783	114.0
1986	5,335,834,965	48,689,018	109.6
1987*	5,191,469,630	50,015,649	103.8

Source: PLN Wilayah IV Cabang Jambi

Note: * These figures are the sum total of the figures from April to December.

. The supply of LPG in Jambi Province was started in 1984 and full-scale supply of LPG was commenced in 1986.

. LPG demand increased remarkably in Jambi Province as shown in Table 3-4, however a slow down of the increase of LPG demand is forecasted for the future.

. LPG consumption in Jambi Province in 1987 was 57.7 tons per month in average and 80% of the consumption was in Jambi City. Of the total consumption, 85% was for household use and 15% was for industrial and other use.

. In this market study, the LPG demand forecast for Jambi Province is made for the household use and the industrial and other use. The mian points of the results are shown in Figure 3-3. Since the forecast is based upon limited data, the maximum case and the minimum case for household use differ greatly and the middle case is considered most probable.

Therefore, the LPG demands in 1995 and 2000 are forecasted as follows:

1995	1,540 tons/year (128 tons/month)
2000	2,640 tons/year (220 tons/month)

Table 3-4 Sales Record of LPG in Jambi Province

	11 kg Cylinder (Cylinders)	Sub Total (t)	45 kg Cylinder (Cylinders)	Sub Total (t)	Total (t)	
1986 Jan. - Sep.*	11,943	155.259			N.A.	
Oct. - Dec.	11,022	121.242	937**	42.165**	N.A.	Average
Total	22,965	276.501	937	42.165	318.666	26.56 (t/mon)
1987 Jan.	4,443	48.873	138	6.210	55.083	
Feb.	3,760	41.360	165	7.425	48.785	
Mar.	3,998	43.978	150	6.750	50.728	
Apr.	5,355	58.905	170	7.650	66.555	
May	4,096	45.056	165	7.425	52.481	
Jun.	4,704	51.744	170	7.650	59.394	
Jul.	4,903	53.933	175	7.875	61.808	
Aug.	3,840	42.240	180	8.100	50.340	
Sep.	4,868	53.548	195	8.775	62.323	
Oct.	4,750	52.250	220	9.900	62.150	
Nov.	4,175	45.925	220	9.900	55.825	
Dec.	5,221	57.431	214	9.630	67.061	Average
Total	54,113	595.243	2,162	97.290	692.533	57.71 (t/mon)

Source: PERTAMINA, PDN, Jambi

Note: * These figures are of 13 kg cylinders.

** These figures are for the total year of 1986.

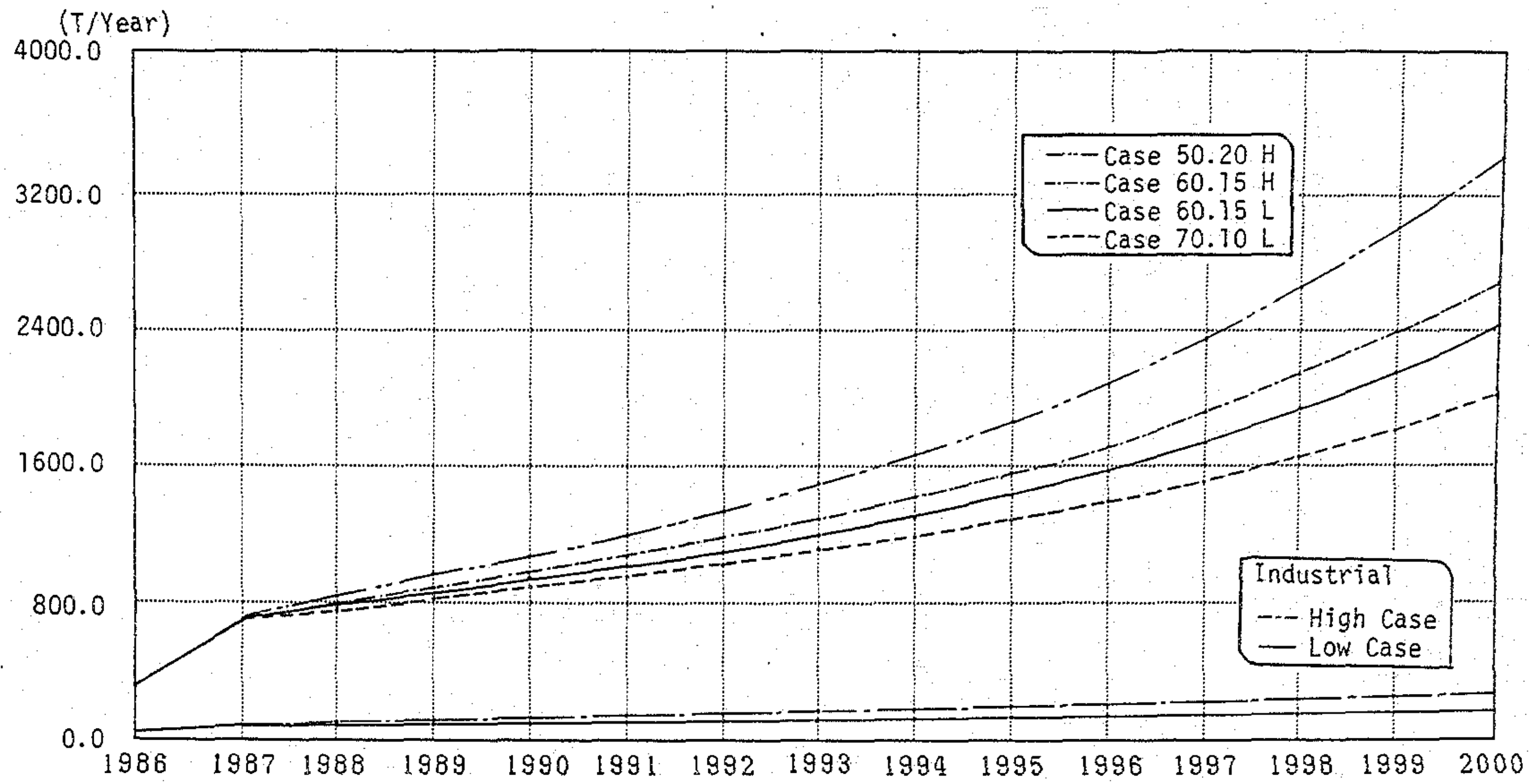


Figure 3-3 Summary of LPG Demand Forecast of Jambi Province

3-4 Price of LPG

. The domestic price of LPG, like other petroleum products, is a standardized price across the country controlled by the government.

Table 3-5 shows LPG sales price prevailed in February, 1988.

Table 3-5 LPG* Price by Point of Sales up to LPG Consumers in Jambi Province (As of February, 1988)

Point of Sales	Sales Price	Unit Price (Rp/kg)
Ex-Refinery	120 US$/T (1 US$ = 1,665 Rp)	199.80
PERTAMINA's Depot in Jambi City	5,515.07 Rp** for 11 kg Cylinder	501.37**
	22,561.65 Rp** for 45 kg Cylinder	501.37**
Dealers in Jambi Province	6,500 Rp for 11 kg Cylinder	590.91***
	26,550 Rp for 45 kg Cylinder	590.00***

Source: PERTAMINA, PDN, Jakarta

Note: * Propane & butane mixture
** Including transportation cost and 10% sales tax
*** This figure is subject to change when the distribution distance exceeds 60 km.

4. NATURAL GAS PRODUCTION

Oil and gas were produced in Sengeti from 1979 to 1982, but production has ceased at present. The gas reservoir in Sengeti is the sole gas source for this project. Therefore, the reserved volume of gas, gas production forecast and gas compositions are crucial factors to the feasibility of the project. The following are results of the study of gas reservoir. However, since the detailed data on underground resources are to confidential for PERTAMINA, sufficient data for project implementation were not made available. Therefore, the technical review of fundamental factors for this study are based on assumptions derived from sound engineering judgment.

4-1 Gas Reservoir

Many faults and unconformities are observed in the geological structure of the South Sumatra Sedimentary Basin where Sengeti field belongs, and a number of oil and gas fields of comparatively small scale exist in this basin.
In the Sengeti field, there are ten gas zones and according to the data of PERTAMINA, their total non-associated gas reserves are as follows:

. Original Gas-in-place:
    Approximately 1.51×10^9 m^3 (53.5 BSCF)
. Recoverable Reserve:
    Approximately 1.44×10^9 m^3 (50.8 BSCF)
. Cumulative Production:
    Approximately 0.11×10^9 m^3 (3.8 BSCF)
. Remaining Recoverable Reserve:
    Approximately 1.33×10^9 m^3 (47.0 BSCF)

4-2 Production History

The production in the past aimed at producing crude oil and condensate. To this end, the fluid from wellheads was separated into oil (condensate) and gas at the GOSP and the oil was sent to Palembang Refinery through the pipeline and the gas was burnt out. However, the decrease of oil production and the increase of gas/oil ratio, coupled with decline of the oil price and the gas reserve conservation policy brought about production suspension.

4-3 Prospect of Natural Gas Production

In order to estimate the delivery rate, pressure, temperature, and compositions of the gas and condensate at the outlet of the GOSP, a study of the production performance of natural gas reservoir, the entire production system performance and the operation conditions of the GOSP is needed.

(1) Behavior of Natural Gas Reserve

Assuming the depth, temperature, and pressure of the reservoir and judging from gas composition data given by PERTAMINA, this gas reservoir is considered a single phase gas reservoir. The gas composition of the reservoir is not expected to change with the elapse of production time. The pressure change of the gas reservoir due to gas production can be assumed by applying the equation of state and material balance.

Figure 4-1 shows the change of reservoir pressure performance with varying production rates between 2 and 10 MMSCFD. From this Figure, if the gas production rate is kept within 2 to 4 MMSCFD, the life of the gas reservoir is estimated over 20 years.

