THE REPUBLIC OF INDONESIA

# STUDY REPORT ON REHABILITATION AND DEVELOPMENT OF TOWN GAS

November 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

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# PREFACE

The Government of Japan, at the request of the Government of The Republic of Indonesia, decided to undertake a study for rehabilitation and development of town gas in Indonesia, and commissioned its task of implementation to the Japan International Cooperation Agency.

Accordingly, the Agency organized a survey team consisting of eight experts headed by Shin-ichiro Okawa (Tokyo Gas Co., Ltd.), and sent the team to Indonesia for a period of 23 days from March 7 to March 29, 1975.

During the survey work there, the team held discussion meetings with PGN, PUTL, MIGAS, BAPPENAS and other organizations involved, and at the same time, the team visited PGN plants in Jakarta, Bandung, Cirebon, Surabaya and Medan to carryout the field survey.

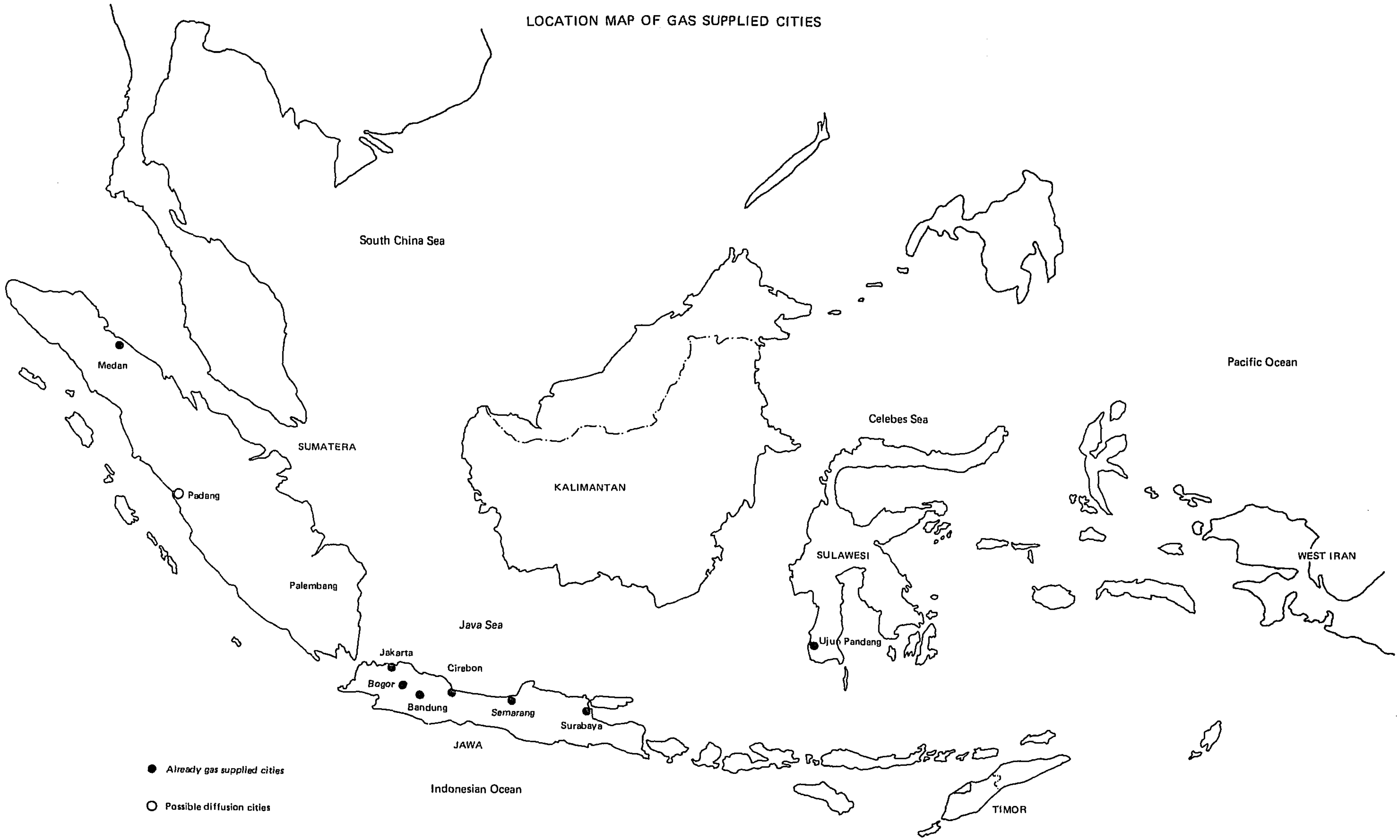
Hereby presented is a report based upon the finding the team has attained in Indonesia as well as at home.

Nothing would be more gratifying to us than if this report could be of any help for the development of town gas enterprise in Indonesia as well as the industrial development and the improvement of general living of the people of Indonesia, and could contribute to the promotion of friendship between the two nations.

Finally, I take this opportunity to express my hearty gratitude to the Government of The Republic of Indonesia and other authorities concerned who assisted the team in various ways. Particular thanks are to Ir. G. Pandegirot, President Director of Perusahaan Gas Nagara, and his staff, who did spend much of their time in guiding and discussing with the team.

November, 1975

Shinsaku Hogen
President Director
JICA


LOCATION MAP OF GAS SUPPLIED CITIES
South China Sea
Pacific Ocean
Celebes Sea
Medan
SUMATERA
Padang
KALIMANTAN
SULAWESI
WEST IRAN
Palembang
Java Sea
Jakarta
Cirebon
Bogor
Bandung
Semarang
Surabaya
Ujung Pandang
JAWA
Indonesian Ocean
TIMOR
Already gas supplied cities
Possible diffusion cities

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# INTRODUCTION

INTRODUCTION

1. Background of the Survey

Operation of a gas enterprise in Indonesia was initiated in the 1860's when the country was under the Dutch rule, so that it has a history of more than 100 years. After the nationalization effected in 1958, the gas enterprise was placed under the control of the Ministry of Public Works and Power and have been run by PGN (State Gas Corporation). PGN has its main office in Jakarta, and manufactures and distributes gas at a total of eight stations located in Jakarta, Bogor, Bandung, Cirebon, Semarang, Surabaya, Medan, and Ujung Pandang.

At present, PGN's production and distribution facilities are deteriorated to a notable extent due to the fact that no effective repair services have been made since the nationalization.

Although a number of rehabilitation and development plans were mapped out by PGN either on its own or with the assistance of foreign experts in the past, none have actually been carried out in a satisfactory manner.

It is anticipated that the demand for gas in Indonesia will be phenomenally augmented in the coming years on account of the sharp population increase and accelerated pace of economic development, and this in turn is expected to add to the importance of gas as the main source of energy for urban areas.
Indonesia is now pressed hard for reexamination of the Master Plan under which to fill the growing demand for gas and enhance the utilization of natural gas for raw material.

Occasioned by the severity of the situation, the Indonesian government requested Japan's cooperation in the reexamination of the said Master Plan, and Japanese government acceded to this request and sent a survey team to Indonesia.

## 2. Objectives of the Survey

The survey was conducted for the purpose of making a general study on the following items.

(1) Evaluation of future prospects of gas within the framework of the national energy policy.

(2) Reviewal for formulation of a "Revised Master Plan" aiming at rehabilitation and development of gas production and distribution facilities (consisting specifically of studies and analysis of the existing data relating to Jakarta area).

a) Financial and managerial aspects.

b) Planning and engineering aspects.

## 3. Outline of the Survey

The survey team stayed in Indonesia for 23 days from March 7 to 29, 1975 and carried out a field study according to the itinerary shown in Section 4 of this chapter. Due to the limited time allowed for the survey, the team was unable to visit all the stations of PGN, nor was it possible for the team to discuss at length with all the pertinent authorities in Indonesia. Nevertheless, thanks to the unlimited cooperation and assistance extended by PGN and other agencies of Indonesian government, the team was enabled to complete the survey as scheduled and collect various and valuable data and information.

After its return to Tokyo, the team engaged in the consolidation and analysis of the collected data and made a series of studies and discussions, the outcome of which was compiled into the present report.

The field survey was conducted by the following eight experts. In the home study made in Japan, these experts were aided by the staff of the Japan Gas Association headed by Mr. Takagi, Director.

List of Members of the Survey Team

| Name | Assignment | Affiliation |
|---|---|---|
| Shin-ichiro OKAWA | Team leader, overall project management | Tokyo Gas Co., Ltd. |
| Kazuo TAKAYAMA | Planning and institution | Ministry of International Trade and Industry |
| Yositoki WAKIYAMA | Financing planning | Tokyo Gas Co., Ltd. |
| Yuzo ONO | Marketing analysis | Tokyo Gas Co., Ltd. |
| Hiroki OKIMI | Plant engineering | Osaka Gas Co., Ltd. |
| Toshio YADOMOTO | Gas distribution engineering | Osaka Gas Co., Ltd. |
| Hiroshi MITSUHASHI | Gas combustion engineering and natural gas conversion planning | Tokyo Gas Co., Ltd. |
| Fumio NISHIWAKI | Liaison and coordination | Japan International Cooperation Agency |

4. Itinerary of the Survey Team

| Date | Description |
|---|---|
| March 7 (Fri) | Arrival in Jakarta. |
| March 8 (Sat) | Courtesy calls made on the Japanese Embassy in Jakarta and PGN, with arrangements made for the survey schedule. |
| March 9 (Sun) | Intra-team discussion and arrangements for the survey schedule. |
| March 10(Mon) | Consultation with PGN. |
| March 11(Tus) | Observation of PGN's Jakarta station, and inspection of consumers. |
| March 12(Wed) | Discussion with PGN. |
| March 13(Thu) | Courtesy call made on PUTL (Ministry of Public Works and Power). |
| March 14(Fri) | Discussion with PGN. |

| Date | Description |
|---|---|
| March 15 (Sat) | Visit to D.K.I. Jakarta (Jakarta Municipal Office); Departure from Jakarta for Bandung in the afternoon. |
| March 16 (Sun) | Inspection of PGN's Bandung station and Bongas station. |
| March 17 (Mon) | Inspection of Cirebon station, and natural gas wells in Bongas and Jatibarang areas; Departure from Cirebon and arrival in Jakarta in the afternoon. |
| March 18 (Tus) | Visit to the Power Research Institute. |
| March 19 (Wed) | Party A (3 team members): Visit to PERTAMINA.<br>Party B (5 team members): Inspection of Medan station. |
| March 20 (Thu) | Party A: Visit to BAPPENAS and Ministry of Industry<br>Party B: Inspection of natural gas wells in the vicinity of Medan. |
| March 21 (Fri) | Inspection of Surabaya station. |
| March 22 (Sat) | Consolidation and arrangement of data. |
| March 23 (Sun) | Intra-team discussion about the survey results. |
| March 24 (Mon) | Preparation of the interim report. |
| March 25 (Tus) | Preparation of the interim report. |
| March 26 (Wed) | Visit to MIGAS (Natural Gas Department, Ministry of Mining). |
| March 27 (Thu) | Submission of the interim report to PGN. |
| March 28 (Fri) | Inspection of pipeline maintenance work in Jakarta city. |
| March 29 (Sat) | Submission of the interim report to PUTL; Departure from Jakarta and arrival in Singapore in the afternoon. |
| March 30 (Sun) | Arrival in Tokyo. |

List of Organizations Visited (excl. PGN)

| Date of Visit | Organization | Officials Interviewed |
|---|---|---|
| March 13 | PUTL | H.E. Mr. Eli Sungkono, Secretary General, and Drs. Lego Nirwono, Chief of Planning Board and Foreign Relations Bureau. |
| March 15 | DKI Jakarta | Ir. Herbowo, Director, and Ir. T.W. Simbolon, Director. |
| March 18 | Power Research Institute | Dr. A. Arismunandar, Director. |
| March 19 | PERTAMINA | Ir. Trisulo, Director. |
| March 20 | BAPPENAS | Mr. Sugen Soendjaswadi |
| March 20 | Ministry of Industry | Mrs. Kusbandia<br>Ir. Harahap<br>Ir. Saiful<br>(Officials of Planning Department) |
| March 26 | MIGAS | Ir. Sumbaryono, Chief of Planning Department and other officials. |

# SUMMARY & RECOMMENDATIONS

## SUMMARY AND RECOMMENDATIONS

### 1. GAS IN THE FUTURE

In accordance with the Five Year Plan of the first (1969 - 1973) and the second (1974 - 1978) phases, the development of the national economy, promotion of industrialization and fortification of the nation's strength have been underway in Indonesia. On the other hand, the population has been constantly increasing on a rapid basis, and the cityward tendency of the population is progressing with most of the population located in Java. In order to make harmonized economic growth and improvement of the people's living possible, it is necessary to establish a long-range civic plan. The future status of town gas must be reviewed as a part of this plan.

As to the energy consumption, a conversion to the commercial energy such as petroleum and natural gas, etc. from the current ligneous fuel, which is said to occupy 60% of the total fuel consumption at present, should be developed. The development of natural gas has recently progressed in west Java, northern Sumatra, and eastern Kalimantan, etc. There are sufficient possibilities to enable the industrial development and economic growth through effective utilization of such.

Under the abovementioned circumstances, the Indonesian gas industry should be reviewed from a new angle. It is required that town gas be realized and expanded in a way most suited to Indonesia on its way to becoming a modern nation.

At present, firewood, charcoal, kerosene, LPG and town gas are being used for fuels in urban areas. Firewood and charcoal among these are less effective in energy efficiency and in convenience. It is undesirable to further promote the usage of these energies in order to protect natural resources. LPG has a number of safety problems. Its inland transportation and storage in densely populated areas in particular are dangerous. While town gas is a little more costly in its price, it is superior in efficiency, convenience, and safety factors. It is the best as the heat energy resource for populous areas. The advantages of town gas will further increase when natural gas is used.

Because of these advantages, town gas is widely used in major cities in the world. In Indonesia, there is a considerably potential demand both for industrial use and for domestic use. However, the gas utility situation in Indonesia has lost the confidence of consumers due to degraded facilities, poor quality and services. It by no means meets the potential demand. Therefore, it is necessary for the government and PGN to immediately improve and develop town gas.

## 2. RECOMMENDED POSTURE & APPROACH

As an exclusive town gas utility enterprise in Indonesia, PGN has the following social responsibilities:

(1) To generally and continuously supply gas to consumers.

(2) Supplied gas should be trustworthy and of standard quality.

(3) With respect to the supply conditions such as charges, etc., unjustifiable discrimination should be eliminated.

(4) To maintain efficient management; consequently, the charges should be kept within a reasonable range by rationalized management.

(5) To secure and maintain public safety and the prevention of public nuisances.

Unfortunately, PGN is not fulfilling these responsibilities at the present moment. Therefore, as mentioned above, it is necessary to immediately improve and develop this business.

As a strategy for the rehabilitation and development schedule, the following points must be considered as priority:

(1) Gain maximum effectiveness with minimum investment.

(2) Rehabilitation must come first, and development (or expansion) should be left as the second step.

(3) The immediate objective should be the restoration of consumers' confidence; the target level should be that of the period when the business was most prosperous (1962 - 1964).

Based upon the above strategy, we would like to recommend the following for rehabilitation and development of the business.

(1) Raw Material & Production Facilities

As raw material, natural gas would be the best from a viewpoint of quality and economy. Therefore, shift to the natural gas should be positively planned in those areas where natural gas introduction is possible.

Among the existing gas production, coal gas and diesel oil catalytic cracking gas are comparatively high in calorific value, and it seems possible to use them continuously for the time being.

Partial combustion gas from diesel oil, which is the major gas PGN currently supplies, contains considerable amount of impurities and is low in calorific value. It is most important to thoroughly strengthen the gas purification and to take measures to increase the calorific value.

The following is a table showing a recommended production method for each works of PGN:

Recommendation of Gas Production Method for Each PGN-STATION

| | Natural Gas | Coal Gas | LPG-Air | Diesel Oil Partial Combustion + LPG | Onia-Gegi |
|---|---|---|---|---|---|
| Medan | ** | | | | |
| Jakarta | ** | * | | | |
| Bogor | * | | ** | ** | |
| Bandung | | *** | | ** | |
| Cirebon | *** | | | | |
| Semarang | | ** | | ** | |
| Surabaya | * | ** | | | *** |
| Ujung Pandang | | | ** | | |

*** Continue with the current method. **Recommendable.

* Possible.

(2) Supply Facilities

(a) Supply pipes --

Most of the existing gas supply pipes were laid during the period of the Dutch reign. They are badly worn out causing gas leakage. The leakage is not only dangerous but also increases unaccounted gas volume, adversely affecting the P/L of PGN. It also results in collecting water leading to an inferior supply. Therefore, it is imperative for PGN to restore these leaking pipes. The total replacement of the pipes as planned previously, however, is too costly and impractical. For purposes of making an effective restoration, the first thing is to precisely investigate and analyze the leakage, and then to restore those parts and/or to replace only the leaking portions with new supply pipes.

(b) Improvement of Supply Method --

As a countermeasure against the inferior supply, it is necessary to review the piping network and to examine employment of mid-pressure supply method.

(c) Gas Meters --

At present, metering delays and measurement errors are considerable because of tar adherence or too large a meter capacity. A gas meter is a business record between PGN and its customers. There should not be any big measurement errors. To correct the situation, it is necessary to (1) install a meter of an appropriate capacity, and (2) conduct regular inspection of the meter.

(3) Better Efficiency in Management

For a healthy operation of gas business, PGN should become a well-balanced enterprise on a long-term basis. For this purpose, the following improvements in the management are required:

(a) Establishment and execution of a long-range plan.

(b) Effective utilization of man-power.

(c) Effective utilization of available funds.

(d) Fortification and improvement of sales and service activities.

## 3. REHABILITATION & DEVELOPMENT OF PGN-JAKARTA

Jakarta, as the capital of Indonesia, is a symbol of development to a modern nation. At the same time, it is one of the most over-populated large cities in the world. Because of this fact, the necessity of town gas is significant. It should be given top priority for rehabilitation and development.

Therefore, we would like to mention the rehabilitation and development of Jakarta in particular as a case study.

The key to town gas promotion in Jakarta is the introduction of natural gas. A natural gas pipeline is currently being built between Cilamaya and Cilegon, and the introduction of natural gas into Jakarta from this pipeline is being studied. Due to the importance of town gas in Jakarta, the government must plan a positive introduction schedule of natural gas for subsequent execution.

If the construction of the pipeline progresses in accordance with the schedule, the introduction of natural gas into Jakarta will be materialized by the end of 1978. As a preparation for the introduction as well as to fill the interim period, it is necessary to improve the existing production facilities, to restore the existing pipes, and to place middle-pressure mains for better gas quality and supply. The natural gas introduction schedule in Jakarta including the abovementioned rehabilitation will be described hereunder. The estimated expenses to be incurred should be approximately 4.3 billion rupia (= US$10 million).

The Rehabilitation/Development Schedule - Jakarta

| | |
|---|---|
| 1975 | Investigation & preparation period |
| 1976 | Improvement of production facilities |
| 1976 - 1978 | Rehabilitation of pipelines and gas meters |
| 1978 | Establishment of middle-pressure mains (10 km) |
| 1978 | Establishment of main pipeline (44 km) of natural gas. Conversion to natural gas. |

With respect to the estimated P/L of this schedule, it is predicted that in 1983, PGN will achieve an operating profit on an assumption that the required funds be obtained at a 12% interest for a 20 year long-term basis.

## 4. GOVERNMENTAL SUPPORT

Town gas in Indonesia will achieve radical development upon proper rehabilitation and development measures. It will greatly contribute to the industrial development, economic growth as well as the improvement of general living of the people of Indonesia. For such purposes, it is believed that the Indonesian government should positively support the PGN's rehabilitation and development program. The following items are desired to be supported by the government:

1) Coordination among various government authorities concerned for the establishment and execution of the program.

2) Financial support on a long-term basis.

3) Stable procurement of raw materials such as natural gas, etc.

4) Supervision for the protection of consumers interests.

In any event, the rehabilitation and development of town gas would require a great effort. The united effort in promotion of the project with due recognition between PGN and the government authorities would be indispensable.

## 5. RECOMMENDED STEPS OF FUTURE STUDIES

It is recommended that the following studies be made in future by PGN as follow-up activity of the team's study.

(1) Study of a Detailed Plan Presupposing Natural Gas Conversion of Jakarta Station

1) Survey of defective parts of pipeline, and determination of the method and schedule of their rehabilitation.

2) Determination of the route of the natural gas transmission line, and formulation of its construction plan.

3) Formulation of an implementation plan of the natural gas conversion.

4) Formulation of a gas service expansion plan compatible with the availability of natural gas, and establishment of measures for increasing customers.

5) Estimation of the required capital input, study of the fund raising method, and establishment of a financial plan.

(2) Study of a Master Plan of Entire PGN

1) Formulation of a master plan for all stations excluding Jakarta.

2) Study of the feasibility of establishing new stations (in Palembang, Padang, etc.).

Items 1) and 2) above are to be undertaken on the basis of the planning of future production and distribution facilities and investment described in the report (pp. 145 ∿ 158).

3) Determination of the development priority of respective stations.

4) Estimation of the required capital input, study of the fund raising method, and establishment of a financial plan.

5) Formulation of long-range development plan of the entire PGN.

Two study teams headed by the Chief of the Research and Planning Department should be established within PGN in order to carry out these studies for a period of six months to a year.

The study teams should comprise experts assigned to the following plans and sectors.

(1) Jakarta Station Natural Gas Conversion Study Team

1) Pipeline Plan .......... Planning and guidance in site works.

2) Conversion Plan ........ Gas distribution and conversion techniques.

3) Investment Plan ........ Investment, fund raising, financial plan.

(2) Master Plan Study Team

1) Production Sector.

2) Distribution Sector.

3) Management Control Sector.

Notes: Manager of each station is to participate in the study as need arises.

These two teams are to take over the duties of the project team organized some time ago under the decree of the Minister for Public Works and Power to study the development of town gas and utilization of natural gas.

# CHAPTER I

# UTILIZATION OF GAS ENERGY

# CHAPTER I. UTILIZATION OF GAS ENERGY

## 1. Energy Situation in Indonesia

The 1973 commercial energy consumption in Indonesia registered approximately 67 million barrels in terms of petroleum and about 17,700 thousand tons in terms of coal. As is clear from the breakdown shown in Table I-1, it is estimated that petroleum accounts for 90.2% (4.5% for thermal power generation) of this total consumption, natural gas for 8%, coal for 0.7%, and hydroelectric power for 1.3%.

Table I-1. Breakdown of Commercial Energy Consumption in Indonesia (1973)

| Energy Source | Actual Consumption | Conversion into Coal | Ratio |
|---|---|---|---|
| Petroleum | 60 million barrels | 16,000 thousand tons | 90.2% |
| (for thermal power generation) | (3 million barrels) | (800 thousand tons) | (4.5) |
| Natural Gas | 29 BSCF | 140 thousand tons | 7.8 |
| Coal | 110 thousand tons | 110 thousand tons | 0.7 |
| Hydroelectric Power | 400 thousand KW, 500 million KWH | 23 thousand tons | 1.3 |
| TOTAL | 67 million barrels in terms of petroleum | 17,774 thousand tons | 100.0% |

As can be readily deduced from the percentage ratios given above, Indonesia depends on petroleum for the supply of the greater part of commercial energy she requires.

In 1973, Indonesia produced a total of 77,580 thousand kℓ ( = approx. 488 million barrels of crude oil), which is equivalent to 2.3% of the world's total crude oil production registered in that year or more than 8 times the aforementioned domestic petroleum consumption (approx. 60 million barrels).

Table I-2. Production, Export and Consumption of Crude Oil in Indonesia (1973)

Unit: Thousand kℓ

| | |
|---|---|
| Production | 77,580 |
| Export | 58,748 |
| Domestic Consumption | 18,832 |
| Refining: | |
| Total volume refined | 18,865 |
| Production | 17,034 |
| Export | 8,987 |
| Net domestic consumption | 9,271 |

Source: First Oil Trading, Ltd., "Petroleum Statistics of Indonesia" compiled from the statistical data of MIGAS.

The abundant petroleum resources enable Indonesia to fill more than 90% of her commercial energy demand and supply the greater part of her crude oil production to the world's market and earn the foreign exchange required for the country's economic development.

Conversely speaking, however, this fact points to the low energy demand and the need for structural improvement of the energy consumption pattern. Specifically, the 1974 commercial energy consumption per capita in Indonesia registered 114.7 kg in terms of coal (Note 1) which is as small as one hundredth of the consumption in the United States, one fiftieth of the consumption in the United Kingdom and West Germany, and one thirtieth of the value recorded in Japan. (Note 2) It must be pointed out here that the greater part of the country's energy demand is filled by non-commercial energy sources such as wood and charcoal.

Although no accurate data are available on the non-commercial energy consumption, it merits attention that 187 kg in terms of coal was adopted as the 1970 non-commercial per capita energy consumption at the Symposium on Energy, Resources and the Environment held in Jakarta in February 1975. (Note 3) This value is equivalent to 70% of Indonesia's total energy consumption. Compared with commercial energy, non-commercial energy is inferior in both fuel efficiency and handling convenience, and its consumption should be reduced in a rational way in order to materialize effective utilization of national resources. It must be noted that forest resources are very important for production of furnitures, construction materials and pulp wood, and that overcutting of trees inevitably leads to the devastation of forest land and exerts an adverse influence on the conservation of national land.

In the coming years, therefore, maximum effort should be made to cut down the ratio of non-commercial energy consumption through substitution by commercial energy. It may as well be mentioned that at the said symposium, it was recommended that the ratio of non-commercial energy consumption be reduced to 4.8% of the present level by the year 2000.

Indonesia's energy demand is expected to grow sharply in future with the rapid population increase, progress of economic development, and improvement of the people's income level. The 1971 census indicated that Indonesia had a population of 122 million which was estimated to increase at an annual rate of 2.8%. According to Mr. Sumitro, (Note 4) the annual population growth rate is expected to drop by about 25% in future but the total population of the country is estimated to reach 246 million in 2,000.

At a number of recent seminars on energy demand, (Note 5) the target energy consumption per capita for the year 2,000 was set at 4 barrels in terms of petroleum (= 784 kg in terms of coal).

This target value is considerably lower than the aforementioned 1970 level of the United States (11,300 kg in terms of coal) and 1971 consumption levels in other countries including Korea (860 kg), Mongolia (945 kg), and Singapore (851 kg).(Note 6) Nevertheless, if this target value is attained, the country's energy demand in 2,000 will reach a total of 157.7 million kℓ which is as many as 17 times the 1973 consumption level, and it will of course be possible to fill this total demand by petroleum.

However, considering the fact that petroleum plays the important role in acquiring the precious foreign currency income and that the country's industrial development is likely to give rise to growing demand for petroleum for operation of petrochemical and other industries which will turn out products with high added-value, Indonesia will not be able to continue to resort to her petroleum resources for the supply of necessary energies. For this reason, Mr. Wijarso strongly voiced the need for developing alternative energies and suggested the following energy supply pattern to meet the prospective demand in 2,000.

Table I-3. Desirable Pattern of Energy Supply for 2,000

Unit: $10^3$ kℓ in terms of petroleum

| | |
|---|---|
| Petroleum | 118,500 |
| Geothermal energy | 700 |
| Hydroelectric power | 7,500 |
| Coal | 9,000 |
| Nuclear energy | 12,000 |
| Natural gas | 10,000 |
| TOTAL | 157,700 |

Source: Wijarso, "Some Aspects of Energy Resources Development in Indonesia to the Year 2,000," February 1975.

Of these alternative energies, geothermal and nuclear energies are still in the stage of researches, but the development of hydroelectric power and natural gas is in rapid progress at present. In particular, annual production of natural gas is planned to be augmented from the present level of 52.75 BSCF to 669.41 BSCF under the Second Five Year Development Plan (1974/5 ∿ 1978/9) for use as new fuel source as well as for operation of petrochemical industry and export (after processed into LNG). During the team's visit to the Power Research Institute, Dr. Arismunadar, director of the institute, emphasized the need for accelerated development and effective utilization of natural gas, stating that a large amount of petroleum that would otherwise be consumed in Indonesia could be exported to earn the much needed foreign exchange income.

While it leaves no doubt that the development of alternative energies is of great importance, the team wishes to point out that not much consideration is given for their efficient utilization which is just as important as the development effort. It is therefore recommended that careful consideration be given in planning the utilization method, distribution pattern, and distribution facilities of the new energies. Specifically, it will be required to make a detailed study on the energy conversion coefficient, handling convenience and safety factor of each newly developed energy source in order to establish the distribution pattern and facilities most compatible with the desirable utilization pattern of each individual kind of energy. These points will be discussed at length in the next section for energy supply to urban and suburban areas.

(Note 1) Value estimated at the National Energy Seminar, July 1974.

(Note 2) 1970 consumption of primary energy by countries.

| Country | Total Consumption (million t) | Per Capita Consumption (kg) |
|---|---|---|
| United States | 2,279.0 | 11,100 |
| United Kingdom | 299.1 | 5,400 |
| West Germany | 317.1 | 5,200 |
| Japan | 332.4 | 3,200 |

(Consumption expressed in million tons and kg of coal.)

Source: "Comprehensive Energy Statistics," 1973 edition, compiled by Japanese Ministry of International Trade and Industry.

(Note 3) Symposium on Energy, Resources and the Environment, February 1975.

(Note 4) Sumitro Djojohadikusumo: "Indonesia towards the Year 2,000," February 1975.

(Note 5) 1) First Management Course for Oil and Natural Gas Executives, October 1973.

2) National Energy Seminar, July 1974.

3) Symposium on Energy, Resources and the Environment, February 1975.

(Note 6) Aforementioned "Indonesia towards the Year 2,000 and "Energy Resources in the ECAFE Region (August 31, 1973)" compiled from ECAFE's data.

2. Desirable Pattern of Thermal Energy Distribution in Urban Areas

Thermal energy sources currently used in urban areas include wood, charcoal, kerosene, LPG, electricity, and gas. Of these, wood and charcoal, which produce the so-called non-commercial energy, are poor in both energy efficiency and handling convenience, and their consumption should be reduced in the future for conservation of forest resources as described in the preceding section.

Accordingly, discussion advanced in this section covers the energy efficiency, handling convenience, safety, and price of kerosene, LPG, electricity and gas.

2.1 Comparison of Energy Efficiency

Gas is the least subject to the loss incurred in the route from the source to the consumer. In particular, when natural gas is used, the efficiency rises to almost 100%, which means complete freedom from loss.

Petroleum products such as kerosene, LPG and heavy oil are subject to a refining loss of about 5% and exhibit an energy efficiency of about 95%. The energy source having the poorest energy efficiency is electricity. Thermoelectricity, in particular, exhibits an efficiency of only 35% when heavy oil is used for its generation (See Table I-4).

In the case of hydroelectric power, the generation loss can be disregarded but since the transmission loss is as large 10%, the overall energy efficiency declines to 90%. The actual effiency varies by the use and appliance so that it is necessary to consider the appliance heat efficiency. As is clear from Table I-4, however, gas exhibits the highest energy efficiency irrespective of the use and appliance.

## Table I-4. Overall Efficiencies of Urban Energies (Heat)

| Percentage of heat value received by consumers against the overall heat value of the primary energies | Users | | Heat source and appliances for the utilization | (Heat value received by consumers) x (Appliance efficiency) | Overall efficiency | Relative efficiencies Town gas = 100 |
|---|---|---|---|---|---|---|
| Town gas = 100<br>(In case the town gas is manufactured from LNG)<br>(1) LNG → Gas 100<br>(2) Transportation 100<br>(1) x (2) = 100 | Home consumption | Cooking | Town gas (Portable cooking stove) | 100 x 45 | 45 | 100 |
| | | | Electricity (Portable cooking stove) | 35 x 65 | 23 | 51 |
| | | | LPG (Portable cooking stove) | 95 x 45 | 43 | 96 |
| Electricity (Thermoelectricity) = 35<br>(Heavy oil burning)<br>(1) Crude oil → Heavy oil 95<br>(2) Heavy oil → Electricity 40<br>(3) Power transmission 90<br>(1) x (2) x (3) = 35 | | Rice Cooking | Town gas (Rice cooker) | 100 x 50 | 50 | 100 |
| | | | Electricity (Rice cooker) | 35 x 80 | 28 | 56 |
| | | | LPG (Rice cooker) | 95 x 50 | 48 | 96 |
| | | Room Heating | Town gas (stove) | 100 x 80 | 80 | 100 |
| | | | Electricity (stove) | 35 x 80 | 28 | 35 |
| | | | Kerosene (stove) | 95 x 80 | 76 | 95 |
| Kerosene<br>LPG } = 95<br>Heavy oil<br>(1) Heavy oil refining 95<br>(2) Transportation 100<br>(1) x (2) = 95 | | Hot Water Supply | Town gas (water heater) | 100 x 75 | 75 | 100 |
| | | | Electricity (water heater) | 35 x 95 | 33 | 44 |
| | | | LPG (water heater) | 95 x 75 | 71 | 95 |
| | For industrial uses | | Town gas (boiler) | 100 x 85 | 85 | 100 |
| | | | Heavy oil (boiler) | 95 x 75 | 71 | 84 |
| | | | Town gas (Smelting furnace) | 100 x 45 | 45 | 100 |
| | | | Heavy oil (Smelting furnace) | 95 x 20 | 19 | 42 |

## 2.2 Comparison of Handling Convenience

The handling convenience not only varies by the purpose of use but is also judged by the user's own subjective impression, so that its numerical expression for the purpose of comparison entails difficulty.

By the term "handling convenience" is generally meant the availability of the energy in question at any time and in any quantity desired as well as the degree of simplicity of appliance operation. Accordingly, electricity and gas are most convenient to handle because they can be supplied at any time in the desired quantity simply by depressing the pushbutton switch or turning the cock. Compared with these two kinds of energies, kerosene and LPG are lower in handling convenience because they need to be purchased each time and a certain amount of stock must be kept at all times. In areas where the distribution mechanism is not well consolidated, therefore, it is rather difficult to use these energies at any time and in any desired quantity.

## 2.3 Comparison of Safety

If not used in the proper way, fuels are liable to develop a fire or explosion hazard which could inflict an extensive damage of properties and loss of human lives, especially in large cities. In this section, therefore, the safety of energies is discussed for three stages, i.e., manufacturing stage, transmission stage, and consumption stage.

Expecting hydroelectric power, all energies such as thermo-electricity, gas, kerosene and LPG involve just about the same degree of danger in their manufacturing process. However, if natural gas is used as the source of energy, the danger in the manufacturing stage can be completely eliminated.

The transmission stage is most vulnerable to danger, and an accident developing in this stage causes the heaviest damage. Electricity and gas which are supplied by transmission lines and pipelines are safer than LPG and kerosene.

Although a hazardous accident could occur as a result of their leakage, such an accident can be prevented by the establishment of a well organized security system. Energies involving the highest degree of danger in the transmission stage are kerosene and LPG which are supplied by railway or road transportation. This high degree of danger is intensified by the use of tank lorries running through areas subjected to heavy traffic congestion as well as by the need for establishing a number of relaying bases within the urban area. Construction of fuel bases in densely populated urban areas poses a serious security problem. It is for this high degree of transmission danger that neither kerosene nor LPG is used as main energy source in most of over-populated cities of the world.

The danger involved in the consumption stage arises from the inadequate design or installation of the appliance or from the inadvertent operation by the user, which are prone to result in the leakage of fuel and consequently in a fire or explosion hazard. However, the team was informed that virtually no explosion accidents resulting from leakage had occurred in Indonesia, and this may perhaps be attributable to the open structure of Indonesian residential houses. It appears that the danger in the consumption stage comes from the storage of fuels. Hence, kerosene and LPG involve a greater danger than electricity and gas.

## 2.4 Comparison of Price

Table I-5 shows the consumer price per unit quantity and calorific value of respective energies. As can be seen in this table, kerosene is very inexpensive, whereas the price of electricity and gas per calorific value is relatively high. Although the high price of electricity and gas can be justified to an extent by the excellent handling convenience, the team felt that the prevailing rates are just too high relative to the price of kerosene. In Japan, electricity costs the highest, followed by gas which is on the price level equivalent to or slightly lower than LPG, and kerosene is the cheapest and costs about one third of gas and LPG.

The price ratios of the first three energies, i.e., electricity, gas and LPG, are approximately the same as that in Indonesia but kerosene is conspicuously cheap. This low price level of kerosene in Indonesia is maintained by the government policy for restricting its use to home consumption alone and for suppressing its price escalation through subsidial measures. However, the government is planning to decrease the amount of subsidy in the coming years. When the subsidial measures are completely withdrawn, kerosene will lose its cost advantage because its current import price amounts to Rp 4.71 per 1,000 Kcal which is not much different from the price of LPG and gas. When considered from the viewpoint of national economy, increased consumption of kerosene whose supply must resort partly to import is not desirable because it is detrimental to the international balance of payments.

Table I-5. Price Comparison of Energies

| | Unit Q'ty | Kcal per Unit Q'ty | Heat Efficiency (Home consumption) | Heat Efficiency (Industrial uses) | Domestic Price | | | Export (Import) Price | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Rp/US$ per unit Q'ty | Rp per $10^3$Kcal | US$ per $10^6$BTU | US$ | Rp per $10^3$Kcal | US$ per $10^6$BTU |
| Kerosene 1 | ℓ | 8,340 | 48 | 80 | * 15.0 | 1.80 | 1.09 | 15/bbℓ | 4.71 | 2.85 |
| Kerosene 2 | | | | | **25.0 | 3.00 | 1.82 | | | |
| Diesel Oil | ℓ | 9,100 | 45 | 75 | 21.0 | 2.31 | 1.39 | 13.50/bbℓ | 3.88 | 2.35 |
| Residue Oil | ℓ | 9,100 | 40 | 70 | 21.0 | 2.31 | 1.39 | 14.00/bbℓ | 4.03 | 2.44 |
| Manufactured Gas 1 | $m^3$ | 3,200 | 60-80 | 80 | 40.0 | 12.50 | 7.54 | - | - | - |
| Manufactured Gas 2 | $m^3$ | 4,000 | | | 40.0 | 10.00 | 6.03 | | | |
| LPG | kg | 11,600 | 60-80 | 80 | 100.0 | 8.62 | 5.20 | 11.0/bbℓ | 0.60 | 2.79 |
| Coal<br>Ombilan<br>Australia<br>W. Germany | <br>kg<br>kg<br>kg | 7,000 | 35 | - | 54 | 7.70 | 4.65 | 18.0/ton | 1.07 | 0.65 |
| Coke<br>W. Germany<br>Taiwan | <br>kg<br>kg | 6,300 | 35 | - | <br>150<br>130 | <br>23.8<br>20.6 | <br>14.37<br>12.43 | - | - | - |
| Charcoal | kg | 7,100 | 28 | - | 78 | 10.99 | 6.65 | - | - | - |
| Electricity | kwh | 860 | 60-100 | 80 | 13.50 | 15.70 | 9.51 | - | - | - |
| Crude | ℓ | 8,600 | - | - | - | - | - | 12.60/bbℓ | 3.83 | 2.32 |

Source: Statistical Data of PGN.

Note) * Formal Pertamina Price at terminal

** Market price

## 2.5 Desirable Energy Distribution Pattern

The discussion advanced in the foregoing sections is summarized in Table I-6 from which Table I-7 showing the most desirable energy sources for urban areas was prepared.

Table I-6. Comparison of Various Factors of Energies

| | Energy Efficiency | Handling Convenience | Safety | Price |
|---|---|---|---|---|
| Kerosene | Δ | x | x | o |
| LPG | Δ | x | x | Δ |
| Gas | o | o | o | x |
| Electricity | x | o | o | x |

Notes: o - Excellent
Δ - Acceptable
x - Poor

Table I-7. Optimum Energies for Consumption in Urban Areas

| | For lighting and Power | For Fuel |
|---|---|---|
| Overcongested Area | Electricity | Gas |
| Non-congested Area | Electricity | Kerosene and LPG |

The optimum energy distribution pattern shown in Table I-7 is proposed for the following reasons:

(1) Electricity excels other energies in handling convenience and safety, and its consumption for lighting and power plant operation is likely to be augmented in future. However, since its energy efficiency is low and price high relative to other energies, its use for fuel is not recommended.

(2) Kerosene, LPG and gas can be cited as sources of fuel. Of these, gas costs higher than other energies but excels in handling convenience and safety, so that it is suited to use for fuel in densely populated areas.

(3) Safety must be given prime consideration in selecting the energy for Jakarta and other highly congested areas. It is mainly for the sake of safety that gas is used for home consumption in the majority of densely populated cities of the world such as Tokyo, New York, London and Paris.

(4) In non-congested areas, gas will have to give place to LPG or kerosene because the construction of its distribution network incurs a huge cost.

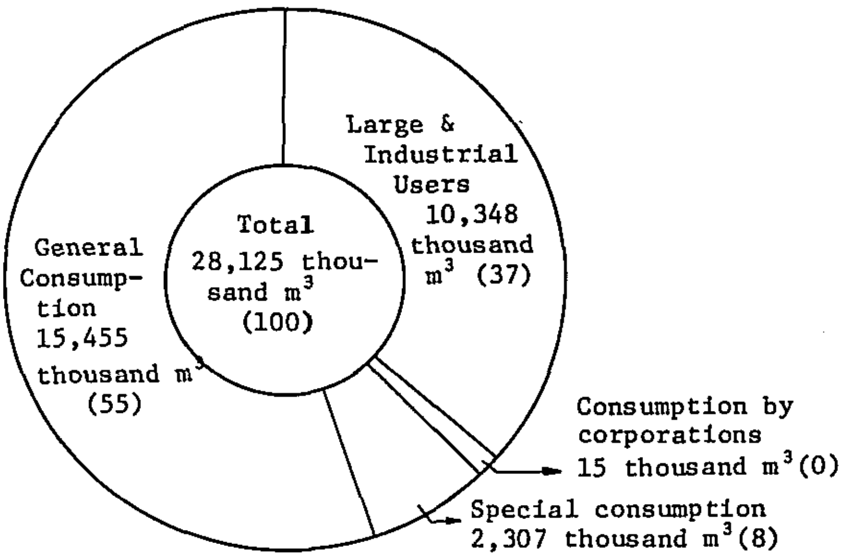
The team wishes to point out that energies for home consumption were discussed for the most part in the foregoing sections, and that energies for industrial uses should be studied from different angles.

## 3. Future Prospects of Gas

### 3.1 Uses of Gas

Gas is used as fuel for industrial as well as domestic purposes. At present, about 60% of gas supplied by PGN is for domestic consumption and about 40% for industrial and commercial purposes.

Fig. I-1 PGN's Gas Sales in 1973




Notes: 1. Special consumption covers the supply of gas to the government officials and members of the armed forces. Hence, the home consumption is the sum total of the special consumption and general consumption.

2. Large and industrial users include those consuming gas for commercial purposes.

3. Figures in parentheses denote percentages.

Gas supplied for home consumption is used solely for cooking and water heating because the climate in Indonesia dispenses with the need of heating apparatus and the people have no habit of taking a hot bath.

The annual home consumption per user is 833 $m^3$ (1973) which is not very large, but this is expected to increase as the modernization of residential houses and improvement of living standard are prompted in future with the expansion of national economy. It is likely that when these improvements are achieved, new uses of gas such as for air-conditioning will be developed, besides cooking and water heating.

As regards the industrial consumption, the team noted during its survey period that gas is used at a limestone plant in Cirebon, a biscuit plant in Medan, and an electric bulb plant and a bottle making factory in Surabaya. Gas is prone to be regarded unfit for large scale industrial consumption because it costs higher than petroleum-derived fuels, such as heavy oil and kerosene. However, since gas allows for delicate adjustments such as stabilization of the flame in shape and size and is also completely free from pollution problems, it is an ideal fuel for certain types of industry. As shown in Table I-8, it is widely used for industrial purposes in suburban areas in Japan.

## Table I-8 Various Industrial Gas Furnaces

- Heating furnaces
  - Metal heating furnaces
    - Forging furnaces
    - Rolling furnaces
    - Heat soaking ovens
    - Preheating furnaces
    - Other heating furnaces
  - Equipments to heat gas glass-wares, ceramics etc.
    - Furnaces to bake pocelains, ceramics etc.
    - Furnaces to bake glass bottles, print marks, bake enamelwares etc.
    - Other heating equipments to form ampules, thermos bottles etc.
- Heat treatment furnaces
  - Method heat treatment ovens
    - Quenching ovens
    - Annealing ovens
    - Tempering ovens
    - Carbon impregnating ovens
    - Kilns
    - Homogenizing ovens
    - Normalizing ovens
    - Aging ovens
  - Heat treatment ovens for glasswares, ceramics etc.
  - Atmosphere gas generators
    - RX gas generators
    - DX gas generators
    - Other atmospheric gas generators ammonia decomposing ovens etc.
- Liquid phase heaters ... Submerged heating, underfiring ovens, submerged combustion, direct gas/liquid phase heat exchanging heaters
- Air conditioners
- Boilers
- Toxic material disposers ... Incinerators, flue gas treatment, and odor removers
- Melting ovens
  - Metal melting ovens
    - Cupolas
    - Retaining ovens
    - Refraction ovens
    - Underfired melting ovens
    - Submerged melting ovens
  - Glass melting ovens
    - Refraction ovens
    - Cupolas
  - Salt melting ovens
    - Cupolas
    - Submerged melting ovens
    - Underfired melting ovens
  - Other melting ovens
    - Ovens to melt glue, pitch asphalt, fat etc.
- Drying and baking ovens
  - Creasing and drying equipments
    - Creasing and drying equipments
    - Cloth drying
    - Casting core driers
    - Other driers ... Driers for rice crackers, maring products and pharmaceuticals
  - Drying of solvents
    - Varnish drying
    - Paint drying
    - Ink drying
  - Adhesive drying ... Drying of card boards and building plywood
  - Other driers
    - Shell mold driers
    - Baking
    - Heat setting
    - Teflon baking
    - Heating for resin forming

The aforementioned advantages of gas are not yet made full use of in Indonesia on account of the poor quality of PGN's gas which is causing industrial consumers a substantial difficulty. When PGN's gas is improved in quality and solves the difficulty currently involved in its use, it will better meet the industrial demand. Use of gas for industrial purposes should be promoted in overpopulated cities like Jakarta as well as in light industrial estates to be established in the suburbs of Jakarta by reason of its safety and pollution-free nature.