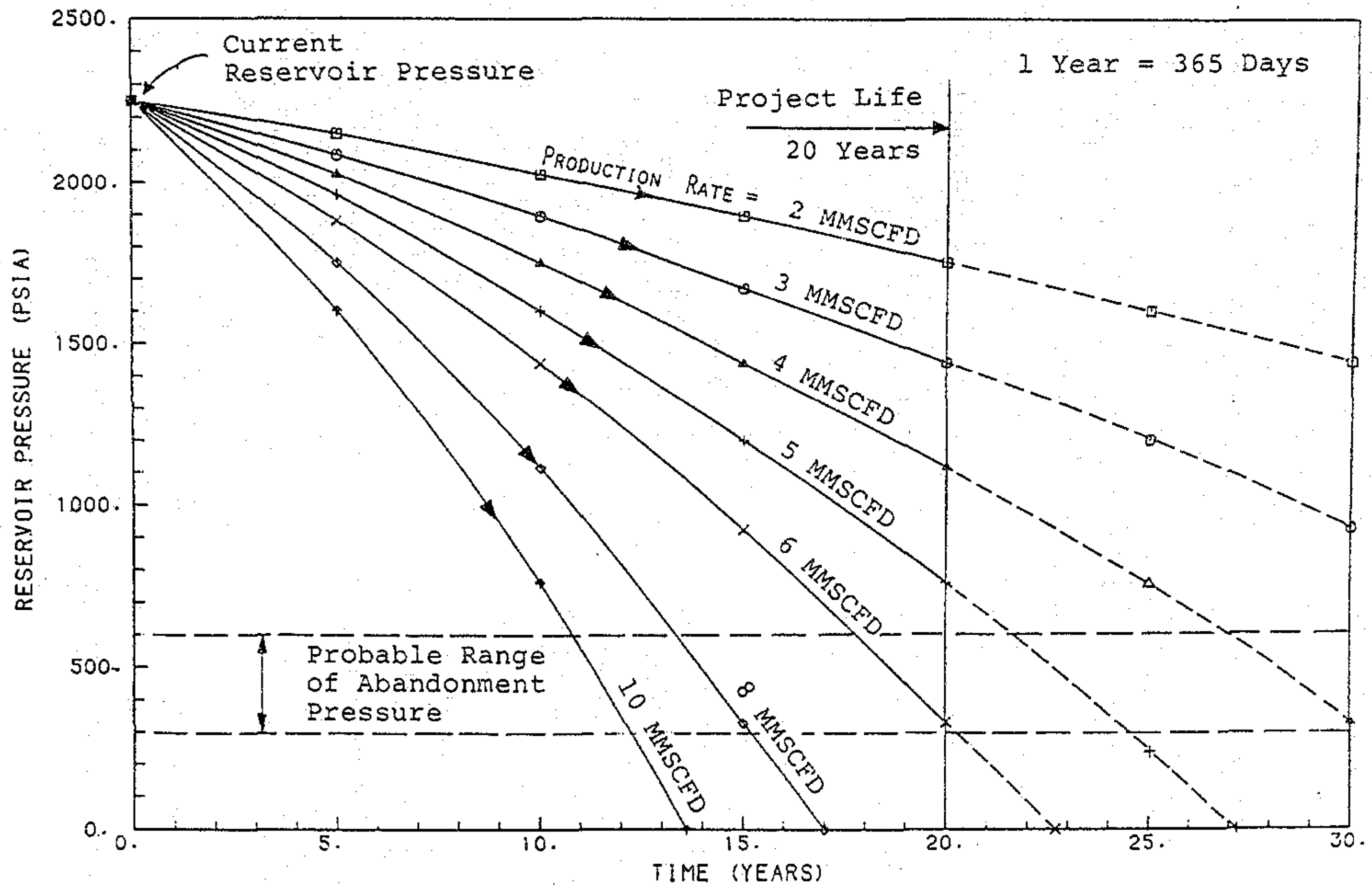


Figure 4-1 Reservoir Pressure Performance with Varying Production Rates

(2) Natural Gas Production Systems Analysis

Gas reservoir analysis, production well deliverability analysis and analysis of fluid flow in the wellbore and flowline were conducted and the individual well production rate was calculated. The results are shown in Table 4-1.

Table 4-1 Change Over Time of the Individual Well Production Rates

Field Total Production Rate	Optimum Well Production Rate (MMSCFD)		
	Start of Production	10 Years After	20 Years After
2 MMSCFD	2.00	2.00	1.60
3 MMSCFD	2.48	1.80	1.20
4 MMSCFD	2.48	1.60	0.80

It is clear from this Table that, if the production rate is in the range of 2 to 4 MMSCFD for the entire gas field, the required number of the wells will be 2 to 3 wells in the early to the middle stage of the production. 2 to 6 wells will be needed to supply the required gas quantity in the late stage of the production.

(3) Fluid Composition at GOSP Outlet

When this project is implemented, the fluid from wellheads will be separated into condensate and gas at the outlet of the existing GOSP and then sent to the downstream facilities. As shown in Figure 4-2 the separation ratio and compositions differ depending on the operating pressure of High Pressure Separator. In other words, some variation of feed gas composition can be absorbed by the adjustment of the operating pressure of the High Pressure Separator and gas of a constant composition can be supplied.

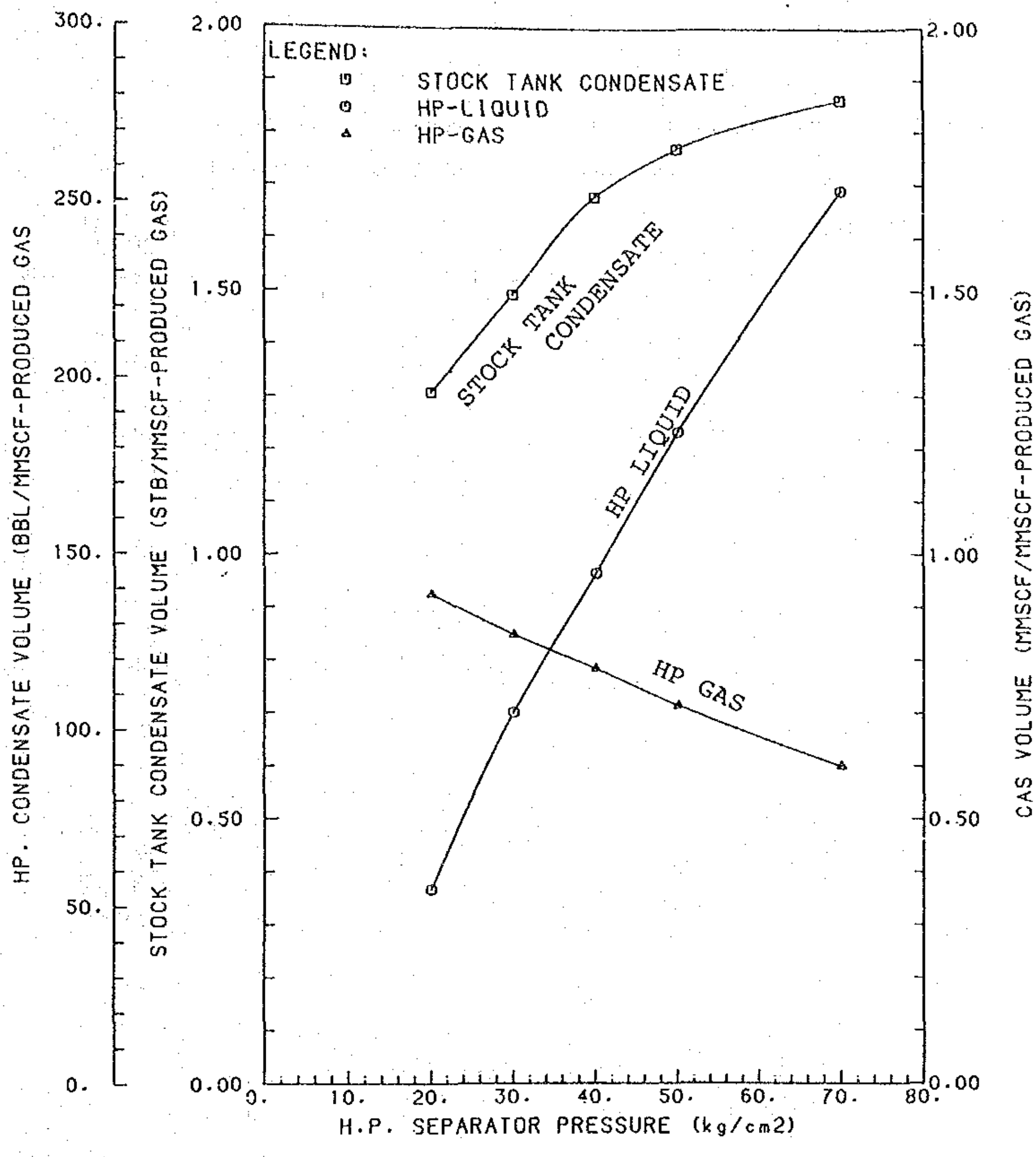


Figure 4-2 Effect of Separator Pressure on Volume of Gas and Condensate

In order to supply the gas to the proposed power plant without using expensive compressors, the operating pressure of High Pressure Separator will be kept at approximately 25 kg/cm^2G. The compositions of the condensate and the gas at this pressure are shown in Table 4-2.

Table 4-2 Composition of Separated Gas and Condensate for 25 kg/cm^2G Separator Pressure (Assumed Gas Composition)

Component		Composition *1		
		Feed	Gas	Liquid
CO_2		6.15	6.69	2.17
C1		51.57	57.26	9.30
C2		14.82	15.38	10.66
C3		15.15	13.51	27.35
iC4		3.48	3.49	10.84
nC4		5.28	3.34	19.76
iC5		2.06	0.85	11.08
nC5		1.38	0.49	8.03
$C6^+$		0.11	0.01	0.87
Mol. Weight		29.80	27.07	50.12
Mols		100.00	88.14	11.86
Water Content	*2	1.4700	0.1691	
	*3	1.47	0.19	

Notes:

*1) Composition ; mol %

*2) Unit - mols/100 mols - Feed

*3) Unit - mols/100 mols - Stage Separated Gas

(4) Control of Flow Rate of Natural Gas

Control of the flow rate of the natural gas produced from wellheads is carried out by throttling of the bean installed in the wellhead structure. If the wellhead structure is installed with a fixed bean, the flow rate of the natural gas is decided solely by the size of the bean. Therefore, in order to change the flow rate of the natural gas, the gas production should be stopped temporarily for changing the bean. Fine adjustment of the flow rate is very difficult, if not impossible.

As mentioned above, the control of the flow rate of the natural gas is not easy. Therefore, adoption of a gas utilization method which does not require flow rate adjustment is recommendable.

5. PROJECT SCHEME

In order to evaluate and implement the project, it is necessary to determine the optimum combinations of processing facilities, capacities of facilities and locations of facility installation that are appropriate for the characteristics of feed natural gas and volume of gas reservoirs with relation to demand of electricity and LPG as the final products. In other words, a determination of the project scheme is necessary.

The following is the explanation of the project scheme determination.

5-1 Determination of Power Generation System

(1) Capacity of Power Generating Facility

According to the electricity demand forecast of Jambi City and surrounding areas, a supply shortage for the peak load is anticipated in 1994/95 and consequently, the construction of a power plant of 20 MW output is necessary. Since the proposed power plant will use natural gas, it is desirable for the plant to be used as a base load power station which does not require the adjustment of the flow rate.

(2) Power Generation Method

The following three power generation systems are evaluated as the applicable methods for this project and the results are shown in Tables 5-1 and 5-2.
After evaluating overall aspects of these generating systems, the dual-fuel engine generating method was selected.

(3) Power Plant Site

The following three candidate sites are selected as plant sites of the proposed power station.

. Sengeti
. A location between Setiti and Jambi City
. Payo Selincah

These sites are compared in terms of construction cost of pipelines and transmission/distribution lines in addition to the overall economics of transmission loss. As shown in Table 5-3, Payo Selincah is selected as the candidate plant site.

Table 5-1 Comparison of Prime Movers

	Dual-Fuel Engine	Gas Turbine	Steam Turbine
Output	Almost no influence by atmospheric temperature Influenced by fuel (Knocking limit)	Influenced by atmospheric temperature Not influenced by fuel	Influenced by cooling water temperature Not influenced by fuel
Used fuel	Gas & Liquid fuel (requested dual)	Gas or liquid fuel	Gas, liquid fuel and/or coal
Cooling water	Radiator or cooling tower Relatively small amount is required.	Not required	Relatively large amount is required.
Installing weight	Relatively heavy	Light	Moderate
Operation & maintenance	Very similar to diesel engine, so easily operated by local operator	Special facility for overhauling is required.	Special knowledge is required for local operator
Environmental influence	Relatively high noise level and high NOx	Relatively high noise level	Exhaust gas emission control is relatively easy.

Table 5-2 Economic Comparison of Power Generating System

(Unit: US$/year)

	Dual-Fuel Engine	Gas Turbine	Steam Turbine
Engine Capacity	5 MW x 4	10 MW x 2	20 MW x 1
Normal Output	17 MW	17 MW	17 MW
Thermal Efficiency	36 %	20 %	25 %
Construction Cost (US$)	27,500,000	18,000,000	28,500,000
Capital Cost			
Case-A @ 25%	6,875,000	4,500,000	7,125,000
Case-B @ 12%	3,300,000	2,160,000	3,420,000
Fuel Cost			
Gas			
Case-1	3,197,876	6,523,666	5,218,933
Case-2	2,654,363	5,414,900	4,331,921
Case-3	1,895,974	3,867,786	3,094,229
Fuel Oil (Pilot)	521,824		
Lube Oil	198,016		
Annual Cost			
A-1	* 10,792,716	11,023,666	12,343,933
A-2	10,249,203	* 9,914,900	11,456,921
A-3	9,490,814	* 8,367,786	10,219,229
B-1	* 7,217,716	8,683,666	8,638,933
B-2	* 6,674,203	7,574,900	7,751,921
B-3	* 5,915,814	6,027,786	6,514,229

Note: * Shows least expense method for each case

Table 5-3 Economic Comparison of Plant Site for Power Station

(Unit: Million Rp)

	Case A (Sengeti)	Case B (Setiti)	Case C (Payo Selincah)
Construction Cost			
Pipeline	0.0	1,198.8	2,397.6
Transmission Line	2,445.3	1,683.0	789.0
Sub-total	2,445.3	2,881.8	3,186.6
Power Loss	4,935.7	3,380.6	170.2
Total	7,381.0	6,262.4	3,356.8

5-2 Determination of Natural Gas Pretreating System

A natural gas pipeline shall be installed for transferring the gas from the GOSP to the proposed power station. If the gas from the GOSP is sent through the pipeline without pretreatment, heavy hydrocarbons and water will condense due to falls in temperature, reducing transmission efficiency as well as causing corrosion of the pipeline. Therefore, it is necessary to install a pretreating facility for removing heavy hydrocarbons and water contained in the gas. Since gas transmission temperature is relatively high in this project, a high percentage of removal is not necessary. Therefore, the self-gas-cooling process by adiabatic expansion (an isenthalpic expansion) is adopted because of its low plant and operation costs resulting from its simple configuration. The location of the pretreating facility is at the inlet of the gas pipeline, namely, adjacent to the site of the existing GOSP.

5-3 Determination of LPG Recovery System

(1) LPG Recovery Method

The recovered LPG will be used as fuel for the household use and industrial use. In order to recover LPG from the natural gas, a process to recover LPG from HP Separator condensate or a process to recover LPG from HP Separator gas is applicable to this project. In view of characteristics of the natural gas, amount of LPG to be recovered, the utilization of natural resources, and operability of the process, the process to recover the LPG from the condensate is more suitable for this project. Figure 5-1 shows this recovery process.

(2) LPG Production Volume

According to the LPG demand forecast in Jambi district, the production volume of 10 tons per day will suffice to cover the demand of this region for some time.

(3) Plant Site

Sengeti and Setiti were selected as the candidate plant sites. These sites were compared in terms of supply of raw material, transportation of the product and the effective use of auxiliary facilities, and Sengeti was selected as the candidate plant site.

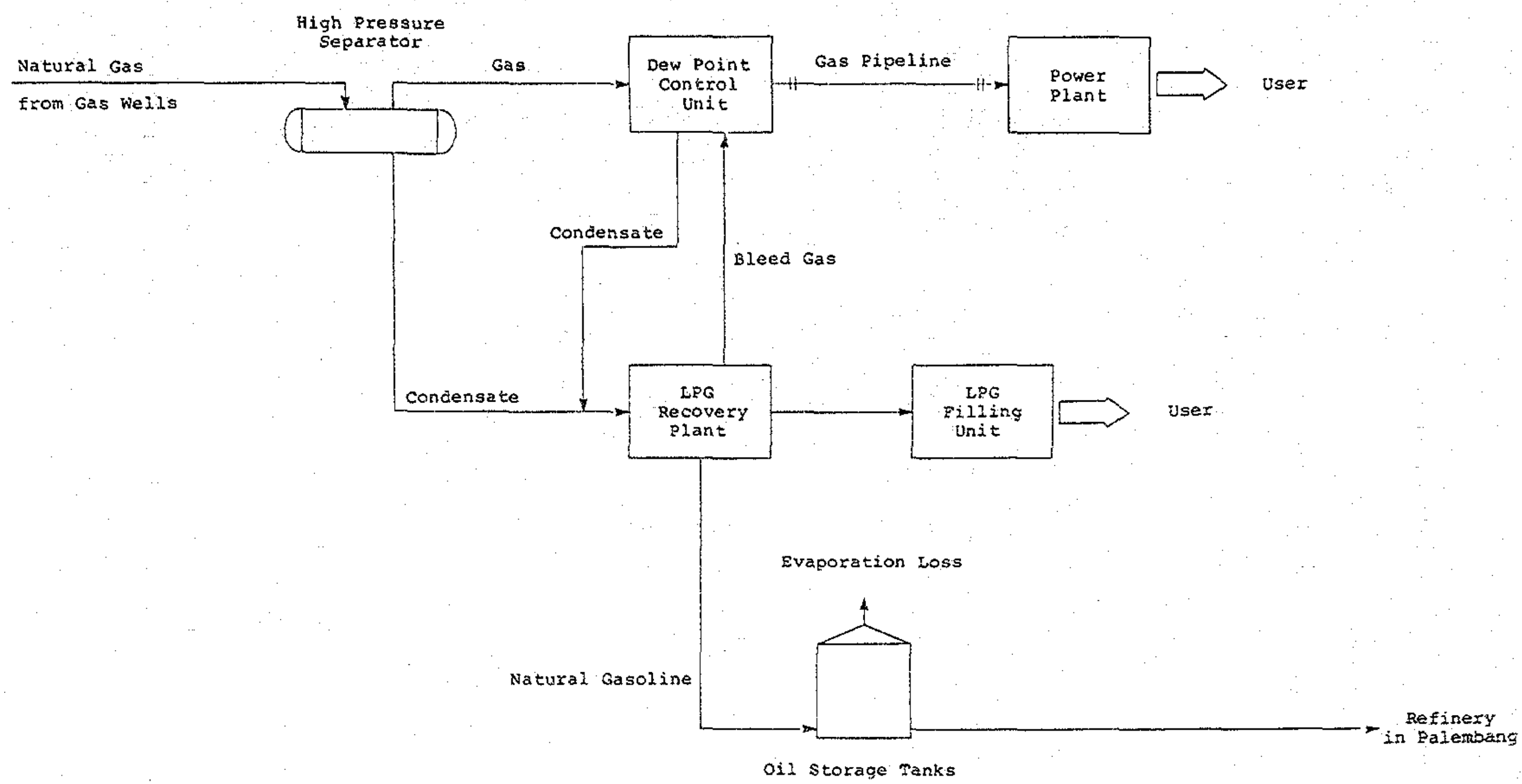


Figure 5-1 Process Configuration of LPG Recovery System from High Pressure Separator Condensate

5-4 Overall System Evaluation

It is necessary to plan and coordinate an overall system with due consideration paid to safety measures and environmental protection measures, after integrating individual capacity of facilities described above, in order to steadily and safely produce electricity and LPG without causing pollution.
The following points are considered for this project.

(1) Utilization of Natural Resources

If fluid drawn from each facility is wastefully expelled as un-usable fraction, it will contaminate the environment as well as be a loss of precious natural resources.
Therefore, the overall flow was designed so it would utilize each fraction contained in the natural gas effectively.

(2) Allowance of Capacity of Facility

The capacity of each facility is established based on the demand forecast and characteristics of the natural gas, both of which were derived from various assumptions. Therefore, the actual values may differ from these defined values. Even in this case, each facility should be designed so that their capacities can absorb such differences as much as possible and the operating pressure of some of their equipment can be changed.

(3) Safety Measures

The following points are considered in order to secure the safety of operating personnel and residents.

. As a safety measure, a gas blow-down pipe with a pressure regulating valve is provided in the natural gas production and the treating system, for preventing the operating pressure from exceeding the design pressure.

. The installation of gas pipelines is planned for areas where population density is low and the special protection measures will be provided for the section across roads and the part crossing the Batang Hari river. Adequate anti-corrosion measures will be taken. Block valves will be installed in several locations as an emergency measure.

. As a safety measure for LPG recovery system, safety valves will be provided at each distillation tower.

. In order to protect the power generating facility from an emergency in the fuel gas supply system, two block valves are provided in series in the gas supply system. The installation of a system is planned for changing operation to the diesel oil operation automatically in case of emergencies in the gas supply.

(4) Pollution Control

Appropriate measures of pollution control will be implemented for facilities which may contaminate the environment.

6. NATURAL GAS PRETREATING FACILITY

The outline of this facility is as follows:

. The facility is a dew point control device using the self-cooling method by adiabatic expansion.

. Its purpose is the partial removal of heavy hydrocarbons and water in the gas and the reduction of dew point of the gas to suit it for the pipeline transmission.

. Dew point of the treated gas is set at 15°C, 5°C lower than the minimum gas temperature of the gas being transmitted through the pipeline.

- The volume of the treated gas corresponds to the required fuel gas for the power plant and utility gas required by the LPG Recovery Plant and the maximum volume is 3.1 MMSCFD.

- The total of the differential pressure due to adiabatic expansion needed for self-cooling of the gas and the pressure loss through the pretreating facility is about 9 kg/cm^2 and the outlet pressure of the treated gas is 16 kg/cm^2G.
  This pressure is enough to transfer the required amount of the gas to the proposed power plant through the pipeline.

7. CONCEPTUAL DESIGN OF LPG RECOVERY PLANT

7-1 Outline of the Facility

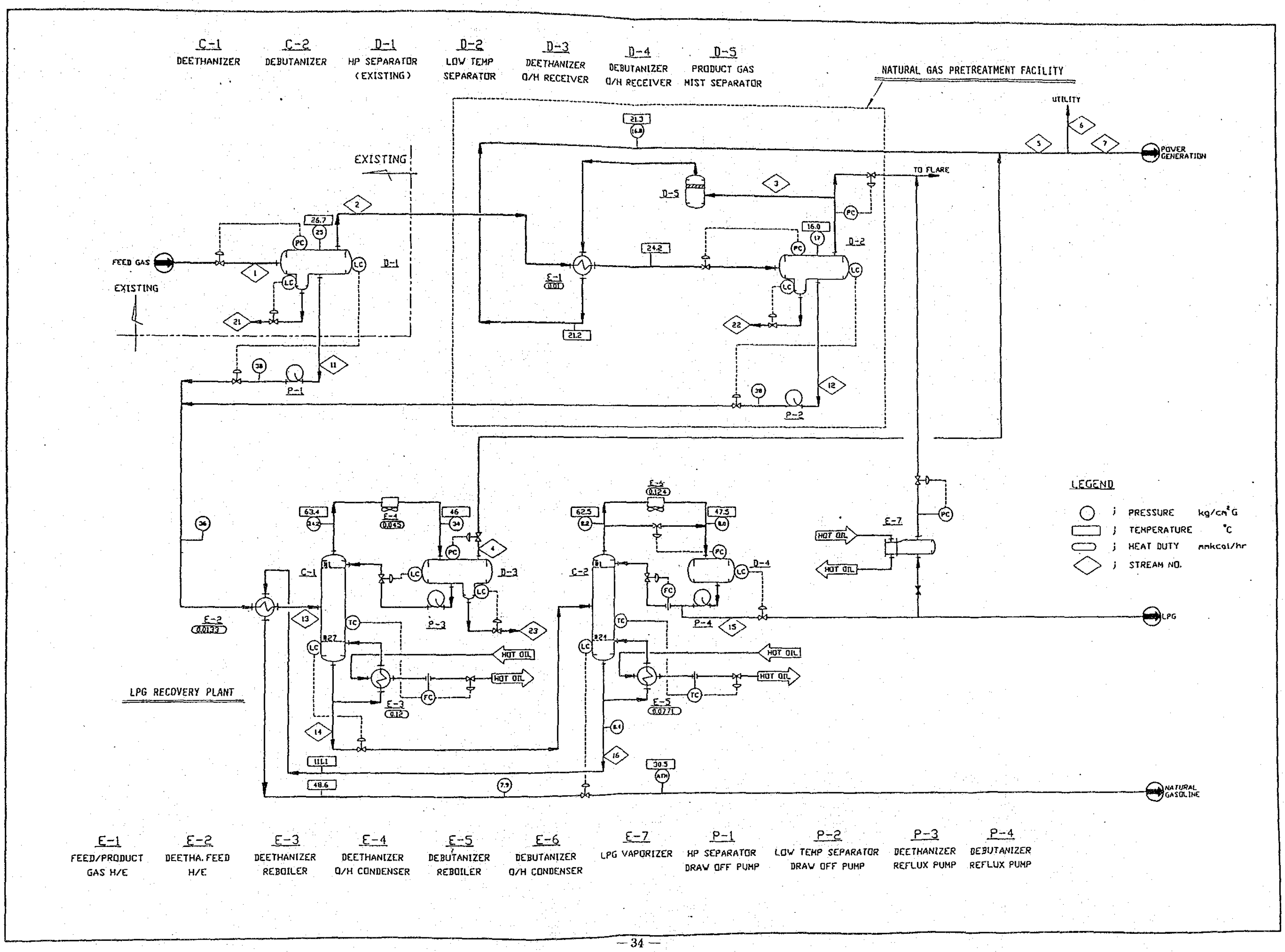
The LPG Recovery Plant is a facility for separating LPG fraction by distillation, using the condensate supplied from the GOSP as the feed raw material. Its main equipment consists of a deethanizer to separate light components in the condensate and a debutanizer to separate heavy components in the condensate. Each piece of equipment is designed so they together produce on-specification LPG product, and even some variation of feed material compositions from set values can be compensated for by changing their operating conditions.
Figure 7-1 shows the process flow diagram of the overall gas processing system including LPG Recovery Plant and Figure 7-2 shows a plot plan of the gas treating facilities.