There is probability that natural gas will be used as feedstock of gas in Indonesia. When this probability is brought to reality, the primary energy can be directly supplied to consumers, whereby the energy efficiency and gas quality will be both largely improved. Furthermore, if the feedstock natural gas is obtainable at a low cost, it will become possible to cut down the gas rates and fill a greater demand for industrial purposes. In this connection, it deserves attention that PGN is planning to supply gas to the PLN's power plant when its Medan station succeeds in introducing natural gas. It is recommended that the Indonesian government takes a positive attitude toward effective utilization of natural gas resources, and promote its introduction into the gas distribution network, as well as its enhanced supply for industrial uses with account taken of the condition of occurrence and development of gas wells.

## 3.2 Potential Demand for Gas

Discussion advanced in this section deals with the future saturation rate or the potential demand of gas.

Calculations were worked out to obtain the potential demand in the year 2,000 on the following conditions without making any distinction between home consumption and industrial consumption (ratio of the two sectors supposed to remain the same) and by assuming that priority would be given to gas in all urbanized areas irrespective of the presence and capacity of production facilities and distribution pipelines:

Calculation Criteria:

1) Population: (Note 1)

Java Island .................. 150 million

Areas other than Java Is. ..... 100 :

2) Urbanization Rate: (Note 1)

Java Island .................. 40%

Areas other than Java Is. ..... 20%

3) Number of family members ..... 6 persons per household.

4) Percentage of permanent houses:

Java Island .................. 40%

Areas other than Java Is. ..... 30%

5) Gas consumption per user: (Note 2)

Java Island .................. 2,500 $m^3$

Areas other than Java Is. ..... 2,000 $m^3$

Calculation of Potential Gas Demand:

Java Island -

150 million persons x 40%
= 60 million persons .......... Population of urban areas

60 million persons ÷ 6 persons
= 10 million ................. Number of households in urban areas

10 million x 40%
= 4 million .................. Number of permanent houses (≒ number of potential gas users)

4 million x 2,500 $m^3$
= 10,000 million $m^3$ ........... Potential gas demand

Areas other than Java Island -

100 million persons x 20% = 20 million persons

20 million persons ÷ 6 persons = 3.33 million

3.33 million x 30%
= 1 million ................. Number of potential gas users

1 million x 2,000 $m^3$
= 2,000 million $m^3$ ........... Potential gas demand

Total for the whole archipelago -

Number of potential gas users ..... 5 million

Total gas demand ..................... 12,000 million $m^3$

The total potential demand of 12,000 million $m^3$ obtained by the above calculation is equivalent to $50.4 \times 10^{12}$ Kcal in heat value or to $5.6 \times 16^6$ kℓ of petroleum demand(Note 3), and it accounts for 3.5% of the total energy demand for 2,000 which is estimated at $157.7 \times 10^6$ kℓ in terms of petroleum demand in Section 1.

Needless to say, all these figures are based on assumptive conditions, but the likelihood of their becoming a reality may be high because there is high probability that the people's income level will be elevated and gas consumption for industrial purposes will be largely augmented in future. Note must be taken here of the fact that the number of consumers presently covered by PGN and the annual gas sales of PGN are respectively, 21,319 and 27,922,000 $m^3$ (1974), as compared with 5,000,000 users and 12,000,000,000 $m^3$ estimated for the year 2,000. This means that although gas is the best energy source for use in urban areas and has a high potential demand as described in Section 2, it is neither abundantly supplied to fill the demand for various reasons, nor is it given the evaluation it deserves. The government and PGN are therefore urged to take due account of the importance, utility and future prospects of gas, and carry out plans designed for improvement of the existing situation and for augmented supply to meet the future demand. Elucidation of such plans will be given in the following pages.

Note 1. In the year 2,000, the population of Java Island will reach 150 million and the whole island will turn into a megalopolis. Sumitro Djojohadikusumo: "Indonesia towards the Year 2,000", February 1975.

Note 2. Consumption of PGN gas per user (1973)

Java Island ......... 1,272 $m^3$

Areas other than .... 1,547 $m^3$

Consumption per user in Java was set at 2,500 $m^3$
because of the prospective demand increase
for industrial purposes.
Heat value per cubic meter of gas ranges from
3,000 to 3,600 Kcal at present.
In the calculation, however, PGN's standard
heat value of 4,200 Kcal/$m^3$ was adopted.

Note 3. 12,000 million $m^3$ x 4,200 Kcal/$m^3$ = $50.4 \times 10^{12}$ Kcal

$50.4 \times 10^{12} \div 9{,}000 (Kcal/\ell) = 5.6 \times 10^{6} (K\ell)$
(in terms of petroleum)

$$\frac{5.6 \times 10^{6}}{157.7 \times 10^{6}} \times 100 = 3.55\%$$

# CHAPTER II

# EXISTING CONDITION AND PROBLEMS OF PGN

# CHAPTER II. EXISTING CONDITION AND PROBLEMS OF PGN

## 1. History and Position of PGN

### 1.1 History

The gas enterprise in Indonesia was established in 1863, and was operated by N.V. NIGM, an enterprise of the Netherlands which ruled the country in those days, and was taken over by N.V. OGEM in 1945 after Indonesia gained her independence. In 1958, the enterprise was nationalized and placed under the control of a government department which undertook the operation of both gas and electric enterprises. In 1965, both enterprises were separated from the said department and placed under the management of newly established organizations, i.e., PGN (State Gas Corporation) and PLN (State Electricity Corporation). The Fig. II-1 briefly illustrates the history of PGN.

While PLN has pursued a steady course of development supported by the growing demand for electric power, PGN's development has been rather slow and inactive.

Fig. II-1 History of PGN

**N.V.NIGM**

Juridical person established in 1863 under the Dutch colonial regulations; operation of gas enterprise initiated in 1864.

↓

**N.V.OGEM**

Absorbed by N.V.OGEM (Overseas Electricity & Gas Corporation) under the laws of the Netherlands in 1945 after independence of Indonesia; operation of electric enterprise also taken over by this company.

↓

**Nationalization**

1958

↓

**BPU.PLN**

PLN PLN PLN ... PLN

Electricity Gas

Placed under General Exective Body (BPU), 1960∿1965.

↓

**PUTL**

Dit. Gen. Power and Electricity .. ..

PLN PGN

National company under Ministry of Public Works and Power. 1965∿now (except 1973).

1.2 Position of PGN

The government's attitude towards PGN is manifested in its evaluation of PGN as a state operated enterprise.

In recent years, the Indonesian government has followed the policy for classifying state operated enterprises into three types with the view to promoting their operation on an independent basis. These three types are (1) PERSERO which is owned by the State but run by the enterprise itself, just as private enterprises, (2) PERJAN which is controlled by a government department or division, and (3) PERUM which is organized into a public corporation and stands in between PERSERO and PERJAN.

PLN is already classified as PERUM, but no decision has yet been made on the future status of PGN. This means that the comprehensive study on gas enterprise still should be made. The lack of recognition for the gas enterprise as an important public utility may well be explained by the fact that the gas saturation rate is only about 1%, even in Jakarta. As described in Chapter I, however, gas is an ideal type of energy source for supply to overpopulated urban areas and can never be disregarded in planning efficient utilization of Indonesia's natural resources. Development of the gas enterprise should therefore be accelerated under the national energy policy to be framed and followed in the future.

Considering the importance and public nature of the gas supply service, the team is of the opinion that PGN should be organized into PERUM also in the future, just as PLN.

1.3 Relationship with Other State Enterprises

In the face of delayed development of the gas enterprise, the energy requirement in urban areas must necessarily be filled by other sources.

Specifically, electricity for lighting and power plant operation has been supplied increasingly by PLN which has grown smoothly since its independence in 1965. Thermal energy demand, on the other hand, is met mainly by kerosene and partly by LPG. Jakarta city has population of about 5 millions. Assuming that each household has an average of 8 family members, the total number of households in the city turns out to be 620 thousand. Of these 620 thousand households, 6 thousand use gas, 10 thousand LPG, and the remaining 600 thousand or more households use kerosene. This situation is clearly indicative of the poor gas supply service of PGN and also suggests that kerosene and LPG suppliers are playing an important role in providing energies to urban areas.

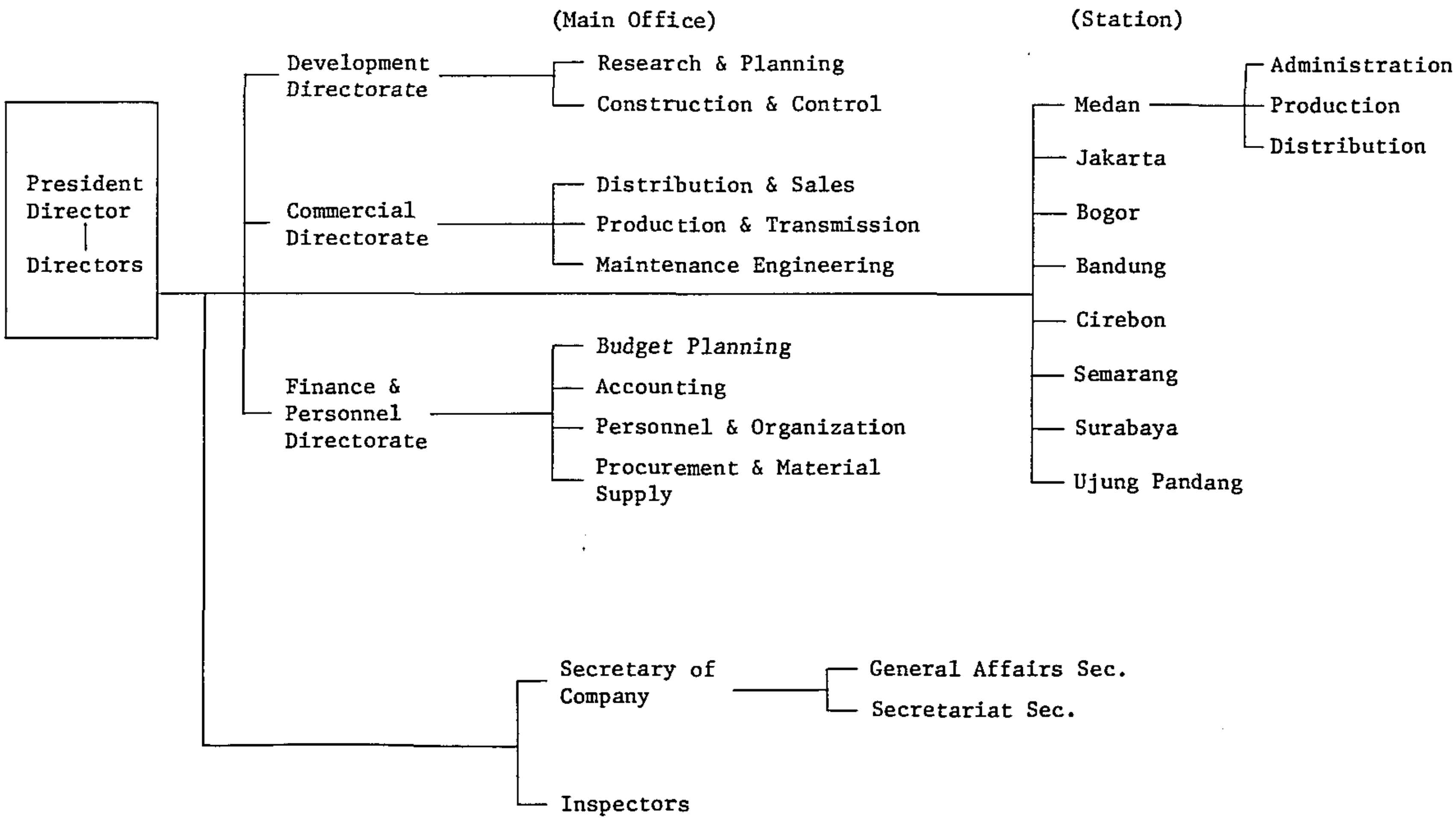
Both LPG and kerosene are supplied to retailers by PERTAMINA (State Operated Petroleum Corporation) which is known to be meeting 99% of the thermal energy demand in Jakarta. PERTAMINA is also the supplier of heavy oil (I.D.O.) which is the raw material for gas production, so that it is closely affiliated with PGN. PGN also maintains close relations with PLN since both belonged to the same organization in the past and are serving as public utility at present.

## 2. Management of PGN

### 2.1 General Condition

PGN has its main office in Jakarta and its gas production and distribution services are performed by the stations located in eight cities. i.e., Medan, Jakarta, Bogor, Bandung, Cirebon, Semarang, Surabaya, and Ujung Pandang. The organization of PGN is as illustrated below (Fig. II-2).

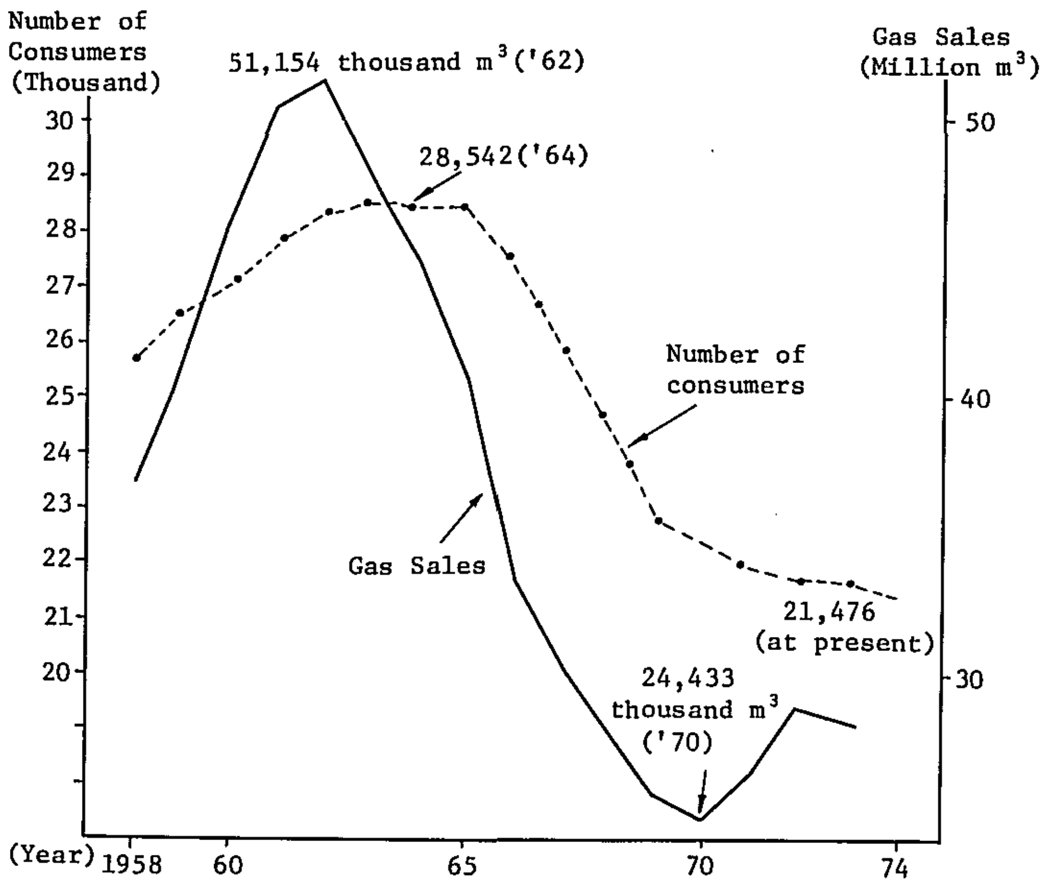
Fig. II - 2 Organization of PGN



Data made available to the team including those on the transition of management condition indicate that the sales of gas registered 36 million $m^3$ in 1957, with the peak sales of 51 million $m^3$ recorded in 1962. It is also known from the said data that 1973 marked a sale of 28 million $m^3$.

As regards the number of consumers which serves as a criterion for judging the scale of a gas enterprise, 1957 registered 26,000 and 1964 and 1974 respectively marked 28,500 and 21,500 to depict a curve which is approximately parallel to that of sales volume. Thus, it is clear that the gas enterprise reached its peak in the 1963 ∿ 1964 period and has declined thereafter.

Fig. II-3 Transition of Gas Sales and Number of Consumers



The global move towards energy conversion was observed early in the 1960's when coal became expensive and eventually gave place to petroleum which was relatively cheaper.
In this conversion period, PGN should have effected to raw material conversion and exerted effort for checking the price escalation of the raw material in order to maintain a reasonable price level and satisfactory quality of gas. However, PGN failed to make these improvements due to the lack of experience of up-to-date combustion techniques and satisfactory production facilities, and this is the main cause of the decline of the gas enterprise after 1963 ∿ 1964 period. Since those days, no improvement has been effected to the quality of gas.

Although it is known that there is a substantial potential demand for gas, PGN's sales are not on the upward trend because of the poor gas quality and incomplete gas supply condition. Its gas facilities are considerably deteriorated, as described later. Especially, gas leakage and drop of supply pressure are caused by the deterioration of pipelines to degrade the quality of services for consumers.

In order for PGN to break out of the present poor situation, it is necessary, above all other things, to improve the gas quality and supply conditions so as to regain the confidence of consumers and develop the latent demand for gas.

## 2.2 Demand for Gas

The gas demand in Indonesia in terms of actual consumption is 28 million $m^3$ (1973; standard heat value - 4,200 Kcal/$m^3$), of which 55% goes to home consumption and 45% is used for industrial and commercial purposes. Of a total of 21,700 users, general households account for 84% and industrial and other users for 16%. Thus, the greater part of demand is supplied for home consumption.

Gas for home consumption is used for cooking, and gas ranges occupy the great majority of the appliances, though a small number of instantaneous water heaters are also used. Consumption per user averages 71 $m^3$/month which is equivalent to 20 ∿ 25 $m^3$/month if converted on the basis of a heat value of 10,000 Kcal/$m^3$. This is lower than the average home gas consumption in Japan which is 30.3 $m^3/10^4$ Kcal, but may be considered substantially high because the average daily temperature never drops below 25°C throughout the year in Indonesia. Gas demand for home consumption is practically free from seasonal fluctuation because the atmospheric temperature is subject to little or no change in this country.

As will be clear from the diagram showing the past transition of gas supply, the demand has been dwindling since it reached the peak early in the 1960's. Users who stopped using gas after the early 1960's are known to have shifted to either LPG or kerosene. This decline of demand is something unconceivable under normal conditions because gas is the best source of thermal energy required in urban areas and its demand should surpass the present supply in a substantial measure.
However, the gas consumption is actually on the downward trend for various reasons which need to be clarified.

## 2.3 Accounting

PGN's profit and loss statement, balance sheet, and operating expenses are shown in the appendix 4 ∿ 6. Comparison of sales proceeds between 1967 and 1972 indicates that Rp 290 million recorded in 1967 increased by about 2.7 times to a total of Rp 795 million. This increase, however, was produced not by the increment of supply but by the escalation of gas rates. The sales volume has been on the decline. Specifically, 1967 recorded a total sales volume of 30 million $m^3$ for gas and 7.9 thousand tons for coke. In 1972, these values dropped to 29 million $m^3$ for gas (3% drop) and to 2.7 thousand tons for coke (66% drop). The average sales price of gas per $m^3$, which was Rp

7.2 in 1967 was raised to Rp 22.4 in 1972. Similarly, the average sales price of coke per ton was raised from Rp 8,600 to Rp 36,000 on account of the market price fluctuation.
Thus, the sales price of gas was increased by 3 times and that of coke by 4 times.

PGN's operation and overhead costs also increased sharply. Wages per worker which stood at Rp 30,000 in 1967 increased by 6 times to Rp 180,000 in 1972. The raw material cost per 1 $m^3$ of manufactured gas likewise rose from Rp. 3.2 to Rp. 12.6. The total operation cost which recorded Rp 236 million in 1967 increased by about 4 times to Rp 928 million in 1972.
The operation cost per 1 $m^3$ of manufactured gas escalated by more than 4 times from Rp 5.9 to Rp 24.4.

Comparison of income and expenditure makes it clear that while the former increased by 2.7 times, the latter rose by more than 4 times. It can therefore by readily understood that PGN's accounting condition was quite aggravated in 1972, as compared with the situation in 1967.

Decline of PGN's earning rate is clearly manifested in the turnover ratio of total liabilities and net worth. To be more precise, a ratio of 24.7% marked in 1967, dropped drastically to -2.9% in 1972. This phenomenal drop is ascribable to a number of reasons such as the profit decline resulting from the increase of expenditures which far surpassed the income increase, installation of additional assets under the First Five Year Plan, and increase of floating assets ensued from the poor collection rate of gas charges. In addition, Appendix 6 showing the ratios of major operation costs indicates that both the prime cost and personnel cost occupy a large percentage and that the defrayment ratio of interest has risen in recent years.

The following table shows the increase of expenditure per 1 $m^3$ of gas over the past years.

Table II-1 Increase of Expenditure per 1 $m^3$ of Gas

Unit: Rp/$m^3$

| | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|---|---|
| Manufacturing Cost | 4.41 | 10.88 | 12.84 | 11.98 | 15.62 | 16.51 |
| Distribution and Sales Expenses | 1.16 | 2.88 | 4.11 | 5.18 | 4.88 | 4.91 |
| General Administration Expenses | 0.36 | 0.87 | 1.53 | 2.93 | 2.55 | 2.99 |
| (Sub-Total) | (5.93) | (14.63) | (18.48) | (20.09) | (23.05) | (24.41) |
| Miscellaneous Operating Cost & Non-operating Cost | ▲ 0.23 | ▲ 0.50 | 0.65 | 0.58 | 0.22 | 0.01 |
| Cost Reduction by Income from By-products | ▲ 1.85 | ▲ 2.88 | ▲ 1.59 | ▲ 5.00 | ▲ 5.68 | ▲ 3.21 |
| Cost Increase due to Gas Leakage, etc. | 1.22 | 3.52 | 5.48 | 3.55 | 3.92 | 6.51 |
| Total Production Cost of Gas | 5.07 | 14.77 | 23.02 | 19.22 | 21.51 | 27.72 |
| Average Sales Price of Gas | 7.19 | 17.08 | 21.64 | 20.86 | 22.64 | 22.44 |
| Cost in case total quantity of by-products is sold in the year of production at the price prevailing in that year. | 3.03 | 15.55 | 16.12 | 23.84 | 20.98 | 21.29 |

The above table clearly shows that each item of accounts increased year after year, and also indicates the following facts:

1) Sales cost kept on increasing due to gas leakage.
2) Cost increment due to gas leakage accounted for as much as 23% of the sales cost in 1972.

The deficit recorded in the profit and loss statement for 1969 and 1972 can be obtained by comparing the sales price and gas cost which are both given in the above table.

The table also indicates that 1969 and 1972 would not have recorded a deficit if the total quantity of by-products had been sold at the prevailing market price in each year. Conversely, the deficit for 1970 did not appear on the profit and loss statement because it was covered by the sales proceeds of coke produced in 1969.

PGN made an important decision in 1969 when it ran into a deficit. It produced about 8,500 tons of coke from coking coal imported with Rp 130 million of fund borrowed from BAPINDO. However, since the coke market was sluggish, PGN failed to sell the total quantity produced. This has resulted in the inability of PGN to repay the loan to date, so that the interest accruing each year has been accumulated to aggravate the balance of incomings and outgoings.

Although the attempt of PGN's management to produce coke with the loan from BAPINDO ended in a failure, this positive and forward looking policy is to be highly valued in that it aimed at increasing the profit through sales of by-products and improving the gas quality as well. In fact, it was the income from by-products that enabled PGN to maintain the same gas rates until 1974 since its previous revision in 1968. It may as well be mentioned that Japanese gas enterprises underwent a similar experience in the past.

It is believed that PGN was forced to raise the gas rates on account of the galloping increase of personnel cost, material cost and other expenses. However, the 1974 revision of the gas rates is evidence to show that PGN has not exerted sufficient entrepreneurial effort to cut down the cost and increase the profit rate. The past record shows that despite of the escalating personnel cost, the gas sales have kept on dwindling to reduce the profit rate year after year.
Nevertheless, it deserves high evaluation that PGN dismissed about 500 workers in March 1974.

The team wishes to point out here that it is prohibitive for any enterprise to increase the number of workers without good reason, and that any waste left unavoided endangers the enterprise itself.

PGN is under the pressure of increasing material cost which occupies a large portion of the gas cost. The team learned that diesel oil, the main material of gas, is supplied by PERTAMINA but its price is the same as the market price. Since the material cost directly affects the gas cost, effort should be made to secure the raw material at as low a price as possible. It is known that government subsidy is granted to maintain the consumer price of kerosene on a low level. Considering the fact that the gas material is just as important as kerosene for the people's daily life, PGN should approach the government with the request for a similar subsidial measure.

PGN is by no means in a good financial situation, as can be readily seen from its balance sheet, and from its inability to refund the bank loan introduced in 1969. The main cause of the difficulty involved in the capital turnover is the poor collection rate of gas charges. As of the end of 1972, uncollected gas charges amounted to a total of Rp 350 million which is more than 50% of PGN's total gas sales for that year. It is incumbent on PGN to approach in a resolute attitude those consumers who are delayed in the payment of gas charges so as to reduce the balance of charge account to a normal level.

## 2.4 Improvement of Labour Productivity

The labour productivity of PGN is extremely low when compared with that of gas enterprises in Japan. In 1972, the gas production and gross sales per worker of PGN were respectively 26,000 $m^3$ and Rp 580 thousand, which are by far the lower than 333,000 $m^3$ and Rp 17,000 thousand (= 12,000 thousand yen) attained per worker of Tokyo Gas Co.

In the case of PGN, distribution of its eight stations in an extensive area and the small number of consumers make it impossible to obtain the increased returns to scale, but some effective measures should be devised and implemented to improve the present low productivity. The staff members at the main office (PUSAT) which is a non-operating sector of PGN account for 12% of the total number of employees (1972).
In order to improve the profit rate per employee, workers in non-operating sectors should be reduced in number and transferred to operating sectors.

Some PGN workers with whom the team was able to interview seemed to take themselves as clerical workers and showed little positive effort to perform any work beyond the limits of their duties. They exhibited little effort to acquaint themselves with the duties of other workers so that they could not explain the work performed by their colleagues. Under the situation, it cannot be hoped to effect rationalization by personnel realignment or expansion of duties, nor can it be expected that each employee will find his work interesting and worthy of effort because he is bound to be assigned to the same duty for many years. Establishment of an in-service training and education system is therefore proposed in order to make all workers capable of any work required in any aspect of PGN's activities. The team wishes to emphasize that the improvement of the overall efficiency of any organization is attained only when each member comes to have a deeper understanding of his duties and the capacity for performing a wide range of activities.

## 2.5 Long-term Planning

PGN has worked out two long-term plans under the government policy, i.e., the First Five Year Plan (1969 ∿ 1973) and the Second Five Year Plan (1974 ∿ 1978).

Since the two plans comprised chiefly of equipment investment programmes, the team felt that they were formulated primarily to secure the necessary budgetary appropriation.
Although the PELITA (Five Year Plan) may be accepted as fulfilling the necessary conditions, the team is of the opinion that PGN will have to map out a long-term management and operation plan to provide the basis upon which to implement the PELITA.

At present, PGN, is managed without definite guiding principles established from a long-term point of view. Accordingly, it is not in a position to determine, from the long-term view point, the influence of the future change in general entrepreneurial climate, or to judge what problems are of vital importance for PGN and by which time solution should be brought for such problems. The Five Year Development Plan incorporates the equipment investment programmes for the most part, but it neither indicates the basic facts necessitating actions for profitable management, and the time and influence of such actions, nor presents a clear-cut long-term management policy. To be more specific, it given no definite long-term prospect on the following points:

1) Financial burden expected to be incurred in connection with equipment investment.
2) Benefit derivable from equipment investment.
3) Influence on the financial situation exerted by possible alternation of the equipment investment programme.
4) Whether the present number of workers prove optimum in future.
5) How the raw material conversion is to be promoted.
6) Optimum wage level.
7) Whether the gas rates should be revised in future.

8) If so, when the revision is to be effected.

9) How the management rationalization is to be effected.

In the Five Year Development Plan, the majority of space is devoted to equipment investment programmes. The team feels compelled to point out that the primary purpose of the Plan is to establish the management policy.

PGN has already completed its First Five Year Development Plan. Although an estimated total of Rp 2,500 million was invested during the five year development period, the team failed to notice any appreciable improvements that could be ascribed to this huge capital input. 75% of the investment acount was appropriated to production and distribution facilities, but this produced no such effects as conspicuous improvement of gas quality, increase of the total length of pipelines, or sharp decrease of the gas volume so far unaccounted for. There may be a diversity of reasons responsible for this rather poor investment effect, but the decisive reason is probably the failure to make a careful prior study on the investment effect in the formulation of the plan, which naturally resulted in the unplanned distribution of the fund to all stations.

It is therefore recommended that a five year plan incorporating not only the equipment investment programmes but also the management policy and long-term income and disbursement plan be newly formulated.

3. Consumers' Evaluation of Gas

1) Price

| | | |
|---|---|---|
| a) | Cheap | 6.7% |
| b) | Ordinary | 20.8 |
| c) | Expensive | 72.5 |

| | | |
|---|---|---|
| 2) | Services not satisfactory | 35.0% |
| 3) | Gas quality not satisfactory | 7.4 |
| 4) | Supply pressure too low | 34.1 |
| 5) | Meter rental too high | 9.3 |
| 6) | Gas price not proper | 16.3 |
| 7) | Continuous use of gas | |
| | a) Want to continue using | 40.5% |
| | b) Intend to stop using | 15.1 |
| | c) Don't know | 44.4 |

The above data were collected by a survey conducted in 1971 by International Consulting Service, Inc. from 1,221 respondents selected from among PGN's consumers living in Jakarta.

Major findings of the survey are summarized below.

(1) More than 70% of the respondents replied that the gas rates were too high, but those who actually considered that the gas price was too high accounted for slightly more than 20% of these respondents or 16% of all respondents.

(2) Some respondents complained about the poor quality of services such as dripping, replacement of meter, adjustment of appliance, etc. which PGN's service personnel performed to repair the blocking up of pipelines due to tar and the fluctuation of combustion characteristics ensued from the change in the mixing ratio of coke oven gas and partial combustion gas. Some others expressed dissatisfaction with the supply pressure and poor flame. All these complaints were raised because of the poor gas quality and poor maintenance of distribution facilities.

(3) About 15% of the respondents who expressed the intension to stop using gas equalled in number those who complained that the gas rates were high.

(4) 40% of the respondents replied that they would continue using gas. This indicates that rather many consumers admit the advantages of gas, although they complain about the high gas price.

(5) It was noted that the consumers inclined to use gas continuously are dissatisfied with the gas quality. They can be induced to use gas continuously if the supply pressure is raised.
In the case of these consumers, the price is not the matter of prime concern.

From the survey results summarized above, it can be said that PGN should expend every effort to improve the gas quality and supply condition before any other things. It can also be said that most consumers understand and value the advantage of gas, though they commented that the gas rates are too high.

## 4. Production and Its Problems

### 4.1 Production Facilities and Operation Records

Except at its Cirebon station where the conversion to natural gas supply was completed in October 1974, PGN employs coke ovens, GEIM type diesel oil partial combustion generators, and ONIA-GEGI type diesel oil catalytic reformers for production of gas and by-products.
Arrangement, installed capacity and actual capacity of the production facilities at respective stations are shown in Table II-2. Table II-3 shows the material requirements as well as the production, sales, and quality of gas produced by these facilities in 1974. Table II-4 shows the data on the production of by-products.

Table II-2. PGN Gas Production Capacity (1975 based on PGN's data)

| Station | Coal Gas | | Diesel oil Partial combustion Gas | | Diesel Oil Catalytic Reformer Gas | | Total production Capacity | | Holder Capacity | Pressure Distribution Capacity |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coal Feed Rate K/D | Gas Production Capacity $Mm^3/D$ | Installed Capacity $Mm^3/D$ | Actual Capacity $Mm^3/D$ | Installed Capacity $Mm^3/D$ | Actual Capacity $Mm^3/D$ | Installed Capacity $Mm^3/D$ | Actual Capacity $Mm^3/D$ | $m^3$ | $m^3/H$ |
| Medan | 12 | 7.2 | 18.0 | 12.0 | - | - | 25.2 | 19.2 | 4,000 | 500 |
| Jakarta | 36 | 16.2 | 42.9 | 36.0 | - | - | 59.1 | 52.2 | 32,500 | 2,000 |
| Bogor | - | - | 15.4 | 7.2 | - | - | 15.4 | 7.2 | 2,840 | 400 |
| Bandung | 12 | 7.2 | 27.4 | 19.2 | - | - | 34.6 | 26.4 | 11,600 | 1,000 |
| Cirebon | - | - | - | - | - | - | - | - | 1,350 | (Natural Gas Supply Capacity) (4,200) |
| Semarang | 18 | 8.1 | 27.4 | 19.2 | - | - | 35.5 | 27.3 | 8,100 | 750 |
| Surabaya | 24 1/2 | 11.0 | 10.3 | 7.2 | ONIA GEGI 54.9 | 38.4 | 21.3 | 56.6 | 21,900 | 2,900 |
| Ujung Pandang | - | - | 15.4 | 7.2 | - | - | 15.4 | 7.2 | 2,580 | 200 |
| Total | 102.5 | 49.7 | 211.7 | 146.4 | 54.9 | 38.4 | 261.4 | 196.1 | 84,870 | (Excl. Natural Gas) 7,750 |

Table II-3. PGN Gas Production and Sales (1974)

| Station | Raw Material Requirement | | Gas Production $10^3 m^3$ | | | | Sales/Distribution Volume | | Gas Quality | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coal ton | Diesel Oil kℓ | Coal Gas | Oil Gas | Natural Gas | Total (Operation Rate)* | Sales volume $10^3 m^3$ | Unaccounted Ratio % | Calorific value $Kcal/m^3$ | Specific Gravity (Air=1) |
| Medan | 0 | 1,385 | 0 | 3,560 | - | 3,560 (39%) | 2,126 | 40.3 | 3,200 | 0.90 |
| Jakarta | 604 | 7,281 | **** 1,171 | 11,875 | - | 13,086 (61%) | 8,436 | 35.5 | 3,600 | 0.78 |
| Bogor | - | 926 | - | 1,456 | - | 1,456 (26%) | 1,143 | 21.5 | 3,200 | 0.90 |
| Bandung | 379 | 5,463 | 2,111 | 5,773 | - | 7,884 (62%) | 6,049 | 23.3 | 3,800 | 0.94 |
| Cirebon | - | 321 | - | 564 | ** 10,277 | 10,841 | *** 10,631 | 1.9 | 6,100 | 1.03 |
| Semarang | 0 | 1,473 | 0 | 2,998 | - | 2,998 (23%) | 2,073 | 30.8 | 3,441 | 0.91 |
| Surabaya | 0 | 8,403 | 0 | 8,528 | - | 8,528 (31%) | 6,764 | 20.7 | 4,798 | 0.56 |
| Ujung Pandang | - | 465 | - | 888 | - | 888 (16%) | 700 | 21.2 | 3,271 | 0.91 |
| Total | 983 | 25,717 | 3,282 | 35,642 | 10,277 | 49,201 | 37,922 | 22.9 | - | - |

* : Figures in parentheses indicate the operation rate against the nominal capacity.
** : Conversion to natural gas supply was completed on October 16.
*** : Unaccounted ratio for home consumption exceeds 60% though this figure does not appear because the greater part of production is used for industrial purpose.
**** : It is suggested that PGN check this figure which seems to represent the production at Bandung.

Table II-4. Production and Sales of By-Products (1974)

ton/year
kℓ/year

| Station | Raw Material Requirement | | Production of By-products | | | | Sales of By-products | | | | Coke Production Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coal ton | Diesel oil kℓ | Coke ton | Parel ton | Breeze ton | Tar kℓ | Coke ton | Parel ton | Breeze ton | Tar kℓ | ton |
| Medan | 0 | 1,385 | 0 | 0 | 0 | 24 | 0 | - | 0 | 24 | 2,190 |
| Jakarta | 604 | 7,281 | 228 | 113 | 62 | 338 | 1,158 | - | 216 | 348 | 6,570 |
| Bogor | - | 926 | - | - | - | 193 | - | - | - | 194 | - |
| Bandung | 379 | 5,463 | 140 | 51 | 37 | 572 | 705 | - | 154 | 624 | 2,190 |
| Cirebon | - | 321* | - | - | - | 15 | - | - | - | 15 | - |
| Semarang | 0 | 1,473 | 0 | 0 | 0 | 184 | 0 | - | 0 | 184 | 3,285 |
| Surabaya | 0 | 8,403 | 0 | 0 | 0 | 1,083 | 0 | - | 0 | 1,050 | 4,471 |
| Ujung Pandang | - | 465 | - | - | - | 40 | - | - | - | 138 | - |
| Total | 983 | 25,717 | 368 | 164 | 99 | 2,449 | 1,863 | - | 370 | 2,577 | 18,706 |

* : Material consumption prior to the conversion to natural gas supply on October 15.

** : Coke yield after 24 hours of dry distillation - 500 kg/t (coal).
(This value appears to be too small)

## 4.2 Production Processes

### (1) Flow Sheet

The flow sheet of the production facilities installed at PGN Jakarta station (coke oven and diesel oil partial combustion equipment) is shown in Fig. II-4. Production facilities installed at other stations are similar to those of Jakarta station. However, the ONIA-GEGI type heavy oil reformer installed at Surabaya station, which is not illustrated in this report, is smaller than, but identical in design to, similar equipments used in Japan until recently.

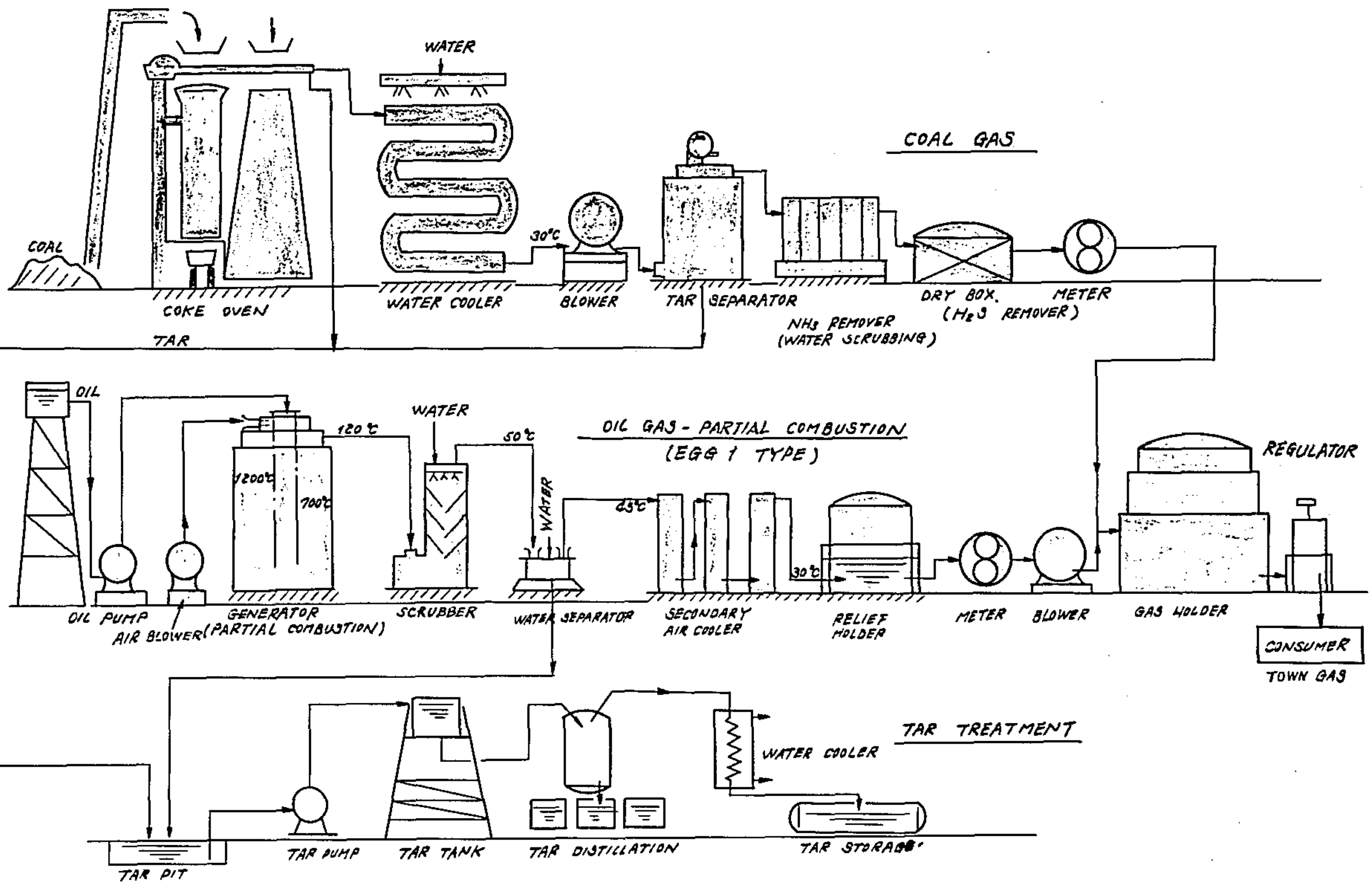



Fig. II-4 Production Facilities of PGN Jakarta Station

(2) Partial Combustion Generator

Of the production facilities above, the partial combustion generator presents many problems which occur in the production process.
Specifically, it does not permit the smooth progress of thermal decomposition process because its gas generator is of one cylinder type of extremely simple structure, so that the manufactured gas contains a large amount of CO (carbon monoxide) and higher hydrocarbons. This equipment was originally installed for supplementary production of coal gas and has been used in such a way that it would not produce more than 20% of the total gas volume sent out. At Jakarta station, however, it covers more than 80% of the total gas sent out and in addition, gas is occasionally manufactured by the operation of this equipment alone. Since the impurities contained in the manufactured gas are likely to include naphthalene and NO (nitrogen monoxide), the manufactured gas is vulnerable to the formation of gum paste compounds and is also highly corrosive. Gas manufactured by this equipment exhibits poor combustion characteristics because its specific gravity is high and flame speed is slow.

(3) Coal Gas (Coke Oven Gas)

The coke oven produces coal gas which is quite satisfactory in quality and also exhibits the merit of producing coke as by-product. Despite of these merits, the operation rate of the coke oven is extremely low on account of the difficulty in obtaining the material coking coal as shown in Table II-4.

Since the existing coke ovens are very old, their remaining life span is rather short. However, the team noted that all of them have been kept in perfect service condition up to the present time, which is a clear indication that PGN workers have given them careful maintenance and inspection services.

## 4.3 Production Problems

The following are the problems currently involved in the entire production sector of PGN.

(1) Quality of Manufactured Gas (Impurities are contained to excess)

Apart from the calorific value and combustion characteristics which will be discussed later in this report, the manufactured gas contains condensable impurities such as moisture, tar, naphthalene and gum paste compounds which are prone to choke up the distribution facilities and gas appliances. It also contains corrosive and poisonous matters such as ammonia ($NH_3$), hydrogen sulfide ($H_2S$), cyanides and naphthalene. However, none of these impurities can be removed completely in the aforementioned production process.

Tar and higher hydrocarbons inflict serious chocking damage on the distribution facilities. In fact, PGN is forced to repair the blocking failures of pipelines every day and is not in a position to promise smooth gas supply to the consumers. Main causes of this serious situation are the inadequate reforming at partial combustion generator and insufficient purification. However, if gas is cooled completely and higher hydrocarbons are removed to eliminate these causes, then the calorific value and WI (Wobbe index) will drop to decrease the input to gas appliances.

It is probable that the manufactured gas contains NO which forms gum paste compounds together with naphthalene, sulfur and higher hydrocarbons, and this defect is characteristic of the partial combustion process.

It is also probable that substantial quantities of corrosive matters are contained in the manufactured gas because consumers' gas meters develop failures very often. In an extreme case, a brand new gas meter becomes spoiled in a matter of six months.

While these problems are apparently attributable to the production process itself, no remedial measures for ensuring smooth operation and satisfactory maintenance have yet been established because impurities contained in the manufactured gas are not yet quantitatively analyzed.

(2) *Pollution Problems*

The coke oven presents the air pollution problem because it uses diesel oil for fuel. In addition, both the coke oven and the partial combustion generator are not capable of complete separation of effluent tar and water, so that polluted water is discharged into the sewage. Especially in the case of Jakarta station whose plant is located in the city area, the environment probelm has become so acute that relocation of the plant by 1977 is demanded by the residents in the neighbourhood and by the city authority of Jakarta. Jakarta station's future expansion plan is thus seriously affected by such movement.

All these pollution problems come from the selection of raw materials (diesel oil and heavy oil) and production process. Therefore, it would not be possible to bring solution for them unless a huge amount of investment is made.

It is believed, however, that other stations of PGN have not faced such serious pollution problems.

(3) Shortage of Ancillary Equipment

Satisfactory plant management is made difficult on account of the deterioration or shortage of instruments and laboratory equipments.

Comparison of the material requirement with the production of gas and by-products discloses, as shown in Tables II-3 and II-4, that the product yield per unit quantity of raw materials varies largely from station to station. Needless to say, this is mostly ascribable to the material quality, production process and operation condition, but it is quite likely that the measurement error is also responsible for such large yield gap.