7-2 LPG Production Volume

The LPG production volume is designed as follows:

Maximum (Amount corresponding to electricity generation of 20 MW) : 10.8 tons/day

Figure 7-1 Process Flow Diagram of Overall Gas Processing System



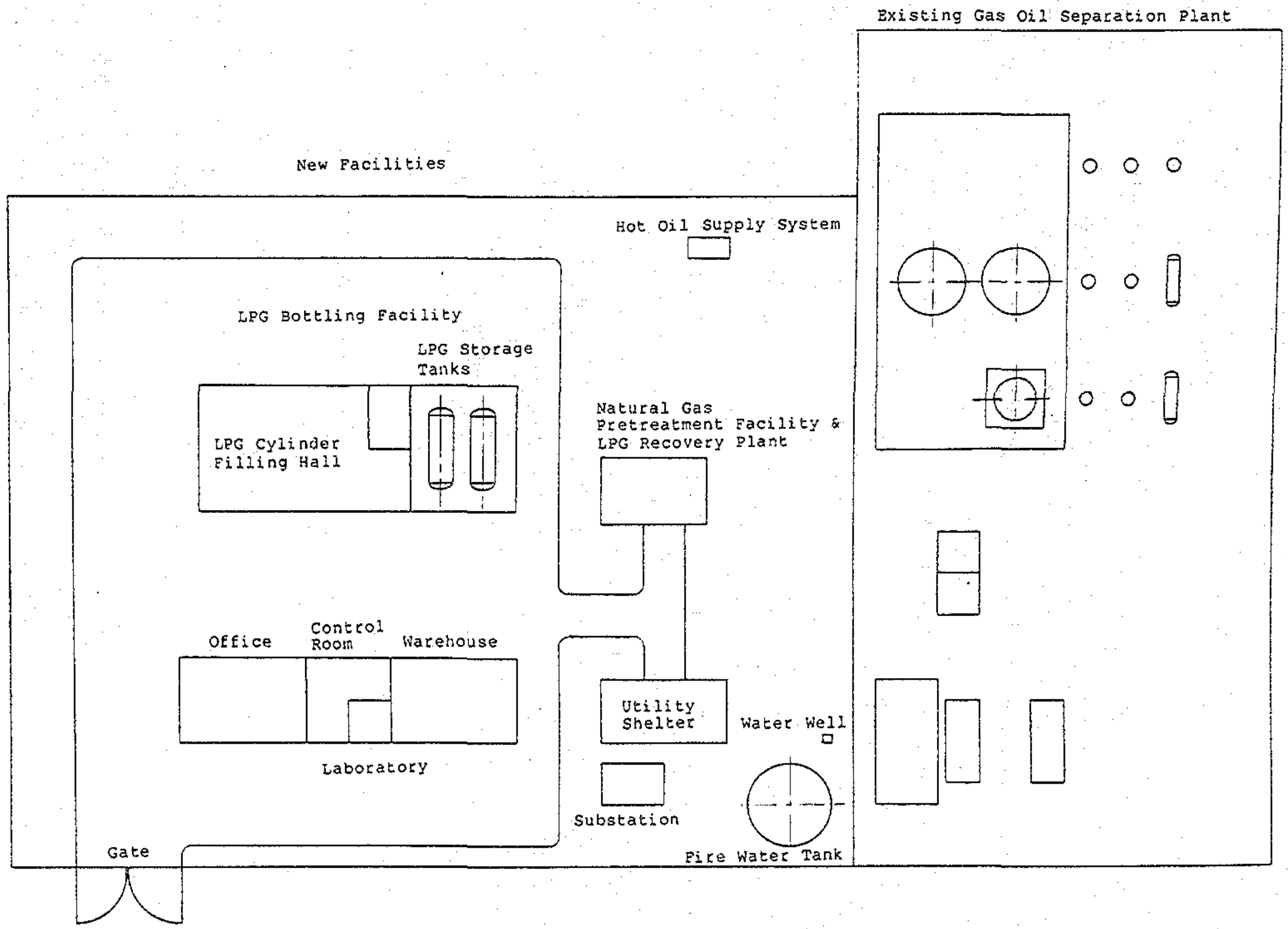


Figure 7-2 Plot Plan of Natural Gas Treating Facilities

Normal (Same as above, but for 17 MW) : 9.0 tons/day

7-3 LPG Filling Station

The LPG produced in the LPG Recovery Plant will be filled in 11 kg cylinders for household use and in 45 kg cylinders for industrial use and handed to the LPG sales agents. A rotating filler for 11 kg cylinders and a stationary filler for 45 kg cylinders will be provided. Their total filling capacity will be 300 tons/month, assuming an 8-hour working day rate. Any excess LPG produced beyond the LPG demand in this district will be transported to Palembang after being filled in cylinders.

7-4 Auxiliary Facilities

The installation of the following auxiliary facilities is planned for the LPG Recovery Plant: power generating facility, instrument air compresssor facility, hot oil facility, fuel oil facility, fire fighting facility, wireless communication facility, control room, office and warehouse. These facilities can be used commonly by other facilities such as the natural gas production facility and the pretreating facility in Sengeti area.

8. CONCEPTUAL DESIGN OF NATURAL GAS PIPELINE

The natural gas pipeline is transmission facility for transferring fuel gas facility from Sengeti to the proposed power plant to be constructed at Payo Selincah. The outlines are as follows:

8-1 Gas Volume to be transmitted

The designed flow rate of gas for this pipeline is 3.2 MMSCFD. This flow rate corresponds to the required fuel gas volume for the power plant being operated at the maximum load of 20 MW geneation.

8-2 Pipeline Route

As shown in Figure 8-1, the pipeline route is selected in the northern part of the Batang Hari river where the population density is low and the influence to environment is small. Its total length is 20 km. The pipeline will be installed underground for the safety for residential people. In selecting the final route, a detailed field survey will be necessary.

8-3 Pipeline Specification

(1) Pipe Size

The necessary amount of the gas can be transported without a compressor with the proper size selection. Thus the selected size of the pipeline is a 6-inch diameter.

(2) Wall Thickness

Wall thickness is set at 7.1 mm in view of internal pressure due to fluid transmission and external factors that ensue during construction. However, the submerged portion across the Batang Hari river will be a pipe with 7.9 mm wall thickness in order to prevent it from floating.

(3) Auxiliary Equipment

. At the inlet of the proposed power plant, a flow meter for gas transaction will be provided.

. Block valves and gas blow-down pipe will be provided in several sections of the pipeline.

. Pig trap will be installed at the inlet and the outlet of the pipeline for the purpose of internal cleaning and maintenance work.

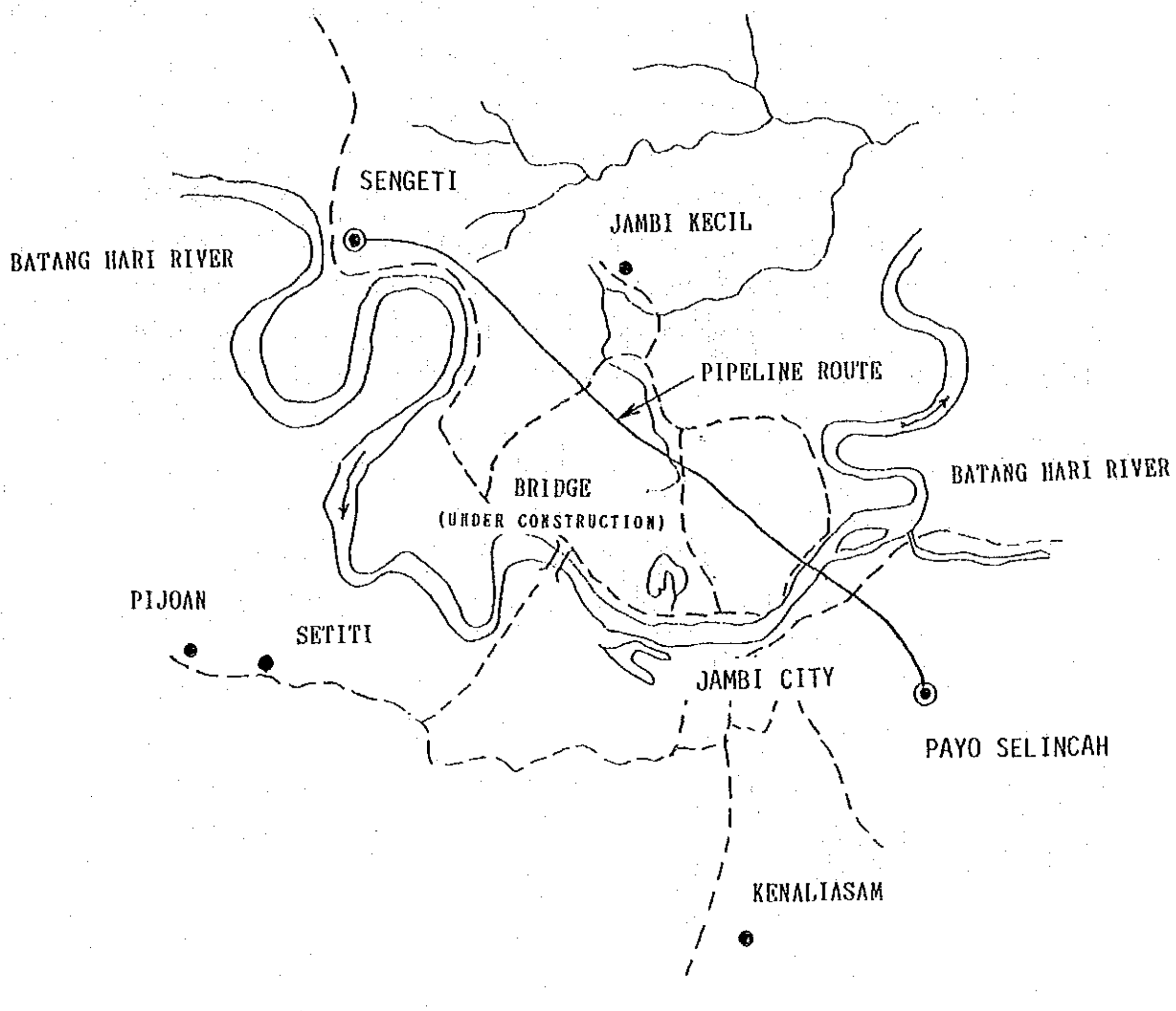


Figure 8-1 Gas Pipeline Route (Sengeti - Payo Selincah)

- To protect the exterior of the buried pipeline, anti-corrosion tape will be wrapped and an electric corrosion protection device will be provided.

9. CONCEPTUAL DESIGN OF POWER PLANT

9-1 Outline of Equipment

The proposed power plant consists of dual-fuel engine generators which use the gas as the main fuel and the liquid fuel as the pilot fuel. Since the dual-fuel engine is a compression-ignited engine, it is only possible to start it by liquid fuel (diesel operation mode) like ordinary diesel engines. The engine thus will be started up or shut down by the diesel operation mode. Also, in the case of an emergency in the fuel supply system, the engine will be automatically changed to the diesel operation mode.

9-2 Generation Capacity

Rated generating capacity :	5 MW x 4 sets	Total 20 MW
Normal generating capacity:	4.25 MW x 4 sets	Total 17 MW

9-3 Fuel Consumption

Figure 9-1 shows the relation between load ratio and fuel consumption of dual-fuel engine.

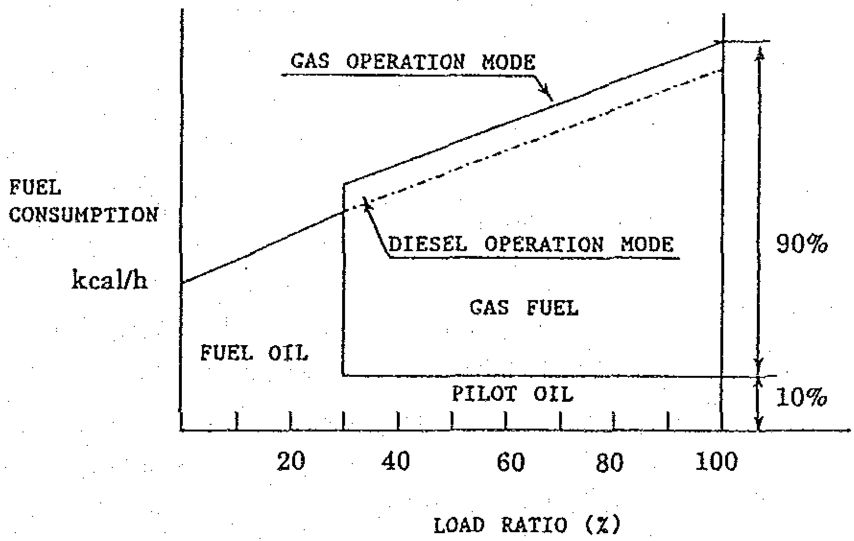


Figure 9-1 Fuel Consumption - Load Ratio

The dual-fuel engine will be started up using liquid fuel and at the stage when the load reaches 30% of the rated output, it is ready to be changed to the operation using both gas fuel and liquid fuel (gas operation mode). In the gas operation mode, a certain amount of liquid fuel (approximately 10% of the required heating value at the rated load) will be supplied regardless of the load ratio and the gas fuel corresponding to load ratio is supplied at the same time.

9-4 Engine Accessories and Auxiliary Equipment

(1) Engine Generator Accessory Equipment

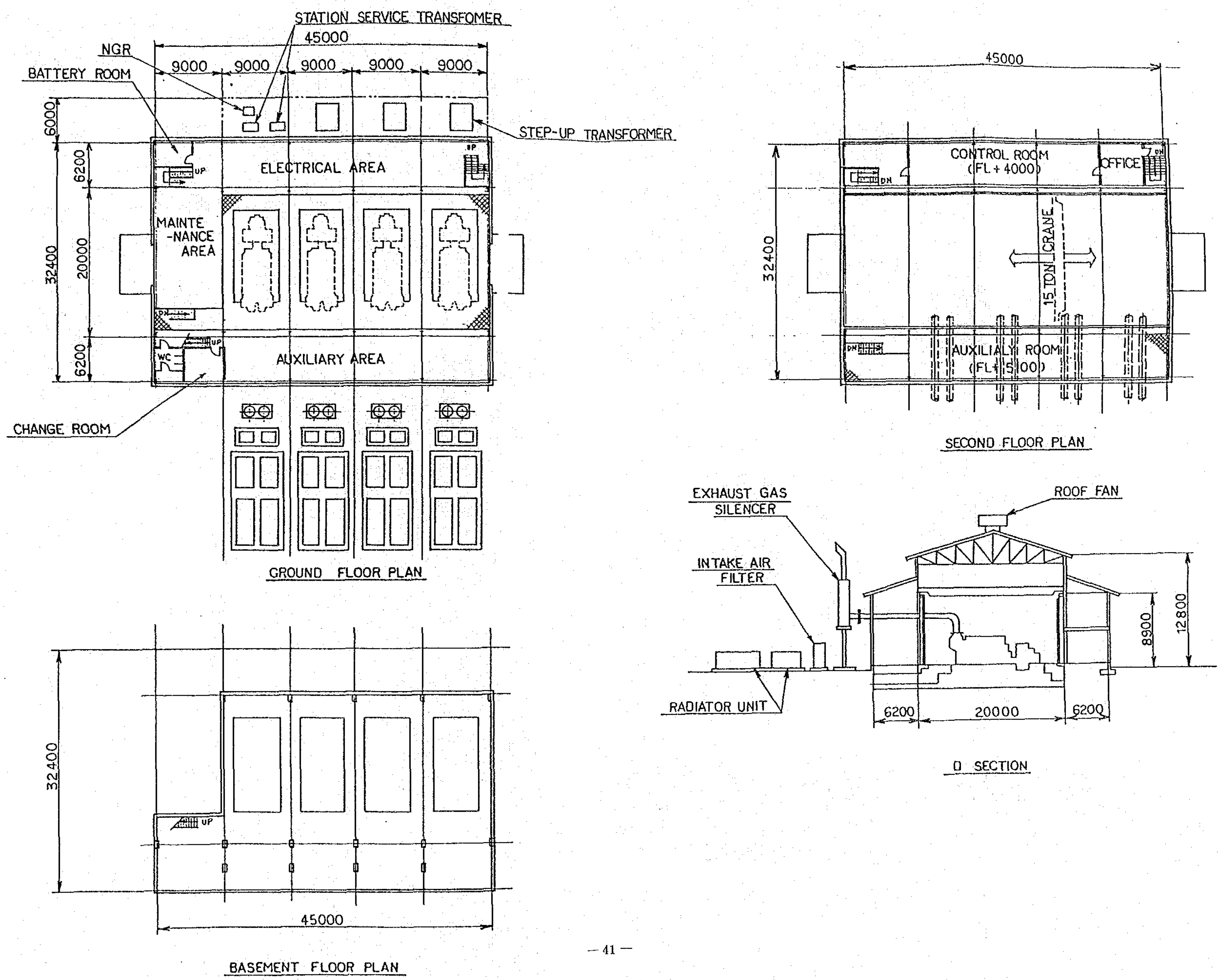
The following equipment will be provided for steady and safe operation of the plant.

- Start-up air system (air compressor and air receiver)
- Lubricating oil system (lube oil sump tank, lube oil pump, oil cooler, oil purifier)
- Fuel oil system (fuel oil transfer pump, service tank, fuel oil pump)
- Fuel gas system (surge tank, gas pressure control valve, gas shut-off valve, flame arrester)
- Engine cooling system (cooling water circulating pump, radiator)
- Suction and exhaust system (air filter, radiator, silencer)
- Electric system (20 kV step-up transformer, station transformer, electric board)
- Control board

(2) Auxiliary Facility

- Generator building (Figure 9-2)
- Fuel oil storage tank
- Workshop
- Sludge incinerator
- Fire fighting equipment
- Warehouse
- Water supply (well, well water pump)

Figure 9-2 Arrangement of Power House



10. CONCEPTUAL DESIGN OF POWER TRANSMISSION AND DISTRIBUTION FACILITY

10-1 Outline of Additional Facilities

By the addition of the proposed power plant, 17,000 kW will be added to the generated electricity of Jambi district. This electricity is mainly supplied to the industrial zone in the east part of the city during day time and to the residential zone in the south-west part of the city during night time. In addition to the existing transmission and distribution lines, two tie lines and five distribution lines will be added as shown in Figure 10-1.

10-2 Installation of Tie Line

In order to make the parallel running and interchange of power possible, the 0.3 km distance between the existing Payo Selincah power plant and the proposed power plant and 9 km distance between the Payo Selincah power plant and the switching station in the center of the city will be connected by tie lines.
Both lines will be installed underground with a voltage of 20 kV.

10-3 Installation of Distribution Lines

In order to supply electricity to the industrial zone in the east side of Jambi City, one distribution line from the proposed power plant and two distribution lines from the Payo Selincah power plant will be installed. Two distribution lines also will be installed from the switching station to supply electricity for the residential and educational zone in the south-west part of the city. These distribution lines are of the overhead suspended type of 20 kV voltage, similar to the existing lines.

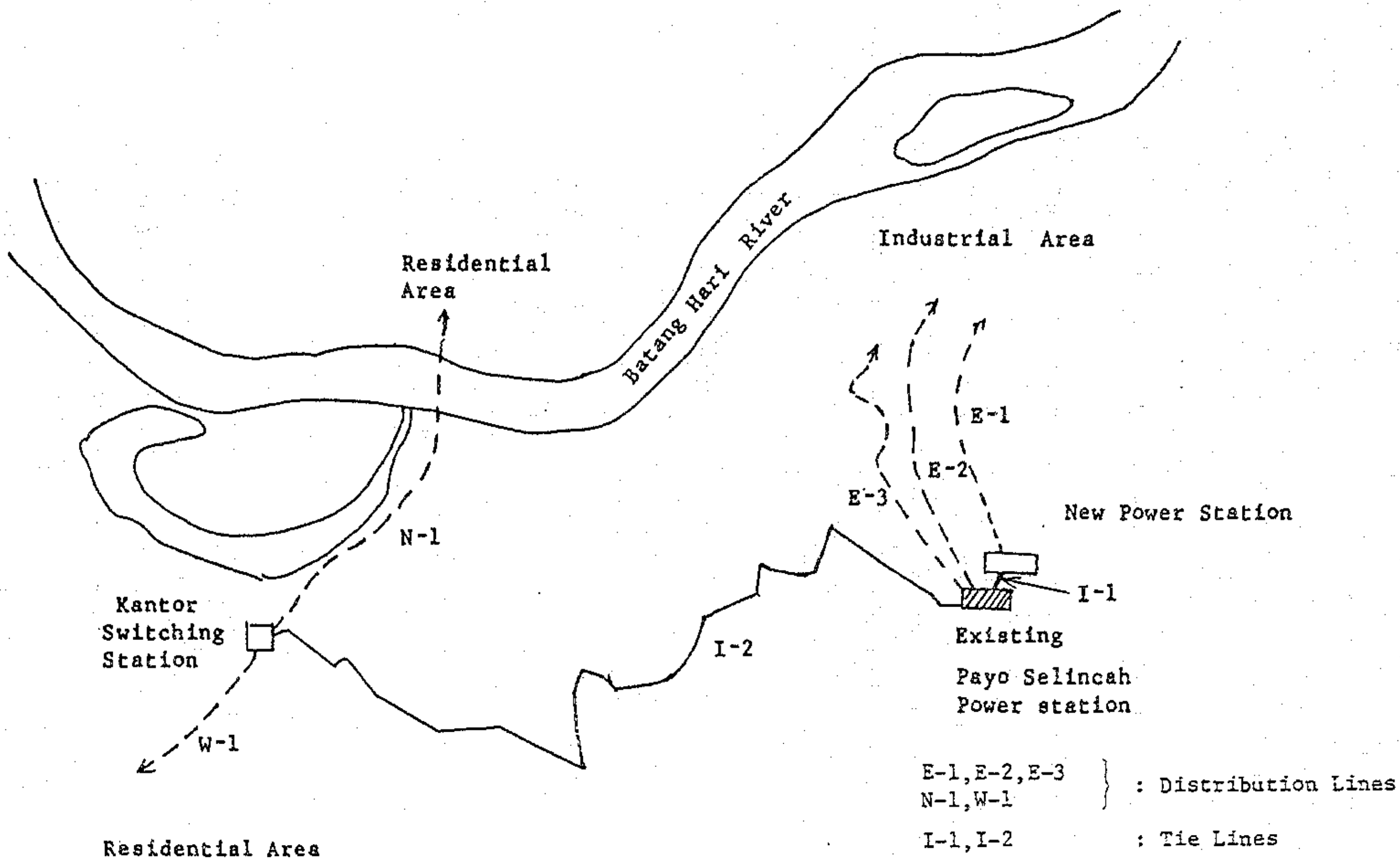


Figure 10-1 Distribution Lines and Tie Lines in the Jambi City Area after Completion of the Proposed Power Plant

11. CONSTRUCTION WORK

Construction work at four project sites in Jambi district will be carried out concurrently. In order to commence the operation of each facility according to schedule, it is necessary to coordinate the overall construction schedule paying due attention to site conditions and weather conditions.