While the measurement of the gas flow rate, temperature, pressure, calorific value and specific gravity is of great importance, the team noted that no dependable and highly accurate instruments are available.

Analysis of gas components is another very important task. Although gas chromatography and other superlative equipments are available at Jakarta station, they are not used for practical purpose due to the lack of supporting materials and experience.

(4) Low Efficiency of Production Facilities

The most serious problem lies in the production process itself. Accurate analysis of the energy efficiency with reliable instruments should naturally be included in the production process, but the team found no sufficient analytical stage in any plant. Moreover, there seem some plants devoid of a satisfactory waste heat recovering system. It is probable that these plants are satisfied with a low energy efficiency.

The team also noted that coke ovens are mostly operated manually by labourers.

However, in view of the present labour condition in Indonesia and the fact that the coke ovens were installed many years ago, the team felt that such low labour productivity might be endured.

(5) Low Utilization Rate of Coal

Construction of a new coke oven calls for the input of a huge amount of fund. However, as far as existing oven concerns, it contributes to the improvement of management because the gas production cost after deducting the income from by-products becomes extremely low. Although PGN is the only coke producer in Indonesia and the annual coke demand from sugar plants and other consumers is as large as 40,000 tons, PGN sold only about 2,000 tons of coke in 1974 (See Table II-4).
In addition, PGN's coke production capacity is as large as 18,000 tons (though the actual capacity may be smaller than this value because of the deterioration of ovens), and the domestic market price is maintained at a high level of about Rp 130,000/ton because of the active coke importation from Taiwan and West Germany.

However, the low operation rate of coke ovens is attributable to the shortage of material coal which is caused by lack of fund and capacity of PGN for securing coking coal and poor transportation facilities (port facilities in particular). Considering the fact that raw material coal must be imported from countries like Australia, PGN is not to be blamed for the low operation rate but the central government should be urged to provide the necessary back-up and establish a system under which material coal can be smoothly supplied to PGN.

(6) Excessive Installed Capacity

As compared with the installed capacity shown in Table II-2, the operation rate shown in Table II-3 is extremely low, which is one of the outstanding features of the stations in Bogor, Semarang, Surabaya, and Ujung Pandang.

Although the low operation rate may be explained as an inevitable consequence of the transfer of large production facilities from the Dutch enterprise or the prevailing low gas demand, it should still be pointed out that the installed capacity is excessively large because Indonesia's gas demand is free from any large seasonal fluctuation. It follows, therefore, that an optimum equipment investment plan should be mapped out in future in order to cut down the maintenance and personnel costs.

## 4.4 Existing Gas Sending Out Conditions

### (1) Gas Sending Out Facilities

All blowers are of old models and have been put in use for several tens of years, but they are still in good service condition. All are in a very good state of repair which is almost astonishing and suggests that PGN workers have exerted incessant effort for their maintenance.

In the coming years, however, it will be necessary to plan their replacement after careful examination of the motor efficiency, maintenance cost, and the remaining service span.

Gas holders (all water-sealed type) are vulnearable to corrosion by gas, but most are also in a good state of repair and working perfectly.

### (2) Sending Out Pattern and Its Influence on Production Facilities.

Sending out patterns are illustrated in the following figures.

- Fig. II-5 - Monthly Gas Sent Out from PGN Jakarta Station
- Fig. II-6 - Hourly Gas Sent Out from PGN Jakarta Station and Supply Pressure.
- Fig. II-7 - Hourly Gas Sent Out from PGN Cirebon Station and Supply Pressure.

Fig. II-5 indicates that the demand for gas is relatively free from seasonal fluctuation, which means that no large restraints will be imposed on the operation planning. The difference between the production and sales shown in the same figure makes it clear that the percent leakage is lower in the wet season (December ∿ March) than in the dry season.

As seen in Figs. II-6 and II-7, the volume of gas sent out daily from Cirebon station reaches its peak between 9:00 and 12:00 hrs, while that sent out from Jakarta station reaches its maximum peak between 17:00 and 20:00 hrs, second peak at 8:00 hrs, and third peak at 13:00 hrs, thus depicting an urban pattern of gas supply.
Both stations start sending out gas early in the morning; and at midnight, both send out less than half the volume sent out in the daytime.

However, since the difference between the daytime and nighttime gas volumes is smaller than the gas holder capacity (See Table II-2), it imposes no influence at all on the load fluctuation of production facilities. Accordingly, it will be possible to operate coke ovens under a practically constant load.

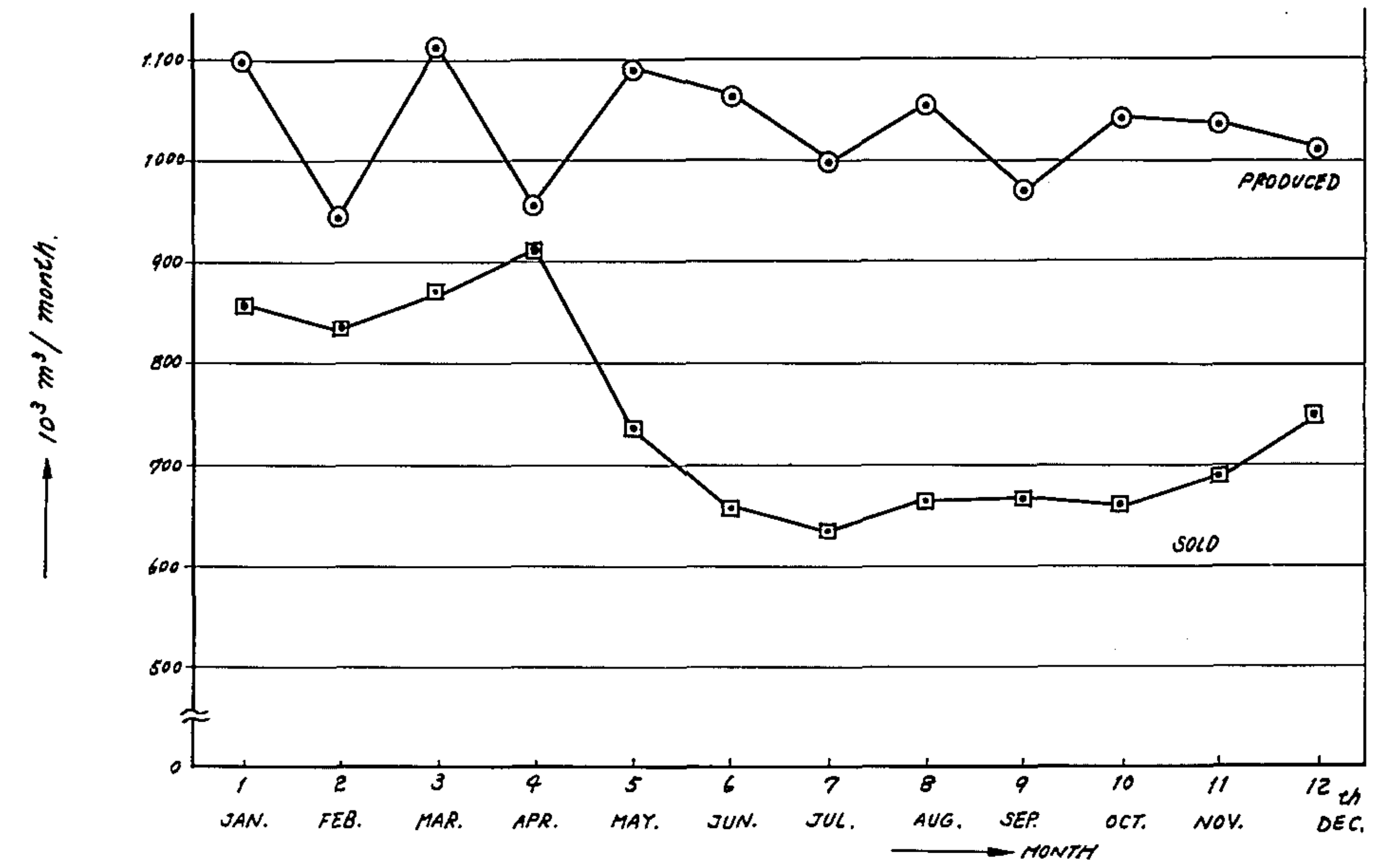
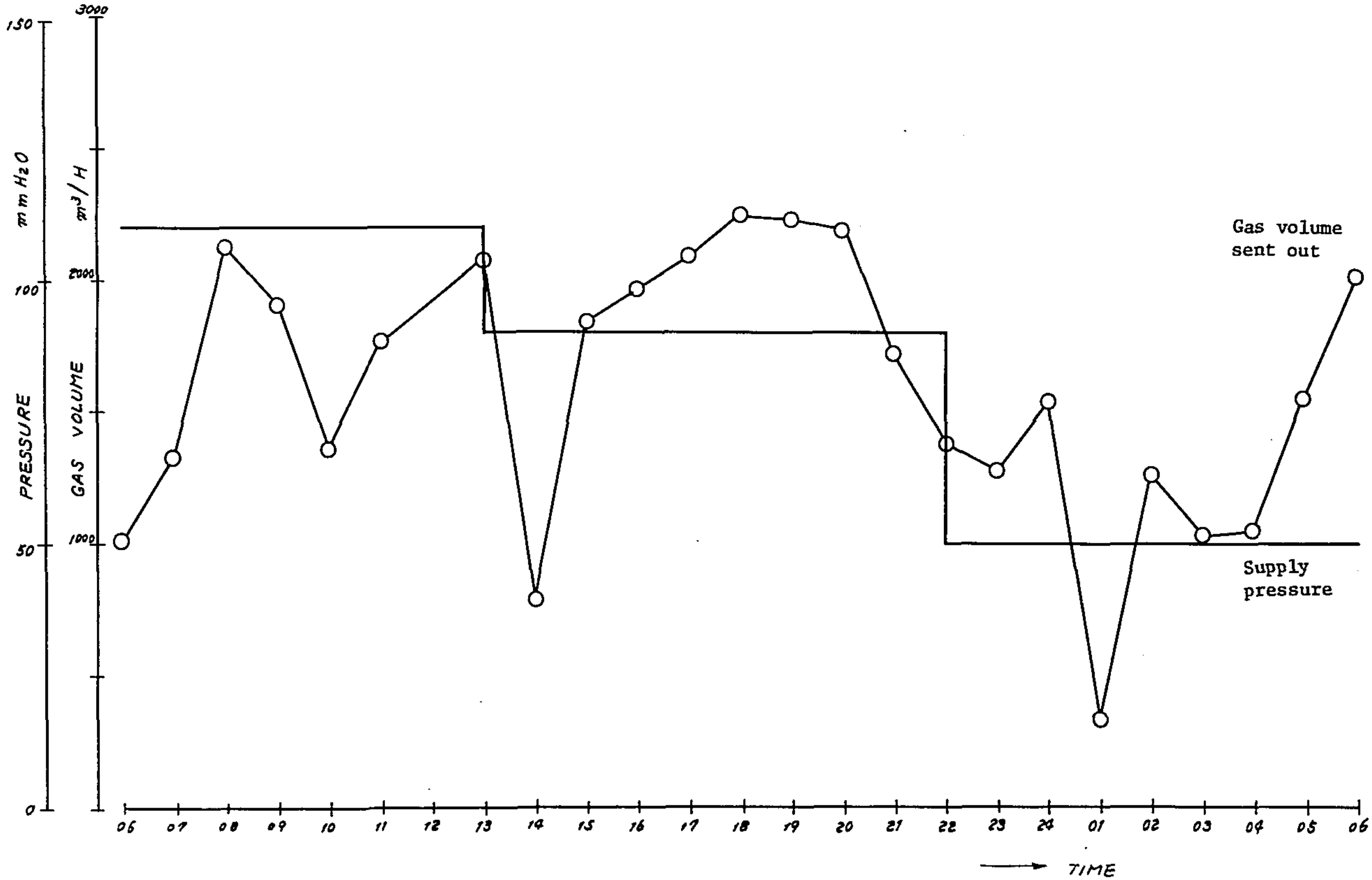



Fig. II-5. Monthly Gas Sent Out from PGN Jakarta Station (1973)


150
100
50
0
mm $H_2O$
PRESSURE
3000
2000
1000
$m^3/H$
GAS VOLUME
06
07
08
09
10
11
12
13
14
15
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21
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23
24
01
02
03
04
05
06
TIME
Gas volume sent out
Supply pressure

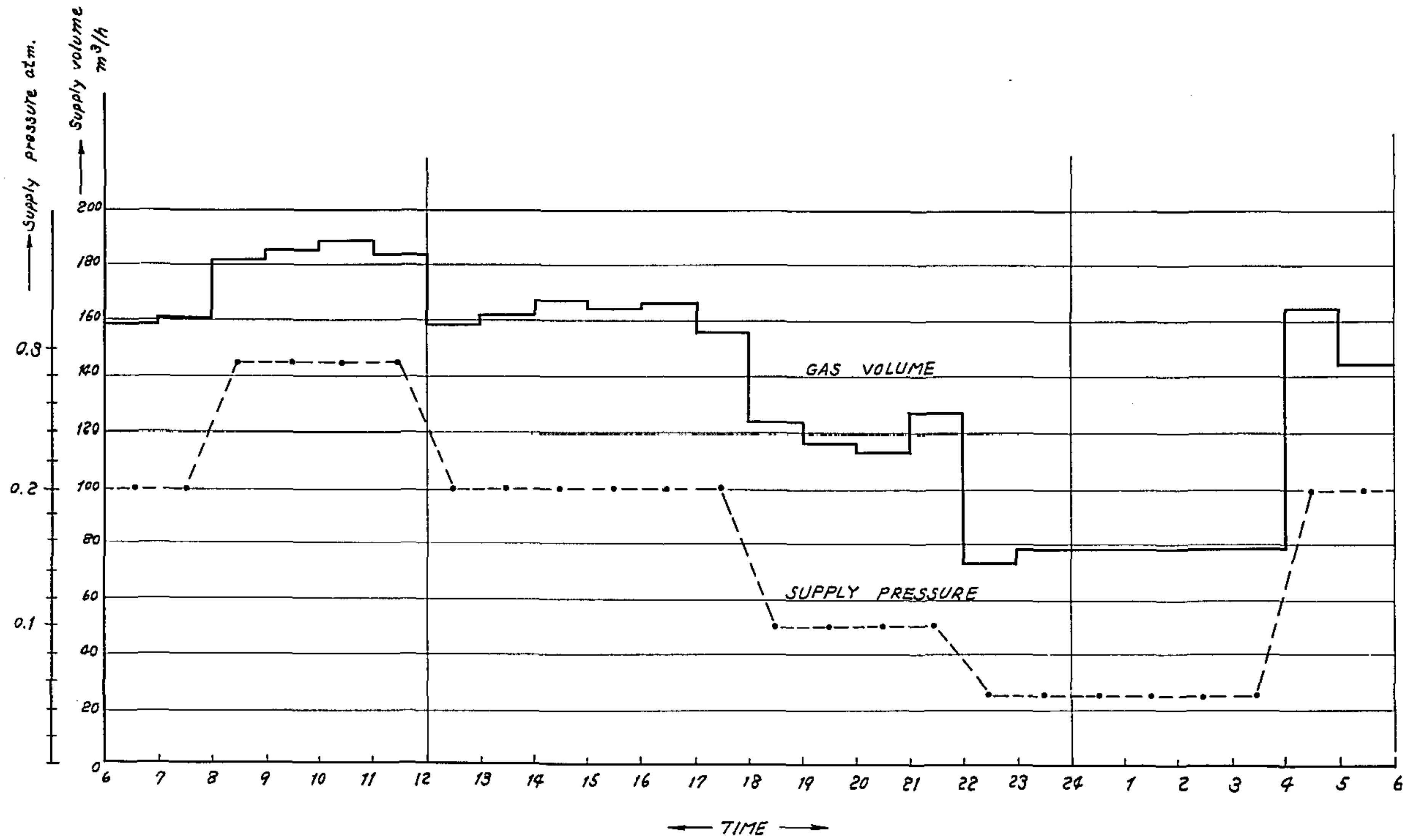



Fig. II-7. Hourly Gas Sent Out from PGN Cirebon Station

(3) Supply Pressure

The supply pressure bears closely upon the gas sending out condition. The gas volumes shown in Fig. II-6 (Jakarta station) and II-7 (Cirebon station), respectively, include about 30% and more than 60% (only in town) of leak gas volume. The supply pressure is controlled as plotted in Figs. II-6 and II-7 so as to send gas to consumers at the minimum required pressure and thereby minimize the volume of leakage gas. Hence, the gas pressure at the user's end is subject to an extreme fluctuation.

## 5. Distribution and its Problems

### 5.1 Pipeline

PGN's gas distribution system employs gas holders for low pressure distribution. Cirebon station adopts high pressure transmission (approx. 6 $kg/cm^2$) using natural gas transmission lines. Jakarta, Bandung and some other stations are known to be adopting a medium pressure of about 3,000 mmAq in part to augment the transmission capacity, and distributing the supplied gas into low pressure pipelines after passing it through the governor.

Total length of installed pipeline networks is shown in Table II-5.

The pipeline length per consumer is about 50 m for all stations excepting Ujung Pandang station which has installed an average of 100 m of pipeline per customer. Thus, the pipeline length per customer is far larger than in Japan, which is ascribable to the extensive compounds of customers' houses in the service area, and to the limited number of customers along the pipelines which can be readily imagined from the current saturation rate. With the future increase of customers, therefore, the pipeline length per consumer will naturally become shorter.

Table II-5. Total Length of Installed Pipeline Network and Length per Consumer (Unit: m)

| | 1962 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|---|---|---|
| MEDAN | 64.581 | ( Δ 20)<br>66.664 | ( 90)<br>66.754 | ( 76)<br>66.830 | ( 8)<br>66.838 | (1.580)<br>68.418 | (3.709)<br>72.127 |
| JAKARTA | 226.425 | 229.610 | (Δ 494)<br>229.116 | 229.116 | ( 1)<br>229.117 | 229.117 | 229.117 |
| BOGOR | 52.757 | ( 663)<br>55.000 | ( 196)<br>55.196 | ( 65)<br>55.261 | 55.261 | 55.261 | 55.261 |
| BANDUNG | 173.240 | ( 1)<br>176.747 | ( Δ 7)<br>176.740 | ( 6)<br>176.746 | 176.746 | 176.746 | (Δ5.134)<br>171.612 |
| CIREBON | 25.550 | ( Δ 19)<br>27.487 | ( Δ 20)<br>27.467 | ( 60)<br>27.527 | 27.527 | 27.527 | ( 378)<br>27.905 |
| SEMARANG | 93.772 | 99.718 | (Δ4.000)<br>95.718 | ( 940)<br>94.778 | ( 940)<br>95.718 | 95.718 | 95.718 |
| SURABAYA | 193.550 | ( 365)<br>194.400 | 194.400 | 194.400 | 194.400 | 194.400 | (12.502)<br>206.902 |
| UJUNG PANDANG | 33.736 | ( 174)<br>33.613 | ( 100)<br>33.713 | ( 219)<br>33.932 | 33.932 | 33.932 | (5.762)<br>39.694 |
| TOTAL | 863.561 | (5.164)<br>883.239 | (Δ4.135)<br>879.104 | ( Δ 514)<br>878.590 | ( 949)<br>879.539 | (1.580)<br>881.119 | (18.217)<br>899.336 |
| MEDAN | 32,1 | 33,3 | 34,9 | 37,3 | 38,5 | 42,4 | 48,1 |
| JAKARTA | 27,4 | 30,9 | 33,9 | 36,6 | 37,9 | 38,4 | 37,2 |
| BOGOR | 36,6 | 41,3 | 44,3 | 46,4 | 47,6 | 48,5 | 50,5 |
| BANDUNG | 28,8 | 29,3 | 29,6 | 31,0 | 31,3 | 31,7 | 30.8 |
| CIREBON | 34,6 | 36,7 | 41,3 | 43,7 | 44,8 | 45,0 | 46,3 |
| SEMARANG | 30,2 | 37,6 | 39,8 | 42,1 | 44,6 | 45,2 | 46,6 |
| SURABAYA | 31,8 | 36,4 | 39,0 | 41,3 | 42,2 | 43,3 | 46,3 |
| UJUNG PANDANG | 51,0 | 74,2 | 80,2 | 83,6 | 84,0 | 84,2 | 98,0 |
| AVERAGE | 30,5 | 34,7 | 36,1 | 38,3 | 39,3 | 40,2 | 41,1 |

Notes ( ): increase or decrease ( Δ )

Upper part: total lengths (m)

Lower part: average length per consumer (m)

Classification of pipelines by diameter is shown in Table II-6 for Jakarta and Medan.

Supply pipes are mostly made of cast iron, and service pipes made of steel.

Many of cast iron pipes are very old, and some are known to have been installed more than 100 years ago when the country was under the Dutch rule. Cast iron pipes are connected by ball and spigot joints and no mechanical joints are used.

Steel service pipes are given deficient rust and corrosion preventive treatment so that they are vulnerable to rapid rust development and corrosion and consequently to heavy gas leakage.

Steel pipes are connected by screw coupling if the diameter is small, and by electric welding if the diameter is large.

In some areas, an optimum supply pressure of 80 ∿ 100 mmAq at the customer's end is not maintained by reason of blocking up of pipelines with tar and naphthalene contained in the manufactured gas due to its insufficient purification, water collection in the pipeline resulting from the groundwater intrusion through the leakage hole, and deficient transmission capacity of the pipeline itself. These defects causes suspension of gas supply in an extreme case. This poor supply condition occasions the customers' constant complaints and its improvement is the most pressing need to be filled by PGN.

Road improvement and widening are in progress in Indonesia under city planning, but is not necessarily accompanied by smooth removal and reinstallation of gas pipelines. In some parts of Jakarta, therefore, pipelines are left installed along the centre line of roads. As things stand now, not only the branching from pipelines but also pipeline maintenance work will be made extremely difficult. In order to eliminate engineering difficulties which will arise from the prevailing situation, it is necessary to prompt the reinstallation of pipelines attendant on the road construction work.

Table II-6. Classification of Pipelines

(Unit: m)

| Diameter | (PGN Jakarta) | | (PGN Medan) | |
|---|---|---|---|---|
| | Cast iron pipe | Steel pipe | Cast iron pipe | Steel pipe |
| 16 | 2,520 | | | |
| 15 | 600 | | | |
| 14 | 530 | | 2,970 | |
| 12 | 7,251 | | 732 | |
| 10 | 13,499 | | 350 | |
| 9 | 2,395 | | | |
| 8 | 23,350 | 5,000 | 3,890 | 1,302 |
| 7 | 750 | | | |
| 6 | 23,217 | 1,000 | 12,300 | 2,670 |
| 5 | 4,231 | | | |
| 4 | 130,930 | 1,500 | 25,977 | 5,794 |
| 3 | 9,395 | | 4,198 | |
| 2 | | 10,056 | | 10,559 |
| 1 1/2 | | 1,217 | | 1,572 |
| TOTAL | 218,668 | 18,773 | 50,417 | 21,897 |
| | 237,441 | | 72,314 | |

## 5.2 Gas Meter

Most gas meters are of dry type, although wet type meters are installed in some areas.

Capacity-wise classification of gas meters installed within the service area of Cirebon station is shown below.

| Capacity | Number |
|---|---|
| 0.8 $m^3$/hr | 1 |
| 3 | 1 |
| 6 | 7 |
| 7.2 | 395 |
| 15 | 2 |
| 20 | 1 |

While similar meters are used by other stations, their capacity is excessively large relative to the gas appliances (gas ranges) for home use. Meters with too large a capacity are not only costly but are prone to invite measurement error. The existing meters should therefore replaced, when their service span has expired, with those having an optimum capacity suited to the gas appliances in use.

All gas meters are imported from abroad. Meters procured in recent years include the products of Gallius (France), Wilson (Netherland), Kromschröder (W. Germany) and Kimmon (Japan).

The team noted that gas meters are considerably deteriorated. This is because new meters are procured in limited numbers and there exists no established standard for systematic replacement of meters. Insufficient purification of manufactured gas was noted to give rise to frequent disorder and failure of meters ensued from adhesion of tar and corrosion. However, due to the limited availability of replacement meters and the shortage of PGN's repair capacity, not all faulty meters are given repair or replacement services, and, as a consequence, gas consumption is estimated without meters in some cases.

Repair of gas meters is conducted by PGN, but not in the proper way. For instance, vinyl films are used in place of sheepskins and synthetic rubbers films for the diaphragm which decisively affects the accuracy of dry type meters. PGN should therefore reinforce its repair capacity and request the meter makers to train the repair workers in the necessary techniques.

Although gas meters are the essential basis of transaction between PGN and its consumers, not even their accuracy is guaranteed at present. PGN is therefore urged to bring remedy to the prevailing inaccurate measurement because it leads only to the distrust on the part of users and will also impede the future effort for raising the saturation rate.

## 5.3 Loss of Gas

The loss of gas (difference between production and sales) is extremely large and the loss rate reaches 20 ∿ 40% as shown in Table II-7. Particularly in Cirebon city where the conversion to natural gas supply has already completed, the loss rate shows an exorbitant value of 60 ∿ 70% excepting industrial use.

Conversion to natural gas increases the calorific value and also decreases the consumption in inverse proportion to the calorific value. However, since a high supply pressure is required to burn the gas having a high calorific value, natural gas conversion tends to increase the percent leakage and consequently the gas loss rate. Natural gas conversion should therefore be preceded by the consolidation and improvement of distribution facilities. Otherwise, a high loss rate occurs as in the case of Cirebon. The conversion also calls for prior installation of odourizing facilities and oil fogging equipments to give an odour and moisture to the supplied gas.

Table II-7. Loss of Gas

| | | 1962 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|---|---|---|
| MEDAN | 1.000 $M^3$ | 483 | 767 | 790 | 958 | 564 | 306 | 938 | 1.096 |
| | % | 11,4 | 24,8 | 30,6 | 30,0 | 24,6 | 12,1 | 29,2 | 42,3 |
| JAKARTA | 1.000 $M^3$ | 1.326 | 2.390 | 3.138 | 2.392 | 1.239 | 1.501 | 2.735 | 2.034 |
| | % | 8,2 | 21,1 | 27,5 | 24,7 | 16,1 | 17,2 | 22,6 | 24,5 |
| BOGOR | 1.000 $M^3$ | 24 | 203 | 242 | 205 | 287 | 182 | 460 | 272 |
| | % | 1,0 | 11,2 | 14,1 | 17,2 | 21,5 | 13,8 | 29,4 | 25,4 |
| BANDUNG | 1.000 $M^3$ | 535 | 1.158 | 1.172 | 1.428 | 1.177 | 1.575 | 1.631 | 944 |
| | % | 4,8 | 13,5 | 14,9 | 19,9 | 18,5 | 20,7 | 20,5 | 18,3 |
| CIREBON | 1.000 $M^3$ | 179 | 139 | 90 | 89 | 117 | 66 | 121 | 76 |
| | % | 12,6 | 12,9 | 10.6 | 12,8 | 16,9 | 9,4 | 15,3 | 14,7 |
| SEMARANG | 1.000 $M^3$ | 647 | 879 | 665 | 840 | 745 | 523 | 536 | 557 |
| | % | 10,6 | 23,8 | 21,9 | 28,7 | 26,7 | 20,6 | 21,2 | 30,1 |
| SURABAYA | 1.000 $M^3$ | 3.086 | 3.966 | 2.590 | 2.126 | 1.445 | 1.713 | 2.058 | 1.269 |
| | % | 21,1 | 42,5 | 31.1 | 24,2 | 18,2 | 20,7 | 22,6 | 18,1 |
| UJUNG PANDANG | 1.000 $M^3$ | 325 | 220 | 227 | 184 | 132 | 73 | 110 | 90 |
| | % | 21,8 | 23,8 | 24,4 | 21,3 | 16,5 | 9,3 | 14,2 | 15,9 |
| TOTAL | 1.000 $M^3$ | 6.574 | 9.711 | 9.551 | 8.223 | 5.726 | 5.940 | 8.591 | 6.338 |
| | % | 11,4 | 24,4 | 26,0 | 24,3 | 19,1 | 18,3 | 22,6 | 23,4 |

Loss = production of gas - sales of gas.

$$\text{Loss rate (\%)} = \frac{\text{Loss}}{\text{Produced gas}} \times 100(\%)$$

The high loss rate described above is not considered ascribable to leakage alone. It is probable that the measurement error accounts largely for the loss.

The following are the major causes of gas loss.

1) Leakage

   a. Leakage caused by the corrosion and breakage of the pipe. Steel pipes including service pipes are vulnerable to such leakage.

   b. Leakage from the loosened coupling in the pipeline.

   c. Leakage from the meter, valve and interior pipe.

   d. Leakage caused by the corrosion of gas holders.

2) Measurement error

   a. Error caused by the failure of meters installed at the users' end, and inaccuracy of such meters.

   b. Error due to misreading of the meter indication.

   c. Error due to malfunction or inaccurate calibration of manufactured gas meters.

3) Loss due to gas quality

   Decrease of gas volume caused by the condensation of higher hydrocarbons in the pipeline. Gas supplied from the partial combustion generator is particularly vulnerable to this loss.

Loss due to the gas quality is rather small, and leakage and measurement error are the main causes of loss. At present, however, effective preventive measures are not established because these causes and the resultant loss have not yet been thoroughly investigated.

Considering the serious financial damage inflicted by the heavy loss of gas, it is imperative on PGN to expend every effort to clear up the cause and reduce the loss rate.

It is to be added that the prevailing high loss rate should be given serious attention from the viewpoint of national energy policy.

The percent leakage before and after natural gas conversion is calculated below.

L : Leakage volume before conversion.

U : User's consumption before conversion.

H : Calorific value before conversion.

Ha : Calorific value after conversion.

d : Specific gravity of gas before conversion.

da : Specific gravity of gas after conversion.

P : Supply pressure before conversion.

Pa : Supply pressure after conversion.

Percent leakages before and after the conversion can be respectively obtained from the following equations.

Rated of leakage before conversion .. $X = \frac{L}{U + L}$

Rate of leakage after conversion ... $Y = \frac{L.\sqrt{\frac{Pa}{P}.\frac{d}{da}}}{L.\sqrt{\frac{Pa}{P}.\frac{d}{da}} + U\,\frac{H}{Ha}}$

The above equations can be rearranged as follows by eliminating U and L. (WI denotes Wobbe Index)

$$Y = \frac{1}{1 + (\frac{1}{X} - 1)\,\frac{H}{Ha}\sqrt{\frac{P}{Pa}.\frac{da}{d}}} = \frac{1}{1 + (\frac{1}{X} - 1)\,\frac{WI}{WIa}\sqrt{\frac{P}{Pa}}}$$

Assuming that

H=3,000, Ha=6,000, d=da=1.0,
P=100 and Pa=200

X and Y, respectively, assume the following values.

| X | Y |
|---|---|
| 20% | 42% |
| 30% | 52% |
| 40% | 65% |

Thus, it is clear that the percent leakage increases largely after the conversion. If WI is larger as in the case of pure methane gas, the percent leakage increases further.

## 6. Combustion Characteristics and Appliances

### 6.1 Calorific Value of Supplied Gas

PGN sets the standard calorific value of gas at 4,200 $Kcal/Nm^3$. At present, however, the calorific value is not stabilized and gas is supplied without hot enrichment or air dilution (See Table II-8).

A more detailed explanation on the fluctuation of calorific value is summarized below:

(1) The calorific value of supplied gas varies from station to station (according to the difference in the production facilities). The fluctuation ranges from about 3,000 $Kcal/Nm^3$ (gas supplied by the operation of the partial combustion generator at Medan Station) to about 6,000 $Kcal/Nm^3$ (natural gas supplied from Cirebon station).

(2) The calorific value of gas supplied from the same station varies according to the operation condition of the production facilities as well as by the operation ratios of the facilities comprising two or more different types. The fluctuation is particularly large in case of Jakarta station.

Table II-8. Combustion Characteristics of Manufactured Gas and Supplied Gas

| | | Analytical values obtained at PGN stations | | | | | | | | Analytical values from 1974 statistics | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jakarta | | | Bandung | | Surabaya | Cirebon | | | | | |
| | Symbol | Supplied gas (1) | Partial combustion gas (2) | Coal gas (3) | Supplied gas (4) | Supplied gas (5) | Catalytic reformer gas (6) | No. 33 well (7) | No. 35 well (8) | Partial combustion gas (9) | Coal gas (10) | Catalytic reformer gas (11) | Supplied gas (12) |
| | $CO_2$ | 2.9 | 2.2 | 4.6 | 3.8 | 7.4 | 6.0 | 42.5 | 26.5 | 2.8 | 5.1 | 4.8 | 3.8 |
| | CnHm | 5.9 | 7.2 | 4.1 | 11.2 | 6.8 | 7.0 | 1.0 | 0.5 | 6.3 | 2.0 | 11.2 | 4.2 |
| | $O_2$ | 0.2 | 0.3 | 0.2 | 0.6 | 0.8 | 0.4 | 0.1 | 0.4 | 0.2 | 0.2 | 0.4 | 0.3 |
| | CO | 13.2 | 16.2 | 11.8 | 8.8 | 11.0 | 23.0 | 0.9 | 0.6 | 15.4 | 13.4 | 15.6 | 14.4 |
| | $H_2$ | 15.8 | 7.6 | 47.0 | 7.0 | 19.0 | 51.0 | 2.4 | 1.0 | 10.7 | 57.0 | 37.7 | 34.0 |
| | $C_3H_8$ | 1.5 | 0.4 | 0.3 | - | - | - | 0.6 | 0.5 | 0.6 | 0.3 | 0.3 | 0.8 |
| | $CH_4$ | 7.7 | 6.1 | 21.5 | 15.6 | 26.6 | 11.0 | 49.5 | 65.5 | 6.4 | 15.0 | 16.6 | 10.8 |
| | $N_2$ | 52.8 | 60.0 | 10.5 | 53.0 | 28.4 | 1.6 | 3.0 | 5.0 | 57.6 | 7.0 | 13.4 | 31.7 |
| Calorific value ($Kcal/Nm^3$) | C.V. | 3308 | 3022 | 4834 | 4490 | 4977 | 4875 | 5184 | 6520 | 2967 | 4095 | 5800 | 3640 |
| Specific gravity (air=1) | S.G. | 0.849 | 0.926 | 0.506 | 0.920 | 0.765 | 0.534 | 0.989 | 0.843 | 0.896 | 0.435 | 0.647 | 0.665 |
| Wobbe index | WI | 3590 | 3140 | 6798 | 4680 | 5692 | 6670 | 5212 | 7100 | 3133 | 6212 | 7210 | 4464 |
| Combustion potential | CP | 33.1 | 24.6 | 88.9 | 24.7 | 43.2 | 99.0 | 18.9 | 23.6 | 27.5 | 107.6 | 73.3 | 60.0 |
| Maximum flame speed (cm/sec.) | SM | 33.6 | 27.7 | 66.2 | 31.5 | 39.8 | 79.1 | 18.4 | 25.1 | 29.1 | 85.7 | 58.2 | 54.8 |
| Theoretical air requirement ($Nm^3$ gas) | Ath | 3.03 | 2.77 | 4.39 | 4.23 | 4.67 | 4.29 | 5.14 | 6.48 | 2.71 | 3.59 | 5.30 | 3.26 |

(Notes) CnHm content calculated by assuming that it is $C_3H_6$

The low calorific value, high specific gravity and slow flame speed are the common defects of gas manufactured by the partial combustion generator. Partial combustion gas is thus quite different in nature from coal gas, and it must be mixed in a lower and fixed ratio to coal gas in order to maintain the stable characteristics of supplied gas. The prevailing fluctuation of calorific value and combustion characteristics of supplied gas occurred because some stations were unable to keep coke ovens in smooth operation and consequently forced to manufacture gas by the operation of partial combustion generators alone.

Fluctuation of the calorific value of supplied gas incurs changes of input and combustion characteristics at the customer's end, and this in turn calls for the adjustment of gas appliances. For this reason, PGN sends out its service personnel whenever it is requested by the user to adjust this appliance. Drop of calorific value results in the increase of gas charge per unit calorific value, and this is one of the cause that induced gas customers to shift to other cheaper energy sources. It also results in an extreme decline of input to gas appliances, which sometimes makes it impossible for the appliances to exhibit their designed function. It is therefore absolutely necessary to maintain the calorific value of supplied gas at a fixed level (e.g. lower limit - 97%).

## 6.2 Combustion Characteristics of Supplied Gas

It is the primary duty of any gas enterprise to assure its customers of the stable supply and maintenance of constant calorific value, but it is equally important to maintain excellent combustion characteristics of supplied gas.

When WI (Wobbe index) and CP (combustion potential) are obtained from the gas component values analyzed by PGN (See Table II-8), the gas interchangeability can be graphically illustrated as shown in Fig. II-8 (Refer to Appendix 8 for details).

The gas interchangeability diagram (Fig. II-8) indicates that gas supplied solely from the partial combustion generator is small in WI and has a very slow flame speed. Its WI and flame speed are both lower than those of Class A gas which is known to have the lowest WI and flame speed in Japan (gas supplied from Medan station is particularly low in both values).

Natural gas supplied from Cirebon station has a large $CO_2$ content, and its flame speed is extremely slow and WI is not very large either.

Surabaya station manufactures gas by the operation of ONIA-GEGI type catalytic reformer alone, so that it supplies gas which is high in both flame speed and WI.

Gas supplied from Bandung station is manufactured by a coke oven, with heavy oil injected for hot enrichment, so that it has a high calorific value but is slow in flame speed.

At Jakarta station, the load of coke oven is extremely low. Hence, gas supplied from this station is only slightly higher in WI and CP than that from other stations where gas is manufactured only by the partial combustion generator.

The interchangeability of supplied gas is allowed to range from 10 to 15% in terms of WI according to the combustion characteristics of gas appliance, and the flame speed is generally classified into fast (C), normal (B) and slow (A) categories.

As will be clear from the above description, only the gas from Surabaya station can be placed under the category of 6C or 7C at present, and it seems that the flame speed of gas from all other stations is equivalent to or slower than that of LPG or methane gas.

Thus, it is only Surabaya station that supplies gas with the same combustion characteristics as coal gas, and all other stations are required to adjust gas appliances within their respective service areas. In the case of stations where both the coke oven and the partial combustion generator are run, the combustion characteristics of supplied mixed gas are vulnerable to an extremely large fluctuation according to the operation ratio of the two equipments.

When the operation ratio is changed at such stations, therefore, the fluctuation of combustion characteristics cannot be coped with by the mere adjustment of the cock or other parts of gas appliances.

The discussion advanced above leads to the conclusion that the gas enterprise should employ optimum production facilities including a suitable calorific value regulator and expend every effort so that the combustion characteristics of supplied gas will be held within the established interchangeability region.

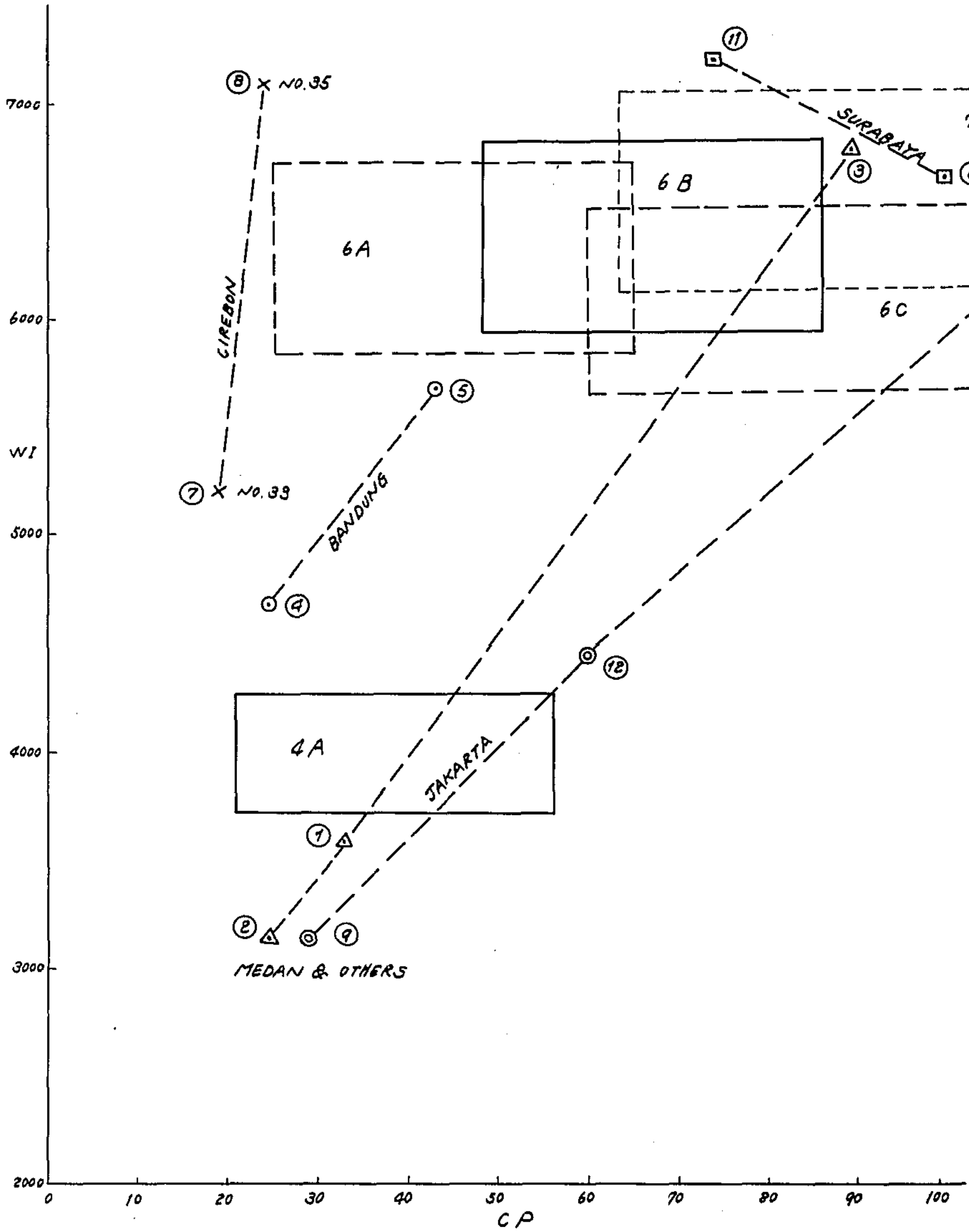



Fig. II-8. Interchangeability Diagram of Supplied Gas (CP - WI Diagram)

## 6.3 Customers' Gas Appliances

As described in the preceding section, the standard calorific value of supplied gas comprising mostly coal gas is set at 4,200 Kcal/$Nm^3$, but supplied gas is actually subjected to a large fluctuation of combustion characteristics and other factors. The team, therefore, made a study to clarify how gas appliances are used and adjusted to cope with such fluctuations.

In the first place, it was noted that due to the low calorific value, WI and supply pressure, customers find it difficult to obtain the required input. They use large diameter nozzles and clean the path of gas to increase the input. Some complained that the supply of gas is impeded or completely stopped because the path of gas is choked up with water collection or impurities in the supply pipe.

### (1) Jakarta area

In this area, gas ranges with a universal burner imported from Europe or United States are widely used for home cooking. Other ordinary gas ranges had different nozzle diameters depending on customers, i.e., 4.5 mmϕ, 3.5mmϕ, and 3.0 mmϕ. It was observed that nozzles with 4.5 mmϕ supply an adequate input of 2,000 ∿ 2,500 Kcal/hr at a supply pressure of 50 mmAq. In this case, however, "lift" was seen when the primary air supply was adjusted so as to make the inner flame visible. This indicates that the flame speed was considerably low and the burner port diameter was not suited to the supplied gas.

Consumers using 3.5 mmϕ and 3.0 mmϕ nozzles all complained about the shortage of input. When the nozzle diameter is 4.5 mmϕ and the supply pressure is 50 mmAq, input can be calculated as follows (Refer to Appendix 9).

$$\text{Input} = 0.011\ k \cdot D^2 \cdot WI \cdot \sqrt{P}$$

$$= 0.011 \times 0.5 \times 4.5^2 \times 3{,}600 \times \sqrt{50}$$

$$= 2{,}200\ \text{Kcal/hr}$$

where, k is the flow rate coefficient through the nozzle, and it changes as shown in Fig. II-9 when the cock opening ranges from 4 to 5 mm in diameter.

The team also inspected gas ranges for commercial purposes at Asoka Hotel and observed that some burners presented yellow tip and some others showed lift. The team was told that these burners were not easy to use because it is difficult to adjust the primary air port.

The team also noted that a small type instantaneous water heater was installed at one of the users' houses, but found that it was not in full use because both water and gas were not supplied sufficiently.