11-1 Outline of the Construction Work

(1) Natural Gas Pretreating Facility and LPG Recovery Plant

In Sengeti area, a natural gas pretreating facility, LPG Recovery Plant and its auxiliary facilities will be constructed. There will be some modification and improvement work for the existing natural gas production facility and the GOSP, although such work is not included in the scope of work for this Feasibility Study.

Most of newly erected facilities are skid-mounted type imported from abroad. Inland transportation and installation will be the main work for these facilities.

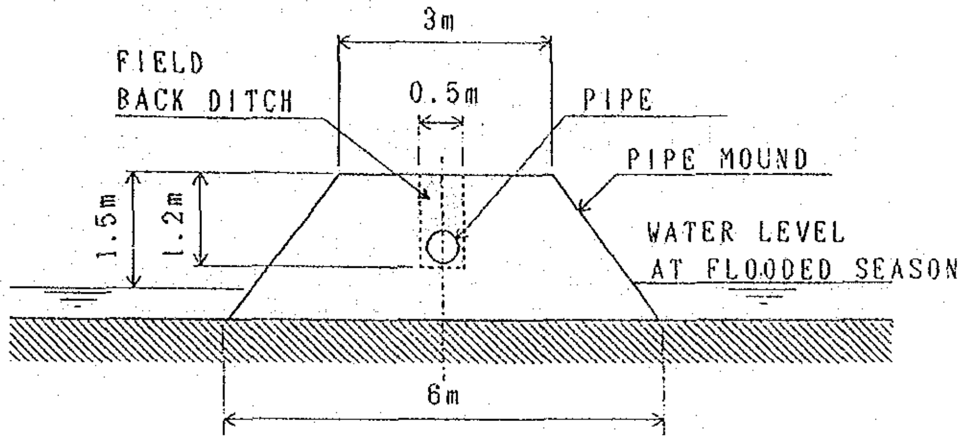
Equipment and materials are planned to be transported using barges during high water of the Batang Hari river while equipment, pipework and instrumentation are to be installed during dry season. Therefore, all foundation work should be completed during dry season prior to delivery of the equipment.

(2) Natural Gas Pipeline

Natural gas pipeline will be laid starting from Sengeti through swampy areas of the northern part of the Batang Hari river, crossing the river at the edge of the Jambi City and reaching to Payo Selincah. Therefore, the important portions of the pipeline work are the laying operation of the underground pipeline through the swampy areas and the river crossing sections.

Figure 11-1 shows sketches of underground pipework. The river crossing of the pipeline is carried out by pulling the welded pipe along the river bed using a mechanical winch.

SWAMP



DRY AREA

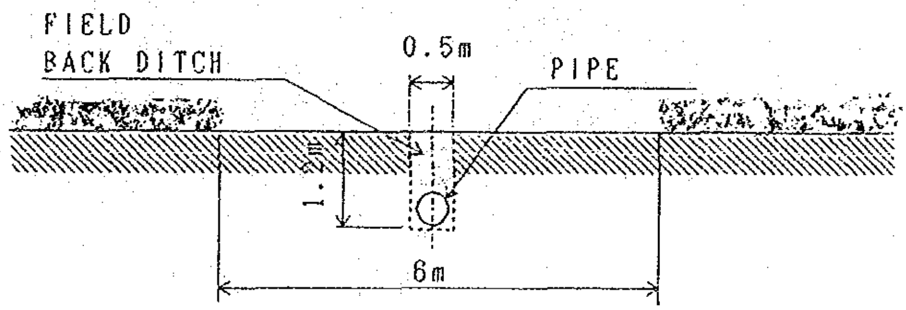


Figure 11-1 Examples of Pipeline Construction

(3) Power Plant

In construction work of the proposed power plant, transportation will be one of the key operations because the engine generators are heavy and large. Since they are rotating machinery and their vibration should be prevented to achieve high efficiency of performance, therefore the foundation should be constructed accurately.
Imported machinery such as engines and generators will be transhipped onto a barge either in Jakarta or in Singapore. A large trailer with many wheel axles should be placed on the barge beforehand onto which the engine generator will be loaded by crane. The barge will travel to Jambi and the trailer will be landed on a special pier, specially constructed for this purpose, and then be transported to the construction site at Payo Selincah.
The foundation for the engine generators will be reinforced by steel bars and be constructed so that it is not damaged by vibration of the engine.

Figure 11-2 shows the outline of the foundation work. In order to support the weight of the engines and foundations, a number of piles will be necessary. The depth, size and actual numbers of the pile will be decided after reviewing the soil data.

(4) Power Transmission and Distribution Facilities

In order to supply the electricity generated by the execution of this project, it is necessary to install two new tie lines and five new distribution lines. It is necessary to coordinate the construction work for these new lines with the improvement program for distribution lines by PLN.

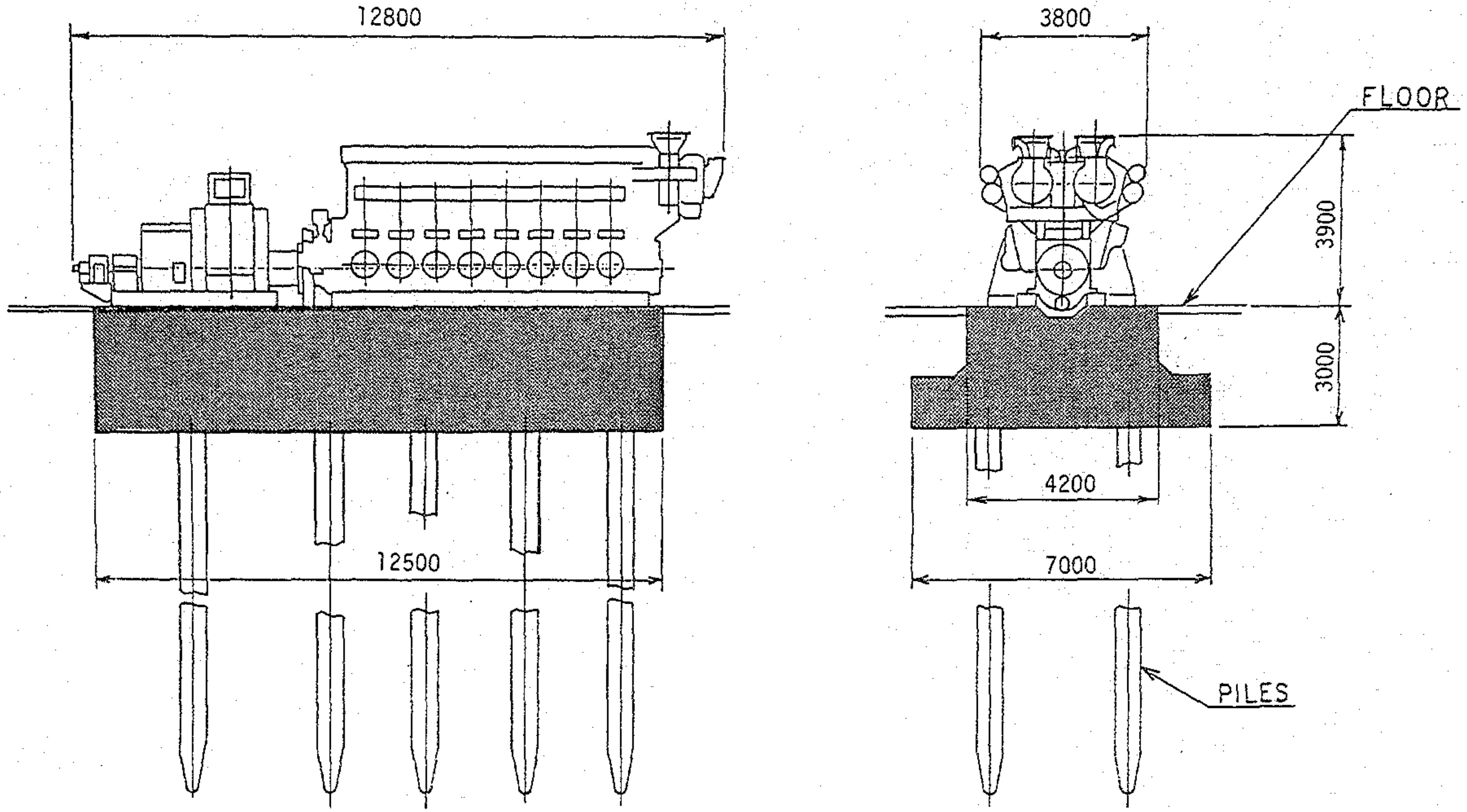


Figure 11-2 An Example of Engine Foundation

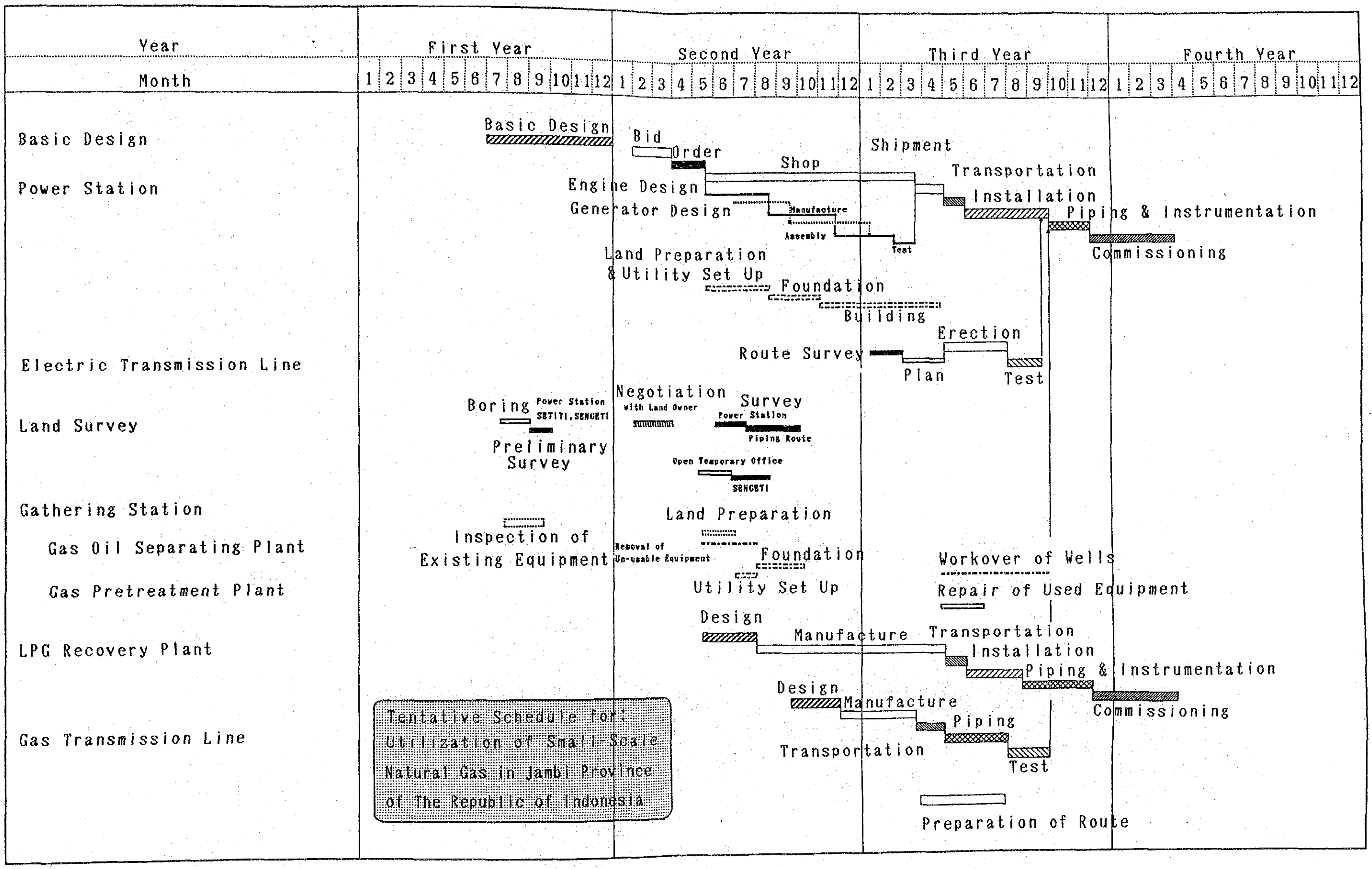
11-2 Construction Schedule

Figure 11-3 shows the overall construction schedule for this project. The schedule is prepared paying due attention to the following two points.

(1) Outdoor construction work at job sites is scheduled to carry out during dry season from the end of April to the end of September.

(2) Transportation using barges is scheduled when the water is high in the Batang Hari river from March to May.

Figure 11-3 Overall Construction Schedule



12. CONSTRUCTION COST

The construction cost of the new facilities to supply electricity and LPG to Jambi district by using the natural gas produced in Sengeti has been estimated. However, costs for modification and repair for the existing facilities have not been estimated.
The cost of the blow-down connecting pipe for the waste gas flaring system was estimated, but the cost for repair work for the existing system was excluded.
Costs for tie lines and main distribution lines were included in the project cost, however the cost for low voltage lines extending from pole transformers were not included because the cost of these lines are borne by consumers.
The costs of the following items are estimated:

1) Natural gas pretreatment plant
2) LPG Recovery plant
3) Natural gas pipeline
4) Power station
5) Transmission and distribution lines

Value of the cost is in Japanese Yen.
The cost is in the value prevailing in February/March 1988. The imported portion is estimated based on the international market price when they are imported from industrialized countries including Japan, U.S.A., European countries and NIES. The local portion is estimated based on the domestic market price in Indonesia.

The results are shown in Table 12-1.

Table 12-1 Summary of Cost Estimation

(Unit: Thousand Yen)

Items	Natural Gas Pretreatment Facility		LPG Recovery Plant		Natural Gas Pipeline		Power Station		Electric Transmission Line		Basic Design and Consulting		Total	
	3.1 MMSCFD		10.8 ton/day		6 inch - 20 km		4 x 5,000 kW							
	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local
Plant Equipments, Building Foundation Construction	6,250	5,800	159,700	145,500	85,500	50,900	2,515,000	400,000	71,700	84,900	0	0	2,838,150	687,100
Ocean Freight and Insurance	300	0	8,000	0	3,000	0	102,000	0	2,500	0	0	0	115,800	0
Inland Transportation	0	200	0	3,800	0	3,500	55,000	54,000	0	1,000	0	0	55,000	62,500
Engineering Fee	1,000	0	24,000	5,000	4,000	3,000	64,000	0	0	*	150,000	20,000	243,000	28,000
Supervising Fee	849	0	21,001	1,800	17,800	2,800	79,900	0	0	*	68,700	2,700	188,250	7,300
Administration Cost	864	0	22,128	0	10,230	0	196,194	0	0	0	0	0	229,416	0
Contingency	600	600	16,000	15,000	2,500	5,000	61,300	47,000	0	*	0	0	80,400	67,600
Land Acquisition	0	2,000	0	19,000	0	38,000	0	12,300	0	*	0	0	0	71,300
Total	9,863	8,600	250,829	190,100	123,030	103,200	3,073,394	513,300	74,200	85,900	218,700	22,700	3,750,016	923,800
	18,463		440,929		226,230		3,586,694		160,100		241,400		4,673,816	

Note: * Covered by PLN

13. OPERATION PLAN

13-1 Annual Operation Plan

(1) Power Plant

Figure 13-1 shows the annual operation plan of the proposed power plant. The plan is based on the following premises.

1) The proposed power plant is used as the base load plant and any shortage of electricity is supplied by the existing power plants.

2) During normal operation, four (4) sets of the generators will be operated at 85% of the rated output.

3) Maintenance will be required two times a year for each unit of the engine generator. During this maintenance period, the other three (3) units will be operated at 90% of the rated capacity. Thus, the total generation will be 135,480 MWh in a year.

(2) LPG Recovery Plant

The capacity of the LPG Recovery Plant, with due consideration to the raw material feed rate and the maintenance period, will be as follows:

During normal operation of the power plant (205 days):
9.03 tons/day
During maintenance period of the power plant (130 days):
7.24 tons/day

Therefore, annual LPG production will be 2,792 tons.

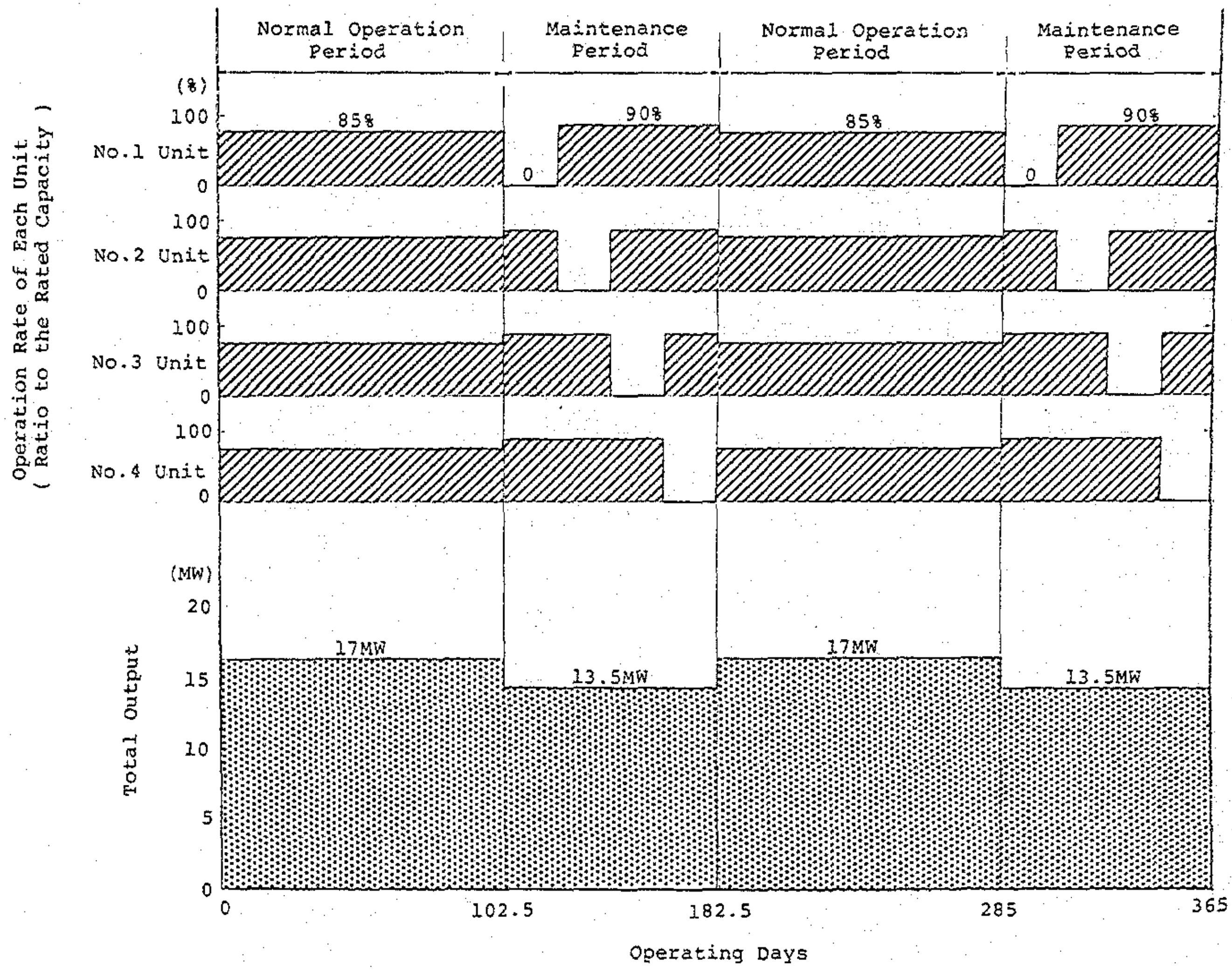


Figure 13-1 Annual Production Plan of the Power Plant

13-2 Organization and Personnel

It is assumed that experienced personnel will be dispatched from PLN for the operation of the proposed power plant and from PERTAMINA for the natural gas related plants including the LPG Recovery Plant. The number of the personnel will be as follows:

Power plant: 17 persons
Natural gas related facilities: 25 persons

All personnel will be trained to a level required for operation of plants by supervisors dispatched from foreign countries.

14. TOTAL INVESTMENT COST

Based on the cost estimation described previously, the pre-operation cost, the initial working capital and the interest during construction are calculated to estimate the required total investment cost. The conditions for calculating the total investment cost are as follows:

(1) Conversion Rate of Currencies

The conversion rates which prevailed in February, 1988, when the field survey was conducted, are applied in this feasibility study.

1 U.S.Dollar = 1,665 Indonesian Rp = 128 Japanese Yen

(2) Price Escalation

All costs are calculated by the present value of 1988 and escalation is not applied.

(3) Tax

Import duty is exempted for all imported materials and equipment for this project.

(4) Source of Funds

It is assumed that the funds to cover the foreign portion will be financed by a long term loan of appropriate loan conditions and the funds for the domestic portion will be covered by its own equity.

For the purpose of conducting financial analysis, two interest rates are introduced, namely, Case 1 with annual interest rate of 12% and Case 2 with 3.5% (Refer to Chapter 16 for details).

(5) Construction Period

Although the construction period is specified as 22 months as explained in CONSTRUCTION WORK, a construction period of 24 months (2 years) is adopted for the purpose of conducting the financial analysis.

A summary of the total investment cost based on the financial sources as defined above is shown in Tables 14-1 and 14-2.

Table 14-1 Total Investment Cost (Case 1)

(Unit: Million Yen)

	Foreign Portion	Local Portion	Total
Plant Construction Cost			
Land Acquisition	0.00	71.30	71.30
Plant	2,838.15	687.10	3,525.25
Ocean Freight & Insurance	115.80	0.00	115.80
Inland Transportation	55.00	62.50	117.50
Engineering Fee	243.00	28.00	271.00
Supervising Fee	188.25	7.30	195.55
Administration Cost	229.42	0.00	229.42
Contingency	80.40	67.60	148.00
Sub-total	3,750.02	923.80	4,673.82
Pre-operation Cost	1.40	46.26	47.66
Initial Working Capital	0.00	19.24	19.24
Interest during Construction	496.74	0.00	496.74
Total	4,248.16	989.30	5,237.46

Table 14-2 Total Investment Cost (Case 2)

(Unit: Million Yen)

	Foreign Portion	Local Portion	Total
Plant Construction Cost			
Land Acquisition	0.00	71.30	71.30
Plant	2,838.15	687.10	3,525.25
Ocean Freight & Insurance	115.80	0.00	115.80
Inland Transportation	55.00	62.50	117.50
Engineering Fee	243.00	28.00	271.00
Supervising Fee	188.25	7.30	195.55
Administration Cost	229.42	0.00	229.42
Contingency	80.40	67.60	148.00
Sub-total	3,750.02	923.80	4,673.82
Pre-operation Cost	1.40	46.26	47.66
Initial Working Capital	0.00	19.24	19.24
Interest during Construction	139.84	0.00	139.84
Total	3,891.25	989.30	4,880.56

15. FINANCIAL ANALYSIS

15-1 Methodology of Financial Analysis

The financial conditions for the proposed power plant and the LPG Recovery Plant are independently analyzed, based on the premises that PERTAMINA will own and manage the production, pretreatment, LPG recovery and pipeline of the natural gas related portions and PLN will own and manage the power generation and transmission and distribution lines. Also, in analyzing the financial feasibility of the power plant, a comparison with a diesel generator power plant is made in terms of unit cost of electricity in order to determine a fuel gas price at the inlet of the proposed power plant.