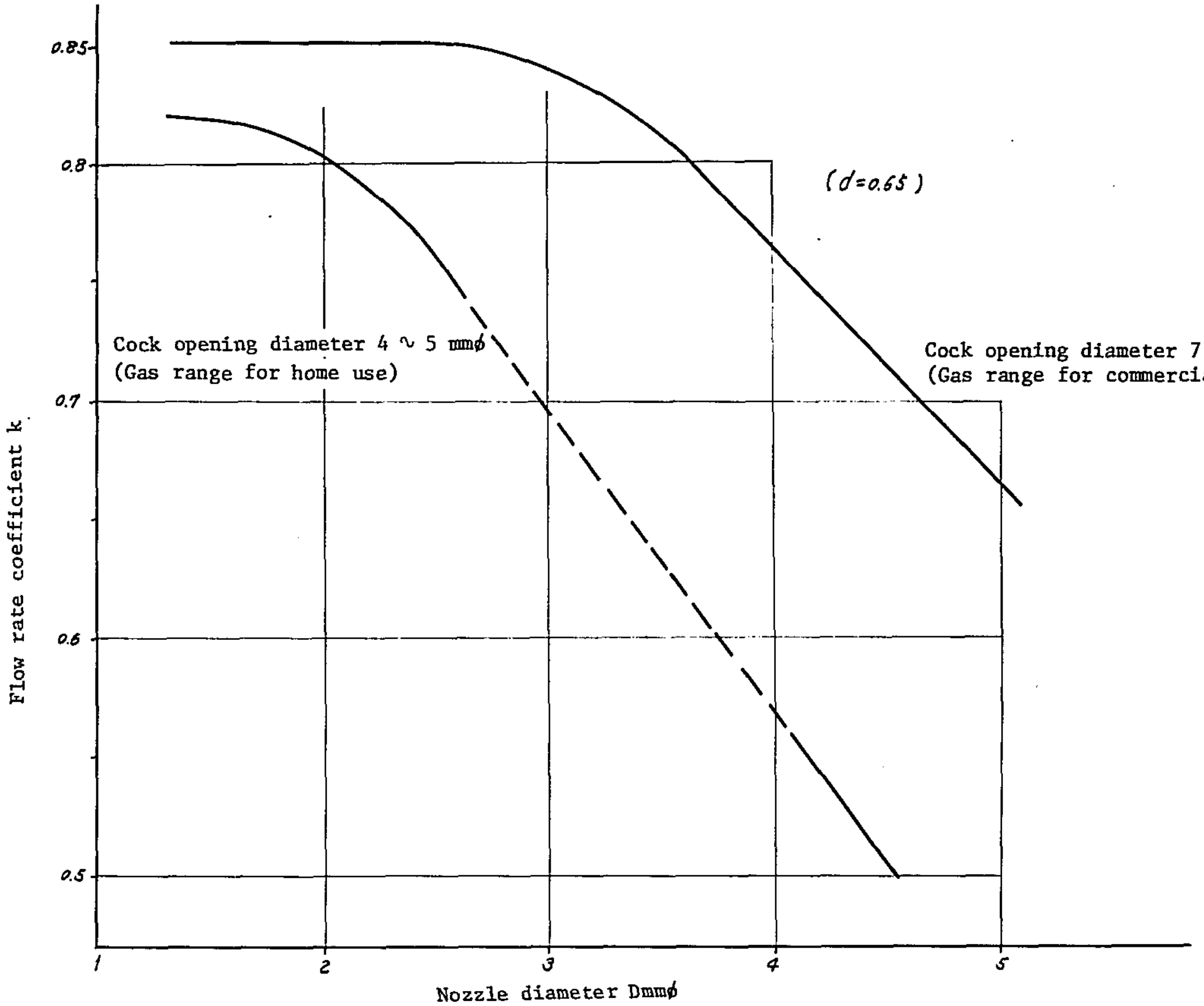



Fig. II-9. Flow Rate Coefficient vs. Nozzle Diameter (d = 0.65)

(2) Medan Area

Gas supplied in this area is manufactured by the partial combustion generator. Although the gas ovens and ranges (products of PGN with large burner ports) installed at a hotel produced a soft flame, neither yellow tip nor lift was observed. This was perhaps because the burner ports and air ports were adequately adjusted.

At a biscuit plant visited by the team, the biscuit making machine incorporated a pipe burner for heating from top and bottom (temperature inside the oven: 230°C). At this plant, a booster was employed to maintain the required gas pressure (200 mmAq). The flame presented yellow tip, indicating that gas had a large $C_nH_m$ content.

(3) Cirebon Area

In this area, the team studied the combustion characteristics of the simple LPG two-burner hot plate for camping imported from the Netherlands which Cirebon station leased to its customers during the conversion period to natural gas. As shown in Fig. II-10, the nozzle diameter of this plate was modified to 2mm, and the primary air port was fully opened when burning LPG. When burning natural gas supplied from Cirebon station, the air port had to be closed totally by a damper in order to prevent "lift."

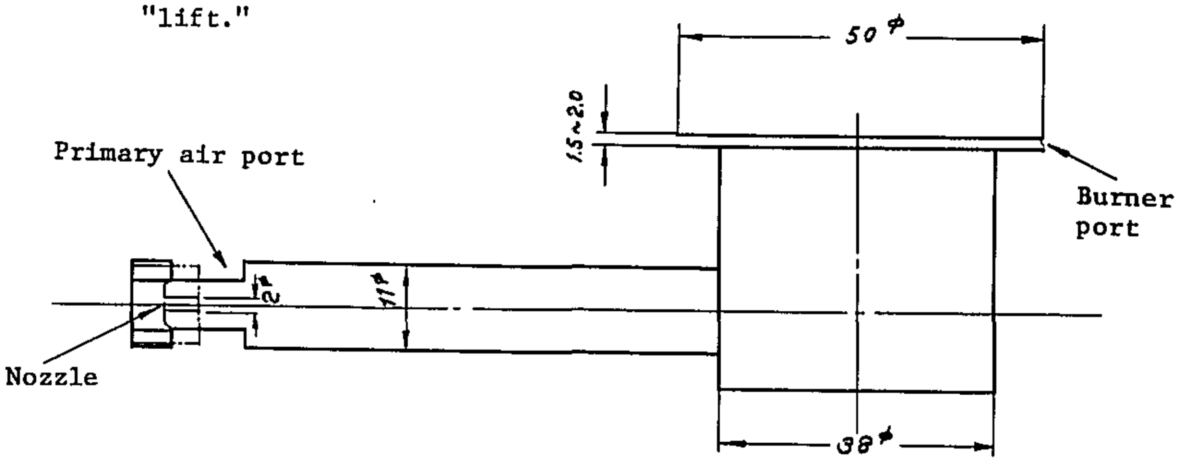



Fig. II-10 Two-Burner Hot Plate Leased by Cirebon Station

Considering the burner port area, burner port loading and nozzle diameter, the said two-burner plate calls for a supply pressure of about 100 mmAq to obtain an adequate input of slightly less than 2,000 Kcal/hr.

The team observed the flame of the burner of a gas range used at a hotel and found that it was very soft. This indicates that supplied gas had a large $CO_2$ content and its flame speed was slow.

Since the natural gas conversion period in Cirebon area was short, Cirebon station found it impossible to conduct the conversion and the appliance adjustment simultaneously. The team was informed that the aforementioned appliance was leased to customers in advance for this reason, and the customers adjusted their appliances in about one month after the conversion.

As will be described later, natural gas conversion cannot be implemented smoothly and further incurs an enormous cumulative cost unless it is started after 2 to 5 years of careful study and preparation.

Observation of the burner used for a lime kiln disclosed that the flame intensity was low perhaps because of the shortage of primary air.

The team learned that the customer lodged a complaint about this shortage of flame intensity and observed that Cirebon station was engaged in the experiment of blast burners intended for pre-mixing of air and gas as well as in the study for increasing the primary air suction volume by raising the supply pressure. Thus, it was noted that Cirebon station was dealing with the complaints from consumers in a positive manner and was also exerting effort to increase the number of customers.

(4) Surabaya Area

In Surabaya area, the team visited the Philips' electric bulb plant and a bottle making factory. The Philips' electric bulb plant is equipped with a booster system but seemed to find it difficult to raise the pressure and maintain it at a constant value. Surabaya station is the only PGN station that supplies gas with a high $H_2$ content. Although this gas is suited to burners for glass blowing, it calls for constant attention because its combustion characteristics are subject to extreme and frequent fluctuation. As will be clear from the interchangeability diagram, coke oven gas excels in interchangeability but presents the problem of fluctuation of combustion characteristics when it is mixed with other gas.

The team wishes to add that for the future natural gas conversion in this area, Surabaya station will be required to conduct strict tests for development of best suitable burners and to carry out trial operations in conformity to the process flow of the Philips' plant.

(5) Supplied Gas vs. Gas Appliances

While the gas enterprise is required to assure its customers of stable supply of gas with stabilized characteristics, it must also conduct active publicity and Public Relation activities to encourage and motivate its customers to use appliances best suited to the supplied gas.

As the first step towards this objective, the appliances currently used by customers should be adjusted according to the characteristics of supplied gas.
The enterprise should also give approval to gas appliances suited to the supplied gas and engage in the sales of such appliances, and further provide consumers with guidance for their proper installation and operation.

# CHAPTER III

## APPROACH TO THE ESTABLISHMENT OF DESIRABLE STATE OF GAS ENTERPRISE

# CHAPTER III. APPROACH TO THE ESTABLISHMENT OF DESIRABLE STATE OF GAS ENTERPRISE

## 1. Gas Enterprise as Public Utility

### 1.1 Social Duties

As described in Chapter I, development of the gas enterprise for smooth energy supply to urban areas is urgently needed in Indonesia in order to ensure effective utilization of the country's natural energy resources as well as to enhance her growth into a modern country.

It is to be noted, however, that the desired development will make it increasingly imperative on the enterprise to fulfil its duties toward society.

To be more specific, the gas enterprise is a monopolistic undertaking responsible for smooth supply of energy needed for the citizens' daily life and for industrial activities, so that it is demanded to assure its customers of stable supply of gas of satisfactory quality at reasonable rates. Failure to fulfil these duties incurs an immense socio-economic influence.

Indonesia's gas enterprise, currently run by PGN in the form of public corporation is a clear indication that Indonesian government considers it essential to place the enterprise under such form for promotion of national economy and public welfare.

As pointed out elsewhere in this report, however, the gas enterprise has not answered the national needs and achieved sound development.

Against this backdrop, the enterprise itself (PGN) should exert every effort for the fulfilment of its duties which are enumerated below.

1) Establishment of a rational and economical management and operation plan, and supply of gas on a constant basis to any user in the serviceable area within the framework of such management plan.

2) Upholding of good gas quality.

3) Maintenance of equal supply conditions for all users in the service area of respective stations, specially in respect of gas rates.

4) Direction of constant effort towards raising the management efficiency, and maintenance of resasonable gas rates.

5) Exertion for preventing environmental pollution and protecting public welfare and safety.

At present, however, these fundamental requirements are not fulfilled. Specifically, the team's study on PGN's existing condition revealed the following problems.

1) Gas quality is not stabilized.

2) Some difference is still observed between general consumers and households of government employees including members of armed forces with respect to the gas rates.

3) The prime cost is made high on account of managerial reasons and as a consequence, PGN's gas is unable to meet price competition from other fuels.

4) Pollution problems and high percent leakage still exist.

Unless solution is brought for these problems, input of huge amount of fund or any latest techniques may not open up the way for PGN's development into a public utility worthy of the name.

1.2 Supervision and Control of Gas Enterprise

As pointed out earlier in this report, Indonesia's gas enterprise is in the stage of delayed development, so that it is not capable of performing its essential functions as a public utility.

PGN is naturally responsible for the situation, but it is to be pointed out that the responsibility falls partly on the government which should have supervised PGN in full recognition of its specific nature. The government should have established and enforced rules governing the operation of PGN to safeguard the interests of consumers and enhance the development of gas enterprise.

Notes: The government control over the gas enterprise is exercised under the provisions of pertinent laws, Cabinet orders, Ministers' decrees, and Regulations governing Power and Public Enterprises. However, most of these statutory provisions are intended rather for administrative guidance than otherwise, and there exist no regulations providing for the protection of consumer interests and the duties to be discharged by the gas enterprise for such protection.

Control over public energy utilities operating in different countries of the world varies to an extent according to their past progress and management system as well as by the political system.

Nevertheless, the need for supplying energy in a rational way for social and economic activities of the nation and thereby assuring the people's welfare is fully recognized in all countries. Hence, suitable supervisory measures are enforced under which the public nature of energy supply services is brought to the fore and the utilities performing such services are required to supply consumers with safe and cheap energies in abundant quantities.

The situation seems somewhat different in Indonesia. Being a public corporation, PGN might be considered that the consumers' interests can be safeguarded without any control measures which are generally required for profit-seeking private enterprises.

In addition, although the Indonesian gas enterprise is a public utility, competitive fuels including kerosene hold a dominant place over gas. This fact is bound to provoke the discussion that the control over the enterprise should be eased.

Considering, however, that the paramount duty of any public utility is to contribute, regardless of its management system and operation condition, towards public welfare through stable supply of services to indeterminate numbers of consumers and industries, and that such services are offered in a monopolistic manner, it leaves little doubt that control of public utilities can never be dispensed with for protecting consumers' interests.

Need for such control can be justified by the fact that the gas enterprise is a public corporation and is therefore required to be managed not for public intersts alone but on a sound and efficient self-supporting accounting basis.

In the United Kingdom where the gas enterprise is state-owned as in Indonesia, the "Gas Law" is enforced to control the whole aspects of gas supply services under the supervision of the Minister of Fuel and Power. In addition, the "Gas Committee" is established under each Regional Gas Bureau to supervise the gas supply services in respective localities. The committee is assigned to the following tasks.

1) Examination of complaints filled by individual consumers.

2) Review of factors affecting the gas supply services as a whole.

3) Deliberation of the management policy and plans prepared by the gas enterprise, and presentation of a report in which such policy and plans are either approved or criticized.

Thus, the committee performs the dual function of conveying the consumers' desires and opinions to the Regional Gas Bureau and explaining the bureau's policy and plans to the consumers.

For the purpose of protecting consumers, the committee is empowered to make studies on the revision of gas rates and improvement of gas facilities, and submit recommendations to the Gas Bureau or the Minister of Fuel and Power on the basis of such studies.

The Gas Law provides for the inspection of the supply pressure, quality, calorific value and meters which are all important for satisfactory gas services, and stipulates that the pertinent supervising office should conduct such inspection.

While all such control and supervision services are performed by special inspection officers of the Ministry of Fuel and Power, the Gas Law provides that gas meters should also be inspected by the officers of the same ministry. Thus, the British gas enterprise is placed under the strict control of a special law (Gas Law) and supervising organs (Ministry of Fuel and Power, Regional Gas Bureaus and Gas Committees) for sound management and protection of consumers, although it is owned by the state just as in Indonesia.

In Japan, gas supply services are offered by private enterprises and public enterprises run by local public bodies. The gas enterprise as a whole, however, is controlled by the "Gas Enterprise Law" under the supervision of the Minister of International Trade and Industry.

Article 1 of the said law, which stipulates the objectives of the gas enterprise, reads as follows:

"The purpose of this law is to protect gas consumers and promote the sound development of the gas enterprise by controlling its management and operation, to secure the safety of the general public through supervision of the construction, maintenance and operation of gas facilities as well as through control over the manufacture and sales of gas appliances and equipment, and further to prevent the development of environmental pollution."

In the subsequent articles, the law also provides for the following matters.

1) Standard and criteria for granting approval to gas enterprise.

2) Obligations of the enterprise to install or provide gas facilities and structures.

3) Duty of the supervising minister to issue approval to supply conditions including the gas rates.

4) Obligations of the enterprise to measure and check the calorific value, supply pressure and combustion characteristics of gas, and to formulate the gas supply plan for each fiscal year.

5) Accounting system and principles to be observed in the determination of gas rates.

6) Obligation of the enterprise to conduct periodical inspection of gas facilities and structures.

7) Duty of the supervising minister to conduct auditing and enter any premises of the enterprise for the purpose of inspection.

8) Duty of the supervising minister to accept and examine the complaints filed by the consumers.

9) Duty of the supervising minister to order the enterprise to hold a public hearing prior to the alteration of the gas supply conditions or rules.

10) Punitive actions and disciplinary measures taken against infringement of the law.

Details of supply conditions including the gas rates, are stipulated in the "Gas Supply Rules" agreed upon between the consumers and the enterprise. For any change to be effected to the supply conditions, the enterprise is required to obtain the prior approval of the Minister for International Trade and Industry and notify the consumers by public announcement.

In the United States, the gas enterprise is placed under the control of a special administrative organ (Public Utility Commission) established in each state. Thus, the controlling institution and system vary from country to country, but the strict control is exercised for protection of consumers in all countries.

The control system to be enforced in Indonesia should be determined with careful account taken of the traits of Indonesian people as well as of the country's political background. However, it is considered advisable to establish, in the first place, a new law expressly stipulating the functions of the gas enterprise from the national point of view and also providing for the protection of consumers and sound development of the enterprise as a public utility. It is preferable that the government exercises control over the gas enterprise on the basis of such a law, and to establish an intermediary organ like the British Gas Committee which serves as a reliable third party coordinating the interests of both the enterprise and the consumers.

When such measures are successfully carried out, the gas enterprise in Indonesia will gain the people's understanding and confidence once again.

## 1.3 Price Policy

The gas rate system currently in force in Indonesia is as described below.

The gas charges, which are collected on a minimum charge basis, are classified into the following three:

1) Charges collected from general consumers.

2) Charges collected from large users under separate contracts.

3) Special charges collected from public organizations and from the households of public servants and members of armed forces.

Besides these charges, extra fees are collected for the use of PGN's equipment and facilities (meters and service pipes). Specifically, a monthly fee of Rp 100 is collected from consumers using PGN's facilities and from the consumers to whom service pipes are leased. These extra fees are collected together with the gas charges under the prepayment system.

Firstly, the gas rates should be compatible with the calorific value of supplied gas.

The current rates are based on a calorific value of 4,200 $Kcal/m^3$. But since in some service areas, the actual calorific value is as low as about 3,000 $Kcal/m^3$, the users there are forced to pay higher charges than specified per unit calorific value.

Therefore, if the calorific value of supplied gas drops below the standard value, the difference in the charge should be settled on a calorie-slide basis.

In the case of Cirebon area, the rates should be so revised as will be compatible with the calorific value of natural gas which is above standard.

Second, it must be pointed out, however, that the special rates applied to the households of government employees and members of armed forces are lower than those collected from general consumers despite the fact there is no difference at all in the pattern of consumption. Compared with the rates applied to general users, the special rates are lower by 60% up to a maximum monthly consumption of 25 $m^3$. It is likely that general and large users may be displeased with this preferential system because they must cover the difference.

Third, under the prepayment system in force, new customers are required to pay in advance for the estimated gas consumption for the first month and thereafter pay, also in advance, for 150 ∿ 200% of the average monthly consumption recorded in a month and a half.

This system may make the prospective users feel uneasy about the gas charges, and further cause their discontent about paying for the unsupplied gas.

It is problem that all the above-mentioned problems may have provoked distrust on the part of consumers and eventually led to the decline of sales of gas.

To regain the users' confidence, the following fundamental requirements will have to be satisfied.

1) Gas rates are so revised as will be compatible with the actual calorific value.

2) No preferential rates are applied to any users.

3) Charges are collected for the actual amount of gas consumed.

It is also important to maintain the gas rates established on the basis of the reasonable prime cost whose calculation should naturally presuppose rational management.

## 2. Rehabilitation and Development Plan

### 2.1 Fundamental Approach

It is incumbent on PGN, the gas supplier in Indonesia, to take rehabilitation and development measures in order to regain the confidence of consumers and play a leading role in the supply of energies to urban and suburban areas. In planning and implementing such rehabilitation and development, due account should be taken of the following points:

1) The plans should be mapped out after careful studies, but once the plans are completed, they should be carried out promptly. As pointed out in Chapter II, PGN is devoid of sufficient capacity for working out plans and putting them into smooth execution. The rehabilitation and development plans need to be formulated on the basis of careful studies and investigations, and should be implemented in strict conformity to the established schedule.

2) The prime purpose of the rehabilitation and development plans are to regain the consumers' confidence and to make gas the primary source of energy in urban areas. To meet this purpose, it is essential to effect improvement in the management and services, in addition to the rehabilitation and development of gas facilities.

3) In order for various plans to be executed smoothly while stabilizing the management, it is required to attain a maximum effect with a minimum input. It must be noted that parallel and prompt implementation of the rehabilitation plans and the development plans will be difficult both financially and technically, and that excessive investment for such parallel implementation may threaten the PGN's management.

4) It is accordingly recommended to undertake the rehabilitation at first, and carry out development in the next stage.

5) For some time to come, rehabilitation should be aimed at attaining the peak demand recorded in the past. For this purpose, it will be required to promote the sales activities and improve the quality of services besides exerting effort for improving the distribution facilities.

6) In order to achieve smoothly these targets described above it is preferable to give priority to certain aspects of development plan such as the choice of more appropreate raw materials (e.g., introduction of natural gas) and consolidation of pipelines, regardless of the point of (4).

7) Investment for rehabilitation and development will invite short-term aggravation of PGN's financial situation and this cannot be totally averted. In order for PGN to perform its duties as a stable gas supplier, efforts should be exerted to make its income and expenditure balanced in the long run.

8) Supply of gas to urban areas is a much needed public undertaking. The government is therefore urged to promote the gas enterprise from the viewpoint of long-term national interests. Specifically, it is recommended that the government offer financial assistance covering part of the fund required in the initial investment stage and guarantee smooth supply of raw materials at lower cost.

9) The planned rehabilitation and development calls for strenuous exertion of all parties concerned. The team wishes to point out that the desired improvement can never be attained unless PGN exerts itself in a positive manner with the cooperation of all pertinent government offices.

The post-war rehabilitation of Japanese gas enterprise, described in Appendix 11, will prove useful in planning and executing the rehabilitation and development scheme.

## 2.2 Development of New Demand

### (1) Principles for Estimation

All of the eight PGN stations are located in provincial capitals where the heavy concentration of population and increased construction of residential houses are expected in the future. Appendix 7 shows the forecast of population and number of permanent houses in the PGN's service areas. Figures shown on the right side of this table range from 20 to 50% for permanent houses. These figures are extremely large when compared to the present number of customers in the respective service areas. The estimated demand per customer is not too low considering the expected modernization of the mode of living, improvement of the average income level, and growth of demand for industrial and commercial purposes.

Accordingly, it can be expected that the sales per customer will grow substantially if improvements are effected to the gas quality, rates and services to regain the consumers' confidence. It is the fundamental duty of PGN to fill such expected demand of consumers for thermal energy.

At present, however, PGN is running on a small scale and its facilities have considerably deteriorated. In addition, it is required to develop into an enterprise operating on a sound self-accounting basis. It will therefore be difficult for PGN to cope with the anticipated sharp demand growth completely, and a substantially long period will be required to fill all such demand. In the case of Japan, many years of consistent effort of gas companies were required before fulfilling all the demand. The team recommends that this fact be borne in mind in working out the rehabilitation and development plans.

Because the demand growth will have to be coped with in stages with consideration given to the progress of the rehabilitation plan as well as to securing the raw materials, including natural gas.

This gradual increase of supply is required also for the following reasons.

Firstly, each station must conduct prior investigations and studies in order to determine how the rehabilitation is to be implemented, and must also map out the rehabilitation plan based on such investigations and studies.

Secondly, it is probable that the demand in this preparatory period will grow at a rate that can be readily estimated from the past trend.

Thirdly, a period of two or three years after completion of the rehabilitation plan will be required to regain the consumers' confidence in gas, and augment their demand.

Fourthly, there is little likelihood that the demand will increase sharply immediately after PGN's supply capacity is augmented by the introduction of natural gas and improvement of production facilities. The reason is that the following problems are involved in the stage of shifting to gas from other fuels.

1) Gas will constantly face competition from alternative fuels, such as LPG and kerosene.

2) New consumers incur a considerably heavy initial capital input for installation of interior pipes and other facilities.

3) PGN must effect a huge amount of investment in order to expand its pipeline network.

(2) Demand Forecast and Cautions for Estimate

With the above-mentioned facts borne in mind, the team prepared a new demand development programme (Table III-1 and APPENDIX 7) aiming at the attainment of the following two objectives.

1) Increase of the number of customers, before or in the first half of the 1980's, to the level of 1962 when PGN recorded the peak demand. Under the programme, it is possible to attain this increase around 1980.

2) Attainment of PGN's target value for 1980 in the latter half the 1980's. This objective can also be achieved under the programme in all areas excluding Medan and Cirebon areas. The target value for Medan area is a little too large, and Cirebon has a small market area, so that the target values for these areas are attainable in the 1990's but not earlier.

After studying the target values for 1980 on the basis of the existing condition of PGN and the above-mentioned problems which will be encountered in future, the team found them too high.

It is believed, however, that they can be attained without much difficulty under the programme which presupposes the following conditions.

1) Incentive conditions are created for the users of competitive fuels to shift to gas. These conditions should include the government's financial aid filling part of the initial fund requirement, establishment of reasonable gas rates, consolidation of statutory aspect, and improvement of services.

2) Gas quality is so improved that gas will hold place over other sources of energy supplied to urban areas.

3) Satisfactory gas appliances are developed so as to increase the demand per customer.

4) Endeavours are made for increasing the demand for industrial and commercial purposes. These endeavours will not only enable PGN to acquire large industrial users, but will also promote the understanding on the part of urban as well as local residents about the advantages of gas.

5) PR activities are conducted in such a manner as will establish a wide route of communication with the general public, and systematic and ceaseless sales promotion effort is exerted through this route.

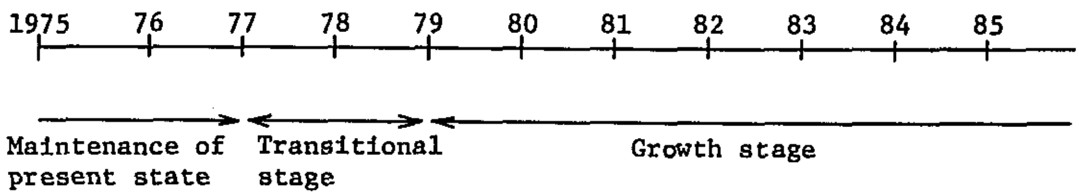



Fig. III-1 Concept of Demand Forecast

Notes: 1. Demand forecast for the growth stage.

Number of customers: The annual growth rate was set at 10%. However, if the ratio of customers to permanent houses exceeds 10%, the growth rate of the number of customers was modified accordingly.

Sales per customer: The annual growth rate was set at 2%. However, Cirebon and other areas where the increase of large users is apparent or highly probable, the growth rate was modified accordingly.

2. For any areas, it was assumed that the natural gas conversion would not be effected until the end of 1978.

Table III-1 Demand forecast

| | Estimated demand | | | Reference value | |
|---|---|---|---|---|---|
| | 1975 | 1980 | 1990 | Actual demand in 1962 | PGN's target demand for 1980 |
| Medan | 1,243 | 1,418 | 3,677 | 2,009 | 5,000 |
| | 1,988 | 2,407 | 7,611 | 3,753 | 8,568 |
| Jakarta | 6,134 | 8,185 | 21,231 | 8,256 | 15,000 |
| | 9,808 | 14,724 | 46,555 | 14,727 | 29,989 |
| Bogor | 1,051 | 1,371 | 3,393 | 1,441 | 2,500 |
| | 1,104 | 1,832 | 5,526 | 2,417 | 2,998 |
| Bandung | 5,481 | 7,108 | 16,659 | 6,016 | 8,000 |
| | 6,621 | 9,710 | 27,742 | 10,827 | 14,199 |
| Cirebon | 581 | 840 | 2,180 | 739 | 3,000 |
| | 657 | 1,049 | 3,318 | 1,274 | 60,786 |
| Semarang | 1,890 | 2,516 | 6,409 | 3,108 | 4,000 |
| | 1,786 | 2,524 | 7,836 | 5,445 | 6,170 |
| Surabaya | 4,181 | 5,568 | 14,414 | 6,086 | 9,000 |
| | 6,622 | 9,703 | 30,620 | 11,549 | 17,658 |
| Ujung Pandang | 415 | 557 | 1,446 | 662 | 1,000 |
| | 686 | 974 | 3,080 | 1,162 | 1,460 |
| Total | 20,976 | 27,563 | 69,409 | 28,317 | 47,500 |
| | 29,272 | 42,923 | 132,288 | 51,154 | 141,828 |

Notes: Upper column - Number of customers

Lower column - Sales volume x $10^3m^3$(4,200 Kcal)

## 2.3 Stable Supply and Desirable Gas Quality

The desirable supply conditions, i.e., stable supply and good quality of gas, are briefly described below since they must be satisfied as an essential prerequisite to the rehabilitation plan of production and distribution facilities.

### (1) Stable Supply

#### 1) Need for stable gas supply

The most outstanding advantage of gas over other fuels is that the user can obtain sufficient calorific value from the supply pipe at any desired time. If the supply is suspended, therefore, half of the utility value of gas will be gone.

It must therefore be noted that constant and smooth supply is the key to regaining the customers' confidence in PGN.

#### 2) Conditions for stable supply

In the first place, improvements must be effected to the distribution pipes, supply pipes and meters to minimize leakage, corrosion and blocking. With the increase of customers, the distribution system should be improved so that gas may be supplied at a higher pressure and thereby increase the transmission efficiency.

The gas pressure at the user's end (supply pressure) should be maintained at an adequate value at all times.

The standard supply pressure accepted internationally is 200 mm for natural gas (WI ≑ 10,000), 150 mm for LPG - air (approx. 7,000 $Kcal/Nm^3$), and 80 ∿ 100 mm for gases whose WI is lower than 7,000.

(2) Desirable Gas Quality

1) Stable calorific value

PGN should note that gas should be sold not in terms of volumetric value but in energy (calorific) value. This concept is accepted as a matter of common sense by any gas industry in the world.

This means that so long as the gas rates are based on the volume of supplied gas, the standard calorific value per unit volume must be maintained.

In the case of Japan, for example, the lower allowable limit of calorific value of supplied gas is set at 97 ∿ 98% of the standard value, and all gas companies are required to maintain the standard calorific value in an average for the whole volume of gas supplied each month.

2) Gas combustion characteristics and interchangeability

In order to maintain satisfactory combustion of gas at the customer's end, the following conditions must be satisfied:

a) Stable input

b) Stable flame free from lift and light-back

c) Complete combustion

d) Optimum temperature and length of flame

Since these conditions are affected by two factors, i.e., WI ( = calorific value/$\sqrt{\text{specific gravity}}$) and flame speed, it is necessary to keep the two factors within the allowable range in order to attain compatibility of gas with the appliance (Refer to Appendix 8).

3) Impurities in gas

In order to prevent the blocking up and corrosion of supply pipes and appliances, and to avoid the development of poisonous components and poisonous burnt products, the following impurities should be held at an exceedingly low level.

| | |
|---|---|
| Solid impurities: | Naphthalene and dust |
| Liquid impurities: | Tar and moisture |
| Gaseous impurities: | NO, $NH_3$, HCN, $H_2S$ and other sulfur compounds. |

In Japan, the Gas Enterprise Law stipulates that sulfur, hydrogen sulfide and ammonia contained in 1 $m^3$ of gas should not exceed 0.5 g, 0.02 g and 0.2 g, respectively.

Natural gas generally contains very little impurities, and is therefore the best source of energy.

## 2.4 Selection of Raw Material

### 2.4.1 Comparison of Gas Materials

1) Conditions to be studied for selection of raw material

While there are a diversity of gas materials such as coal, crude (heavy) oils, naphtha, LPG and natural gas, selection between these materials must be made with due account taken of the type and design of production facilities and therefore calls for a comparative study of the following conditions:

a) Availability of raw material.

b) Cost advantage (purchase price and transportation cost).

c) Scale and construction cost of production facilities suited to raw material.

d) Performance and operation characteristics of production facilities (personnel requirement, capacity for meeting load fluctuation, operation cost, service pressure, and need and availability of operation techniques and maintenance and security techniques).

e) Quality of manufactured gas

° Calorific value.

° Combustion characteristics (specific gravity, wobbe index, and flame speed).

° Amount of impurities (tar, higher hydrocarbons, naphthalene, sulfur, ammonia, etc.).

f) Pollution problems attendant on production process (depending on local conditions).

g) Demand for by-products (quantity and its fluctuation).

These conditions can be summarized as follows:

1) Availability and purchase conditions of raw material.

2) Various conditions of production facilities.

3) Gas quality.

4) Cost of manufactured gas.

Table III-2 shows a comparative study of general items selected from the above conditions.

Table III-2 General Comparison of Gas Materials

| | Condition \ Source | Coal | Crude/heavy oil | Naphtha/kerosene | LPG | Natural gas |
|---|---|---|---|---|---|---|
| Material | Availability | Non-coking coal ... Available from Sumatra<br>Coking coal ... Available from Australia | Produced in Indonesia. | Available from refineries in Indonesia, or imported. | Avilable from refineries in Indonesia, or imported. | Available in some areas of Indonesia. |
| | Price | Ombilin coal from Sumatra: 54,000 Rp/t (7.7 Rp/1,000 Kcal) | Diesel oil: 15,000 Rp/kℓ (1.65 Rp/1,000 Kcal) | International price of naphtha (estimated CIF price): 34,000 Rp/kℓ (4.45 Rp/1,000 Kcal) | International price: 52,000 Rp/t (4.60 Rp/1,000 Kcal) | Unit III: 250 Rp/MCF (0.99 Rp/1,000 Kcal) |

Table to be continued to next page.

Notes: Figures in parentheses indicate the price per unit calorific value.

| Condition \ Source | | Coal | Crude/heavy oil | Naphtha/kerosene | LPG | Natural gas |
|---|---|---|---|---|---|---|
| Production facilities | Scale and construction cost. | High construction cost; large scale required to attain high profit rate. | Construction cost somewhat high; installation of purification facilities, by-products recovering facilities, and waste water treatment facilities required. | Low construction cost. | Lowest construction cost; installation of LPG tanks required but operation in a small scale possible. | No production facilities required, except for small equipments. |
| | Number of workers required | Large | Not very large | Small | Small | Small |
| | Capacity for meeting load fluctuation | Poor | Satisfactory | Satisfactory | Satisfactory | Excellent |
| | Operation cost | High | Not very high | Low | Low | Very low |
| | Prevention of pollution | Difficult | Difficult | Easy | Very easy | No preventive measures required |
| | Other factors | Demand for coke and tar essential; low pressure operation. | Demand for tar essential; low pressure cyclic operation. | Low pressure cyclic operation or continuous operation (partial combustion). | Continuous operation; high pressure running possible. | Continuous operation; high pressure running possible. |

To be continued to next page.

| Condition \ Source | | Coal | Crude/heavy oil | Naphtha/kerosene | LPG | Natural gas |
|---|---|---|---|---|---|---|
| Gas quality | Calorific value | Approx. 5,000 Kcal/$Nm^3$ | Thermal decom-position gas: 11,000 Kcal/$Nm^3$<br>Catalytic re-former gas: 5,500 Kcal/$Nm^3$<br>Partial com-bustion gas: 3,200 Kcal/$Nm^3$ | Catalytic re-former gas: 3,000 Kcal/$Nm^3$ | Butane-air: 7,000 Kcal/$Nm^3$<br>Butane: 31,000 Kcal/$Nm^3$ | 6,000 ∿ 9,000 Kcal/$Nm^3$ |
| | Specific gravity (air=1) | 0.4 | Thermal decom-position gas: 0.8<br>Catalytic re-former: 0.6<br>Partial combus-tion gas: 0.9∿1.0 | Catalytic re-former gas: 0.45<br>Partial combus-tion gas: 0.7∿0.9 | Butane-air: 1.23<br>Butane: 2.0 | 1.0∿0.6 |
| | Flame speed | Fast | Thermal decom-position gas: Fast<br>Partial combus-tion: Slow | Fast | Slow | Slow |

To be continued to next page.

| | Condition \ Source | Coal | Crude/heavy oil | Naphtha/kerosene | LPG | Natural gas |
|---|---|---|---|---|---|---|
| Approximate production cost | Approximate material cost per $1 m^3$ of gas with 4,000Kcal/$Nm^3$ (Figures in parentheses are assumptive units) | Coal gas: $-33$ Rp/$m^3$<br>(Gas(net): 450$m^3$/t<br>Coke: 500kg/t<br>Tar: 50kg/t<br>Price of Taiwanese coke: 130Rp/kg<br>Tar price: 80Rp/kg) | Partial combustion gas: 11 Rp/$m^3$<br>(1,400 $m^3$/kℓ) | Catalytic reformer gas: 23 Rp/$m^3$<br>(Gas: 2,000 $m^3$/kℓ<br>Fuel: 370 ℓ/kℓ)<br>Notes: These materials are supplied from abroad at present. Hence, international prices were adopted, but they should be modified for future planning. | Vaporized gas: 18 Rp/$m^3$<br>(Gas: 2,900 $m^3$/t<br>Vapourizing fuel: 30 $m^3$/t) | Direct distribution: 6 Rp/$m^3$ |
| | Fixed cost (Rp/$m^3$, high rate operation of large-scale facilities in Japan) | Large-scale coke oven: 35 Rp/$m^3$ | Crude thermal decomposition generator 10 Rp/$m^3$ | Catalytic reformer 6 Rp/$m^3$ | LPG evaporator 3 Rp/$m^3$ | |
| | Total(Rp/$m^3$) | 2 | 21 | 29 | 21 | 6 |

Notes: Costs of utilities, supplementary materials, and pressure distribution facilities should be considered separately.

(2) Supply of raw material

Since Indonesia is favoured with rich energy resources, it will be possible to select any desired material in future. At present, however, these natural energy resources are still in the intial stage of development so that gas materials are not necessarily supplied smoothly.

Estimation of future prices of naphtha, kerosene and LPG entails difficulty because all these materials are derived from crude oil whose price is bound to be determined not on the basis of production cost but by the government policy specially in petroleum producing countries like Indonesia.

Prices of petroleum-derived products are dependent on the future development of oil refineries. Hence, the international prices shown in Table III-2 should be construed as mere reference values.

(3) Production facilities

Coal - Production facilities using coal for raw material require a large amount of initial investment and also incur a high fixed cost. They are not recommendable unless there are sufficient funds available to make their scale large enough, and their constant operation feasible. Their construction can neither be advised in areas where the environmental pollution is likely to pose a problem.

However, if such facilities are already in existence and ready for operation and if stable demand for by-products and their relative high price level can be expected, the resultant gas production cost can be reduced remarkably to contribute to the improvement of payability.

Heavy Oil - Production facilities using heavy oils including crude, heavy oil and diesel oil for manufacture of clean gas also demand huge capital input for installation of purification and by-products treating facilities, as well as waste water treating facilities (specially if the plant is located in an urban area). In addition, the production process is quite complicated. Therefore, unless their scale is large enough to produce economies of mass production and the material cost far lower than light oils like naptha, these facilities are not very advantageous.

Light oil - Gas production from naphtha and other light oils is widely adopted in Japan since it calls for simple facilities which can be operated with ease and require no special pollution preventive measures. The purification facilities are composed only of simple scrubbers and dry boxes. Production facilities using light oil are suited to small scale gas production from the material which is supplied smoothly at reasonable cost.

LPG - LPG need only to be evaporated directly, so that the production facilities using LPG are the simplest of all and subject to the least heat loss. The only questions to be considered are the availablity of the material and its cost.

Natural gas - Natural gas does not require any production facilities. It is the best source for town gas.

(4) Relationship between raw material and gas quality

Table III-2 shows the calorific value and specific gravity for each source of energy.

While the calorific value of thermal decomposition gas, LPG and natural gas are very high, naptha decomposition gas and partial combustion gas are low in calorific value.

LPG and partial combustion gas have high specific gravity. For this reason, heavy oil partial combustion gas has a small Wobbe index and accordingly poor combustion characteristics.

Catalytic reformer gas has a large hydrogen content and its flame speed is high (see Table II-8, P89).

Coal gas and heavy oil gas call for the installation of sufficient purification facilities because both contain large amounts of tar, naphthalene and moisture, as well as impurities, such as NO and sulfur.

(5) Production cost

Table III-2 also shows the approximate gas cost calculated for each material in a simple manner on a certain fixed premise. The gas cost thus obtained comprises only the cost of production facilities and the material cost, and does not therefore represent the actual gas cost incurred in Indonesia. The calculation discloses, however, that natural gas and coal are the most advantageous, followed by LPG and heavy oil.

(6) Restraints of the Government's Energy Policy

Although the selection of the gas material is made on the basis of the general factors described above, there are cases where the government's policy becomes a decisive factor.

It is understood that the fundamental policy adopted by the Indonesian government for the utilization of natural gas is as described below.

1) Natural gas produced in Java island (excluding Surabaya district) is to be used preferentially for raw material for iron and steel making industry and fertilizer industry.

2) Natural gas produced in other islands and Surabaya district is to be appropriated for export and supply to the aromatic centres and also used as fuel for power generation and urban consumption.

The government policy regarding petroleum products is as follows.

1) Since supply of LPG is not yet sufficient, it should in principle be sold in bottles in suburban areas and sparsely populated parts of urban areas through PERTAMINA's agencies.

2) Supply of naphtha is just too deficient, so that it should be used only as the raw material of petrochemical industry.

3) Use of kerosene is to be augmented in rural areas to reduce the consumption of fuels of wood origin (firewood and charcoal), but decreased in and around urban areas by promoting the conversion to gas or LPG.

4) Development and use of abundant domestic coal is to be promoted to diminish the reliance on petroleum products.

Under the government's energy policy, raw materials available to PGN are limited to coal and heavy oil, though natural gas is also available in some areas. It is believed possible, however, that some revision based on the conclusion of this report will be effected to the present policy to ensure sound future management of PGN.

### 2.4.2 Need for Natural Gas Conversion and Priority Order of Materials

As described already, natural gas is advantageous over the conventional manufactured gas in the following points and is therefore used in many cities in Japan, Europe and North America.

1) Calorific value and transmission efficiency are both high.

2) 100% gasification rate is attainable.

3) No impurities are contained, and gas components are stabilized.

4) Smaller in specific gravity and safer than LPG.

5) No production facilities and purification facilities are required.

6) Pollution problems resulting from effluent smoke and waste water can be disregarded.

7) Tank lorries or other vehicles are not required for transportation.

8) Facilities and places for the storage of raw material are not needed.

9) Utilities such as electricity and water are not required.

10) Required number of workers is small.

In densely populated areas, therefore, utilization of natural gas should be given top priority if the raw material is available.

In areas where the introduction of natural gas is not feasible, LPG and lighter oils are the most desirable materials, as can be deduced from the evaluation given in the preceding item, followed by heavy oil, and then coal. The former two materials excel the latter two in the following points:

1) Production facilities and purification facilities are simple.

2) Pollution preventive measures against smoke and waste water are not required.

3) Gasification rate is high.

4) Operation of facilities is easy.

5) Required number of workers is small.

However, coal will be found advantageous over other materials if the existing production facilities can be effectively operated.

The priority order of raw material is to be judged according to the availability in respective areas (refer to the following item).

### 2.4.3 Distribution of Energy Resources and Raw Material Suited to Each Area

(1) Natural Gas

It is confirmed that there are abundant deposits of natural gas in Arun (North Sumatra) and Kalimantan. Development of natural gas resources is also in progress in other parts of the country. Table III-3 shows the natural gas utilization plan based on the development plan in each area.

Table III-3 Natural Gas Utilization Plan

(Unit: $10^9$ SCF/Y)

| Area | Present consumption | Planned consumption | Remarks |
|---|---|---|---|
| North Sumatra, Arun | — | 617.80 (1977) | LNG export 8,830 $10^3$t/y |
| North Sumatra, other areas | 12.54 | — | |
| Central Sumatra | 0.01 | — | |
| South Sumatra | 39.40 | 22.00 (1976) | |
| Northwest Java | 3.10 | 76.50(1976/7) | |
| East Kalimantan | 6.44 | 212.30(1976/9) | LNG export 3,200 $10^3$t/y |
| Total | 61.49 | 928.60 | — |

(Source: MIGAS.)

The utilization plan gives top priority to manufacturing industries for supply of natural gas. As regards natural gas utilization by the gas enterprise, Cirebon station has already completed the natural gas conversion. Although the high percent leakage calls for suitable remedial measures, the number of customers in Cirebon area is increasing steadily by virtue of the stable supply.

In addition to the existing transmission line from Northwest Java to Cirebon area, it is planned that a 220km long trunk transmission line will be laid from Cilamaya to Cilegon where Krakatau Steel is located to supply natural gas to the steel plant and fertilizer plant.

The distance from this trunk transmission line to the cities in West Java where PGN's stations are established is shown below:

| | |
|---|---|
| To Jakarta | 20 km |
| To Bogor | 30 km |
| To Bandung | 80 km |

Thus, there is possibility that natural gas will be supplied to these cities. However, supply to Bogor and Bandung which are somewhat distant from the transmission line could be planned only for joint consumption by general customers and industries, if any.

Natural gas utilization in Jakarta is highly promising and recommendable. The present demand in Jakarta is only 3% of the total gas volume planned to be supplied by this transmission line so that its influence on the existing natural gas utilization plan seems negligible. In addition, if natural gas is supplied to industries established in the neighbourhood of Jakarta, it will promote the modernization of the city and to accelerated industrial production as well.

In the vicinity of Medan, development of gas wells in Tanjung Murawa and Diski (approx. 16km and 27km respectively from Medan) is in progress and believed to be quite promising. In Surabaya area, too, occurrence of natural gas is confirmed in suburban areas. At present, investigation is being conducted to clarify the formation of gas layers and deposits.

In Medan and Surabaya areas, therefore, there is ample possibility of utilizing natural gas as efficient source of energy for urban areas.

(2) Petroleum

Indonesia abounds in petroleum resources. However, since her oil refining industry is still in the initial stage of development, the greater part of crude is exported, and the primary products such as naphtha, LPG and kerosene must be imported.

There is no heavy restriction imposed on the regional use of petroleum products because of well developed transportation means. However, there is the problem of price gap resulting from the import control. It is believed that this problem can be solved in future with the development of the oil refining industry. At present, however, use of naphtha for gas material is not economicially justifiable. Hence, LPG is the next best material after natural gas.

PGN may find it inevitable to use heavy oil because it is given preference over other materials under the government's energy policy. Sometimes, heavy oil might prove more advantageous than naphtha if its price could be maintained at the present low level to reduce the running gas cost.

As for Bandung area, it is possible that the material oil will be supplied by the petroleum pipeline from Cilacap now under construction.

(3) Coal

Since domestic coal is poor in coking property, PGN imports the material coal from Australia. Although the imported coal is costly, profitability of coal gas production is fairly good because coke is also imported (approx. 40 thousand t/y) and its domestic market price is maintained at a high level.

The government has recently adopted the policy to promote the development and use of domestic coal. Indonesian coal is excellent ordinary coal featured by low degree of carbonization and small sulfer and ash contents but has no sufficient coking property required for coke production. Hence, it is most desirable that it be used as fuel for power generation and large-scale boiler operation.

Coal gas is manufactured by two major methods, the coke oven method and the direct gasification method represented by SNG production from coal.

In the coke oven method, which is already employed by PGN, coke (50 ∿ 75% of coal) is manufactured together with gas and tar so that the demand for coke should be secured. Since coke ovens incur a very large construction cost and consequently a high fixed cost, it is necessary to secure the stabilized long-term demand so as to be able to maintain a high operation rate. Further, import of material coking coal is required in the case of Indonesia. Mixing rate of domestic coal will be limited to 10 ∿ 15% at most, though this varies by the required quality of coke.

In the recently developed formed coke method, a substantially large rate of ordinary coal can be used as raw material. This method calls for the installation of the equipment for forming coal powder with pitch and can be applied only in a small scale, so that it incurs a large installation cost and is not economically commendable. However, it may be found adequate in future if the availability of coking coal becomes limited or any large demand for coke arises.

As for the direct coal gasification Lurgi method is already applied for practical purpose and also researches are conducted in a number of countries for developing the method of manufacturing SNG from coal. SNG production processes are intended to be applied for actual production after 1980, and all of them are not only complicated and large in scale but also involve high pressure equipment. Their introduction is not therefore feasible at present.

Thus, it is most desriable that Indonesian coal (Ombilin coal and Bukit Asum coal) be used as fuel for power generation and industrial purposes. Its use for economically feasible gas production will be possible only within the limits of stable coke demand and for mixing with imported coking coal.

## 2.5 Planning of Production Facilities

### 2.5.1 Areas Capable of Natural Gas Conversion

Use of natural gas for the gas enterprise should be promoted from the national point of view.

PGN's service areas can be classified as follows according to the possibility of introducing natural gas.

1) Area where natural conversion is completed.
   Cirebon area

2) Areas where the conversion is highly possible and recommendable.

   Jakarta .......... Located 20 ∿ 44 km from the trunk transmission line of natural gas.

   Medan ............ Development of gas wells is in progress in the neighbourhood of Medan city.

3) Areas with conversion potential.

   Bogor ............ Located 30km from the said trunk transmission line; conversion under the Ja-Bo-Ta-Bek plan to be studied (Refer to Chapter IV).

   Surabaya ......... Investigation of the deposit and underground formation to be completed.

   Bandung .......... Inland hilly area located 80km from the trunk transmission line.

4) Areas having little conversion possibility at present
   Semarang and Ujung Pandang.

Thus, Jakarta and Medan are the only areas having a high conversion potential at present. It is strongly recommended that all quarters concerned exert every effort to materialize the natural gas conversion in these areas.

In other areas, PGN will have to resort to production facilities for the supply of gas. In this section, therefore, planning of production facilities is discussed with emphasis placed on the aspects common to all stations.

### 2.5.2 Planning of Effective Utilization of Coal Gas

So long as there is constant demand for coke and the material coal is available, operation of coal gas production facilities will be instrumental in improving the PGN management. Nevertheless, PGN produced only 1,860 tons of coke in 1974 despite the fact it is the only coke maker in Indonesia and the annual demand for coke is as high as 40,000 tons. The situation calls for implementation of every effective measure designed on the basis of the following investigations for augmented coal gas production.

1) Investigation of future demand for coke.
2) Investigation of the marketing route for development of new demand.
3) Investigation of the coke quality desired by consumers.
4) Study on the effective utilization of domestic coal.
5) Investigation of the sources and supply routes of imported coal.
6) Request for the government's aid in the smooth supply of material coal.

Since the price of imported coal is much higher than the prevailing world market price, it is recommended that the government offer financial back-up and strong support in the negotiation with foreign firms through which coal is imported on a private basis.

Considering the fact that the demand for coke comes chiefly from the sugar industry in Central Java, construction of additional coke ovens deserves attention for augmenting coke production in Semarang area.

### 2.5.3 Planning on Partial Combustion Generators

The existing heavy oil partial combustion generators are inefficient and do not serve as the main gas production facilities. Within the limits of budgetary appropriation, therefore, they should be modified and improved, or replaced with lighter oil catalytic reformers. This modification and replacement plan should be preceded by the study of the following items in order to attain a high investment effect and to determine the replacement order as well as the optimum method for improving the gas quality:

(1) Study of deterioration

The remaining service span of respective production facilities should be made clear by studying their operation and maintenance conditions and maintenance cost and by interviewing operators.

The annual maintenance of ordinary production facilities is about 3% of their acquisition cost. It is advantageous in the long run to give high replacement priority to any unit whose maintenance cost far surpasses this value.

(2) Study of gasification efficiency

Plants exhibiting a low product yield and a poor heat efficiency should be given high modification or replacement priority.

(3) Analysis of impurities and investigation of troubles

Moisture, tar, higher hydrocarbons, naphthalene, gum paste compounds, total sulfur, hydrogen sulfide, ammonia and cyanides contained in the manufactured gas should be subject to a quantitative analysis. In addition, causes of troubles invited by tar content and causes of corrosion of distribution pipes and meters should be cleared up.

Such analysis and investigation will make it possible to pass correct judgement on the following matters for each partial combustion plant.

1) Need for early replacement.

2) Need for removing choking matters and corrosive matters in case the plant is capable of another several years' continuous operation.

3) Whether the improvement of operation condition suffices or additional installation of gas scrubbers is required in case the plant calls for the removal of choking matters.

4) Whether ammonia remover or desulfurization is required in case the plant calls for the removal of corrosive matters.

If a large scale modification is required as a result of the judgement, replacement may prove more advantageous.

The judgement formed on the above questions will make it justifiable to take the following measures:

1) Replacement of production facilities

Since diesel oil is fundamentally unsuited for use as gas material, it is preferable that the replacement be effected for adoption of lighter oils or perhaps LPG, by reason of price and availability. If LPG is adopted, selection between the LPG-air system and the LPG catalytic reforming system must be made.

2) Intensified gas cooling using the existing facilities

In this case, the lighter oil content is removed from the manufactured gas so that the combustion characteristics could be impaired due to the decline of calorific value and Wobbe index. This will call for addition of a small quantity of LPG for enrichment.

3) Additional installation of scrubbing towers or dry boxes.

Measure 2) and 3) are applicable to the case where there is no other way than continuous operation of existing production facilities with a sacrifice of quality in order to improve the profit rate by taking advantage of the low cost of diesel oil as a raw material.

### 2.5.4 Consolidation of Auxiliary Facilities

Rational control of gas production calls for the consolidation of the following auxiliary facilities.

(1) Calorific value regulators

(2) Gas component analysis equipment

(3) Calorific value and specific gravity meters

(4) Instrument testers (standard testers)

(5) Impurity analyzers

### 2.5.5 Study of LPG Facilities

(1) Selection of LPG

While use of lighter oils (naphtha or LPG) is the decisive means to improve the gas quality, LPG is more advantageous than naphtha for the following reasons.

1) Naphtha costs higher than LPG per unit calorific value (international price).

2) Import of a limited quantity of naphtha by the gas enterprise alone is practically impossible.

3) LPG can be supplied from PERTAMINA's terminal and tank lorries.

Needless to say, LPG should be supplied not at the price quoted for home consumption but at a reduced industrial price not including the handling cost. In Japan, LPG supplied for home consumption costs Rp 210/kg, but it is offered at Rp 64/kg for industrial users. The government's support may be required to maintain a reasonable price level of LPG for PGN.

(2) Method of LPG utilization

The following methods are conceivable for utilization of LPG by PGN.

1) LPG-air system

In the case in Japan, this system generally produces a calorific value of 7,000 Kcal/$Nm^3$. Since the specific gravity is 1.23, care must be taken if excessive leakage from distribution pipes is detected. LPG-air system is applicable to low pressure distribution, i.e., small scale operation.

2) LPG catalytic reforming + LPG injection

This system is most advisable since it promises to produce gas equivalent to the currently supplied gas in various characteristics.

3) Combination of existing facilities with LPG injection

Direct LPG injection is advisable as a means to cope with the decline of calorific value incidental to the partial combustion process. If higher hydrocarbons can be removed by the modification and improvement of the existing purification facilities, this system is effective for maintaining the required calorific value and WI.

Selection between these systems should be made with careful consideration given to the conditions and future plans of respective stations as well as to the production cost, calorific value, and material requirement.

(3) Construction cost of LPG evaporation facilities

Rough estimate of construction cost of LPG facilities having a capacity of 5,000 $Nm^3/d$ (4,000 $Kcal/Nm^3$) and requiring 1.7 tons of LPG daily is given below. Figures are based on the cost required in Japan with the exception of transportation cost.

1) LPG-air system

| | | $x10^3$Rp |
|---|---|---|
| a) | LPG facilities (15 t tank, pump, vaporizer, air mixer, etc.) | 9,600 |
| b) | Pipings and valves | 4,200 |
| c) | Foundation work, and electrical and instrumentation systems | 5,900 |
| d) | Transportation, investigation and training costs | 3,800 |
| | Total | 23,500 |

2) LPG catalytic reformer with a capacity of 5,000 $Nm^3/d$ (4,000 $Kcal/Nm^3$) and requiring 1.7 tons of LPG daily.

| | | $x10^3$ Rp |
|---|---|---|
| a) | LPG facilities (15 t tank, gasifier, heat exchanger, pump, etc.) | 26,900 |
| b) | Pipings and valves | 26,000 |
| c) | Instrumentation and lighting systems | 20,000 |
| d) | Catalyst | 1,500 |
| e) | Transportation, know-how and others | 10,000 |
| | Total | 84,400 |

2.5.6 Future Production Facilities and Investment for Each Station

During the present survey, the team was unable to gather sufficient data and information with which to make detailed recommendations on the facilities to be installed at respective stations. In order to make such recommendations, a further detailed survey must be conducted so as to study the life span of production facilities and causes of impurities and troubles as well as to clarify for each station the future situation of raw material supply, prospect for marketing by-products, operation and maintenance ability, and structure of gas demands.

Table III-4 shows a comparison between the current installed capacity and the projected sending out volume of each station. The future course of development proposed below for each station is based on the following preconditions.

Preconditions:

1) Estimated sending out volume .......... See Table III-4.

2) Material .......... Most advantageous material available in each area is to be used.

3) Partial combustion generators ........ Existing facilities to be continuously used for some time to come.

4) Installed capacity .. 
   - o Stations with natural gas conversion plan -- Capable of sending out the gas volume projected for 1980.
   - o Stations without natural gas conversion plan -- Capable of sending out the gas volume projected for 1985.

   Stand-by facilities for emergency use to be installed at all stations.

5) Construction cost ... To be estimated from an optimistic point of view.

(1) Medan

The natural gas conversion plan should be prompted because there are a number of promising gas wells developed in the vicinity of Medan. Promotion of the plan not only conforms to the government's energy policy but also involves no particular obstructive factors. It is expected that there will arise gas demands for power generation and industrial uses in addition to the demand by general users. If all these demands are to be filled by PGN, the conversion plan will have greater feasibility. The development plan can be mapped out after the example set for Jakarta station, with the gas demand for industrial purpose surveyed in advance by PGN.

It is to be noted that Medan suffers the highest percent leakage of all stations. All endeavours should therefore be exerted to repair the pipeline and minimize the leakage before implementing the conversion plan.

(2) Jakarta

As described in Chapter IV, natural gas introduction from the Cilamaya - Cilegon natural gas distribution trunk line is commendable because the station is located in the capital region of the country.

(3) Bogor

Bogor station has the natural gas conversion potential as Jakarta station, but the feasibility of the conversion plan is rather low because of the following minus factors.

a) Gas demand by general users is too small.

b) The station is located as long as 30 km from the proposed route of natural gas distribution trunk line

c) There is no likelihood that the demand for industrial purposes will airse in future.

Accordingly, conversion to the LPG - air system is commendable to meet the prospected demand of the station. LPG consumption for the projected demand of 1985 is about 2.6 t/d.

Since the use of LPG does not conform to the government's energy policy, it is desirable that the government take special measures allowing the use of LPG in small cities including Bogor. If such revision of the energy policy is not feasible, diesel oil or coal will have to be used. However, installation of full-scale production facilities using these materials is not economically feasible because they incur a fixed cost which is too large relative to the station's annual income which does not even reach Rp 60 million.

The remaining alternative is to keep on using the existing facilities until the energy policy is revised. In this case, the gas quality should be improved by minor remodelling of the purification facilities, and the calorific value and WI should be maintained at the specified values by mixing a small amount (100 kg/d) of LPG in gas. It is to be noted that the validity of this plan is largely influenced by the remaining life span of the diesel oil partial combustion generator.

(4) Bandung

This station is located in a hilly inland area and is not therefore conditioned favourably for the supply of raw material. However, since petroleum transportation from Cilacap by a pipeline is planned, it is desirable that the gas material be supplied through this pipeline. In this case, supply of pollution-free lighter oil (naphtha) is preferable but considering the government's energy policy, it is likely that diesel oil will be supplied. Hence, the introduction of a diesel oil catalytic reformer will have to be considered.

However, since no accurate data are available concerning the completion of the pipeline, it is proposed that the existing facilities (coke oven or diesel oil partial combustion generator) be maintained in as good a service condition as possible until the supply of gas material by the pipeline becomes possible. In this case, the calorific value and WI should be maintained at the specified value by improving the purification equipment and by injecting a small amount of LPG (5% of manufactured gas). LPG consumption for this purpose is about 0.7 t/d in 1985.

It is recommended that the government permit PGN to use a small amount of LPG for such quality improvement.

(5) Semarang

Since Semarang station is close to the coke consuming area and the sea port, prime effort should be directed towards augmented production of coke oven gas. If the future demand for coke can be stabilized in some way or other, even additional installation of coke ovens may become possible because the station is the only coke manufacturing establishment in Indonesia.

In this case, however, study must be made as to why the gas demand is so low relative to the installed capacity and whether it is possible to develop a large new demand for industrial purposes.

Introduction of natural gas from gas wells recently developed in Cepu may be considered as an alternative plan. However, considering the distance from Cepu (170 km) and the present demand level in Semarang (approx. 3,000 x $10^3 m^3/y$), this plan does not seem economically feasible unless a large new demand by industrial users is created.

Setting aside the possibility of such natural gas conversion, it is proposed that either of the following two methods be employed if the supply of coke oven gas fails to fill the demand.

1) Partial combustion gas + direct LPG injection by continuous operation of the existing facilities with improvement effected to the purification facilities.

2) LPG catalytic reformer gas + direct LPG injection if LPG is available in large quantities and at low. cost.

The team recommends method 1) in consideration of the government's energy policy. LPG requirement in 1985 is 140 kg/d for method 1) and 2 t/d for method 2), and these will serve as a criterion for planning production facilities.

If it is possible to increase the gas demand to 4 - 5 times the present level by creating a big industrial demand, then the construction of a diesel oil catalytic reformer plant such as ONIA-GEGI merits consideration.

(6) Surabaya

Insofar as the production method is concerned, Surabaya station has no serious problems. Since coal gas and catalytic reformer gas (ONIA-GEGI) are similar in both WI and flame speed, coke oven and ONIA-GENI can be alternatively used without troubles.

However, the station is demanded to fill the prospective industrial gas demand in Surabaya and to make decision on the utilization of natural gas recently developed in Pladue.

Demand increase in the immediate future should preferably be filled by the operation of the coke oven. If there arises a further demand increase, it will be necessary to install additional ONIA-GEGI or prompt the natural gas introduction.

Pladue is located about 140 km to the west of Surabaya. A pipeline covering this distance should therefore be constructed for natural gas introduction. The construction cost varies by the pipe diameter to be determined according to the prospective industrial gas demand in the station's service area, but it will be in the neighbourhood of Rp 6 billion. Since at least 20% of this amount, or Rp 1.2 billion, must be disbursed each year as fixed cost, it is estimated from the case of Jakarta station that 100 million $m^3$/y (300 thousand $m^3$/d) of new demand must be created. Needless to say, the feasibility of this plan should be carefully studied by separate surveys.

There is possibility of developing new gas wells in places closer to Surabya than Pladue, but the continuation of the present production system is proposed here to meet the demand in the immediate future.

(7) Ujung Pandang

Sales volume of this station is the smallest of all the eight stations (700 thousand $m^3$/y). Since the scale is thus too small, this station calls for the same consideration as given to Bogor station. Specifically, conversion to the LPG - air system is recommended provided that the material LPG is available. Installation of a full-scale diesel oil gasification plant is difficult because the station will not be able bear the burden of fixed cost. LPG requirement in 1985 for the LPG - air system is about 1.5 t/d. If no substantial demand increase can be expected for future, direct supply of LPG in bottles or through the distribution network may be considered.

If the use of LPG is not permitted under the government's energy policy, there will be no choice but to maintain the existing facilities and improve the gas quality by improving the purification equipment and by injecting a small amount of LPG.

In view of the scale of the station which is very small as described above, the team considers that the government should give special permission to the use of LPG.

(8) Palembang

There is no PGN's station in Palembang. However, the petro-chemical plants to be established in this area will produce effluent gas. Establishment and operation of a new station using this effluent gas as material for town gas deserves consideration.

(9) Padang

Padang is a good sea port on the western coast of Sumatra facing the Indonesian Ocean and located close to Ombilin mine where high quality coal is produced and to Indarung where cement industry is established. PGN's station is not yet established in Padang city which equals Bogor in scale.

To take advantage of this natural condition, the government and PGN have recently started examining the possibility of running coke ovens in this area using 400 thousand tons of Ombilin coal a year. The manufactured coal gas is planned to be supplied to Padang city and to the cement industry in Indarung, and coke is planned to be exported.

Although detailed examination of this plan is not included in the team's scope of study, the following points may as well be pointed out.

1) Ombilin coal has a low degree of carbonization and is featured by its small ash and sulphur contents and large volatile matter and moisture contents. It is an excellent fuel for power generation and boiler operation, but not suited to coke production because of its poor coking property and fluidity.

2) Either of the following two methods will have to be adopted for coke production using Ombilin coal as raw material.

   a) Production by the ordinary coke oven using a mixture of Ombilin coal and imported coking coal.

   b) Production by the formed coke production method.

   The former limits the mixing rate of Ombilin coal to 10 ∿ 15%, while the commercial production by the latter method, which is still in the stage of development, incurs high equipment cost and is possible only in a small scale. Both methods call for prior experiments and researches.

3) Coke oven is costly, and its introduction is not economically feasible, nor can it be used for the design life span unless stabilized demand and consequently a high operation rate is secured. In addition, the coke properties (size, strength, ash content, sulphur content, etc.) need to be set in advance because they differ largely by the purpose of use (iron and steel making, cast iron making, carbide production, fuel, gas production, sugar refining, etc.).

4) If the location of the coke oven plant is to be selected from among Ombilin, Padang and Indarung, Padang would be most suitable because it has a good sea port.

The future course of development proposed above for each station of PGN and two other areas is summarized in Table III-5 with the commendable system of production.

Table III-4 - Installation Plan of PGN Gas Production Facilities (Excl. Cirebon Station)

$10^3m^3$/year

| Names of Units | Current Installed Capacity | | | Actual Capacity 1975 | Result of Production 1974 | Projected Gas Demands | | | Proposed Installation & Operation (Preliminary) |
|---|---|---|---|---|---|---|---|---|---|
| | Types of Gas & Capacities | | Total | | | 1980 | 1985 | 1990 | |
| Medan | CG<br>PC | 2,628<br>6,570<br>(3) | 9,198 | 7,008 | 3,560 %<br>(40.3) | 2,680 / 2,408<br>(10%) | 4,630 / 4,282<br>(7.5%) | 8,010 / 7,612<br>(5%) | o Natural gas conversion by about 1980 or ealier. |
| Jakarta | CG<br>PC | 5,913<br>15,643<br>(5) | 21,556 | 19,053 | 13,086<br>(25.5) | 16,350 / 14,725<br>(10%) | 28,300 / 26,183<br>(7.5%) | 49,100 / 46,556<br>(5%) | o Natural gas conversion in or around 1979.<br>o Production increase of CG.<br>o LPG injection, 180 t/y (0.5 t/d) at 1985. |
| Bogor | PC | 5,631<br>(3) | 5,631 | 2,628 | 1,456<br>(21.5) | 2,190 / 1,833<br>(10%) | 3,480 / 3,219<br>(7.5%) | 5,830 / 5,527<br>(5%) | o Conversion to LPG - air system.<br>o LPG requirement - 960 t/y (2.6 t/d) at 1985. |
| Bandung | CG<br>PC | 2,628<br>10,012<br>(4) | 12,630 | 9,636 | 7,884<br>(23.3) | 10,790 / 9,710<br>(10%) | 17,920 / 16,587<br>(7.5%) | 29,200 / 27,742<br>(5%) | o Maintenance of present production level of CG (2,600 x $10^3m^3$/y).<br>o Improvement of PC purification.<br>o *Existing facilities to be kept* in good service condition until completion of naphtha pipeline.<br>o LPG injection, 260 t/y (0.7 t/d) at 1985. |
| Semarang | CG<br>PC | 2,956<br>10,012<br>(4) | 12,968 | 9,964 | 2,998<br>(30.8) | 2,800 / 2,524<br>(10%) | 4,850 / 4,481<br>(7.5%) | 8,250 / 7,836<br>(5%) | o Production increase of CG.<br>o Improvement of PC purification.<br>o LPG injection, 50 t/y (140 kg/d) at 1985. |
| Surabaya | CG<br>ONIA<br><br>PC | 4,024<br>20,022<br>(2)<br>3,752<br>(2) | 27,798 | 20,668 | 8,528<br>(20.7) | 10,780 / 9,703<br>(10%) | 18,620 / 17,255<br>(7.5%) | 32,250 / 30,621<br>(5%) | o Maintenance of present operation.<br>o Present operation to be maintained until natural gas introduction becomes feasible. |

Table to be continued to next page

| Names of Units | Current Installed Capacity | | | Actual Capacity 1975 | Result of Production 1974 | Projected Gas Demands | | | Proposed Installation & Operation (Preliminary) |
|---|---|---|---|---|---|---|---|---|---|
| | Types of Gas & Capacities | | Total | | | 1980 | 1985 | 1990 | |
| U'Pandang | PC | 5,631 (3) | 5,631 | 2,628 | 888 (21.2) | 1,080 / 974 (10%) | 1,870 / 1,733 (7.5%) | 3,240 / 3,081 (5%) | o Conversion to LPG - air system. LPG injection 530 t/y (1.5 t/d) at 1985. |
| Total | - | | 95,422 | 71,585 | 38,360 | 46,670 / 41,877 | 79,670 / 73,740 | 135,880 / 128,975 | |
| Remarks | Parentheses indicate numbers of units. | | | | Parentheses indicate percent leakage. | Upper figure - Production; lower figure - demand. Parentheses indicate percent leakage (projected). | | | |

Table III-5 - Production System Proposed for Each Station

| | Natural Gas | Coke Oven Gas | LPG-Air | Partial Combustion Gas + LPG | ONIA-GEGI | Remarks |
|---|---|---|---|---|---|---|
| 1 Medan | ○ | | | | | Possibility of natural gas conversion is high, and there is high gas demand. |
| 2 Jakarta | ○ | △ | | | | There is a good gas demand and the possibility of natural gas introduction is high. If conditions permit, natural gas production is to be augmented before introducing natural gas. |
| 3 Bogor | △ | | ○ | ○ | | Economically handicapped because of the small scale and the long distance from the natural gas distribution trunk line. Production system to be studied within the framework of JA-BO-TA-BEK scheme. |
| 4 Bandung | × | ○ | | ○ | | Both demand and operation scale are large. Coke oven gas is advantageous if transportation of coking coal and by-products is feasible. |
| 5 Cirebon | ◎ | | | | | Natural gas conversion already completed. |
| 6 Semarang | × | ○ | | ○ | | Close to the sea port, and coke demand expected from sugar industry, etc. in nearby district. |
| 7 Surabaya | △ | ○ | | | ◎ | Close to the sea port, and great gas demand expected from glass industry. Coke oven gas and ONIA-GEGI gas interchangeable. |
| 8 U'Pandang | × | | ○ | | | Small in operation scale. Large-scale plant not advantageous. |
| 9 Palemban | | | | | | Utilization of effluent gas from the planned petrochemical industry conceivable. |

◎ Present system to be maintained. ○ Recommendable. △ Possible. × Not possible.
Diesel oil partial combustion generator not commendable as permanent facility because of its intrinsic defects and low efficiency.

### 2.5.7 Rough Estimate of Investment in New Production Facilities

Rough estimate of the capital input required for new production facilities was made on the basis of the installation policy described in the preceding item as well as the following preconditions.

Preconditions:

1) LPG installed capacity ........... 
   - o Large enough to send out gas volume prospected for 1980 if natural gas in introduction is conceivable.
   - o Large enough to send out gas volume prospected for 1985 if no natural gas introduction is considered.

2) 3 units to be installed with 1 unit kept idle but in good service condition for easier overhauling maintenance and repair.
   (Total installed capacity -- 1.5 times the required capacity)

3) Facilities cost .... Assumed to be proportionate to 0.6th power of capacity.

4) Purification improvement ........
   - o Scrubber -- Rp 8,000 $10^3$
   - o Dry box -- Rp 10,000 $10^3$

   1,150 $m^3/h$ for both Jakarta and Bandung.

5) Calorific value adjustment .........
   - o Natural gas introduction -- Calorimeter only.
   - o LPG - air -- Indicator and manual controller.

o Mixing of two or more different gases -- Automatic calorific value adjustment.

Results of trial calculation are shown in Table III-6.

Table III-6 - Estimated Cost of New Production Facilities

(Unit: $10^3$Rp)

| Station | LPG Requirement 1980 ∿ 1985 | Purification Improvement | Facilities Cost | | | |
|---|---|---|---|---|---|---|
| | | | LPG Facilities | Purification Improvement | Calorific Value Adjustment | Total |
| Medan | - t/D | - | - | - | 10,000 | 10,000 |
| Jakarta* | 0.5 (direct injection) | to be effected | 23,000 | 18,000 | 15,000 | 56,000 |
| Bogor | 2.6 (LPG-Air) | - | 62,000 | - | 10,000 | 72,000 |
| Bandung | 0.7 (direct injection) | to be effected | 28,000 | 18,000 | 15,000 | 61,000 |
| Semarang | 2.0 (catalytic reformer) | - | 140,000 | - | 15,000 | 155,000 |
| Surabaya | - | - | - | - | 10,000 | 10,000 |
| Ujun Pandang | 1.5 (LPG-Air) | - | 44,000 | - | 10,000 | 54,000 |
| Total | - | - | 297,000 | 36,000 | 85,000 | 418,000 |

* Refer to Chapter IV.

## 2.6 Planning on Distribution Facilities

The prime and fundamental duty of the gas enterprise is to connect all its customers with pipelines and assure them of stable and safe supply of gas at any time and in any desired quantity. Therefore, pipelines constitute the core of all gas facilities, and keeping them in perfect service condition is of great importance. The difficult situation PGN now faces is assignable to the failure to perform this basic duty. Unless rehabilitation of distribution facilities is effected quickly and completely, PGN cannot hope for any future development.

What counts most in executing the rehabilitation of distribution facilities is to set a clear target and work out a plan under which maximum effect can be attained with an optimum investment.

### 2.6.1 Past Rehabilitation Activities (1969 ∿ 1973)

Under the First Five Year Plan, rehabilitation was effected to 148km of pipelines, or 17% of the total length of installed pipelines. Under the same plan, rehabilitation of 6,456 gas meters of 30% of a total of 28,712 meters was carried out.

The rehabilitation rate attained under the First Five Year Plan is not low at all, so that it should be produced with improvements in some form or other. However, not much improvements were attained as evidenced by the percent leakage of gas which recorded 24.3% in 1969 and 23.4% in 1973.

It is imperative on PGN to bear such achievement in mind and make a detailed prior study so that the rehabilitation will be implemented in an effective way.

### 2.6.2 Rehabilitation and Development of Pipelines

(1) Measures against leakage

All PGN stations suffer a high percent leakage. It is considered that this high rate is assignable largely, if not totally, to leakage from pipelines. Although no fire or explosion accidents resulting from leakage actually occurred in the past, this high percent leakage should be reduced quickly, especially in urban areas to prevent the possible development of hazardous accidents.

The following are the major causes of leakage from pipelines:

a) Corrosion on pieps and couplings

b) Loosening of couplings

c) Cracking and breakage of pipes

Loosening of couplings occurs most frequently, but the breakage causes the heavier loss of gas. Leakage due to the corrosion or breakage of pipes and risers of water pots is also very liable to occur. PGN is therefore required to conduct an investigation of pipelines to detect which of these causes is most responsible for leakage, and formulate a rehabilitation plan under which a concentrated effort will be made to remove the detected cause.

The commonest method employed for leakage investigation is to drill boreholes in the ground above the pipelines at intervals of 2 ∿ 6 m, and check for the leakage by the smell of gas or by means of a gas detector. If leakage is detected by this method, boring is conducted in a number of places in the close neighborhood to find out where the gas concentration is the heaviest, and this is followed by the excavation of earth, checking of the pipe, and repair of leak hole.

Rehabilitation of pipelines will produce an appreciable and quick effect if the following steps are followed.

1) Thoroughgoing investigation of leaking places

2) Study into the causes of leakage

3) Formulation of an effective rehabilitation plan based on such investigation and study.

4) Implementation of the rehabilitation plan

(2) Measures against poor supply condition due to water collection in pipelines

Water collection in the pipeline blocks up the flow of gas and causes poor supply. Periodical water purging from water pots is not conducted in a thoroughgoing manner, and the resultant poor supply condition is causing distrust on the part of customers.
The following are the major causes of water collection.

a) Condensation of moisture content of gas

b) Intrusion of groundwater at a pressure higher than the gas pressure through loosened couplings of pipe, holes caused by corrosion, and cracks.

Water collection assignable to cause a) is not serious and can be solved by periodical water purging because condensation of the moisture content takes place near the plant.

Water collection due to cause b) is most liable to occur in places where the supply pipes or water pot stand pipes are installed as well as in places where the threaded part of such pipes are corroded or broken.

In places subjected to the intrusion of a large volume of groundwater, it is necessary to clear up the cause, repair the defective parts and restore the supply condition. Until such investigation and repair are implemented, water purging should be continued so as to maintain satisfactory supply condition. The team wishes to point out that the water purging should be carefully planned and executed because the poor supply condition is the primary cause of the customer's distrust.

(3) Measures against poor supply condition ensued from deficient transmission capacity

In certain areas, the transmission capacity of pipelines falls short of the demand with the result that the supply pressure at the customer's end drops below the permissible level. This occurs mostly when the pipe diameter is too small relative to the demand, but there are other causes such as the water collection in the pipeline and choking up of the pipeline by rust, naphthalene and tar.

To remove this failure, the gas pressure is measured at major points of the distribution network to find out which sections or points of the network are subject to a large pressure drop. It is preferable that the gas pressure in the pipeline be measured during the peak distribution hours by means of the drain pot or other suitable device. In case the drain pot is not available, the pressure should be measured at the customer's gas cock. In addition, it is important to conduct a network analysis based on the demands estimated for each area. Comparison of the data of pressure measurement and those of network analysis makes it possible to find out whether the pressure decline is caused by the small pipe diameter or blocking up of pipeline.

(4) Improvement of distribution system

At present, PGN adopts the low pressure distribution system for the greater part of its network, although the medium pressure distribution at about 3,000 $mmH_2O$ is introduced in some parts.

It is considered difficult for PGN to cope with the anticipated growth demand by the currently employed low pressure distribution alone.

It is generally accepted that the low pressure distribution system can cover a maximum of about 5,000 customers and a service area of about $2km^2$. Although PGN's service area is quite extensive, the small number of customers has made it possible to meet the demand by the low pressure distribution in the past. When the demand increases in future, it will not be possible to maintain the required supply pressure by this system, but installation of large diameter low pressure pipes is not recommendable for economical reasons. The most practical way to make use of the existing pipeline network would be to lay medium pressure pipelines (lower than $3kg/cm^2$), with pressure regulators installed in districts with a high gas demand for supply of gas into low pressure pipelines.

The pipeline rehabilitation and development plan outlined above should include the improvement of the jointing method of cast iron pipes, selection of material, and training in the construction techniques.

Due to the limited time allowed for the survey, the team was unable to make a detailed study on the existing condition of distribution facilities. The final rehabilitation plan will therefore have to be mapped out on the basis of the findings of future surveys.

When the final plan is formulated, it should be executed with prime effort directed towards dispelling the customers' misgivings about gas. Especially, concentrated endeavours should be exerted to reduce gas leakage and ensure stable supply in parallel with the improvement of gas quality.

Rehabilitation of pipelines should be given top priority in Jakarta and Medan areas because the natural gas conversion planned for these areas will not produce the expected effect before the rehabilitation is completed.

The team wishes to add that the aforementioned plans for investigation and rehabilitation will have to be prepared with the assistance of experts.

### 2.6.3 Rehabilitation of Gas Meters

Gas is sold by measuring the supplied volume by gas meters. Gas meters should therefore be accurate enough to satisfy the customers. The team noted, however, that failure of gas meters occurs frequently and PGN's repair capacity is rather limited, and felt that gas rates might not be collected for the actual supplied volume in some cases.

The following services should be offered under the gas meter rehabilitation plan:

1) Repalcement of defective meters with new ones

2) Reinforcement of PGN's repair capacity

3) Assurance of an optimum stock of new meters

Many of the currently used meters have too large a capacity for use at home. Unless large output water heaters are installed, a capacity of $3m^3$/hr suffices for home consumption and meters with too large a capacity are prone to cause reading error. It must also be noted that gas meters should be dismantled and checked after a predetermined period of use.

Periodical inspection under normal condition should be conducted at intervals of about ten years, although this naturally varies by the quality and characteristics of gas.

## 2.7 Gas Appliances Used by Customers

With the improvement of gas quality and stabilization of supply pressure, the customers are required to use gas appliances compatible with such improvement and stabilization. In order to enable the customers to obtain such appliances with ease, PGN must check and select adequate types of appliances and supply them to the customers or to place on suitable marketing routes. PGN should also conduct PR and guidance activities to enlighten and acquaint the customers with the proper method of installation and use of gas meters.

For the desired development of industrial and commercial demand, combustion techniques meeting such demand must be available. PGN is therefore required to improve combustion techniques and train its technical staff and experts in such techniques.

# 3. Improvement of PGN's Management

Attainment of the technical improvements discussed in the foregoing pages does not promise to regain the customers' confidence, nor does it support PGN's smooth development if PGN is managed in a careless and loose manner. To supply the customers with reasonably, priced and high quality gas and win their confidence, the executive staff of PGN must exert continuous effort for the improvement of management.

Management improvement is attainable by the administrative and organizational rationalization, and sound growth of any enterprise presupposes such rationalization.

Description given in the following sections deals with major aspects of PGN's management desired to be improved in parallel with the aforementioned technical aspects.

### 3.1 Formulation of Long-term Management Plan

The Second Five Year Plan (PELITA II) was formulated as PGN's long-term management plan, but the plan devotes the greater part of its space to equipment investment programmes and does not indicate the demand estimate necessitating such investment, prospective development of new demand and the production programme meeting such new demand, income and expenditure programme, or funds supply and demand programme. If the PGN's management is desired to be improved under the Plan, these estimates and programmes should be additionally included after careful review and study.

The long-term management plan of any gas enterprise must comprise the following as its main components:

1) Diffusion and marketing policy

2) Production and distribution programme

3) Material demand and supply programme

4) Organizational and labour programme

5) Financial programme

In addition, it must be mapped out after studying the coordination and compatibility with the related state or municipal plans such as the city planning, energy development programme, etc. On the basis of the plan thus formulated, the implementation plan should be worked out for each year and the achievements in any one year are used as the basis for revising the long-term plan itself for the subsequent years. To put in other words, it is necessary to follow three steps, i.e. plan (formulation of plan), do (implementation of plan) and see (revision of plan). Detailed and concrete programmes can usually be incorporated in an annual plan or an implementation plan, but this is difficult in the case of a long-term plan. Hence, the revision of a long-term plan is something unavoidable and should be effected on the strength of achievements of each year. It is prohibitive to prepare a plan whose completion is next to impossibility, and long-term plan which does not reflect the planners' volition for improvement is not worthy of the name. Such poorly formulated plans do not provide anything like guiding principles for future development of the enterprise, and also cause erroneous judgement by the managerial staff and policy planners.

## 3.2 Improvement of Organization and Labour Productivity

The decisive factors that bear closely on smooth management of any enterprise are the organizational set-up and quality of workers.

PGN's organization is fairly simplified, but the productivity of its workers is not very high. The number of customers per worker is only 35 at present which is far smaller than in other countries and should be increased to at least 100 for promotion of management rationalization and demand expansion. For this purpose, it is required to improve the organization and elevate the quality and morale of workers. Although the existing organization of PGN suffices for routine duties, it is devoid or short of sectors for expansion and growth of enterprise, e.g., planning and implementation sector for development of new demand, raw material procurement sector, and workers' education and training sector. Being a public utility, PGN is required to perform routine services without fail but it is also required to supply gas to as many customers as possible. Hence, its organization should be so improved as will fill the expanding demand for gas.

Improvement of labour productivity is attained by the their training and education as well as by their proper realignment.

PGN is now required to train its staffs and workers so that they will all be acquainted with every aspect of PGN's services, with the capacity for basing their judgements on the cost and for working out various plans. Training of employees is also needed to make them capable of performing any duties and meeting the anticipated demand growth with enthusiasm and interest.

Assignment of employees to the duties suited to their respective capacities and thereby augment their willingness to work is just as important as the elevation of their quality. Employees find their duties interesting and worthy of exertion and their contribution to the enterprise increases only when they are given the opportunity to exhibit their capacity to the full.

It is therefore recommended that PGN reduce the number of employees assigned to routine work sectors and increase the productivity through such qualitiative improvement and proper realignment of employees. It is also recommended that the surpuls personnel be assigned to poorly staffed marketing sector to develop new demand and improve the profit rate.

### 3.3 Marketing Policy

PGN has no gas diffusion and marketing policy established from a long-term viewpoint as yet. The gas sales can be promoted by the following two measures:

1) Expansion of the distribution network to acquire new customers.

2) Sales of new gas appliances to existing customers for diversification of gas consumption.

New customers secured by measure 1) will include both general consumers and large industrial consumers. In the demand promotion activities, priority is given to areas where large sales volume can be expected from small equipment investment. In certain cases, therefore, it is advisable that the demand increase effort be exerted not in the radial direction but in different areas separated from each other.

Demand development activities should be started with good future prospects in the most advantageous area selected on the basis of a careful demand survey, estimated requirement of new pipeline network, calculation of required capital input, fund raising plan, and gas charge collection plan. Study must also be made on how the long-range gas diffusion plan is to be carried out from the standpoint of a public utility.

Another way to develop new demand is to encourage the consumers of competitive fuels to gas in areas where the pipeline network is already laid. Prospective users can be readily picked up from the ledger of meter inspection and the network map, and the workers of the marketing sector should approach such prospective customers and explain to them about the handling convenience, cleanliness, and stable supply of gas and induce them to shift to gas. This method is advisable because it incurs little equipment investment and improve the profit rate as well.

Demand expansion by measure 2) calls for the marketing of new uses = new appliances and establishment of a system under which such marketing can be promoted effectively.

It is probable that most general customers use only gas ranges, but they may be induced to use water heaters and ovens which are conductive to increased consumption.

In order to conduct such diversified marketing activities, it is necessary to create a general sales promotion department in the main office which controls the marketing policy of each station and back up its enforcement as well.

As for coke, it is both advisable and effective to control its marketing activities at the main office.

### 3.4 Gas Rates and Fund Raising

As described at the outset of this chapter, the gas enterprise is a public utility and should establish reasonable gas rates that can be justified by highly efficient operation and management. The gas rates should be so set that all benefited consumers will be equally treated. Further, it is preferable to set the rates as low as practicable since gas must meet competition from LPG and other alternative fuels.

The gas enterprise is required to make a large amount of investment for installation of various facilities including pipeline network which is the core of the enterprise, but it takes quite a long time to recover the invested fund.

Therefore, expansion of facilities with loans makes the profit rate low. Profitable operation calls for the availability of abundant fund that can be advanced at low interest rate. The prevailing interest rate on loans is 20% per annum in Indonesia, and this is just too high to attain good payability.

Reasonable gas rates cannot be maintained by the management improvement alone; it calls for the government's assistance in raising the necessary fund at a low interest rate.

As means to alleviate the PGN's financial burden ensued from equipment investment, it may as well be proposed to adopt the burden share system under which part of the construction cost of new pipelines is borne by new customers. In this case, however, it is important to make clear the extent of the customer's burden so that all new customers will be treated equally without discrimination.

### 3.5 Material Procurement Policy

While the raw material bears closely on the production cost of gas, PGN depends on import for the supply of coal and obtain heavy oil from PERTAMINA. But the price of these two materials is the same as the market price, so that PGN must meet severe competition from kerosene whose price level is held low under the government policy.

It is hoped that the government will see that the smooth supply of gas is indispensable for the people's daily life and take the same subsidial measures as applied to kerosene. The team is of the opinion that PGN should approach the government with the request for such measures in the interest of the general public.

As regards the selection of material, it is advised that PGN promotes the development of natural gas and ensure its stable supply to customers. This will make it imperative for PGN to request the government's aid in the smooth supply of abundant quantities of natural gas at low cost.

In the procurement of equipment and material, those whose specification meets the purpose of use should be selected and maximum entrepreneurial effort should be made to reduce their purchase price to a minimum. PGN will be required, from time to time, to contact the pertinent government offices to secure its cooperation in the procurement of equipment and material.

# CHAPTER IV

# REHABILITATION AND DEVELOPMENT OF PGN JAKARTA

# CHAPTER IV. REHABILITATION AND DEVELOPMENT OF PGN JAKARTA

Jakarta, the capital city of the Republic of Indonesia, not only symbolizes the country's rapid pace of modernization but is also known as one of the most congested cities in the world. Demand for gas in Jakarta is far stronger than in any other parts of the country, and makes it justifiable to give top priority to PGN Jakarta under the rehabilitation and development plan. In addition, there is a plan to introduce natural gas to Jakarta in two or three years, and this is likely to prompt the rehabilitation and development of PGN Jakarta.

For these reasons, Jakarta was chosen for the case study which is made in the following pages to examine the rehabilitation and development plan and to make proposals and recommendations. It is to be noted that some of the data on which the case study is based were not fully substantiated due to the limited time allowed for the survey. Implementation of any of the proposed cases should therefore be preceded by a further careful survey.

## 1. Existing State of Jakarta and Future Demand for Gas

### 1.1 Population

It is believed that Jakarta has a population of about 4.5 million at present. Although the city authority is enforcing restriction on the population migration into Jakarta, the city's population is still on the gradual upward trend.

As can be seen in Table IV-1 and Fig.IV-1 (2) showing the population distribution of Jakarta, Central Jakarta and its vicinities are most densely populated. To be more specific, population concentration is seen in Central Jakarta, part of West Jakarta embracing Tambora and Taman Sari as well as part of South Jakarta embodying Tebet and Setia Budi.

Since the population density in Central Jakarta has already reached the point of saturation, it is likely that the other four districts of the city will face a sharp population increase in the coming years.

To cope with this situation, the government is planning to improve the urban infrastructure under the Greater Jakarta Scheme (called JABOTABEK) which embraces Jakarta and nearby cities, such as Bogor, Tangerang and Bekasi.

Under the Great Jakarta Scheme, it is anticipated that Jakarta's population will grow to 8.5 million in the year 2000, and the population increment of 4 million is expected to be distributed in the city's outskirts to expand its boundaries. While it is naturally desirable to supply gas to the whole city area envisaged by the scheme, gas diffusion effort in the coming several years will have to be concentrated in the central part of the present Jakarta.

## 1.2 Diffusion of Gas

Present pipeline installed districts in Jakarta are shown in Fig.IV-3. As can be clearly seen in this figure, the network covers only a small part of the city including Central Jakarta.

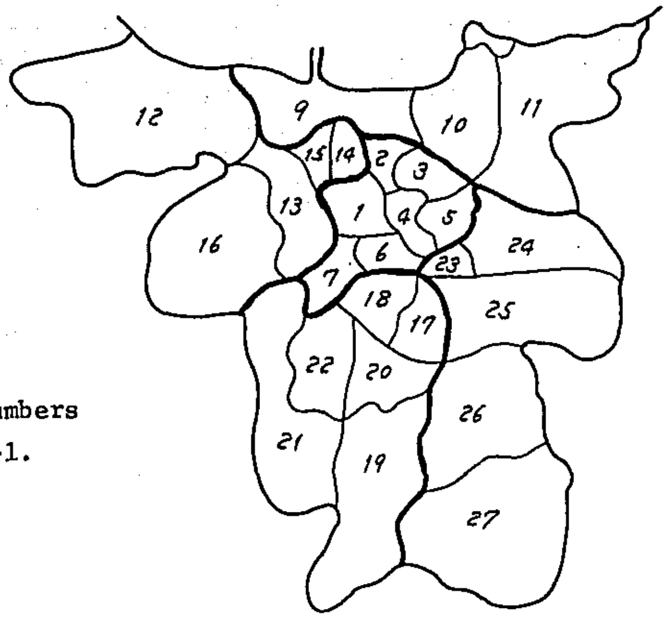
The first step towards future development will therefore be to formulate a Master Plan intended to introduce gas in districts where the population density exceeds 100 persons/ha at present. The master plan envisages gas supply to such additional districts as Kebayorang Baru. The total number of customers in these districts can be obtained from the estimate made in Chapter III and its distribution on the basis of Table IV-3 showing the distribution of permanent houses.