15-2 Major Premises

Major premises for conducting the financial analysis for this project are summarized as follows:

(1) Project Period

. Construction period: 2 years
. Operation life: 20 years

(2) Price

The prices used for the financial analysis are based on the fixed value of February 1988. Value is presented in the local currency and costs for foreign portions are converted to the local currency using the following exchange rate.

. U.S.$1 = 1,665 Rp = 128 Yen

(3) Tax and Depreciation

A corporate tax will be imposed on profits of this project in accordance with the new tax law enforced from 1984. The depreciation is calculated by the declining balance method at a 10% rate for plant machinery. The corporate tax is calculated by a progressive tax rate with a maximum tax rate of 35%.

(4) Operation and Sales Plan

(a) Power Plant

The power plant will be operated at 17 MW for 205 days and at 13.5 MW for 160 days according to the operation plan.
The unit price of electricity is 100 Rp/kWh.

(b) LPG Recovery Plant

2,792 tons per year of LPG recovered by this project will be sold in Jambi district. During the period when the production exceeds the demand of Jambi district, the surplus LPG will be sent to Palembang.
The price of LPG is set as follows:

. Jambi district: 240 U.S.Dollars/ton
. Palembang district: 45 U.S.Dollars/ton

15-3 Operating Cost

Summarized below are the necessary operating costs for LPG recovery and power generation.

(1) Raw Material Cost

The amount of condensate to recover one ton of LPG is 2.35 tons and price of the condensate is set at zero.
The amounts of fuel gas and diesel oil for the power plant are as follows:

. Fuel gas: 1.30×10^6 MMBTU/year
. Diesel oil: 4,413 kl/year

The following three prices for fuel gas are set based on the discussions with BPPT. The price of diesel oil is set at 200 Rp/liter.

. Case-A: 2.53 U.S.$/MMBTU (4,212.45 Rp/MMBTU)
. Case-B: 2.10 U.S.$/MMBTU (3,496.50 Rp/MMBTU)
. Case-C: 1.50 U.S.$/MMBTU (2,497.50 Rp/MMBTU)

(2) Costs of Utilities

Fuel gas of 7.0 MMBTU/ton of LPG is required for the LPG Recovery Plant, and no other utility is needed. The set price for the calculation is 2.10 U.S.$/MMBTU, the middle case of 3 set prices mentioned above.

The power consumed in the power plant is set at 5% of the total generated electricity. The main consumed material in the power plant is lubrication oil. The required amount and its unit price are 1.65 liter/MWh and 1,501.5 Rp/liter respectively.

(3) Labor Costs

The labor costs necessary for this project are summarized as follows:

. LPG Recovery Plant

: 166,880 U.S.Dollars = 277.8 MMRp

. Power Plant

: 152,600 U.S.Dollars = 254.0 MMRp

. Pretreating facility and pipeline

: 41,720 U.S.Dollars = 69.5 MMRp

(4) Maintenance Costs

The maintenance cost for the LPG Recovery Plant is set at 3% of the plant cost. The maintenance cost for the power plant is set at 13 Rp/kWh (1,761 MMRp/year).

(5) Insurance Cost

The insurance cost for the LPG Recovery Plant and for the power plant is set at 0.5% of the plant costs.

15-4 Results of Financial Analysis

(1) LPG Recovery Plant

The LPG manufacturing cost averaged for 20 years is 218 U.S. Dollars/ton in Case 1 applying a normal city bank interest rate and 204 U.S.Dollars/ton in Case 2 applying a soft loan.
The internal rate of return is shown for both cases as follows:

	Case 1	Case 2
ROI (Before tax)	3.6%	3.6%
ROI (After tax)	2.0%	2.0%
ROE (Before tax)	N.R.	7.5%
ROE (After tax)	N.R.	4.4%

N.R. is a negative return which means the internal rate of return is zero or in the negatives.

(2) Power Plant

The unit generating costs for each case are shown in Table 15-1 and the corresponding internal rates of return are shown in Table 15-2.

Table 15-1 Unit Cost of Electricity

Case	Interest (%)	Gas Price ($/MMBTU)	Unit Generating Cost (Rp/kWh)
1-A	12.0	2.53	95
1-B	12.0	2.10	89
1-C	12.0	1.50	79
2-A	3.5	2.53	91
2-B	3.5	2.10	85
2-C	3.5	1.50	75

Table 15-2 Internal Rate of Return

(Unit: %)

	ROI (B/Tax)	ROI (A/Tax)	ROE (B/Tax)	ROE (A/Tax)
Case 1-A	0.0	N.R.	N.R.	N.R.
Case 1-B	2.9	1.6	N.R.	N.R.
Case 1-C	6.2	4.2	1.7	N.R.
Case 2-A	0.0	N.R.	N.R.	N.R.
Case 2-B	2.9	1.6	7.6	3.9
Case 2-C	6.2	4.2	22.1	20.7

N.R.: Negative Return

15-5 Summary of Financial Analysis

(1) LPG Recovery Plant

Since the average LPG manufacturing cost is 204 U.S.Dollars per ton for the interest rate of 3.5% p.a., if LPG is sold at a delivered price at the LPG Plant of 240 U.S.Dollars per ton, the operation of the LPG Recovery Plant is financially feasible. On the other hand, the process for recovering LPG from the gas was also studied and the averaged manufacturing cost is 251 U.S. Dollars per ton.

. If the soft loan is applied, the financial conditions are good and the principle can be repaid without financial difficulties.

. If the LPG demand in Jambi district increases greatly, the amount of LPG sold at a very low price in Palembang will be decreased, and will vastly improve profitability.

. Judged from the above, LPG recovery project is considered financially feasible, as long as the major premises do not changed in great amounts.

(2) Power Plant

. If the soft loan is applied and the gas price is set below 2.1 U.S.Dollar/MMBTU, the operation of the power plant is financially feasible as an independent entity.

. If the gas price is set below 2.43 U.S.Dollars/MMBTU, electricity can be generated at the price lower than that of a diesel generator.

- Since the supply of electricity to communities is a fundamental part of the infrastructure, the viability of the power plant should not be discussed only from the viewpoint of financial analysis. However, if the gas price is set below 2.1 U.S.Dollars /MMBTU and the soft loan is applied, the operation of the power plant is definitely feasible.

- As it is clear from the sensitivity analysis, if, for example, an accident causes a reduction in the amount of generation, the financial conditions deteriorate immensely. Therefore, when the project is implemented, all the operators should be trained thoroughly and the appropriate and opportune maintenance work should be done to ensure continuous operation for generating the planned amount of electricity.

16. ECONOMIC ANALYSIS

16-1 Economic Benefits and Cost

(1) Economic Benefits

(a) Power Plant

In this study, gas generation is considered as an alternative of diesel generation and the economic benefit derived in this project is the saving of diesel oil. The amount of diesel oil which would be saved by implementing this project is 28,432 kl per year.

(b) LPG Recovery Plant

The LPG produced by this project is considered as the alternate fuel of kerosene. The amount of kerosene that will be replaced by LPG is 2,588 tons per year, having taken into account the difference in the heating value of the two fuels.

Besides those mentioned above, another benefit in implementing this project is the reduction of transportation cost since transportation of LPG from Palembang to Jambi will not be required. The projected savings in transportation cost amounts to 65 U.S.Dollars per ton of LPG.

(2) Economic Cost

(a) Power Plant

Since this power plant project is intended to replace diesel generation, the economic costs are difference in plant cost, the cost of gas and difference in insurance cost related to the plant construction cost. The difference of the plant cost is 415 million yen (5,395 million Rp). The economic price of the gas is considered equivalent to crude oil in terms of heating value.

(b) LPG Recovery Plant

All costs, except cost of gas for utility use, considered in the financial analysis are evaluated as the economic cost of LPG Recovery Project. The economic cost of the gas is considered the equivalent of crude oil in terms of heating value.

16-2 Economic Internal Rate of Return

Based on the economic benefits and economic costs mentioned above, the economic internal rate of return (EIRR) achieved by the implementation of this project is calculated.
EIRR for the power plant project and LPG recovery project are as follows:

. Power plant project: 16.4%
. LPG recovery project: 5.5%

EIRR for the power plant project exceeds ROI before tax in the financial analysis. This indicates that the implementation of the power plant project will definitely contributed to Indonesian economy. The LPG recovery project depends on the power plant project. Although the LPG recovery project is small in scale and its economic internal rate of return is not large, the EIRR still exceeds the financial return of investment, which means the LPG recovery project contributes to the economy of the country. Furthermore, the LPG recovery project aims to recover the volatile fraction in the condensate that would vaporize into air if not recovered by the LPG Recovery Plant of this project and it is significant that precious natural resources are utilized and not made to go to waste.

16-3 Influence on Foreign Reserve

By the implementation of this project, the following amount of foreign currency would be saved.

. Power plant project: 38 MMUS$
. LPG recovery project: 6 MMUS$

16-4 Overall Evaluation

The purpose of this project is to generate electricity and to recover LPG from the natural gas which is left unused. The direct economic effect is to save diesel oil and kerosene. Further, this project contributes to earning foreign currency.
In Indonesia, there are a lot of similar small-scale gas reservoirs like that of Sengeti. If effective utilization of small-scale natural gas for power generation is proved by the implementation of this project, this project can be used as a model case of improving electrification of rural areas in the country.
It is believed that the implementation of this project has extremely high social significance for the Republic of Indonesia.

17. CONCLUSION AND RECOMMENDATION

There are a number of large and small gas fields in Indonesia and to date, the large scale gas fields are utilized for the purpose of exporting LNG and LPG. Conversely, the small-scale gas fields, scattered in various parts of Indonesian Archipelagoes, have not been developed or utilized. However, the system to promote regional development by the effective utilization of the natural resources indigenous to the country will be discussed as a new approach for the balanced economic development in Indonesia which would ease the population concentration in the Java Island.

The purpose of this project is to supply electricity and LPG needed in Jambi district by utilizing the natural gas in Sengeti, which is left unused at present. And once this project is implemented, the project will have far-reaching influence on the economic development of the region. If the utilization of the small-scale gas fields proves effective to the regional development, the concepts of this project can be used as the model for the areas similar to Jambi where small-scale gas fields are yet untapped.

The project all in all is assessed reasonable and viable from view-points of market and the availability of raw material feed gas.
Most of the facilities intended for use by this project have already been used in Indonesia and the generating facility of the dual-fuel engine generator has been proven technically viable. Therefore, in implementing this project in Jambi district, it can be stated that there will be no technical obstacles other than the normal and foreseeable one which can be overcome by the cooperation and dedicated efforts of a group of competent engineers. From the view-points of finance and economy, if the gas price is set below 2.1 U.S.$ /MMBTU and the soft loan as described in the financial analysis is applied, the proposed power plant can be operated with financial independence as a separate entity. The LPG recovery project is small in scale and is dependent upon the power plant project; however, it has significance from viewpoint of conservation and effective utilization of precious natural resources.

In the light of the results of the study coupled with the social and regional significance of the project, the study team for this Feasibility Study can confidently say that this project should be promoted and implemented as quickly as possible.

Because the detailed data concerning the gas reservoir are of confidential nature for PERTAMINA, the owner of the gas fields, and sufficient data are not made available to the study team, the technical evaluation and discussion on the gas reserves are based fundamentally on engineering assumption and judgment. Moreover, this project uses Sengeti gas reservoir as the only gas resource, thus the recoverable reserve of the gas, the gas production plan and gas compositions have crucial influence on the entire project. Therefore, in proceeding with the actual implementation of the project, a detailed survey on gas reservoirs shall be carried out as the first step of the work.

It is also necessary to establish an appropriate organization for project execution after BPPT, the Provincial Government of Jambi, PERTAMINA and PLN have in depth discussions.