According to the demand forcast, the total number of customers and saturation rate in Jakarta respectively, are expected to reach more than 50 thousand and about 10% in 2000. However, if PGN's diffusion effort is backed up by strong government support and results in a phenomenal growth of demand after the natural gas conversion, it is possible that all permanent houses will be supplied with natural gas in 2000.

Table IV-1. District-wise Area and Population of Jakarta (1972)

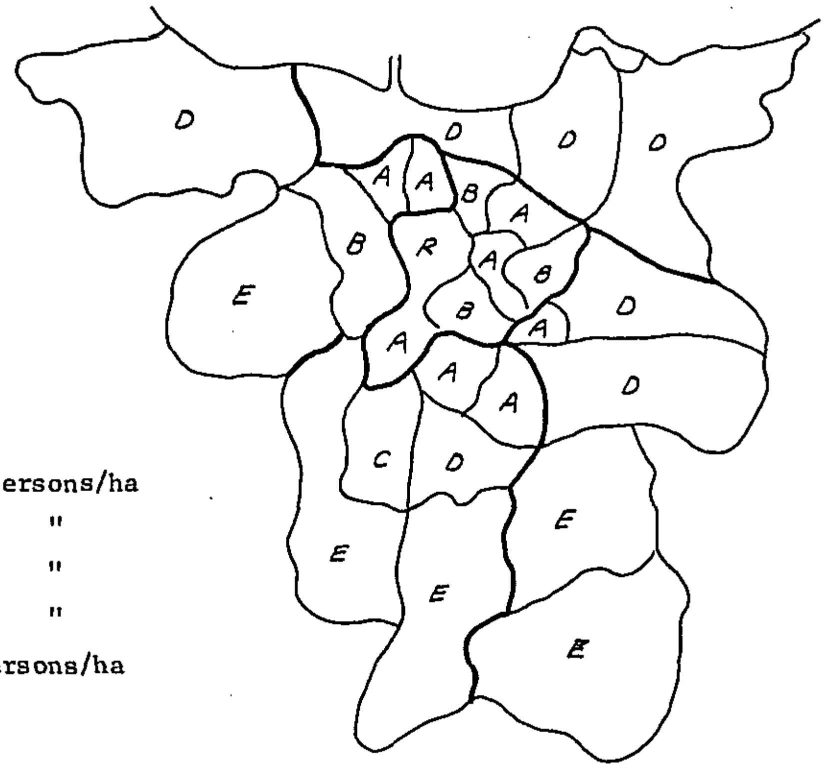
| | Area (ha) | 1972 | | Estimate for 2000 | |
|---|---|---|---|---|---|
| | | Population | Population Density (person/ha) | Population | Population Density |
| 1 Gambir | 859 | 162,071 | 189 | 215,000 | 250 |
| 2 Sawah Besar | 1,057 | 165,561 | 157 | 254,000 | 240 |
| 3 Kemajoran | 889 | 186,631 | 210 | 222,000 | 250 |
| 4 Senen | 382 | 162,096 | 424 | 162,000 | 424 |
| 5 Tjempaka Putih | 941 | 182,797 | 194 | 235,000 | 250 |
| 6 Menteng | 792 | 142,202 | 179 | 198,000 | 250 |
| 7 Tanah Abang | 966 | 259,044 | 268 | 259,000 | 268 |
| Central Jakarta | 5,886 | 1,260,402 | 214 | 1,545,000 | 262 |
| 8 Pulau Seribu | 921 | 8,453 | 9 | 47,000 | 51 |
| 9 Pendjaringan | 2,337 | 177,805 | 76 | 374,000 | 160 |
| 10 Tandjung Priok | 2,290 | 154,300 | 67 | 344,000 | 150 |
| 11 Kodja | 5,044 | 252,258 | 50 | 656,000 | 130 |
| North Jakarta | 10,502 | 592,896 | 59 | 1,421,000 | 135 |
| 12 Tjengkareng | 6,596 | 93,189 | 14 | 469,000 | 71 |
| 13 Grogol/Petamburan | 1,736 | 280,884 | 162 | 417,000 | 240 |
| 14 Tambora | 729 | 236,063 | 324 | 236,000 | 324 |
| 15 Taman Sari | 404 | 154,956 | 384 | 155,000 | 384 |
| 16 Kebun Djeruk | 4,164 | 74,627 | 18 | 333,000 | 80 |
| West Jakarta | 13,629 | 839,719 | 62 | 1,610,000 | 118 |
| 17 Tebet | 935 | 214,923 | 230 | 234,000 | 250 |
| 18 Setia Budi | 944 | 245,971 | 260 | 245,000 | 260 |
| 19 Pasar Minggu | 4,156 | 116,371 | 28 | 457,000 | 110 |
| 20 Mempang Prapatan | 1,846 | 126,719 | 69 | 277,000 | 150 |
| 21 Kebajoran Lama | 4,060 | 193,046 | 48 | 528,000 | 130 |
| 22 Kebajoran Baru | 1,388 | 182,120 | 131 | 291,000 | 210 |
| South Jakarta | 13,329 | 1,079,050 | 81 | 2,033,000 | 153 |
| 23 Matraman | 522 | 168,414 | 323 | 169,000 | 323 |
| 24 Pulo Gadung | 2,934 | 184,190 | 63 | 412,000 | 140 |
| 25 Djatinegara | 3,226 | 232,125 | 72 | 484,000 | 150 |
| 26 Kramat Jati | 3,349 | 134,521 | 40 | 402,000 | 120 |
| 27 Pasar Rebo | 5,295 | 88,110 | 17 | 424,000 | 80 |
| East Jakarta | 15,326 | 806,360 | 53 | 1,891,000 | 124 |
| TOTAL | 58,672 | 4,579,427 | 78 | 8,500,000 | 145 |

(I) Names of Districts




Note: For numbers see Table IV-1.

(II) Population Density




A. More than 200 persons/ha
B. " 150 "
C. " 100 "
D. " 50 "
E. Less than 49 persons/ha

Fig. IV-1. Names of Districts and Population density of Jakarta City

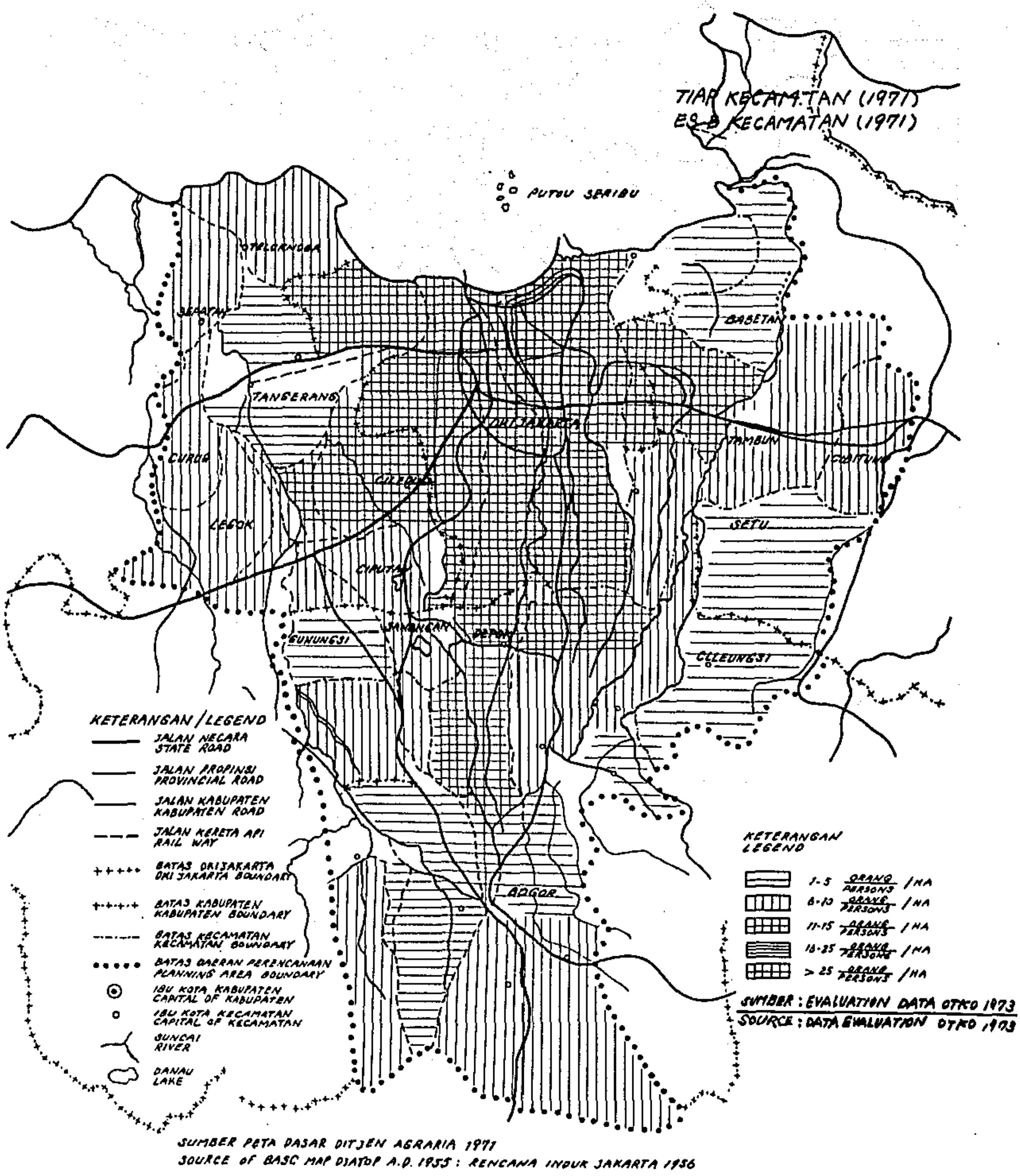



Fig. IV-2. Greater Jakarta Scheme (JABOTABEK)

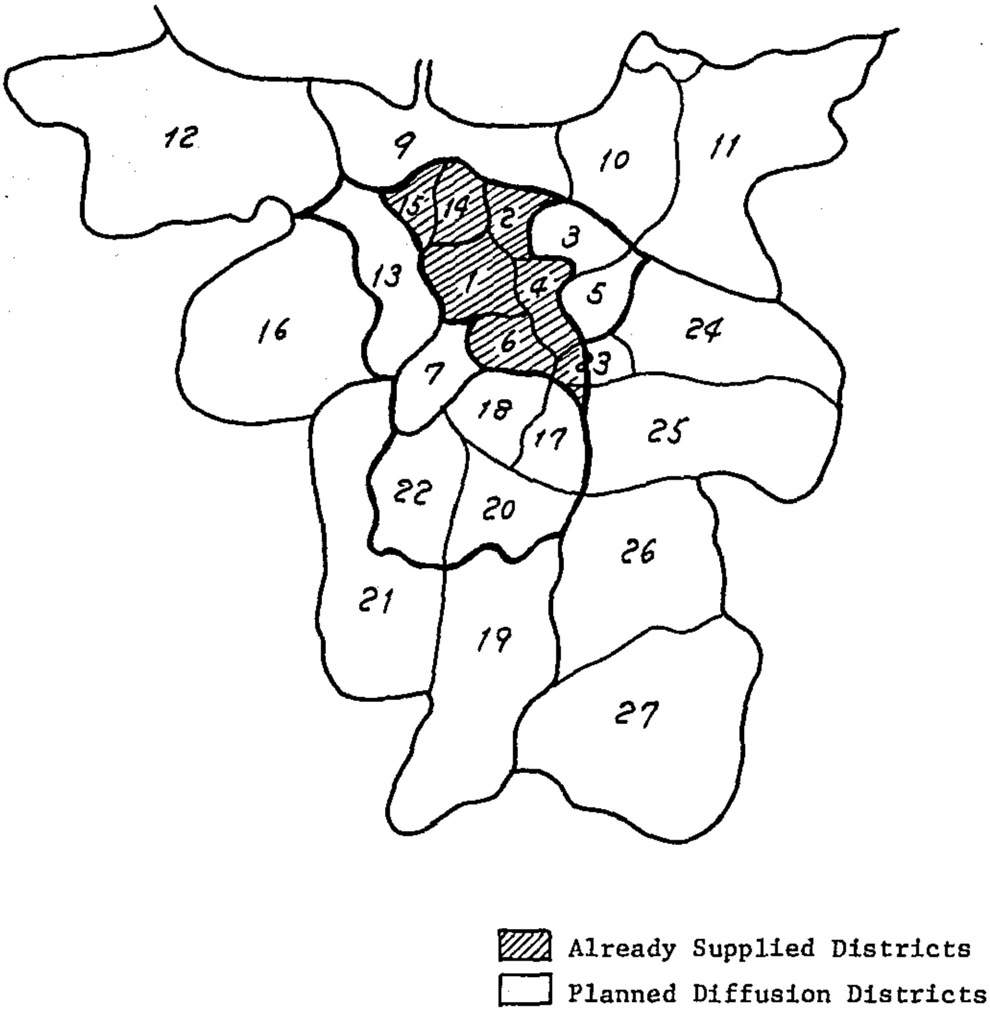



Fig. IV-3. Districts Already Supplied with Gas and Planned Diffusion Districts

Table IV-2. Population Estimate for Jakarta under JABOTABEK

(Unit: million persons)

| | Pop.1971 | Natural growth 71 - 85 | Pop.1985 | Natural growth 85 - 2000 | Pop.2000 | Total natural growth 71 - 2000 |
|---|---|---|---|---|---|---|
| JAKARTA | 4.6 | 1.9 | 6.5 | 2.0 | 8.5 | 3.9 |
| Bo-Ta-Bek | 2.4 | 1.0 | 3.4 | 1.2 | 4.6 | 2.2 |
| JABOTABEK | 7.0 | 2.9 | 9.9 | 3.2 | 13.1 | 6.1 |

Table IV-3. Permanent and Semi-permanent Houses

| | Permanent house | Semi-permanent house | Total | Ratio to Population |
|---|---|---|---|---|
| Gambir | 12,258 | 10,788 | 23,036 | 0.142 |
| Sawah Besar | 9,329 | 9,297 | 18,626 | 0.113 |
| Kemajoran | 6,265 | 17,677 | 23,942 | 0.128 |
| Senen | 4,685 | 3,912 | 8,601 | 0.053 |
| Tjempaka Putih | 1,399 | 2,748 | 4,147 | 0.023 |
| Menteng | 8,165 | 8,568 | 16,733 | 0.118 |
| Tanah Abang | 9,567 | 23,865 | 33,432 | 0.129 |
| Central Jakarta | 51,668 | 76,845 | 128,517 | 0.102 |
| Pulau Seribu | - | - | - | - |
| Pendjaringan | | | | |
| Tandjung Priok | | | | |
| Kodja | | | | |
| North Jakarta | 10,611 | 19,458 | 30,069 | 0.051 |
| Thengkareng | 3,460 | 6,732 | 10,192 | 0.109 |
| Grogol/Petamburan | 12,527 | 14,477 | 27,004 | 0.096 |
| Tambora | 6,218 | 5,366 | 11,584 | 0.049 |
| Taman Sari | 10,898 | 15,443 | 16,341 | 0.105 |
| Kebun Djeruk | 600 | 2,318 | 2,918 | 0.039 |
| West Jakarta | 33,703 | 44,336 | 78,039 | 0.093 |

| | Permanent house | Semi-permanent house | Total | Ratio to Population |
|---|---|---|---|---|
| Tebet | 9,674 | 13,816 | 23,490 | 0.109 |
| Setia Pudi | 4,725 | 7,923 | 12,468 | 0.051 |
| Pasar Minggu | 1,051 | 2,617 | 3,668 | 0.032 |
| Mampang Prapatan | 5,765 | 4,363 | 10,128 | 0.080 |
| Kebajoran Lama | - | - | - | - |
| Kebajoran Baru | 8,650 | 3,500 | 12,150 | 0.067 |
| South Jakarta | 29,865 | 32,219 | 62,084 | 0.058 |
| Matraman<br>Pulo Gadung<br>Djatinegara<br>Kramat Jati<br>Pasar Rebo | | | | |
| East Jakarta | 9,462 | 14,318 | 23,780 | 0.029 |
| TOTAL | 135,313 | 177,176 | 312,489 | 0.068 |

2. Planning of Gas Facilities and Study of Investment

This section deals with the rehabilitation and development plans of gas facilities intended to cope with the above-mentioned growth demand.

If abundant fund is available, it is desirable to install various facilities according to the city planning in full consideration of the prospective demand increase, and all gas facilities should preferably be designed for middle or higher pressure to attain a high transmission efficiency and installed in a systematic manner.

However, noting the fact that PGN Jakarta is in a difficult financial situation and must regain the customer's confidence in gas as quickly as possible, the team drafted a plan for minimum investment required for limited improvement and expansion of the existing facilities.

## 2.1 Planning of Production Facilities

### 2.1.1 Promotion of Natural Gas Conversion

The anticipated development of Krakatau Steel and fertilizer production is expected to open up the way for natural gas conversion in the Jakarta area.

As repeatedly pointed out in Chapter III, supply of natural gas to densely populated districts as an energy source is most desirable from the viewpoint of overall utilization of energy resources. Introduction of natural gas to Jakarta is quite significant in that it contributes to the modernization of the city which is the symbol of the country and also serves for industrial development in surburan areas.

In this report, therefore, a basic plan of production facilities presupposing positive natural gas introduction to Jakarta is proposed as most commendable (Case 1). However, there is possibility that the natural gas conversion under this plan may be made difficult due to limited production of natural gas or restrictions placed under the government's energy policy. If such difficulty arises, the preferable alternative material will be lighter oils as discussed from different points of view in Chapter III. To provide for the possible case where the use of lighter oils, which shows a global upward trend, proves impossible under the government policy and coal or diesel oil must be used as raw material, two alternative plans (Case 2 for installation of diesel oil catalytic reformer and Case 3 for installation of coke oven) are also proposed for payability comparison.

There could arise the case where the shortage of natural gas after completion of the conversion makes it inevitable to supply manufactured gas. In this case, either of the following two methods should be resorted to because ordinary manufactured gas and natural gas differ largely from each other in flame speed and do not promise compatibility of gas appliances.

a) Development of specially manufactured gas, i.e., SNG (substitute natural gas).

b) Division of the service area into two districts (e.g., separate supply to industrial district).

At the present technical level, however, the former calls for the installation of high pressure facilities using lighter oil. The latter, on the other hand, calls for the construction of a double distribution network and for re-conversion from natural gas which both lead to the increase of production cost. Implementation of the latter may be found impossible if studied from a practical point of view. Thus, it is necessary to study and confirm the future availability of natural gas. Further discussion on this matter is omitted here because it is a problem to be coped with in the remote future and the energy situation could change before such problem actually arises.

Planning of production facilities is discussed below for each of Cases 1, 2 and 3. It is to be noted that the installation work should be preceded by the estimation of the required gas production which can be obtained from the following equation using the percent leakage estimated or planned separately.

$$\text{Required production (estimate)} = \frac{\text{Estimated gas sales volume}}{1 - \text{Fraction leakage}}$$

Table IV-4 shows the estimated required production (converted to 4,200 $Kcal/m^3$) as calculated with consideration given to the reduction of percent leakage by the repair of pipeline as well as to the difference in percent leakage between the supply of natural gas and that of manufactured gas. The table does not give the production to fill new industrial demand which is to be separately studied by PGN.

Table IV-4. Estimated Gas Production

(Unit: thousand $m^3$)

| | Gas Sales | With NG Introduction | | Without NG Introduction | |
|---|---|---|---|---|---|
| | | Percent Leakage | Production | Percent Leakage | Production |
| 1975 | 9,808 | 35 % | 15,089 | 35 % | 15,089 |
| 76 | 10,087 | 25 | 13,449 | 25 | 13,449 |
| 77 | 10,843 | 16 | 12,908 | 16 | 12,908 |
| 78 | 11,696 | 11.0 * | 13,142 | 9.0 | 12,853 |
| 79 | 13,123 | 10.5 | 14,663 | 5.5 | 13,887 |
| 80 | 14,724 | 10.0 | 16,360 | 5.0 | 15,499 |
| 81 | 16,521 | 9.5 | 18,255 | 5.0 | 17,391 |
| 82 | 18,536 | 9.0 | 2,0369 | 4.5 | 19,409 |
| 83 | 20,798 | 8.5 | 22,730 | 4.5 | 21,778 |
| 84 | 23,335 | 8.0 | 25,364 | 4.0 | 24,308 |
| 85 | 26,182 | 7.5 | 28,305 | 4.0 | 27,273 |
| 86 | 29,376 | 7.0 | 31,587 | 3.5 | 30,441 |
| 87 | 32,960 | 6.5 | 35,251 | 3.5 | 34,155 |
| 88 | 36,981 | 6.0 | 39,341 | 3.0 | 38,125 |
| 89 | 41,493 | 5.5 | 43,908 | 3.0 | 42,776 |
| 90 | 46,555 | 5.0 | 49,005 | 2.5 | 47,749 |

* Average value was adopted on account of the expected conversion.

### 2.1.2 Production Facilities Presupposing Natural Gas Conversion (Case 1)

Considering the construction schedule of the natural gas distribution trunk line, it is probable that a period of at least three years will be required before the conversion is materialized. In this three year period, rational countermeasures against gas leakage should be taken in parallel with the following measures which are to be enforced in the field of production.

a) Reduction of the tar content in gas.
b) Removal of corrosive matters from gas.
c) Improvement of combustion characteristics (Wobbe index).
d) Countermeasures against deterioration of facilities.
e) Countermeasures against environmental pollution.

Measures a) and b) are closely related to the leakage prevention and both must be enforced to assure the customers of smooth gas supply and regain their confidence in PGN's services. However, it is advisable to improve the gas quality by effecting minor improvements to the existing purification facilities because any large capital input in the plant to be closed in the near future cannot be justified.

The improvements should cover the following.

1) Installation of additional scrubbers for removal of higher hydrocarbons from gas.

2) Installation of new dry boxes for removal of corrosive matter ($H_2S$).

3) LPG enrichment (5% of manufactured partial combustion gas) for improvement of the combustion characteristics.

These improvements should be effected after checking the components of higher hydrocarbons and confirming that the corrosive matter is actually composed of $H_2S$.

The following table shows the gas production plan prepared on the basis of the estimated required production shown in Table IV-4. It is desirable to increase the coal gas production as much as possible by maintaining the existing facilities with the natural gas conversion assumed to be completed towards the end of 1978. In the following production plan, however, output of coal gas is planned to be increased by degrees.

Production Plan (Case 1)

Gas Sending Out Volume (4200 Kcal/$m^3$, $10^6 m^3/y$)

| Year | Total | CG | PC | LPG | NG | Remarks |
|---|---|---|---|---|---|---|
| 1975 | 15.1 | 2.0 | 13.1 | | | |
| 76 | 13.4 | 3.0 | 10.4 | | | |
| 77 | 12.9 | 4.0 | 8.5 | 0.4 | | |
| 78 | 13.1 | 4.0 | 8.6 | 0.5 | | |
| 79 | 14.7 | | | | 14.7 | Conversion to natural gas at the end of 1978 |
| 1980 | 16.4 | | | | 16.4 | |
| 81 | 18.3 | | | | 18.3 | |
| 82 | 20.4 | | | | 20.4 | |
| 83 | 22.7 | | | | 22.7 | |
| 84 | 25.4 | | | | 25.4 | |
| 85 | 28.3 | | | | 28.3 | |
| 86 | 31.6 | | | | 31.6 | |

Assuming that of a total sending out volume of 13,142 thousand $m^3$ prospected for 1978, 4,000 thousand $m^3$ can be covered by coal gas, the production of partial combustion gas + LPG turns out to be 9,142 thousand $m^3$/y (25,000 $m^3$/d) and the daily LPG enrichment which is 5% of this value can calculated as follows.

$$25{,}000\ m^3/d \times 0.05 \times \frac{4{,}200\ Kcal/m^3}{11{,}600\ Kcal/Kg} = 453\ kg/d$$

Assuming, again, that the average load factor is 80%, the required installed capacity turns out to be as calculated below.

453/0.8 = 570 (kg/d)

The facilities cost as estimated on the basis of this value is shown below.

Cost of Production Facilities

| | |
|---|---|
| • LPG facilities (incl. LPG tank) | Rp 23,000 x $10^3$ |
| • Calorific value regulator, etc. | 21,000 |
| • Additional scrubbers | 13,000 |
| • New dry boxes | 16,000 |
| TOTAL | Rp 73,000 |

2.1.3 Case of Diesel Oil Catalytic Reformer (Case 2)

Although diesel oil can be most efficiently used if burnt directly by burner as industrial fuel, its use as gas material is studied below.

Since the existing Jakarta station is required to be relocated, the production facilities should be established at Dean Mogot or Klender in the suburban area of Jakarta together with utility facilities and office buildings.

Preconditions for the establishment of a diesel oil catalytic reformer plant are listed below.

1) The new plant is assumed to be located in Dean Mogot. The distributing pipeline should therefore be extended for 3 km.

2) Considering the required gas quality and PGN's past experience, a catalytic reforming process similar to that of ONIA-GEGI will be employed, with the calorific value adjusted by air.

3) The product yield will be set at the following values based on record of Surabaya station.

Gas 1,160 $m^3$ (4,200 Kcal/$m^3$)/Kl - diesel oil

Tar 129 Kl/Kl - diesel oil

Diesel oil includes heating oil.

4) Each reformer unit will have a production capacity of 40,000 $m^3$/d, and the first two units will be installed in 1978.

5) Considering the seasonal fluctuation of the gas sale volume, the annual average operation rate of the plant will be set at less than 80%, and a spare unit will always be maintained for the purpose of overhauling maintenance and emergency operation.

6) Gas production and additional installation of facilities in the second and subsequent years will be carried out according to the following plan.

Production Plan (Case 2)

Gas Production ($10^6 m^3$/y)

| Year | Total | CG | PC | LPG | OG | Remarks |
|---|---|---|---|---|---|---|
| 1975 | 15.1 | 2.0 | 13.1 | | | Operation of the existing plant |
| 1976 | 13.4 | 3.0 | 10.4 | | | |
| 1977 | 12.9 | 4.0 | 8.5 | 0.4 | | (Quality improvement by LPG enrichment) |
| 1978 | 12.9 | | | | 12.9 | Installation of new reformer units, OG 40 x $10^3 m^3$/d x 2 (Operation rate 44%) |
| 1979 | 13.9 | | | | 13.9 | - (48%) |
| 1980 | 15.5 | | | | 15.5 | Installation of an additional unit, 40 x $10^3 m^3$/d (Operation rate 53% + 1 spare unit) |
| 1981 | 17.4 | | | | 17.4 | ( " 63% + " ) |

| Year | Total | CG | PC | LPG | OG | Remarks |
|---|---|---|---|---|---|---|
| 1982 | 19.4 | | | | 19.4 | (Operation rate 67% + 1 spare unit) |
| 1983 | 21.8 | | | | 21.8 | ( " 75% + " ) |
| 1984 | 24.3 | | | | 24.3 | ( " 83% + " ) |
| 1985 | 27.3 | | | | 27.3 | Installation of an additional units, 40 x $10^3 m^3/d$ ( " 62% + " ) |
| 1986 | 30.4 | | | | 30.4 | ( " 69% + " ) |
| 1987 | 34.2 | | | | 34.2 | ( " 78% + " ) |

7) Plant construction will be completed in a year, and will include the installation of the following facilites.

| | [Gasification Facilities] | [Purification Facilities] | [Other] |
|---|---|---|---|
| 1977 | $40x10^3m^3/D$ x 2 | $80x10^3m^3/D$ x 1 + Tar treatment | Supporting facilities |
| 1979 | $40x10^3m^3/D$ x 1 | $80x10^3m^3/D$ x 1 | - |
| 1984 | $40x10^3m^3/D$ x 1 | - | - |

8) Plant operation up to 1977 will be the same in Case 1.

Approximate costs of facilities as estimated on the basis of the above preconditions are shown below. The estimate is based on the 1975 commodity price without regard to any future rises in price due to inflation.

a) 1977

| | |
|---|---|
| Diesel oil catalytic reformer units (40,000 $m^3$/d x 2) | Rp 150 x $10^6$ |
| Purification facilities (80,000 $m^3$/d) + tar treating facilities | 100 |
| Pipings, valves, electric works, and instrumentation | 100 |
| Diesel oil tanks (1,000 Kl x 2) | 70 |
| Gas sending out facilities (holder, blower and calorific value regulator) | 225 |
| Catalyst | 20 |
| Foundations, building, mounts and frames, and fire fighting equipment | 93 |
| Import expenses | 450 |
| Installation work | 91 |
| Engineering and training fees | 169 |
| Extension of distribution pipeline required by the plant relocation | 350 |
| Total | Rp 1,818 x $10^6$ |

b) 1979

| | |
|---|---|
| Diesel oil catalytic reformer unit (40,000 $m^3$/d x 1) | Rp 90 x $10^6$ |
| Purification facilities (80,000 $m^3$/d) | 70 |
| Pipings, valves, electric works, and instrumentation | 65 |
| Catalyst | 10 |
| Foundation work, mounts and frames, etc. | 19 |
| Import expenses | 153 |
| Installation work | 31 |
| Engineering fee | 28 |
| Total | Rp 466 x $10^6$ |

c) 1984

| | |
|---|---|
| Diesel oil catalytic reformer unit ($40,000\ m^3/d \times 1$) | Rp $60 \times 10^6$ |
| Pipings, electric work and instrumentation | 20 |
| Catalyst | 10 |
| Foundation work, mounts and frames, etc. | 7 |
| Import expenses | 58 |
| Installation work | 12 |
| Engineering fee | 11 |
| Total | Rp $178 \times 10^6$ |

Since catalyst is required for the operation of the proposed facilities, its cost must be added to the annual maintenance cost of the plant. Amount to be renewed ranges from 10 to 20% of the initially charged amount. Assuming that about 15% of the initially charged amount should be renewed, the annual cost of catalyst turns out to be as shown below.

| Year | Cost of Catalyst Replenishment |
|---|---|
| 1978 ∿ 79 | $4,000 \times 10^3$ Rp/year |
| 1980 ∿ 85 | 6,000 " |
| 1986 ∿ 87 | 8,000 " |

## 2.1.4 Case of Coke Oven (Case 3)

Coke ovens promise a large income from by-products so that their payability calculation produces favourable figures unless the material coal is very costly or investment for complete pollution-preventive measures is required as in Japan, although they call for a very high initial capital input. While it is very important for any coke oven plant to be constructed at a favourably conditioned site, the proposed plant site in Dean Mogot is not wide enough (36,000 $m^2$), nor does it seem to guarantee smooth transportation of coal and by-products. An extensive yard is required for the storage of coal and coke. In case uninterrupted supply of coal and smooth shipment of products are not assured, their stock must be increased and the area of the storage yard must also be increased. If the supply of coal is to be secured for a minimum of three months' operation of coke ovens having a daily capacity of 150 t-coal, then the coal yard must have an area of more than 15,000 $m^2$. Planning of production facilities described below presupposes solution or absence of all these problems.

Preconditions for the construction of a coke oven plant are listed below.

1) The coke oven installation plan must be based on the study of the prospective coke demand. In this plan, the total coke demand is estimated at 40,000 t/y and PGN is assumed to fill all this demand. Additional coke ovens could be installed if the demand increases beyond this level.

2) The product yield will be tentatively set at the following values using PGN's past data.

| | |
|---|---|
| Gas | 450 $m^3$ (4,200 Kcal/$m^3$)/t - coal |
| Coal | 500 kg/t - coal |
| Tar | 50 kg/t - coal |

In the case of Japan, the coke yield is usually in the neighbourhood of 700 kg/t - coal. In the actual design of the plant, therefore, reexamination of the above values and selection of suitable material coal will be required.

3) Portion of manufactured gas is generally used as fuel. In this plan, however, diesel oil is assumed to be used as in the existing facilities.

Diesel oil consumption 80 l/t - coal

4) Maximum installed capacity of coke ovens

The present installed capacity of other stations is as shown below.

| Station | Coal Consumption | Coke Production Capacity |
|---|---|---|
| Medan | 12 t/D | 6 t/D |
| Bandung | 12 | 6 |
| Semarang | 18 | 9 |
| Surabaya | 24.5 | 12.25 |
| Total | 66.5 | 33.25 t/D |

The maximum allowable coke production at Jakarta station:

$$40{,}000 - 33.25 \times 365 = 27{,}900 \ t/y \approx 75 \ t/d$$

Hence,

$$\text{Coal consumption} = 27{,}900/0.500 \approx 55{,}000 \ t/y = 150 \ t/d$$

$$\text{Gas production capacity} = 55{,}000 \times 450 \approx 25 \times 10^6 m^3/y \approx 68 \times 10^3 m^3/d$$

5) Range of load factor fluctuation of coke oven

70 ∿ 100%

6) LPG injection facilities will be installed for the purpose of maintenance and to cope with load fluctuation. If the required gas production exceeds the production capacity of coke ovens, the shortage will be covered by LPG. If the production drops below the coke oven capacity, then 5% of LPG will be injected for security purpose and to cope with the demand fluctuation.

7) The period required for the first coke oven to be commissioned is estimated to be 3 to 4 years after starting the plan.

8) Installation of production facilities using oil is not considered for this plan, although it will be required after 1987.

9) Production plan up to 1978 will be the same as in Case 1.

10) Gas production plan and coke oven installation plan conforming to the above conditions will be as shown below.

Production Plan (Case 3)

Gas Production (4,200 $Kcal/m^3$, $10^6 m^3/Y$)

| Year | Total | CG | PC | LPG | Remarks |
|---|---|---|---|---|---|
| 1975 | 15.1 | 2.0 | 13.0 | - | Operation of the existing plant. |
| 76 | 13.4 | 3.0 | 10.4 | - | |
| 77 | 12.9 | 4.0 | 8.5 | 0.4 | Quality improvement by LPG enrichment. |
| 78 | 12.9 | 4.0 | 8.6 | 0.5 | " |
| 79 | 13.9 | 13.2 | - | 0.7 | Establishment of a new coke oven plant, 100 t/d, 50% LPG. |
| 1980 | 15.5 | 14.7 | - | 0.8 | " |
| 81 | 17.4 | 16.4 | - | 1.0 | " |
| 82 | 19.4 | 16.4 | - | 3.0 | " |
| 83 | 21.8 | 20.7 | - | 1.1 | Installation of an additional coke oven, 50 t/d. |
| 84 | 24.3 | 23.1 | - | 1.2 | |
| 1985 | 27.3 | 24.7 | - | 2.6 | |
| 86 | 30.4 | 24.7 | - | 5.7 | |
| 87 | 34.2 | 24.7 | - | (9.5) | |

11) Accordingly, the plant construction plan will be as follows.

| | | |
|---|---|---|
| 1978 | First coke oven | 100 t-coal/d |
| | LPG facilities | 5.4 t/d |
| 1983 | Additional coke oven | 50 t-coal/d |

Approximate costs of facilities as estimated on the basis of the above preconditions are shown below. As in Case 2, the estimate is based on the 1975 commodity price without regard to any future price esclation due to inflation, and does not include facilities and equipment for coal unloading and coke shipment.

a) 1978

| | |
|---|---|
| Coke oven (100 t/d) and auxiliary equipments | Rp 525 x $10^6$ |
| Refining and sending out facilities (incl. gas holder) | 483 |
| Buildings and utility facilities (boiler, etc) | 123 |
| Import expenses | 683 |
| Overhead cost | 225 |
| Engineering and training fees | 175 |
| LPG facilities (5.4 t/d) | 90 |
| Extension of distribution pipeline attendant on the plant relocation (3 km) | 350 |
| Total | Rp 3,056 x $10^6$ |

b) 1983

| | |
|---|---|
| Additional coke oven | Rp 340 x $10^6$ |
| Import expenses | 225 |
| Installation work | 70 |
| Overhead cost | 188 |
| Engineering fee | 40 |
| Total | Rp 863 x $10^6$ |

2.1.5 Comparative Study of the Three Cases

Comparison of production costs as estimated from the investment required for the three cases is made below.

For the purpose of this comparative study, the estimated annual averages of the fixed cost of new facilities and the material cost are shown in Table IV-5 for the tne year period from 1976 to 1985 (Unit: Rp $10^3$/year). It is to be noted that the process of calculation by which this table was prepared includes some assumptions differing from the preconditions adopted for the study of income and expenditure made elsewhere in this report. Specifically, rises in commodity price due to inflation is disregarded, and all the costs other than those of production facilities and materials, such as labour cost, auxiliary materials cost, administration and management cost, pressure feed cost, etc. are excluded.

Existing facilities are assumed to be operated until the introduction of new facilities, with the coal gas production set at 5,000 x $10^3 m^3$/y. The fixed cost including the maintenance cost is set at 3% of the acquision cost, the interest at 12% of the book value, and depreciation period at 10 years for production facilities and 20 years for the natural gas distribution trunk line.

Study of Table IV-5 discloses the following facts.

a) Annual average cost of production facilities and material is lower than Rp 300 million under the natural gas conversion plan, but exceeds Rp 400 million under the other two plans.

b) Initial capital input required for Cases 2 and 3 is very large and prone to impose a heavy financial pressure on PGN.

c) Prices of tar and coke, assumed at Rp 80,000/Kl and Rp 130,000/t respectively, are much higher than those in the international market and could drop largely with the future industrial development. If the market price of these by-products falls, Cases 2 and 3 will incur a far higher cost than calculated.

On the basis of the above payability study and the foregoing discussion on the selection of raw material, it is recommended that Case 1 be adopted for production with account taken of the following points.

1) Considering the need of gas in urban areas and the advantages of natural gas, the natural gas introduction is an essential prerequisite to the sound development of PGN and is also commendable from the point of view of production cost.

2) Until the conversion is materialized, gas production from coal should be augmented as much as possible to improve the balance of payments.

3) The gas quality should be improved by additional installation of scrubbers and other suitable improvement of the existing partial combustion generators.

4) LPG should be mixed with partial combustion gas in order to improve the combustion characteristics and regain the confidence of customers.

A more detailed comparative study is made later in this report on the income and expenditures of the three cases.

Table IV-5 - Comparison of Fixed and Material Cost between the Three Cases (Average of 1976 ∿ 1985 period)

| | | | Natural Gas Conversion | Diesel Oil Catalytic Reformer | Coke Oven | Remarks |
|---|---|---|---|---|---|---|
| | | | Case 1 | Case 2 | Case 3 | |
| New Investment | Production Facilities | $10^3$Rp | 73,000 | 2,462,000 | 3,919,000 | |
| | Natural gas Distribution Trunk Line | " | 1,540,000 | - | - | |
| | Total | " | 1,613,000 | 2,462,000 | 3,919,000 | |
| Annual Average Fixed Cost | Depreciation Expense | $10^3$Rp | 58,800 | 181,300 | 237,700 | 10 years for production facilities and 20 years |
| | Interest | " | 135,300 | 130,600 | 223,500 | 12% of book value |
| | Maintenance Cost | " | 39,000 | 62,100 | 92,000 | 3% of acquisition cost |
| | Total | " | 233,100 | 374,000 | 553,200 | |
| Annual Average Material Cost | Coal Gas | $10^3$Rp | ( 1,500) Δ19,200 | ( 1,000) Δ12,800 | ( 1,500+12,920) Δ184,580 | (Costs of coal and fuel) - (Income from coke and tar) |
| | Partial Combustion Gas | " | ( 2,330) 11,630 | ( 1,586) 7,910 | ( 2,346) 11,710 | Diesel oil cost - Income from tar |
| | Diesel Oil Catalytic Reformer Gas | " | - | (15,250) 61,460 | - | " |
| | LPG | " | ( 120) 4,310 | ( 40) 1,440 | ( 70+ 1,040) 39,830 | |
| | Natural Gas | " | (14,604) 61,340 | - | - | |
| | Total | " | (18,554) 58,080 | (17,876) 58,010 | (17,876) Δ133,040 | |
| Total of Facilities and Material Costs | | $10^3$Rp | 291,180 | 432,010 | 420,160 | |
| Cost per Unit Sales Volume | | Rp/$m^3$ | <16,584> 17.56 | <16,584> 26.05 | <16,584> 25.34 | |

Notes:
1. Fixed cost and material cost were obtained by dividing the total cost for 10 years by 10.
2. Figures in parentheses (     ) and brackets <     > indicate the average gas production and average gas sale respectively in $10^3m^3$ (4,200 Kcal/$m^3$)/year.
3. Unit material cost after excluding the income from by-products is -12.8 for coal gas, 4.99 for partial combustion, 4.03 for oil gas, 35.9 for LPG and 4.2 for natural gas (Unit - Rp/$m^3$).
4. All costs other than those of raw material and new production facilities are disregarded.

## 2.2 Planning of Distribution Facilities

As described already, Jakarta station suffers a heavy percent leakage and there are cases where the gas supply is stopped when rain falls. These are causing distrust on the part of customers and also inviting a heavy loss of material. In addition if natural gas conversion effected, therefore, the following problems will arise.

1) Rise of supply pressure of gas through low pressure line, and rise of calorific value of leak gas invite a higher percent leakage.

2) Since Jakarta is larger than Cireben, natural gas introduction call for sector-zoning of the city, which in turn makes it necessary to effect improvement to pipelines.

The following description deals chiefly with the measures for coping with these problems:

(1) Rehabilitation of Pipelines

Under the First Five Year Plan, rehabilitation of a total of 52,604m of pipelines was completed as shown in Table IV-6.

Table IV-6. Pipeline Rehabilitation in Pelita I

| Diameter | Length |
|---|---|
| 4" | 37,978$^{m}$ |
| 6" | 2,750 |
| 8" | 12,876 |
| Total | 52,604 |

This is equivalent to about 22% of the total length of pipelines installed in Jakarta city. The rehabilitation plan required for future must be mapped out on the basis of a thoroughgoing investigation of all leaking places. Although the quantitative clarification of leakage involves substantial difficulty, the objective of the rehabilitation will be attained if 50% of all pipelines is covered.

Table IV-7. Pipeline Rehabilitation Plan

| Diameter | Length | Unit Cost | Total Cost |
|---|---|---|---|
| 10" | 7,000m | 35,000Rp/m | $245,000 \times 10^3$Rp |
| 8" | 12,000 | 28,000 | 336,000 |
| 6" | 12,000 | 21,000 | 252,000 |
| 4" | 30,000 | 14,000 | 420,000 |
| Total | 61,000 | | 1,253,000 |

Reference Table - Estimated Unit Cost of Pipelines

(Cast Iron Pipe)

| Diameter | Instal-lation Cost | Material cost | Total |
|---|---|---|---|
| 10" | 8,000Rp/m | 27,000Rp/m | 35,000Rp/m |
| 8" | 6,400 | 21,600 | 28,000 |
| 6" | 4,800 | 16,200 | 21,000 |
| 4" | 3,200 | 10,800 | 14,000 |

(2) Improvement of Distribution Method

It is known that the demand grows sharply when the gas quality and supply conditions are improved by some means or other. Such demand growth cannot be coped with the existing distribution network of Jakarta city.

Hence, some improvement should be effected to the pipelines with account taken of the expected trend of demand growth. It is to be pointed out that in large cities like Jakarta, gas should be supplied in medium or higher pressure lines having a high transmission efficiency.

In this item, the line arrangement is planned on the assumption that natural gas will be introduced into Jakarta. Accordingly, the loop line should preferably link the existing plant and the holder base (Fig. IV-4). It is advisable, however, to install the east line for natural gas conversion at first, and then install the west line with the increase of demand and thereby complete a loop line.

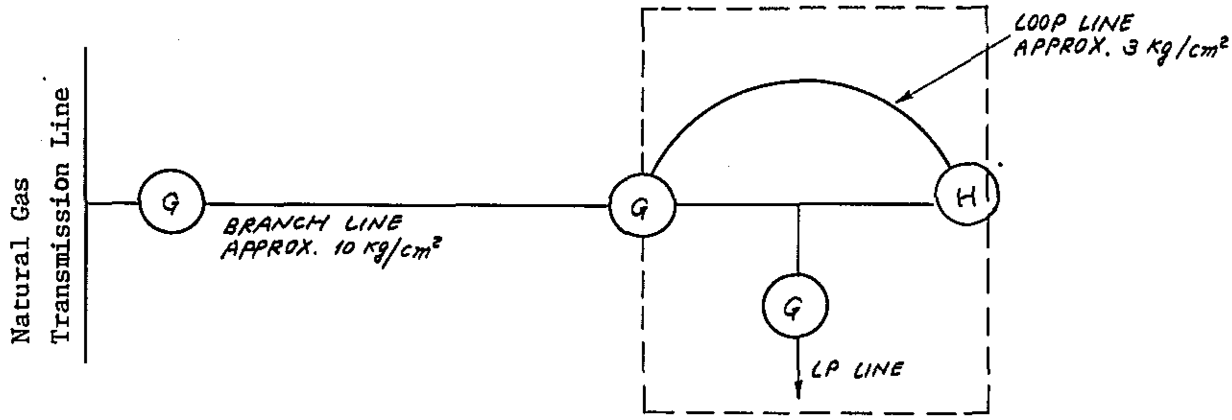
The cost required for installation of the east line is shown below:

Table IV-8. Installation Cost of Pipelines (medium pressure pipes, less than 3 $kg/cm^2$)

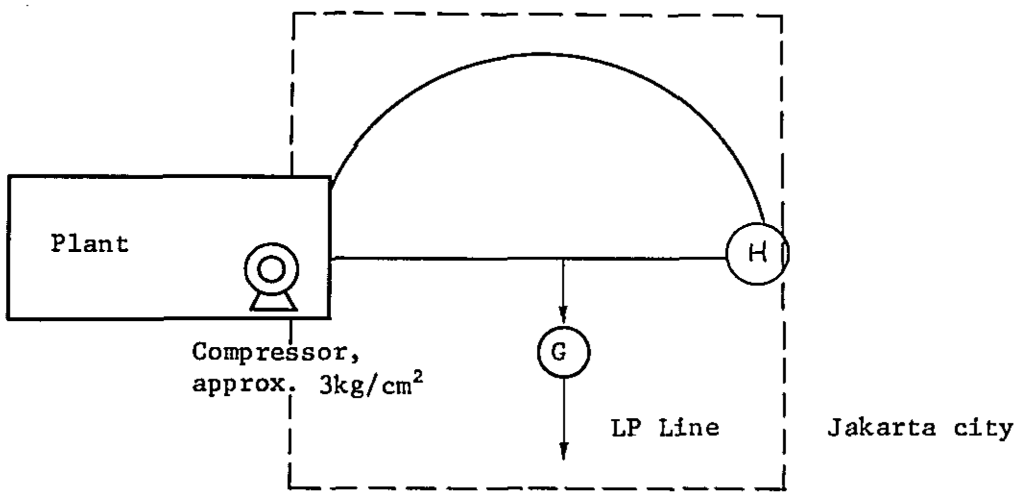
| Diameter | Length | Unit Cost | Total Cost |
|---|---|---|---|
| 10" | 10,000m | 30,000Rp/m | $350,000 \times 10^3$Rp |
| Regulator | Three Point | $3,000 \times 10^3$Rp | 9,000 |
| TOTAL | - | - | 359,000 |

If manufactured gas is to be supplied, the existing or relocated plant must be equipped with compressors and the loop line calls for a larger diameter because of the low calorific value of gas (Fig. IV-4).

(I) Case of natural gas conversion




(II) Case of manufactured gas




Notes: Ⓖ Governer
Ⓗ Gas Holder
LP Low Pressure

Fig. IV-4. Proposed Distribution System

The transmission capacity as converted to calorific flow rate varies as shown below:

Transmission of Calorific Quantity:

$$H\,Q = KHi\sqrt{\frac{(P_1^2 - P_2^2)\,D^5}{S\,L}}$$

Q : Flow Rate
H : Calorific Value
S : Specific Gravity
$P_1$: Pressure at Point 1
$P_2$: Pressure at Point 2
D : Pipe Diameter
L : Pipe Length

Assuming that $P_1$, $P_2$, D and L are all unchanged between manufactured and natural gases,

$$\frac{H_N Q}{H_M Q} = \frac{H_N\sqrt{S_M}}{H_M\sqrt{S_N}} = \frac{8{,}000}{4{,}200} \cdot \frac{\sqrt{0.9}}{\sqrt{0.65}} \fallingdotseq 2.2$$

where N and M denote natural gas and manufactured gas respectively.

Thus, the transmission must be increased by 2.2 times, and if the pipe diameter is to be increased to cover this increment, about 40% increase in diameter is required as calculated below:

$$\sqrt{\left(\frac{D_M}{D_N}\right)^5} = 2.2 \qquad \therefore D_M/D_N = 1.4$$

(3) Rehabilitation of Gas Meters

Although a total of 1,886 gas meters were repaired under the First Five Year Plan, it is necessary to purchase 4,000 new gas meters (including those for stock) in order to ensure accurate measurement of the volume of gas sold. Gas meters currently used are too large in capacity, and should be replaced in stages with those for household consumption having a capacity of 3 $m^3/hr$.

It is to be added that the reading of too large or too slow meters becomes further smaller, especially after the natural gas conversion, and incurs a heavy profit loss on PGN.

The cost required for procurement of 4,000 gas meters is shown below.

Table IV-9. Cost of Gas Meters (for Rehabilitation)

| Capacity | Quantity | Unit Price | Total Cost |
|---|---|---|---|
| $3m^3/h$ | 4,000 | 15,000Rp | $60,000 \times 10^3$Rp |

(4) Investment in Distribution Facilities with the Increase of Customers

The following points must be studied prior to any new investment planned to meet the demand growth:

1) How far the demand can be expanded with the existing distribution network,
2) How much will be the customers' burden share in case the pipeline is extended to secure new customers.

It is assumed that the existing network will be used until 1980, i.e., until the demand level of 1962 is regained. In this case, PGN's investment is required only for the installation of supply pipes and gas meters.

For the network expansion to be effected after 1980, it is assumed that the rate of burden of share of new customers in the cost of main and branch lines will be 50%. This burden share may be found rather heavy from the prevailing custom or the financial footing of new customers.

Nevertheless, it is to be pointed that the gas enterprise is essentially a public utility and is expected to protect the interests and rights of the existing customers. If the increase of new customers with lighter burden share results in poor payability on the part of PGN and further in the raising of gas rates or poor services, PGN will mistake the means for the end.

It is therefore recommended that a theoretically substantiated burden share system be established under which the cost to be borne by PGN and customers for installation of main and branch lines can be made clear.

The unit cost per customer in 1975 is assumed to be Rp 200,000 (Rp 15,000 each for meter and supply pipe), and the annual increase rate of installation cost is set at 5%

PGN's investment calculated on the assumptions for the period up to 1985 turns out to be Rp 933 x $10^6$. (See Table IV-16)

| | |
|---|---|
| Meter | Rp 148 x $10^6$ |
| Supply Pipe | 148 |
| Main & Branch Line | 637 |
| Total: | 933 x $10^6$ |

The following is the annual investment plan of distribution facilities prepared on the assumption that the natural gas will be introduced toward the end of 1978.

| | |
|---|---|
| 1976 | Investigation for rehabilitation of distribution facilities, and review and formulation of final rehabilitation plan. |
| 1977 ∫ 78 | Rehabilitation of leaking pipes and defective gas meters. |
| 1978 | Installation of medium pressure pipelines. |

## 2.3 Introduction of Natural Gas

Natural gas conversion plan is mentioned here as it is the most effective for rehabilitation and development of PGN Jakarta.

### (1) Natural Gas Transmission

The natural gas transmission line will branch off from the Cilamaya - Cilegon line. The branching point is not known yet but No. 1 Booster Station would be suitable. (See Fig. IV-5) A governor will be installed at the branching point to reduce the gas pressure to 8 - 10 kg/cm$^2$ and then supplied in a 250ϕ steel pipeline to Jatinegara, 44km apart from the branching point (No. 1 Booster Station).

Assuming that the supply pressure at the customer's end is 3 kg/cm$^2$, the transmission capacity of the said pipeline can be obtained as follows:

$$Q = K\sqrt{\frac{(P_1{}^2 - P_2{}^2)D^5}{SL}} \qquad \text{(Cox' formula)}$$

$$= 52.3\sqrt{\frac{\{(8.03)^2 - (4.03)^2\} \times 25^5}{44 \times 10^3 \times 0.65}}$$

$$= 6{,}760\ m^3/h \quad (S = 0.65)$$

Gas consumption on peak demand days and during peak demand hours is will be as tabulated below:

**Fig. IV-5 Natural Gas Introduction Plan**

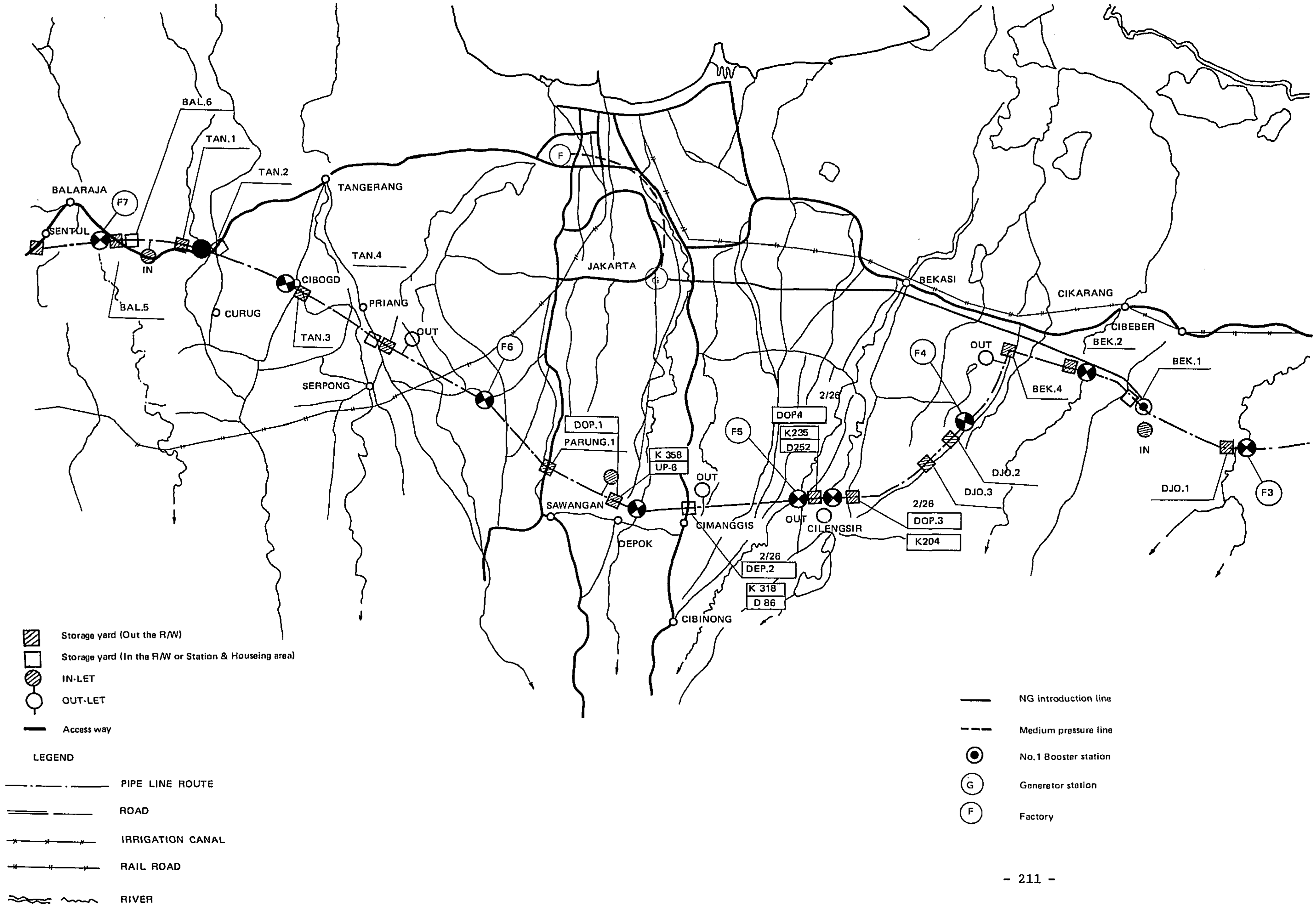
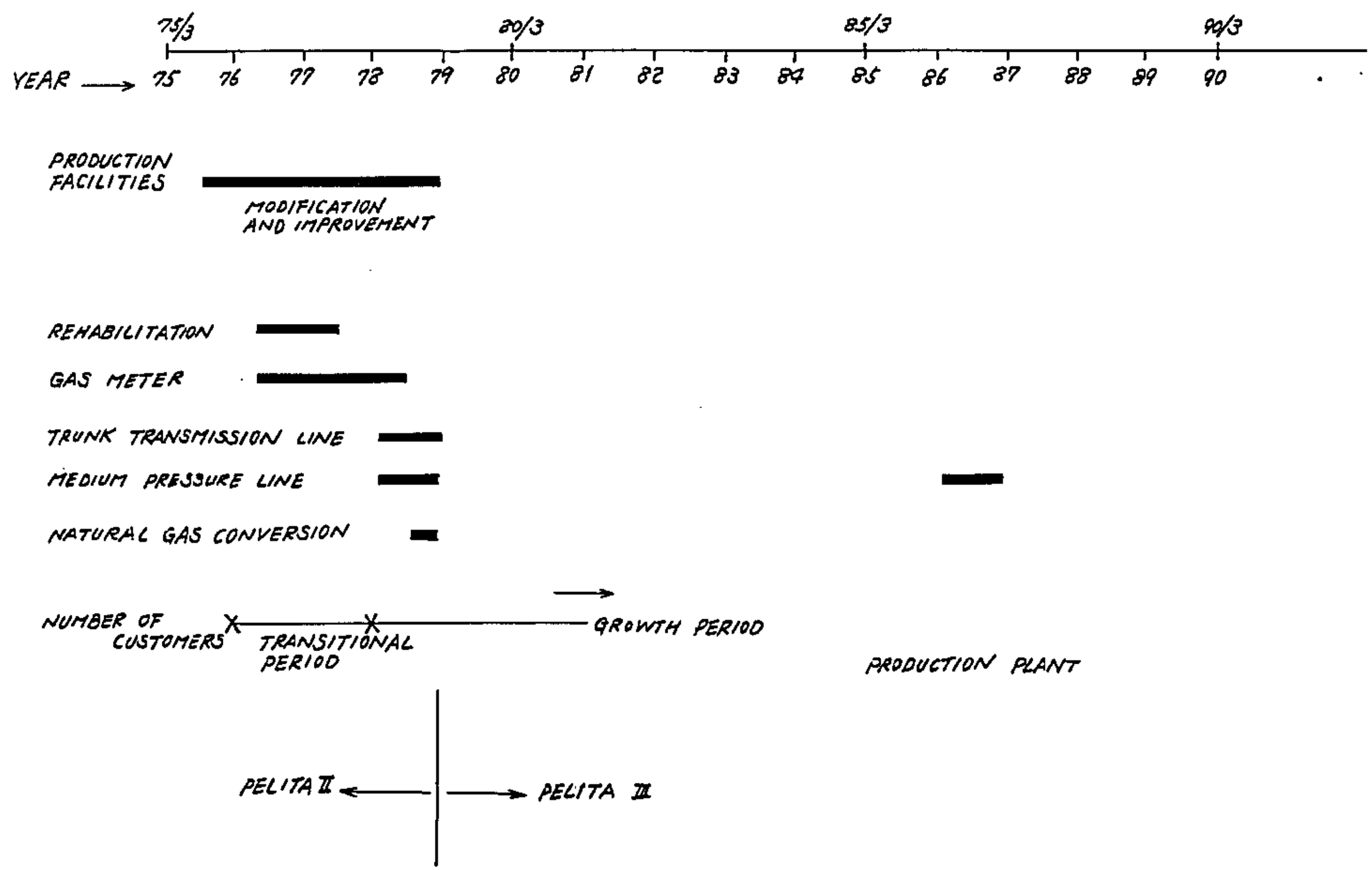


Fig. IV-5. Programme for Case 1 (Natural Gas Conversion)



| | Annual Consumption | Consumption on Peak Days (0.3%) | Consumption during Peak Hours (5%) |
|---|---|---|---|
| 1980 | 9,710 $m^3$ | 29,000$m^3$/D | 1,450$m^3$/H |
| 1985 | 16,587 | 49,700 | 2,485 |
| 1990 | 27,742 | 83,300 | 4,165 |

Thus, it is clear that the said pipeline can meet the demand up to 1990, but installation of additional lines will be required after 1990.

(2) Natural Gas Distribution Trunk Line

It is desirable that natural gas be supplied from Jatinegara to the plant in a 250ø pipeline having a length of about 10km after reducing its pressure to 2 - 3 kg/$cm^2$.

Since there is need to reduce the pressure loss, this line will reach the limit of its transmission capacity by 1985 (2,000 - 3,000 $m^3$/h), so that it will be required to install a west circuit trunk line after that.

At the branching point from the said line, a governor will be installed to supply gas into the existing low pressure line. It is also plausible that high pressure holders will be installed in Jatinegara.

(3) Expenditure for Natural Gas Conversion

It is necessary to take due account of the expenditure for natural gas conversion which is detailed in the appendix.

The expenditure per customer can be held below the Rp 10,000 level if the conversion is undertaken by PGN's workers. It must be noted that assistance from other PGN stations is required for the conversion.

The costs and specifications described above are summarized in the following table:

Table IV-10. Expenditure for Natural Gas Conversion

| Distribution Facilities | Specification | Cost |
|---|---|---|
| Natural Gas Introduction Line (Branching Point - Jatinegara) | 44km ($10kg/cm^2$) | $1,540,000 x 10^3$Rp |
| Medium Pressure Line (Jatinegara - Jakarta city) | 10Km ($3kg/cm^2$) | 359,000 |
| Natural Gas Conversion Expenditure | Approx. 6,000 customers | 55,000 |

(5) Summary of Projected Investment

Summarizing the plans described in Items (1) - (4), the total projected investment required for natural gas conversion amounts to approximately $4.3 \times 10^9$ Rupia (US$10 million).

Table IV-11. Total Amount of Projected Investment

| | |
|---|---|
| Production Facilities (incl. LPG injection) | $73 \times 10^6$Rp |
| Rehabilitation (pipeline) | 1,253 |
| Gas Meters | 60 |
| Natural Gas Introduction Line | 1,540 |
| Medium Pressure Line | 359 |
| Natural Gas Conversion | 55 |
| Distribution Expansion | 933 |
| | $4,273 \times 10^6$Rp |

3. Economic Evaluation for PGN Jakarta

As described in Sections 1 and 2, natural gas is expected to be introduced to the Jakarta area. Pending the completion of natural gas conversion, it will be most advisable to manufacture coal gas and partial combustion gas enriched with LPG in order to maintain the gas supply service.

However, if the natural gas conversion proves impossible it is quite possible that the natural gas (Case 1) must be substituted by diesel oil catalytic reformer gas (Case 2) or coal gas (Case 3). Hence, payability analysis is made for each of the following three cases.

Case 1. Natural gas conversion

Case 2. Natural gas conversion is not materialized and diesel oil catalytic reformer gas is supplied with the present calorific value maintained.

Case 3. Natural gas conversion is not materialized and coal gas is supplied by new coke ovens installed to take advantage of high market price of coke.

In the following pages, a detailed payability analysis is made on Case 1, followed by the study of Cases 2 and 3 which was carried out in the similar manner.

3.1 Case 1 - Natural Gas Conversion

The following are the major factors studied for the purpose of economic evaluation of case 1:

(1) Gas Rates

Considering the competition from alternative fuels and the duties of PGN as a public utility, it is desirable that the gas rates be held as low as possible. In this study, it is assumed that the rate will increase by about 5 Rp/$m^3$ in the first 3 years, but will later be maintained without revision through entrepreneurial effort to be exerted after 1982 when PGN's payability is expected to be improved.

It is also assumed that after the natural gas conversion, the rates will be calculated on the calorie-slide basis.

(2) Pipe and Meter Charges

The pipe and meter chargers are assumed to be raised at a rate of Rp 20 a year proportionately with the increase of gas rates but that they will be maintained after 1982.

(3) By-products (See the Production Plan)

Before the natural gas conversion, PGN will supply customers with coal gas and partial combustion gas enriched with LPG. Although the production cost of coal gas is high, it can be offset by the high price level of by-products such as coke and tar. Hence, it is possible to obtain high quality coal gas at low cost. Accordingly, the production plan shown in Table IV-13 was formulated in which the percentage of coal gas production is assumed to be increased gradually.

Income from Items (1), (2) and (3) above is shown in Table IV-12.

Table IV-12. Annual Revenue of PGN Jakarta (Case 1)

(Unit: $10^6$Rp)

| | Number of Customers | Gas Sales ($10^3m^3$) | Unit Price (Rp) | Monthly meter charge (Rp) | Monthly pipe charge (Rp) | Income from Gas Sales | Income from Meter Rental | Income from Pipe Rental | Income from By-Products Sales | Total In-come |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 6,134 | 9,808 | 37.0 | 100 | 100 | 363 | 7 | 7 | 244 | 621 |
| 1976 | 6,136 | 10,087 | 40.0 | 120 | 120 | 402 | 9 | 9 | 315 | 735 |
| 77 | 6,443 | 10,843 | 40.0 | 120 | 120 | 434 | 9 | 9 | 468 | 920 |
| 78 | 6,765 | 11,696 | 40.0 | 120 | 120 | 468 | 10 | 10 | 314 | 802 |
| 79 | 7,441 | 13,123 | 45.0 | 140 | 140 | 591 | 13 | 13 | 0 | 617 |
| 80 | 8,185 | 14,724 | 45.0 | 140 | 140 | 663 | 14 | 14 | 0 | 691 |
| 81 | 9,004 | 16,521 | 45.0 | 140 | 140 | 834 | 15 | 15 | 0 | 864 |
| 82 | 9,904 | 18,536 | 50.0 | 160 | 160 | 927 | 19 | 19 | 0 | 965 |
| 83 | 10,895 | 20,798 | 50.0 | 160 | 160 | 1,040 | 21 | 21 | 0 | 1,082 |
| 84 | 11,984 | 23,335 | 50 50.0 | 160 | 160 | 1,167 | 23 | 23 | 0 | 1,213 |
| 85 | 13,183 | 26,182 | 50.0 | 160 | 160 | 1,309 | 25 | 25 | 0 | 1,359 |

Table IV-13. Production Plan (for Case 1 before NG Conversion)

Basic Data

| | | |
|---|---|---|
| Coal gas | Annual production | 5,350 thousand $m^3$ |
| | Production per unit weight of coal | 450 $m^3/t$ |
| | Coke production | 500 kg/t-coal |
| | Tar production | 50 kg/t-coal |
| | Heavy oil for fuel | 0.08 Kℓ/t - coal |
| Partial combustion gas | Annual production | Annual gas sales minus annual coal gas production |
| | Production per unit volume of oil | 1,400 $m^3$/kℓ (gasification efficiency considered) |
| | Tar production | 0.1 kg/kℓ -oil |
| LPG requirement | 5% of heat value of partial combustion gas | |

Basic Price of Materials and By-products

| | |
|---|---|
| Coal | 54,000 Rp/t |
| Diesel oil | 15,000 Rp/kℓ |
| LPG | 52,000 Rp/t |
| Coke | 130,000 Rp/t |
| Tar | 80,000 Rp/t |

Operation Plan

| | Gas Sales ($x10^3m^3$) | Percent leakage | Sending Out Volume ($x10^3m^3$) | Coke Oven Operation Rate |
|---|---|---|---|---|
| 75 | 9,808 | 35% | 15,089 | 20% |
| 76 | 10,087 | 25 | 13,449 | 30% |
| 77 | 10,843 | 16 | 12,908 | 50% |
| 78 | 11,696 | 11.0 | 13,142 | 70% |

Calculation of Annual Expenditure and Income

Coke oven operation rate = x, Annual gas sales = V ($\times 10^3 m^3$)

Coal $\frac{5,350}{450} \times \frac{x}{100} \times 54,000 \times 1,000$ ........... (A)

Heavy oil for coke oven fuel $\frac{5,350}{450} \times \frac{x}{100} \times 0.08 \times 15,000 \times 1,000$

Heavy oil for PC gas $(V - 5,350 \times \frac{x}{100}) \times \frac{15,000}{1,400} \times 1,000$ ...... (B)

LPG $(V-5,350 \times \frac{x}{100}) \times 0.05 \times \frac{52,000}{3,100} \times 1,000$ ..... (C)

Coke $A \times 0.5 \times \frac{130,000}{54,000}$ ........................ (D)

Tar $A \times 0.05 \times \frac{80,000}{54,000} + B \times 0.1 \times \frac{80,000}{15,000}$ ........ (E)

Production Plan (Unit: $10^6$Rp for values)

| | | Materials | | | | By-products | | | Cost |
|---|---|---|---|---|---|---|---|---|---|
| | | Coal | Diesel oil | LPG | Total | Coke | Tar | Total | |
| 75 | Q'ty | 2.38 $10^3$t | 10,014 $10^3$kℓ | 226 t | | 1.19 $10^3$t | 1,120 $10^3$kℓ | | |
| | Value | 129 | 150 | 12 | 293 | 155 | 89 | 244 | 49 |
| 76 | Q'ty | 3.57 | 8,460 | 191 | | 1.79 | 1,025 | | |
| | Value | 193 | 127 | 10 | 334 | 233 | 82 | 315 | 19 |
| 77 | Q'ty | 5.94 | 7,309 | 165 | | 2.79 | 1,018 | | |
| | Value | 321 | 100 | 9 | 446 | 386 | 82 | 468 | ▲22 |
| 78 | Q'ty | 8.32 | 6,562 | 148 | | 4.16 | 1,072 | | |
| | Value | 449 | 98 | 8 | 565 | 540 | 86 | 626 | ▲61 |

(4) Depreciation

Detailed data required for depreciation planning were not made available to the team. Hence, the calculation was worked out on the principle generally adopted in Japan, and the book value registered at the end of each year was used for depreciation in the following year.

Table IV-14. Depreciation Plan

| | | | |
|---|---|---|---|
| Production Facilities | 10 yrs | Residual Value - 10% | Fixed Instalment Method |
| Rehabilitation Cost | 20 " | " | " |
| Gas Meters | 20 " | " | " |
| Medium Pressure Pipeline | 20 " | " | " |
| Natural Gas Introducing Line | 20 " | " | " |
| Demand Expansion Line | 20 " | " | " |
| Natural Gas Conversion Cost | 3 " | Residual Value - 0 | " |

Results of calculation are shown in Tables IV-15 ∿ 17. Depreciation of the existing assets are separately considered.

Table IV-15. Depreciation Schedule (Case 1)

(Unit: $10^6$Rp)

| | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Production Facilities | | | 73 | | | | | | | | | |
| | | | | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Rehabilitation Cost | | | 500 | 500 | 253 | | | | | | | |
| | | | | 22 | 45 | 56 | 56 | 56 | 56 | 56 | 56 | 56 |
| Gas Meters | | | 20 | 20 | 20 | | | | | | | |
| | | | | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Natural Gas Introducing Line | | | | 770 | 770 | | | | | | | |
| | | | | | 35 | 70 | 70 | 70 | 70 | 70 | 70 | 70 |
| Medium Pressure Pipeline | | | | | 359 | | | | | | | |
| | | | | | | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Natural Gas Conversion Cost | | | | | 55 | | | | | | | |
| | | | | | | 18 | 18 | 19 | | | | |
| Demand Expansion Line | | | | 10 | 12 | 24 | 28 | 126 | 146 | 169 | 194 | 224 |
| | | | | | | 1 | 2 | 3 | 9 | 16 | 23 | 32 |
| Base | | | | | | | | | | | | |
| | (15) | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 |
| Total | | | 593 | 1,300 | 1,469 | 24 | 28 | 126 | 146 | 169 | 194 | 224 |
| | (15) | 14 | 13 | 42 | 100 | 181 | 181 | 182 | 168 | 174 | 180 | 188 |

Upper colume: initial cost
Lower " : depreciation

Note) Base: Depreciation for existing facilities.

Table IV-16. Depreciation Schedule of Service Lines (Case 1)

(Unit: $10^6$Rp)

| | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of Customers | 6,132 | 6,134 | 6,136 | 6,443 | 6,765 | 7,441 | 8,185 | 9,004 | 9,904 | 10,895 | 11,984 | 13,183 |
| Increment of Customers | - | 2 | 2 | 307 | 322 | 676 | 744 | 819 | 900 | 991 | 1,089 | 1,199 |
| Cost per Customer(Rp) | | 170 | 179 | 187 | 197 | 207 | 217 | 228 | 239 | 251 | 264 | 277 |
| Investment for Service Line Installation | | | | | | | | 187 | 215 | 249 | 288 | 332 |
| Customers' Burden Share (%) | | | | | | | | 50 | 50 | 50 | 50 | 50 |
| PGN's Burden Share | | | | | | | | 94 | 108 | 125 | 144 | 166 |
| Gas Meter * | | - | - | 5 | 6 | 12 | 14 | 16 | 19 | 22 | 25 | 29 |
| Supply Pipe ** | | - | - | 5 | 6 | 12 | 14 | 16 | 19 | 22 | 25 | 29 |
| Total | | - | - | 10 | 12 | 24 | 28 | 126 | 146 | 169 | 194 | 224 |
| Depreciation Expense | | | | - | - | 1 | 2 | 3 | 9 | 16 | 23 | 32 |
| Cumulative Total of Acquisition Cost | | | | 10 | 22 | 46 | 74 | 200 | 346 | 515 | 709 | 933 |
| Cumulative Total of Depreciation Expense | | | | - | - | 1 | 3 | 6 | 15 | 31 | 54 | 86 |
| Book Value | | | | 10 | 22 | 45 | 71 | 194 | 331 | 484 | 654 | 847 |

* Gas meters = Investment for service line installation x 0.08823 (1.5/17)
** Supply pipes = " x "

Table IV-17. Book Value Schedule (Case 1)

(Unit: $10^6$Rp)

| | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 83 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cumulative Total of Acquisition Cost | | | 593 | 1,893 | 3,362 | 3,386 | 3,414 | 3,540 | 3,686 | 3,855 | 4,049 | 4,273 |
| Cumulative Total of Depreciation Expense | (15) | 14 | 27 | 69 | 169 | 350 | 531 | 713 | 881 | 1,055 | 1,235 | 1,423 |
| Book Value | | | 566 | 1,824 | 3,193 | 3,036 | 2,883 | 2,827 | 2,805 | 2,800 | 2,814 | 2,850 |

(5) Percent Leakage

The percent leakage must be considered when the production is to be obtained from the sales volume. It is assumed, however, that the leakage can be largely reduced by the rehabilitation. Temporary rise of leakage immediately after the natural gas conversion is regarded as inevitable.

(6) Material Cost

Calculation based on the production plan (See Table IV-13) indicates, as shown below, that the material cost is high in the early stage, but it becomes much lower if the income from by-products is deducted.

$$\frac{293 \times 10^6 Rp}{15.1 \times 10^6 m^3} = 19.4\ Rp/m^3 \quad \text{(Income from by-products } 16.2\ Rp/m^3\text{)}$$

$$\frac{334 \times 10^6 Rp}{13.4 \times 10^6 m^3} = 24.9\ Rp/m^3 \quad \text{( " } 23.5\ Rp/m^3\text{)}$$

$$\frac{446 \times 10^6 Rp}{12.9 \times 10^6 m^3} = 34.5\ Rp/m^3 \quad \text{( " } 36.3\ Rp/m^3\text{)}$$

$$\frac{565 \times 10^6 Rp}{13.1 \times 10^6 m^3} = 43.1\ Rp/m^3 \quad \text{( " } 47.9\ Rp/m^3\text{)}$$

As regards the material cost after the conversion, calculation is worked on the basis of the prevailing cost of natural gas which is 8 Rp/m$^3$ (8,000 Kcal/m$^3$)

$$8 \times \frac{4,200}{8,000} = 4.2\ Rp/m^3$$

The annual growth rate of commodity price is set at 3%. Details of material cost are shown in Table IV-18.

Table IV-18. Material Cost (Case 1)

| | Production | Unit Cost | Total Material Cost |
|---|---|---|---|
| | $\times 10^3 m^3$ | xRp | $\times 10^6$Rp |
| 1975 | 15,089 | - | 290 |
| 76 | 13,449 | - | 330 |
| 77 | 12,908 | - | 439 |
| 78 | 12,852 | (4.43) | 339 |
| 79 | 14,264 | 4.56 | 65 |
| 80 | 16,360 | 4.71 | 77 |
| 81 | 18,255 | 4.88 | 89 |
| 82 | 20,369 | 4.96 | 101 |
| 83 | 22,730 | 5.15 | 117 |
| 84 | 25,364 | 5.28 | 134 |
| 85 | 28,305 | 5.44 | 154 |

(7) Personnel and Welfare Costs

The personnel and welfare costs for 1975 are set at the following values:

Personnel cost 325,000 Rp/person/year

Welfare cost Personnel cost x 20% = 65,000 Rp/person/year

Compared with the 1974 level, these values are higher by slightly more than 11%. The annual increase rate of these costs is set at 10% for subsequent years.

It is assumed that PGN will exert entrepreneurial effort so as not to increase its workers until the number of customers per worker reaches 100. It is considered that PGN will be enabled to effect personnel reduction in the production sector after the conversion, although assistance from other stations will be required during the conversion period. Details of personnel and welfare costs are shown in Table IV-19.

Table IV-19. Personnel and Welfare Cost (Case 1)

| Year | Number of Workers | Personnel Cost per Worker | Welfare Cost per Worker | Annual Personnel Cost | Annual Welfare cost |
|---|---|---|---|---|---|
| 1975 | 191 | 325 $\times 10^6$ Rp | 65 $\times 10^6$ Rp | 62 $\times 10^6$ Rp | 12 $\times 10^6$ Rp |
| 76 | 191 | 357 | 72 | 68 | 14 |
| 77 | 191 | 393 | 79 | 75 | 15 |
| 78 | 220 | 433 | 87 | 95 | 19 |
| 79 | 191 | 476 | 95 | 91 | 18 |
| 80 | 191 | 523 | 105 | 100 | 20 |
| 81 | 191 | 576 | 115 | 110 | 22 |
| 82 | 191 | 633 | 127 | 121 | 24 |
| 83 | 191 | 696 | 139 | 133 | 27 |
| 84 | 191 | 766 | 153 | 147 | 29 |
| 85 | 191 | 843 | 169 | 161 | 32 |

(8) General Administration Cost

An increase of 3% over 1974 level is assumed for the basic general administration cost for 1975.

$$60{,}000 \times 10^3 \text{ Rp}$$

The annual increase rate of this cost is set at 5% for subsequent years.

(9) Demand Development Cost

The demand development cost is set at 100 ∿ 120 Rp/customer/year.

(10) Insurance Cost

The insurance premium is set at 10% of the depreciation expense.

(11) Repair Cost

The repair cost in the later stage is set at 3% of the acquisition cost. The cost will be lower in the early stage when the facilities are new. Hence, 1.0% is assumed for the early stage, 2% for the period starting from 1980, and 3% for the period after 1985.

(12) Interest Expense

The interest expense is set at 12% of "Cumulative total of deficit + Acquistition cost - Cumulative total of depreciation expense = Cumulative total of deficit + Book value."

The costs mentioned in Items (9) ∿ (12) are shown in Table IV-20.

Table IV-20. Annual Loss of PGN Jakarta (Case 1)

(Unit: $10^6$Rp)

| | Material Cost | Personnele Cost | Welfare Cost | General Adminis-tration Cost | Insurance Cost | Demand Expansion Cost | Depreciation Expense | Repair Cost | Overhead Cost | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 293 | 62 | 12 | 60 | 1 | 1 | 14 | 0 | 15 | 458 |
| 76 | 334 | 68 | 14 | 63 | 1 | 1 | 13 | 0 | 16 | 510 |
| 77 | 446 | 75 | 15 | 66 | 4 | 1 | 42 | 6 | 17 | 667 |
| 78 | 311 | 95 | 19 | 69 | 10 | 1 | 100 | 19 | 17 | 641 |
| 79 | 65 | 91 | 18 | 72 | 18 | 1 | 181 | 34 | 18 | 498 |
| 80 | 77 | 100 | 20 | 76 | 18 | 1 | 181 | 67 | 19 | 559 |
| 81 | 89 | 110 | 22 | 80 | 18 | 1 | 182 | 68 | 20 | 590 |
| 82 | 101 | 121 | 24 | 84 | 17 | 1 | 168 | 70 | 21 | 607 |
| 83 | 117 | 133 | 27 | 88 | 17 | 1 | 174 | 73 | 22 | 652 |
| 84 | 134 | 147 | 29 | 92 | 18 | 1 | 180 | 77 | 23 | 701 |
| 85 | 154 | 161 | 32 | 97 | 19 | 2 | 188 | 121 | 24 | 798 |

Ratio of Repair Cost to Acquisition Cost

| Year | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|
| Ratio(%) | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 3.0 |

Table IV-21. Annual Profit and Loss of PGN Jakarta

(Unit: $R_p$ $10^6$)

| | P | L | A P-L | Book Value (year end) | B* Book Value x 12% | C =A-B | Interest to Red Figure D ** | Net Profit or loss E=C-D | Cumulative Total of Profit |
|---|---|---|---|---|---|---|---|---|---|
| 1975 | 621 | 458 | 163 | - | - | 163 | 0 | 166 | 163 |
| 76 | 735 | 510 | 225 | 566 | 34 | 191 | ▲20 | 211 | 377 |
| 77 | 920 | 667 | 253 | 1,824 | 143 | 110 | ▲45 | 155 | 532 |
| 78 | 802 | 641 | 161 | 3,193 | 301 | ▲140 | ▲64 | ▲ 76 | 456 |
| 79 | 591 | 498 | 93 | 3,036 | 374 | ▲281 | ▲55 | ▲226 | 230 |
| 80 | 663 | 559 | 104 | 2,883 | 355 | ▲251 | ▲28 | ▲223 | 7 |
| 81 | 834 | 590 | 244 | 2,827 | 343 | ▲ 99 | ▲ 1 | ▲ 98 | ▲ 91 |
| 82 | 927 | 607 | 320 | 2,805 | 338 | ▲ 18 | 11 | ▲ 29 | ▲120 |
| 83 | 1,040 | 652 | 388 | 2,800 | 336 | 52 | 14 | 38 | ▲ 82 |
| 84 | 1,167 | 701 | 466 | 2,814 | 337 | 129 | 10 | 119 | 37 |
| 85 | 1,309 | 798 | 511 | 2,850 | 340 | 171 | ▲ 4 | 175 | 212 |

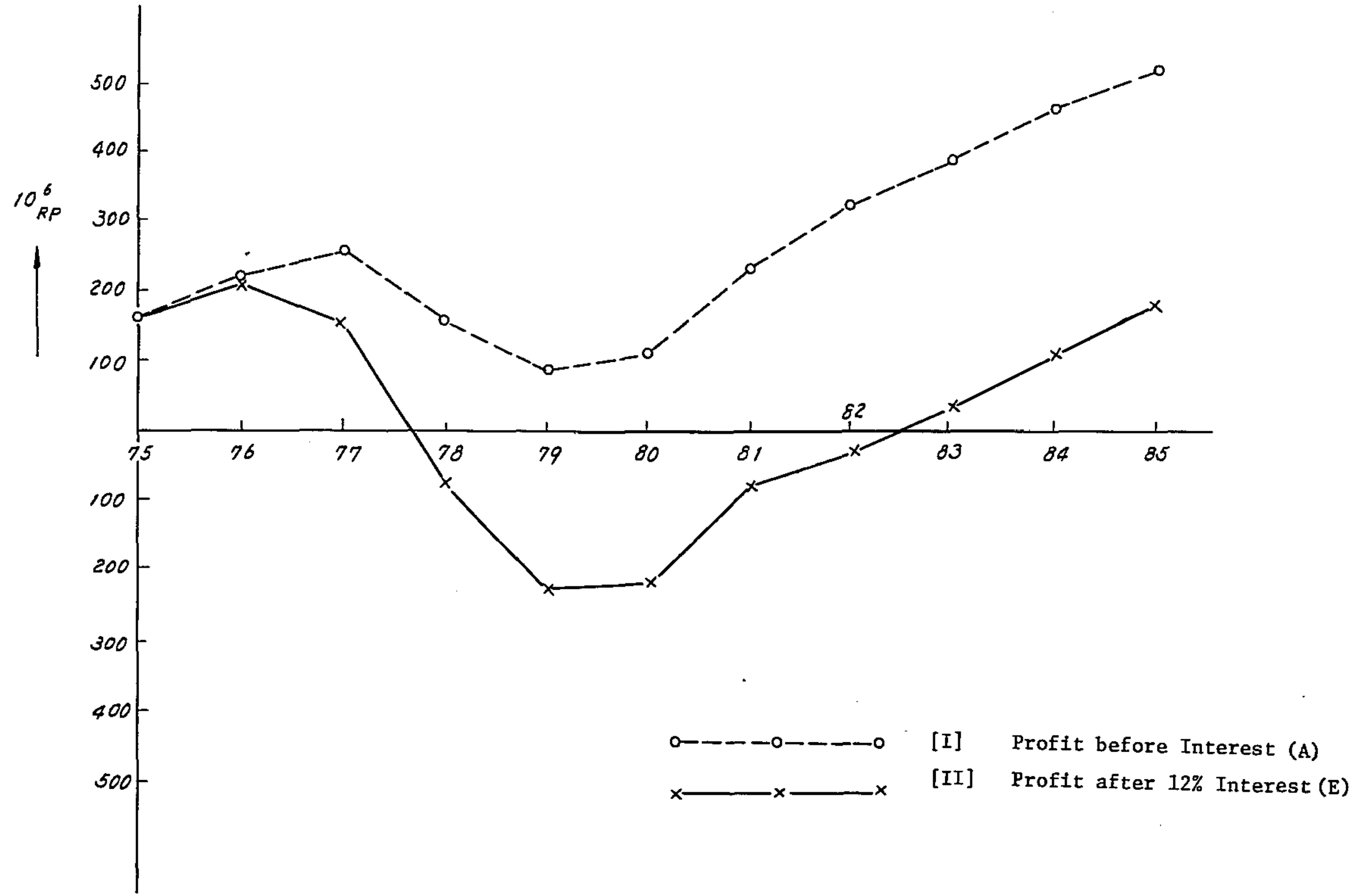
* Interest for average book value;
Average book value during the development period

$$= \frac{\text{Book value at the beginning of the period} + \text{Book value at the end of the period}}{2}$$

** Red-figure Interest = Cumulative total of deficit at the end of the preceding business year x 12%

(Profit interest marked with ▲ when the cumulative total is in black)

Fig. IV-7. Transition of Profit (Case 1)



3.2 Case 2 - Installation of Diesel Oil Catalytic Reformer

Since no natural gas will be introduced in Cases 2 and 3, it is necessary to continuously supply gas of about 4,200 Kcal/$m^3$. This means that the supply condition must be improved with the demand growth. The approximate cost of supply condition improvement is estimated at 20% of the capital input for pipeline construction.

Cost of Supply Condition Improvement
(Unit: x$10^6$Rp)

| | 79 | 80 | 81 | 82 | 83 | 84 | 85 |
|---|---|---|---|---|---|---|---|
| Cost | 10 | 20 | 37 | 43 | 50 | 57 | 66 |

Case 2 calls for investment of about Rp 5.8 billion. Since this amount is about Rp 1.5 billion larger than is required in Case 1, the current account will continue registering red figures due to high interest payable althrough the business account will keep recording slight deficit or black figures. Deficit will continue for almost ten years. Hence, management will be financially difficult unless interest-free fund is provided by the government.

Table IV-22. Projected Investment (Case 2)

| | | |
|---|---|---|
| Production Facilities * | | $x10^6$Rp |
| LPG injection | 73 | |
| 1st investment (1977) | 2,004 | |
| 2nd " (1979) | 566 | |
| 3rd " (1984) | 275 | |
| Rehabilitation (Pipeline) | 1,253 | |
| Gas meters | 60 | |
| Midium Pressure Line | 359 | |
| Distribution Expansion | 933 | |
| Distribution Improvement | 283 | |
| | 5,806 | |

* Annual inflation rate ..... 5%

Table IV-23. Raw Materials & By-products (Case 2)

| | Gas production ($x10^6 m^3$) | * Material (kℓ) | Unit price (Rp/Kℓ) | A Material cost ($x10^6$ Rp) | ** Tar (kℓ) | Unit price (Rp/kℓ) | B By-product revenue ($x10^6$ Rp) | Net Cost A - B ($x10^6$ Rp) |
|---|---|---|---|---|---|---|---|---|
| 1975 | 15.1 | | | | | | | |
| 76 | 13.4 | | | | | | | |
| 77 | 12.9 | | | | | | | |
| 78 | 12.9 | 11,120 | 15,000 | 167 | 1,434 | 80,000 | 115 | 52 |
| 79 | 13.9 | 11,980 | 15,500 | 186 | 1,545 | | 123 | 63 |
| 80 | 15.5 | 13,360 | 15,900 | 212 | 1,723 | | 138 | 74 |
| 81 | 17.4 | 15,000 | 16,400 | 246 | 1,935 | | 155 | 91 |
| 82 | 19.4 | 16,720 | 16,900 | 283 | 2,157 | | 173 | 110 |
| 83 | 21.8 | 18,790 | 17,400 | 327 | 2,424 | | 194 | 133 |
| 84 | 24.3 | 20,950 | 17,900 | 375 | 2,703 | | 216 | 159 |
| 85 | 27.3 | 23,530 | 18,400 | 433 | 3,035 | | 243 | 190 |

* Gas production per unit volume of oil 1,160 $m^3$/Kℓ

** Tar production 0.129 Kℓ/Kℓ

Table IV-24. Revenue (Case 2)

(Unit: $10^6$Rp)

| Year | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gas sales * | | | | | 468 | 591 | 663 | 834 | 927 | 1,040 | 1,167 | 1,309 |
| By-products | | | | | 115 | 123 | 138 | 155 | 173 | 194 | 216 | 243 |
| Total | | 621 | 735 | 920 | 583 | 714 | 801 | 989 | 1,100 | 1,234 | 1,383 | 1,552 |

* including meter & pipe charge

Table IV-25. Depreciation Schedule (Case 2)

(Unit: $10^6$Rp)

| | | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Production Facilities | Upper | | | 73 | 2,004 | | 566 | | | | | 275 | |
| | Lower | | | | 7 | 187 | 187 | 238 | 238 | 238 | 238 | 238 | 263 |
| Rehabilitation Cost | Upper | | | 500 | 500 | 253 | | | | | | | |
| | Lower | | | | 22 | 45 | 56 | 56 | 56 | 56 | 56 | 56 | 56 |
| Gas meter | Upper | | | 20 | 20 | 20 | | | | | | | |
| | Lower | | | | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Medium Pressure Pipeline | Upper | | | | | 359 | | | | | | | |
| | Lower | | | | | | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Demand Expansion Line | Upper | | | | 10 | 12 | 24 | 28 | 126 | 146 | 169 | 194 | 224 |
| | Lower | | | | | | 1 | 2 | 3 | 9 | 16 | 23 | 32 |
| Distribution Improvement | Upper | | | | | | 10 | 20 | 37 | 43 | 50 | 57 | 66 |
| | Lower | | | | | | | | 1 | 3 | 5 | 7 | 10 |
| Base | Upper | | | | | | | | | | | | |
| | Lower | (15) | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 |
| Total | Upper | | | 593 | 2,534 | 644 | 600 | 48 | 163 | 189 | 219 | 526 | 290 |
| | Lower | (15) | 14 | 13 | 42 | 245 | 273 | 324 | 325 | 332 | 340 | 348 | 384 |

Note) Upper column: Amount of investment
Lower column: Depreciation
Base : Depreciation for existing facilites

Table IV-26. Book Value Schedule (Case 2)

(Unit: $10^6$Rp)

| | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cumulative Total of Acquisition Cost | 0 | | 593 | 3,127 | 3,771 | 4,371 | 4,419 | 4,582 | 4,771 | 4,990 | 5,516 | 5,806 |
| Cumulative Total of Depreciation Expence | (15) | 14 | 27 | 69 | 314 | 587 | 911 | 1,236 | 1,568 | 1,908 | 2,256 | 2,640 |
| Book value | | | 566 | 3,059 | 3,457 | 3,784 | 3,508 | 3,346 | 3,203 | 3,082 | 3,260 | 3,166 |

Table IV-27. Annual Loss of PGN Jakarta (Case 2)

(Unit: $10^6$Rp)

| | Material Cost | Personnele Cost | Walfare Cost | General Administration Cost | Insurance Cost | Demand Expansion Cost | Depreciation Expance | Repair Cost | Overhead Cost | Catalyst Cost | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 293 | 62 | 12 | 60 | 1 | 1 | 14 | | 15 | - | 458 |
| 76 | 334 | 68 | 14 | 63 | 1 | 1 | 13 | | 16 | - | 510 |
| 77 | 446 | 75 | 15 | 66 | 4 | 1 | 42 | 6 | 17 | - | 672 |
| 78 | 167 | 82 | 16 | 69 | 25 | 1 | 245 | 32 | 17 | - | 654 |
| 79 | 186 | 91 | 18 | 72 | 27 | 1 | 273 | 38 | 18 | 4 | 728 |
| 80 | 212 | 100 | 20 | 76 | 32 | 1 | 324 | 88 | 19 | 4 | 876 |
| 81 | 246 | 110 | 22 | 80 | 33 | 1 | 325 | 88 | 20 | 6 | 931 |
| 82 | 283 | 121 | 24 | 84 | 33 | 1 | 332 | 92 | 21 | 6 | 997 |
| 83 | 327 | 133 | 27 | 88 | 34 | 1 | 340 | 95 | 22 | 6 | 1,073 |
| 84 | 375 | 146 | 29 | 92 | 35 | 1 | 348 | 99 | 23 | 6 | 1,155 |
| 85 | 433 | 161 | 32 | 97 | 38 | 2 | 384 | | 24 | 6 | 1,342 |

Table IV-28. Annual P/L of PGN Jakarta (Case 2)

(Unit: $10^6$Rp)

| | P | L | A P-L | Book Value (year end) | B* Book Value x 12% | C =A-B | Interest to Red Figure D ** | Net Profit or loss E=C-D | Cumulative Total of Profit |
|---|---|---|---|---|---|---|---|---|---|
| 1975 | 621 | 458 | 163 | | | 163 | | 163 | 163 |
| 76 | 735 | 510 | 225 | 566 | 34 | 191 | ▲ 20 | 211 | 374 |
| 77 | 920 | 672 | 248 | 3,058 | 217 | 31 | ▲ 45 | 76 | 450 |
| 78 | 583 | 654 | ▲ 71 | 3,457 | 391 | ▲462 | ▲ 54 | ▲408 | 42 |
| 79 | 714 | 728 | ▲ 14 | 3,784 | 434 | ▲448 | ▲ 5 | ▲443 | ▲ 401 |
| 80 | 801 | 876 | ▲ 75 | 3,508 | 438 | ▲513 | 48 | ▲561 | ▲ 962 |
| 81 | 989 | 931 | 58 | 3,346 | 411 | ▲353 | 115 | ▲468 | ▲1,430 |
| 82 | 1,100 | 997 | 103 | 3,203 | 393 | ▲290 | 171 | ▲461 | ▲1,891 |
| 83 | 1,234 | 1,073 | 161 | 3,082 | 377 | ▲216 | 227 | ▲443 | ▲2,334 |
| 84 | 1,383 | 1,155 | 228 | 3,260 | 381 | ▲153 | 280 | ▲433 | ▲2,767 |
| 85 | 1,552 | 1,342 | 210 | 3,166 | 386 | ▲176 | 332 | ▲508 | ▲3,275 |

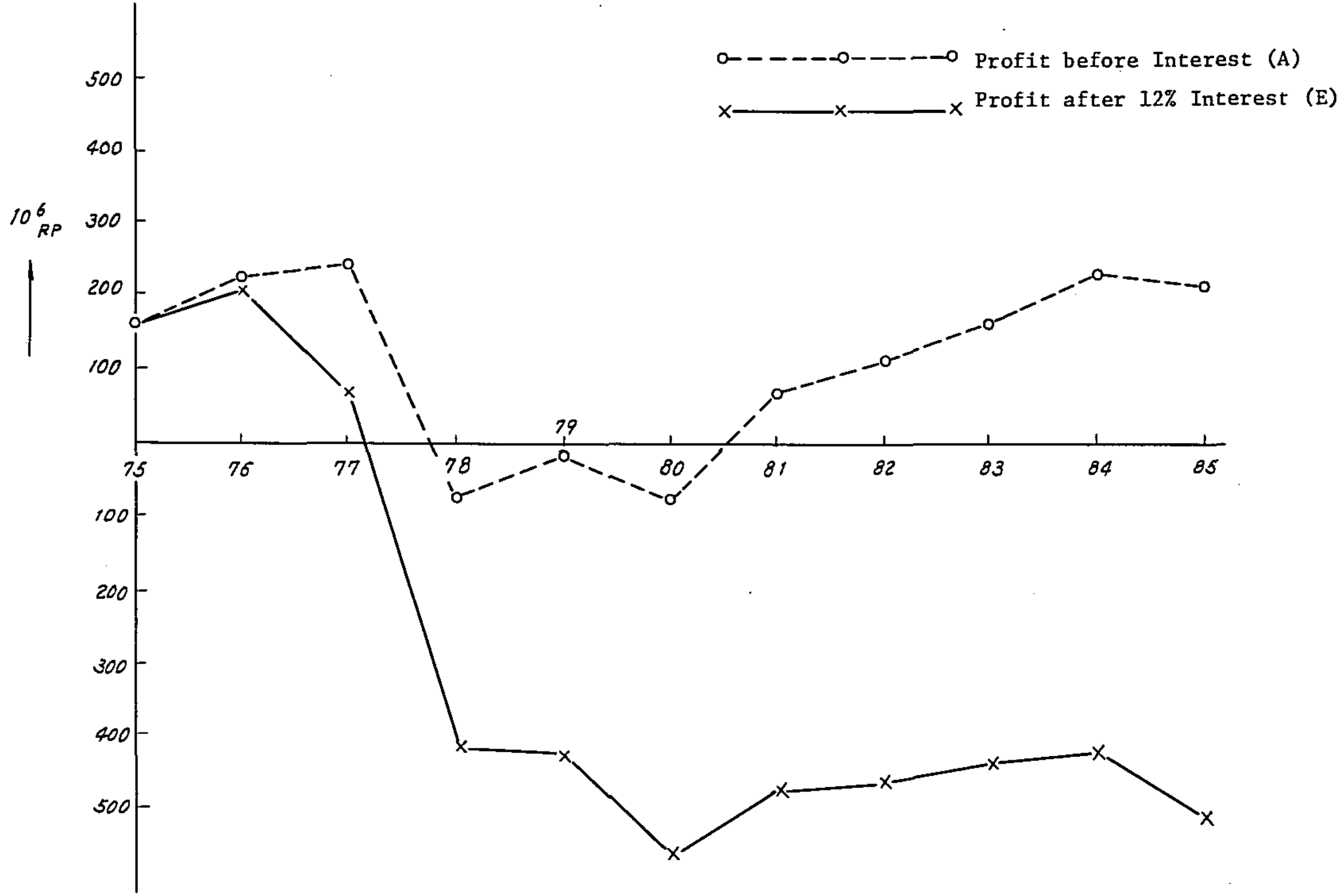
* Interest to average book value;

$$\text{Average book value during the development period} = \frac{\text{Book value at the beginning of the period} + \text{Book value at the end of the period}}{2}$$

** Red-figure Interest = Cumulative total of deficit at the end of the preceding business year x 12%

Profit interest marked with ▲ when the cumulative total is in black.

Fig. IV-8. Transition of Profit (Case 2)



### 3.3 Case 3 - Coal Gas Production

Case 3 calls for investment of about Rp 7.8 billion as shown below. Since this amount is about Rp 3.5 billion larger than is required in Case 1, there will be a heavy burden of interest.

However, since a large income from the sale of coke can be expected, the monthly deficit will remain at a low level. As the amount of interest is large, it will take a considerably long time before the account is improved.

Validity of this plan will naturally vary by the market price of coke, and it leaves some doubt whether the current price level of Rp 130,000/t can be maintained because domestic coke production will be largely augmented.

Hence, Case 3 seems to involve a great risk of investment.

Table IV-29. Projected Investment (Case 3)

| | |
|---|---|
| Production Facilities * | $\times 10^6$ Rp |
| LPG injection | 73 |
| 1st investment (1978) | 3,538 |
| 2nd " (1983) | 1,275 |
| Rehabilitation (Pipeline) | 1,253 |
| Gas meters | 60 |
| Midium Pressure Line | 359 |
| Distribution Expansion | 933 |
| Distribution Improvement | 283 |
| | 7,774 |

* Annual inflation rate ..... 5%

Table IV-30. Raw materials & By-products (Case 3)

(a) Raw Material Cost

| | Gas Production ($10^6 m^3$) | Coal ($10^3 t$) | Unit Price of coal (Rp/t) | Coal Cost ($10^6$ Rp) | Fuel Oil ($10^3$ Kℓ) | Unit Price of Fuel (Rp/kℓ) | Fuel oil Cost ($10^6$ Rp) | LPG (t) | Unit Price of LPG (Rp/t) | LPG Cost $10^6$ Rp | Total Cost ($10^6$ Rp) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 15.1 | | | | | | | | | | |
| 76 | 13.4 | | | | | | | | | | |
| 77 | 12.9 | | | | | | | | | | |
| 78 | 12.9 | | 54,000 | | | 15,000 | | | 52,000 | | |
| 79 | 13.9 | (13.2)* 29.3 | 55,620 | 1,630 | 2.3 | 15,500 | 36 | (0.7)** 226 | 53,560 | 12 | 1,678 |
| 80 | 15.5 | (14.7) 32.7 | 57,290 | 1,873 | 2.6 | 15,900 | 41 | (0.8) 258 | 55,170 | 14 | 1,928 |
| 81 | 17.4 | (16.4) 36.4 | 59,010 | 2,148 | 2.9 | 16,400 | 48 | (1.0) 322 | 56,820 | 18 | 2,214 |
| 82 | 19.4 | (16.4) 36.4 | 60,780 | 2,201 | 2.9 | 16,900 | 49 | (3.0) 967 | 58,530 | 56 | 2,307 |
| 83 | 21.8 | (20.7) 46.0 | 62,600 | 2,880 | 3.7 | 17,400 | 64 | (1.1) 355 | 60,280 | 21 | 2,965 |
| 84 | 24.3 | (23.1) 51.3 | 64,480 | 3,308 | 4.1 | 17,900 | 73 | (1.2) 387 | 62,090 | 24 | 3,405 |
| 85 | 27.3 | (24.6) 54.7 | 66,400 | 3,632 | 4.4 | 18,400 | 81 | (2.7) 871 | 63,950 | 56 | 3,769 |

* Figures in parentheses: portion of coal gas ($10^6 m^3/y$).

** Portion of LPG gas ($10^6 m^3/y$)

Preconditions:
- 1st coke oven investment — 100 t/D ∿ 36,500 t/Y — 450 $m^3/t$ → 16.4 x $10^6 m^3/y$ max.
- 2nd " — 50 t/D ∿ total 150 t/D — 450 $m^3/t$ → 24.6 x $10^6 m^3/y$ max.
- CG-yield — 450 $m^3/t$
- LPG-yield — 3,100 $m^3/t$
- Fuel Oil requirement — 0.08 Kℓ/ton-coal

(b) By-product Revenue

| | Coke ($10^3 t$) | Unit Price of Coke (Rp/t) | Revenue from Coke ($10^6$ Rp) | Tar ($10^3$ Kℓ) | Unit Price of Tar (Rp/kℓ) | Revenue from Tar ($10^6$ Rp) | Total By-products Revenue ($10^6$ Rp) |
|---|---|---|---|---|---|---|---|
| 1975 | | | | | | | |
| 76 | | | | | | | |
| 77 | | | | | | | |
| 78 | | | | | | | |
| 79 | 14.7 | 130,000 | 1,911 | 1.5 | 80,000 | 120 | 2,031 |
| 80 | 16.4 | | 2,132 | 1.6 | | 128 | 2,260 |
| 81 | 18.2 | | 2,366 | 1.8 | | 144 | 2,510 |
| 82 | 18.2 | | 2,366 | 1.8 | | 144 | 2,510 |
| 83 | 23.0 | | 2,990 | 2.3 | | 184 | 3,174 |
| 84 | 25.7 | | 3,341 | 2.6 | | 208 | 3,549 |
| 85 | 27.3 | | 3,549 | 2.7 | | 216 | 3,765 |

Table IV-31. Annual Revenue (Case 3)

(Unit: $10^6$Rp)

| | Gas sales * | By-products | Total |
|---|---|---|---|
| 1975 | | | 621 |
| 76 | | | 735 |
| 77 | | | 920 |
| 78 | 488 | 628 | 1,116 |
| 79 | 591 | 2,031 | 2,622 |
| 80 | 663 | 2,260 | 2,923 |
| 81 | 834 | 2,510 | 3,344 |
| 82 | 927 | 2,510 | 3,437 |
| 83 | 1,040 | 3,174 | 4,214 |
| 84 | 1,167 | 3,549 | 4,716 |
| 85 | 1,309 | 3,765 | 5,134 |

* including meter & pipe charge

Table IV-32. Depreciation Schedule (Case 3)

(Unit: $10^6$Rp)

| | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Production Facilities | | | 73 | | 3,056 | | | | | 863 | | |
| | | | | 7 | 7 | 282 | 282 | 282 | 282 | 282 | 360 | 360 |
| Rehabilitation Cost | | | 500 | 500 | 253 | | | | | | | |
| | | | | 22 | 45 | 56 | 56 | 56 | 56 | 56 | 56 | 56 |
| Gas meter | | | 20 | 20 | 20 | | | | | | | |
| | | | | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Medium Pressure Pipeline | | | | | 359 | | | | | | | |
| | | | | | | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Demand Expansion Line | | | | 10 | 12 | 24 | 28 | 126 | 146 | 169 | 194 | 224 |
| | | | | | | 1 | 2 | 3 | 9 | 16 | 23 | 32 |
| Distribution Improvement | | | | | | 10 | 20 | 37 | 43 | 50 | 56 | 66 |
| | | | | | | | | 1 | 3 | 5 | 7 | 10 |
| Base | | | | | | | | | | | | |
| | (15) | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 |
| Total | | | 593 | 530 | 3,700 | 34 | 48 | 163 | 189 | 1,082 | 251 | 290 |
| | (15) | 14 | 13 | 42 | 65 | 368 | 368 | 369 | 376 | 384 | 470 | 481 |

Note) Upper Column: Amount of investment

Lower Column: Depreciation

Base : Depreciation for existing facilities

Table IV-33. Book Value Schedule (Case 3)

(Unit: $10^6$Rp)

| | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cumulative Total of Acquisition Cost | | | 593 | 1,123 | 4,823 | 4,857 | 4,905 | 5,068 | 5,257 | 6,339 | 6,590 | 6,880 |
| Cumulative Total of Depreciation Expence | (15) | 14 | 27 | 69 | 134 | 502 | 807 | 1,239 | 1,615 | 1,999 | 2,469 | 2,950 |
| Book value | | | 566 | 1,054 | 4,689 | 4,355 | 4,035 | 3,829 | 3,642 | 4,340 | 4,121 | 3,930 |

Table IV-34. Annual Loss of PGN Jakarta (Case 3)

(Unit: $10^6$Rp)

| | Material Cost | Person-nel Cost | Walfare Cost | General Adminis-tration Cost | Insurance Cost | Demand Expan-sion Cost | Deprecia-tion Expense | Repair Cost | Overhead Cost | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 293 | 62 | 12 | 60 | 1 | 1 | 14 | - | 15 | 458 |
| 76 | 344 | 68 | 14 | 63 | 1 | 1 | 13 | - | 16 | 510 |
| 77 | 446 | 75 | 15 | 66 | 4 | 1 | 42 | 6 | 17 | 672 |
| 78 | 565 | 82 | 16 | 69 | 6 | 1 | 65 | 11 | 17 | 832 |
| 79 | 1,678 | 91 | 18 | 72 | 37 | 1 | 368 | 48 | 18 | 2,331 |
| 80 | 1,928 | 100 | 20 | 76 | 37 | 1 | 368 | 97 | 19 | 2,646 |
| 81 | 2,214 | 110 | 22 | 80 | 37 | 1 | 369 | 98 | 20 | 2,951 |
| 82 | 2,307 | 121 | 24 | 84 | 38 | 1 | 376 | 101 | 21 | 3,073 |
| 83 | 2,965 | 133 | 27 | 88 | 38 | 1 | 384 | 105 | 22 | 3,763 |
| 84 | 3,405 | 147 | 29 | 92 | 47 | 1 | 470 | 127 | 23 | 4,341 |
| 85 | 3,769 | 161 | 32 | 97 | 48 | 2 | 481 | 197 | 24 | 4,811 |

Table IV-35. Annual P/L of PGN Jakarta (Case 3)

(Unit: $10^6$Rp)

| | P | L | A P-L | Book Value (year end) | B* Book Value x 12% | C =A-B | Interest to Red Figure D ** | Net Profit or loss E=C-D | Cumulative Total of Profit |
|---|---|---|---|---|---|---|---|---|---|
| 1975 | 621 | 458 | 163 | | | 163 | | 163 | 163 |
| 76 | 735 | 510 | 225 | 566 | 34 | 191 | ▲20 | 211 | 374 |
| 77 | 920 | 672 | 248 | 1,054 | 97 | 151 | ▲45 | 196 | 570 |
| 78 | 1,116 | 832 | 284 | 4,689 | 345 | ▲ 61 | ▲68 | 7 | 577 |
| 79 | 2,622 | 2,331 | 291 | 4,355 | 543 | ▲252 | ▲69 | ▲183 | 394 |
| 80 | 2,923 | 2,646 | 277 | 4,035 | 503 | ▲226 | ▲47 | ▲179 | 215 |
| 81 | 3,344 | 2,951 | 393 | 3,829 | 472 | ▲ 79 | ▲26 | ▲ 53 | 162 |
| 82 | 3,437 | 3,073 | 364 | 3,642 | 448 | ▲ 84 | ▲19 | ▲ 65 | 93 |
| 83 | 4,214 | 3,763 | 451 | 4,340 | 479 | ▲ 28 | ▲11 | ▲ 17 | 76 |
| 84 | 4,716 | 4,341 | 375 | 4,121 | 508 | ▲133 | ▲ 9 | ▲124 | ▲ 48 |
| 85 | 5,134 | 4,811 | 323 | 3,930 | 483 | ▲140 | 6 | ▲146 | ▲194 |

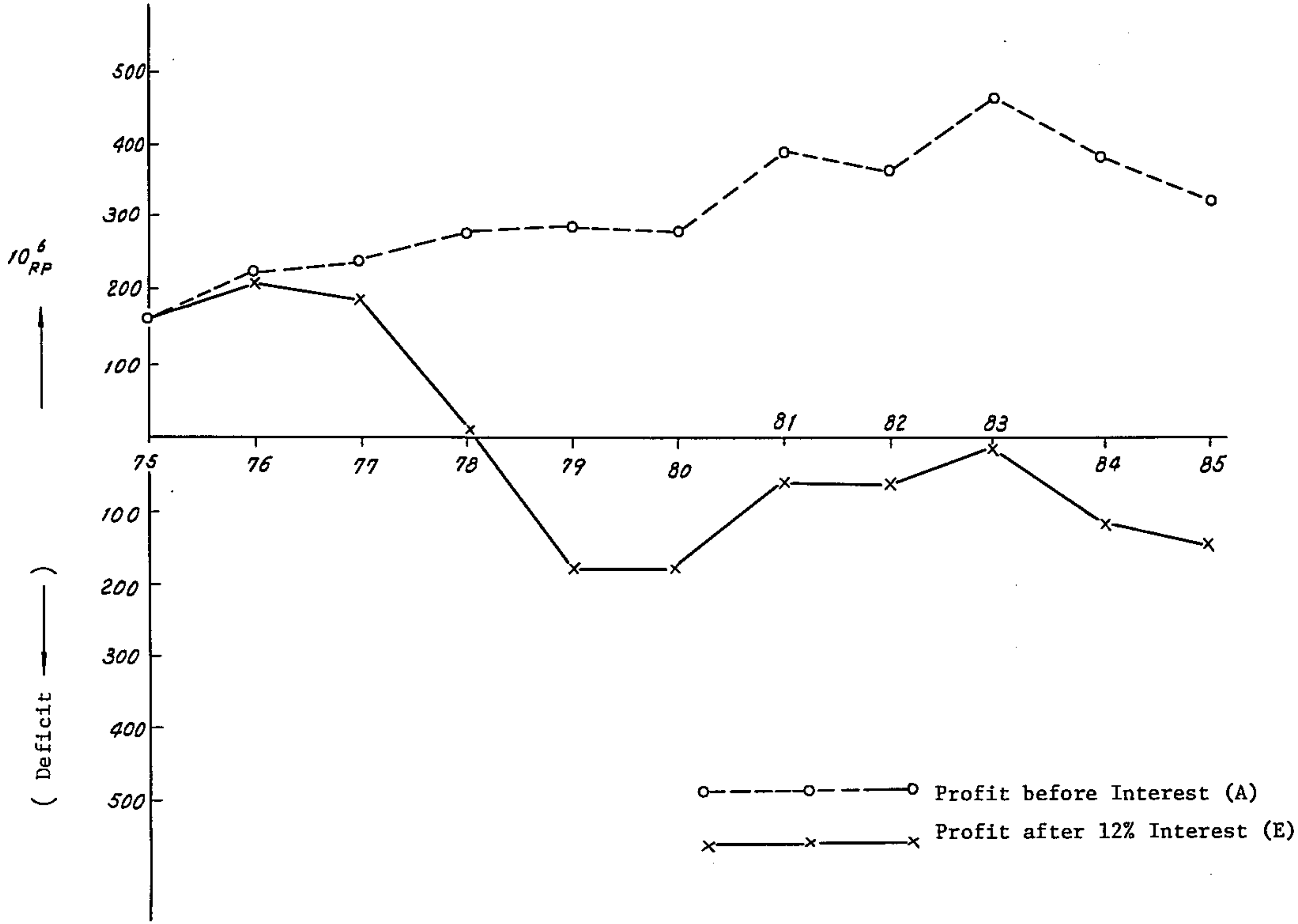
* Interest to average book value;

Average book value during the development period = $\dfrac{\text{Book value at the beginning of the period} + \text{Book value at the end of the period}}{2}$

** Red-figure Interest = Cumulative total of deficit at the end of the preceding business year x 12%

Profit interest marked with ▲ when the cumulative total is in black.

Fig. IV-9. Transition of Profit (Case 3)



3.4 Findings of Economic Evaluation

Transitions of profits (or loss) obtained from expenditures and incomes of PGN Jakarta in Case 1, Case 2 and Case 3 are shown in Fig. IV-7, IV-8 and IV-9 respectively, which indicate the following points:

1 If interest expense is not deducted, black figures will be maintained in all cases.

2 After deduction of the 12% interest, PGN Jakarta (in all cases) will run into deficit after 1977 ∿ 8 due to the investment burden.

3 In Case 1, the first black figure profit after deficit period will be recorded in 1983.
However, in Case 2 and Case 3, deficits will continue more than 10 years due to high interest payments.

4 In Case 1, PGN Jakarta enters into its growth period after 1983.
However, in Case 2 and Case 3, management will be financially difficult unless interest free fund is provided by the government.

5 Hence, Case 1 - Natural Gas Conversion is most suitable for PGN Jakarta from the view point of economic evaluation.

4. Government's Support

As discussed in the foregoing pages, Jakarta as the capital city of the country is in acute need of gas and is given top priority under the rehabilitation and development plan. The government is urged to take full note of this fact and give active support to the PGN Jakarta's rehabilitation and development plan so that the capital's gas supply system will be improved to the level worthy of the name.

Specifically, it is hoped that the following measures will be enforced by the government.

(1) Promotion of Natural Gas Introduction

As described already, natural gas is the best material of gas and its early introduction is strongly hoped for specially because of the fact that the installation of either diesel oil catalytic reformer (Case 2) or coke oven (Case 3) is of very low payability. In Java island, a natural gas transmission line connecting Cilamaya and Cilegon is now under construction, and there is a plan to introduce natural gas to Jakarta from this line as mentioned in Chapter III. However, this plan has not yet been formally adopted because the transmission line is primarily intended to fill the industrial demand in Cilegon area (iron and steel) and for fertilizer industry. In view of the importance of the rehabilitation and development plan of PGN Jakarta and the incontestable fact that early completion of the plan hinges on the natural gas introduction, it is recommended that the government make endeavours to obtain the consensus of opinion of all pertinent offices and organizations and to take adequate actions for early implementation of the natural gas conversion plan.

(2) Preferential Rehabilitation

As pointed out earlier, Jakarta's gas supply system entails a diversity of problems to be solved before natural gas conversion, such as poor gas quality, high percent leakage, aggravated supply conditions, etc. It will therefore be necessary for the government to clearly incorporate the rehabilitation plan into the framework of Jakarta's city planning and promote its preferential execution. For protection of users, it is desirable that the government take an active part in the rehabilitation.

(3) Financial Support

Satisfactory enforcement of measures (1) and (2) above calls for the input of about Rp $4.3 \times 10^9$ ( = US$10 million) within 10 years to come.
Considering its present financial situation, it will be extremely difficult for PGN to raise this amount on its own. The government will therefore be required to either appropriate this fund in the budget or take an adequate measure so as to enable PGN to secure the necessary loan. In preceding sections, study of income and expenditure was made on the assumption that the necessary fund would be advanced on rather soft terms, i.e., at an annual interest rate of 12% and refundable over a period of 20 years. Raising this fund is a must for the rehabilitation and development of PGN Jakarta, and if it is made available on softer terms or disbursed from the Treasury, it will naturally result in quicker improvement of PGN's management and earlier reinvestment for expansion of gas facilities. Further, if the government grants subsidy to cover the interest accruing on loans borrowed to fill temporary deficit, PGN will be managed on a sounder basis.

In Japan, the "First Five Year Plan for Gas Diffusion (1952 - 1957)" was put in execution in the rehabilitation period after the World War II. Under this plan, the number of customers and gas sales respectively increased by 1.6 times and 1.9 times (See the attached data, "Brief Introduction of Development of Japanese Gas Enterprises").

Although the aforementioned study of income and expenditure of PGN Jakarta is based on a low growth rate estimated from the past trend, it is certain that implementation of the rehabilitation and development plan will result in the improvement of the gas quality, supply conditions and services for customers, and will also serve to regain the customers' confidence in gas and secure large numbers of new customers as well. Thus, the plan is sure to lead to a phenomenal improvement and expansion of Jakarta's gas supply system to the level befitting the capital of Indonesia, and at the same time contribute to industrial and economic development as well as people's welfare in Jakarta and surrounding cities.

* * * * *

## APPENDIX

[APPENDIX 1]

Number of Consumers (at year end)

| | | 1962 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|---|---|---|---|
| MEDAN | Domestic | 1.957 | 1.991 | 1.905 | 1.785 | 1.727 | 1.605 | 1.496 |
| | Others | 52 | 8 | 8 | 9 | 8 | 10 | 5 |
| | Total | 2.009 | 1.999 | 1.913 | 1.794 | 1.735 | 1.615 | 1.501 |
| JAKARTA | Domestic | 8.096 | 7.337 | 6.679 | 6.192 | 5.982 | 5.901 | 6.112 |
| | Others | 160 | 89 | 72 | 68 | 60 | 58 | 53 |
| | Total | 8.256 | 7.426 | 6.751 | 6.260 | 6.042 | 5.959 | 6.165 |
| BOGOR | Domestic | 1.393 | 1.311 | 1.228 | 1.174 | 1.144 | 1.125 | 1.097 |
| | Other | 48 | 22 | 19 | 16 | 16 | 14 | 16 |
| | Total | 1.441 | 1.333 | 1.247 | 1.190 | 1.160 | 1.139 | 1.113 |
| BANDUNG | Domestic | 5.865 | 5.952 | 5.892 | 5.631 | 5.575 | 5.514 | 5.512 |
| | Others | 151 | 88 | 75 | 69 | 64 | 63 | 62 |
| | Total | 6.016 | 6.040 | 5.967 | 5.700 | 5.639 | 5.577 | 5.574 |
| CIREBON | Domestic | 724 | 731 | 650 | 615 | 602 | 597 | 598 |
| | Others | 15 | 18 | 15 | 15 | 13 | 15 | 5 |
| | Total | 739 | 749 | 665 | 630 | 615 | 612 | 603 |
| SEMARANG | Domestic | 3.068 | 2.620 | 2.380 | 2.223 | 2.118 | 2.095 | 2.025 |
| | Others | 40 | 32 | 22 | 26 | 28 | 22 | 28 |
| | Total | 3.108 | 2.652 | 2.402 | 2.249 | 2.146 | 2.117 | 2.053 |
| SURABAYA | Domestic | 5.782 | 5.131 | 4.916 | 4.652 | 4.559 | 4.450 | 4.425 |
| | Others | 304 | 217 | 75 | 51 | 47 | 42 | 42 |
| | Total | 6.086 | 5.348 | 4.991 | 4.703 | 4.606 | 4.492 | 4.467 |
| UJUNG PANDANG | Domestic | 640 | 435 | 391 | 398 | 394 | 392 | 394 |
| | Others | 22 | 18 | 28 | 8 | 10 | 11 | 11 |
| | Total | 662 | 453 | 419 | 406 | 404 | 403 | 405 |
| GRAND TOTAL | Domestic | 27.515 | 25.508 | 24.041 | 22.670 | 22.138 | 21.679 | 21.659 |
| | Others | 802 | 492 | 314 | 262 | 246 | 235 | 222 |
| | Total | 28.317 | 26.000 | 24.355 | 22.932 | 22.384 | 21.914 | 21.881 |

[APPENDIX 2]

Quantity of Gas Sales

(Unit: $10^3m^3$)

| | | 1962 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|---|---|---|---|
| MEDAN | Domestic | 2.921 | 2.177 | 1.682 | 1.447 | 1.544 | 1.913 | 1.884 |
| | Others | 832 | 150 | 106 | 115 | 181 | 314 | 388 |
| | Total | 3.753 | 2.327 | 1.788 | 1.562 | 1.725 | 2.227 | 2.272 |
| JAKARTA | Domestic | 10.067 | 7.003 | 6.162 | 5.378 | 4.837 | 5.453 | 8.226 |
| | Others | 4.747 | 1.941 | 2.127 | 1.910 | 1.618 | 1.779 | 1.142 |
| | Total | 14.814 | 8.944 | 8.289 | 7.288 | 6.455 | 7.232 | 9.368 |
| BOGOR | Domestic | 1.456 | 974 | 798 | 624 | 661 | 699 | 712 |
| | Others | 961 | 629 | 680 | 364 | 387 | 437 | 394 |
| | Total | 2.417 | 1.603 | 1.478 | 988 | 1.048 | 1.136 | 1.106 |
| BANDUNG | Domestic | 7.335 | 5.369 | 4.642 | 3,745 | 3.471 | 4.043 | 4.787 |
| | Others | 3.366 | 2.054 | 2.059 | 2.001 | 1.731 | 2.008 | 1.532 |
| | Total | 10.701 | 7.423 | 6.701 | 5.746 | 5.202 | 6.051 | 6.319 |
| CIREBON | Domestic | 927 | 661 | 537 | 418 | 492 | 466 | 452 |
| | Others | 347 | 278 | 224 | 189 | 85 | 169 | 217 |
| | Total | 1.274 | 939 | 761 | 607 | 577 | 635 | 667 |
| SEMARANG | Domestic | 3.926 | 1.950 | 1.689 | 1.716 | 1.352 | 1.354 | 1.717 |
| | Others | 1.519 | 862 | 686 | 370 | 694 | 666 | 278 |
| | Total | 5.445 | 2.812 | 2.375 | 2.086 | 2.046 | 2.020 | 1.995 |
| SURABAYA | Domestic | 6.400 | 3.422 | 3.361 | 3.332 | 3.022 | 3.013 | 4.774 |
| | Others | 5.149 | 1.946 | 2.369 | 3.326 | 3.489 | 3.563 | 2.271 |
| | Total | 11.549 | 5.368 | 5.730 | 6.658 | 6.511 | 6.574 | 7.045 |
| UJUNG PANDANG | Domestic | 635 | 334 | 313 | 301 | 392 | 413 | 368 |
| | Others | 527 | 372 | 391 | 380 | 276 | 298 | 299 |
| | Total | 1.162 | 706 | 704 | 681 | 668 | 711 | 667 |
| GRAND TOTAL | Domestic | 33.668 | 21.901 | 18.547 | 16.961 | 15.772 | 17.345 | 22.920 |
| | Others | 17.448 | 8.232 | 8.642 | 8.655 | 8.459 | 9.243 | 6.521 |
| | Total | 51.116 | 30.133 | 27.189 | 25.616 | 24.231 | 26.588 | 29.441 |

[APPENDIX 3]

Quantity of Gas Production

(Unit: 1.000 $m^3$)

| | 1962 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|---|---|---|
| MEDAN | 4.236 | 3.094 | 2.578 | 2.520 | 2.289 | 2.533 | 3.210 |
| JAKARTA | 16.140 | 11.334 | 11.427 | 9.680 | 7.694 | 8.733 | 12.103 |
| BOGOR | 2.441 | 1.806 | 1.720 | 1.193 | 1.335 | 1.318 | 1.566 |
| BANDUNG | 11.236 | 8.581 | 7.893 | 7.174 | 6.379 | 7.626 | 7.950 |
| CIREBON | 1.426 | 1.078 | 851 | 696 | 694 | 701 | 790 |
| SEMARANG | 6.092 | 3.691 | 3.040 | 2.926 | 2.791 | 2.543 | 2.531 |
| SURABAYA | 14.635 | 9.334 | 8.320 | 8.784 | 7.956 | 8.289 | 9.103 |
| UJUNG PANDANG | 1.487 | 926 | 931 | 865 | 800 | 784 | 777 |
| TOTAL GRAND | 57.690 | 39.844 | 33.839 | 29.957 | 32.528 | 38.030 | 27.068 |

[APPENDIX 4]

Balance Sheet (Include PELITA I) (i)

(1,000 Rupiah)

| Items | 1967 | | 1968 | | 1969 | | 1970 | | 1971 | | 1972 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Balance | % | Balance | % | Balance | % | Balance | % | Balance | % | Balance | % |
| Fixed Assets | | | | | | | | | | | | |
| Land | 3 | - | 3 | - | 3 | - | 3 | - | 3 | - | 3 | - |
| Building | 2.770 | 1,0 | 23.261 | 5,9 | 23.270 | 2,3 | 22.331 | 1,6 | 21.809 | 0,9 | 21,537 | 0.9 |
| Prod. & distri. equipment | 5.334 | 1,9 | 11.656 | 3,0 | 25.938 | 2,6 | 27.995 | 2,1 | 57.359 | 2,4 | 113.756 | 4,4 |
| Vehicle & delivery equip. | 2.312 | 0,8 | 3.482 | 0,9 | 4.935 | 0,5 | 5.518 | 0,4 | 11.155 | 0,5 | 30.226 | 1,2 |
| Office equipment | 671 | 0,2 | 526 | 0,1 | 532 | 0,1 | 558 | - | 696 | 0 | 2.974 | 0,1 |
| Other equipment | 2.186 | 0,7 | 7.466 | 1,9 | 7.798 | 0,8 | 7.880 | 0,6 | 9.806 | 0,4 | 13.566 | 0,5 |
| Construction in process | 1.721 | 0,6 | 9.982 | 2,5 | 149 | - | 551 | - | 1.463 | 0,1 | 7.219 | 0,3 |
| Sub total | 14.997 | 5,2 | 56.376 | 14,3 | 62.625 | 6,3 | 64.836 | 4,7 | 102.291 | 4,3 | 189.281 | 7,4 |
| PELITA I | | | | | 272.730 | 27,2 | 736.882 | 53,9 | 1.240.184 | 51,8 | 1.671.950 | 65,2 |
| Fixed assets total | 14.997 | 5,2 | 56.376 | 14,3 | 335.355 | 33,5 | 801.718 | 58,6 | 1.342.475 | 56,1 | 1.861.231 | 72,6 |
| Current assets Inventories | | | | | | | | | | | | |
| Raw materials | 25.027 | 8,8 | 10.241 | 2,6 | 16.649 | 1,6 | 7.575 | 0,6 | 12.702 | 0,5 | 58.010 | 2,3 |
| Plant materials | 16.156 | 5,6 | 20.348 | 5,2 | 19.799 | 2,0 | 21.853 | 1,6 | 23.317 | 1,0 | 39.928 | 1,5 |
| Products | 23.219 | 8,1 | 4.254 | 1,1 | 17.250 | 1,7 | 685 | - | 2.448 | 0,1 | 22.572 | 0,9 |
| Others | 3.872 | 1,4 | 7.585 | 1,9 | 5.763 | 0,6 | 5.711 | 0,4 | 6.373 | 0,3 | 5.259 | 0,2 |
| Inventories total | 68.274 | 23,9 | 42.428 | 10,8 | 59.461 | 5,9 | 35.824 | 2,6 | 44.840 | 1,9 | 125.749 | 4,9 |
| Cash | | | | | | | | | | | | |
| In hand | 3.835 | 1,3 | 6.169 | 1,5 | 5.913 | 0.6 | 7.565 | 0,5 | 7.510 | 0,3 | 7.086 | 0,3 |
| At banks | 13.647 | 4,8 | 8.914 | 2,3 | 7.521 | 0,7 | 10.687 | 0,8 | 31.483 | 1,3 | 19.460 | 0.7 |
| Cash total | 17.482 | 6,1 | 15.083 | 3,8 | 13.434 | 1,3 | 18.252 | 1,3 | 38.993 | 1,6 | 26.546 | 1,0 |

(to be continued to next pages)

Balance Sheet (Include PELITA I) (ii)

(1,000 Rupiah)

| Items | 1967 | | 1968 | | 1969 | | 1970 | | 1971 | | 1972 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Balance | % | Balance | % | Balance | % | Balance | % | Balance | % | Balance | % |
| Account Receivables | | | | | | | | | | | | |
| Gas | 63.551 | 22,2 | 178.693 | 45,5 | 278.841 | 27,9 | 334.362 | 24,5 | 393.236 | 16,4 | 355.556 | 13,9 |
| By-products | 2.449 | 0,9 | 2.154 | 0,6 | 5.676 | 0,6 | 1.235 | 0,1 | 24.047 | 0,1 | 20.599 | 0,8 |
| Installation | 983 | 0,4 | 1.350 | 0,3 | 2.340 | 0,2 | 2.742 | 0,2 | 1,834 | 0,1 | 4.795 | 0,2 |
| Others | 910 | 0,3 | 170 | - | 78 | - | 10 | - | 526 | - | 110 | - |
| Bad assets | 234 | 0,1 | 220 | 0,1 | 2 | - | 346 | - | 114 | - | 5.589 | 0,2 |
| Account Receivables Total | 68.127 | 23,9 | 182.587 | 46,5 | 286.937 | 28,7 | 338.695 | 24,8 | 419.757 | 17,5 | 386.649 | 15.1 |
| Other Assets | | | | | | | | | | | | |
| Prepayments | 60.828 | 21,3 | 43.510 | 11,1 | 171.555 | 17,1 | 30.621 | 9,5 | 119.791 | 5,0 | 48.349 | 1,9 |
| Advance to employee | 7.400 | 2,6 | 13.542 | 3,4 | 16.902 | 1,7 | 9.395 | 0,7 | 11.039 | 0,5 | 7.266 | 0,3 |
| Account among branches | 45.160 | 15,8 | 35.859 | 9,1 | 117.822 | 11,8 | - | - | - | - | 75.901 | 3,0 |
| Prepayed expense | 3.503 | 1,2 | 3.805 | 1,0 | - | - | 13.500 | 1,0 | 335.547 | 14,0 | 5.039 | 0,2 |
| Others | - | - | - | - | - | - | 20.484 | 1,5 | 82.116 | 3,4 | 26.699 | 1,0 |
| Other assets total | 116.891 | 40,9 | 96.716 | 24,6 | 306.279 | 30,6 | 174.000 | 12,7 | 548.493 | 22,0 | 163.254 | 6,4 |
| Current assets total | 270.774 | 94,8 | 336.814 | 85,7 | 666.111 | 66,5 | 566.771 | 41,4 | 1.052.083 | 43,9 | 702.198 | 27,4 |
| Grand total of assets | 285.771 | 100 | 393.190 | 100 | 1.001.466 | 100 | 1.368.489 | 100 | 2.394.558 | 100 | 1.563.429 | 100 |

(to be continued to next page)

## Balance Sheet (Include PELITA I) (iii)

(1,000 Rupiah)

| Items | 1967 | | 1968 | | 1969 | | 1970 | | 1971 | | 1972 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Balance | % | Balance | % | Balance | % | Balance | % | Balance | % | Balance | % |
| Fixed Liability | | | | | | | | | | | | |
| Deposit received | 3.003 | 1,0 | 4.757 | 1,2 | 2.474 | 0,8 | 9.455 | 0,7 | 10.511 | 0,5 | 12.042 | 0,5 |
| Current Liability | | | | | | | | | | | | |
| Borrowings from bank | - | - | - | - | 130.000 | 13,0 | 130.311 | 9,5 | 177.329 | 7,4 | 282.792 | 11,0 |
| Advance received | 9,865 | 3,4 | 9.854 | 2,5 | 8.074 | 0,8 | 99.528 | 7,3 | 122.621 | 5,1 | 172.921 | 6,7 |
| Account for payable trade | 43.302 | 15,2 | 48.838 | 12,4 | 27.072 | 2,7 | 40.879 | 3,0 | 98.584 | 4,1 | 30.808 | 1,2 |
| (raw material) | (42.654 | - ) | (27.226 | 6,9) | ( 6.710 | 0,7) | (13.349 | 1,0) | (87.413 | 3,6) | ( 2.589 | 0,1) |
| (Others) | ( 648 | - ) | (21.612 | 5,5) | (20.362 | 2,0) | (27.530 | 2,0) | (11.171 | 0,5) | (28.219 | 1,1) |
| Account payable | 7.945 | 2,8 | 12.809 | 3,3 | 204.529 | 20,4 | 32.190 | 2,4 | 40.078 | 1,7 | 68.281 | 2,7 |
| Account among branches | 531.127 | 18,6 | 25.003 | 6,4 | 111.829 | 11,2 | - | - | - | - | - | - |
| Accrued expense | 251 | 0,1 | 3.245 | 0,8 | 8.273 | 0,8 | 21.186 | - | 292.438 | 12,2 | 19.146 | 0,8 |
| Current liability total | 114.490 | 40,1 | 99.749 | 25,4 | 489.777 | 48,9 | 324.094 | 23,7 | 731.050 | 30,5 | 573.948 | 22,4 |
| Liability total | 117.493 | 41,1 | 104.506 | 26,6 | 497.251 | 49,7 | 333.549 | 24,4 | 741.561 | 31,0 | 585.990 | 22,9 |
| Capital | | | | | | | | | | | | |
| Capital | 94 | - | 94 | - | 94 | - | 94 | - | 94 | - | 123 | - |
| General reserve | 73.245 | 25,6 | 255.860 | 65,1 | 244.285 | 24,4 | 280.245 | 20,5 | 397.602 | 16,6 | 476.821 | 18,6 |
| Government fund | 3.288 | 1,2 | 3.288 | 0,8 | 3,288 | 0,3 | 4.580 | 0,3 | 3.288 | 0,1 | 3.288 | 0,1 |
| Government PELITA I | - | - | - | - | 272.730 | 27,2 | 736.882 | 53,9 | 1.240.184 | 51,8 | 1.671.950 | 65,2 |
| Profit/loans (previous year) | 20.145 | 71,1 | 1.613 | 0,4 | 8.711 | 0,9 | 33.859 | 2,5 | 19.077 | 0,8 | 61.127 | 2,4 |
| " (this year) | 71.506 | 25,0 | 27.829 | 7,1 | 24.893 | 2,5 | 46.998 | 3,4 | 30,906 | 1,3 | 113.616 | 4,4 |
| Capital total | 168.278 | 58,9 | 288.684 | 73,4 | 504.215 | 50,3 | 1.034.940 | 75,6 | 1.652.997 | 69,0 | 1.977.439 | 77,1 |
| Grand total of Liability | 285.771 | 100 | 393.190 | 100 | 1.001.466 | 100 | 1.368.489 | 100 | 2.394.558 | 100 | 2.563.429 | 100 |

[APPENDIX 5]

Profit/Loss Statement (Estimated)

(1,000 Rupiah)

| | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|---|---|
| 1. Sales of products. | | | | | | |
| Gas | 216.584 | 464.498 | 554.334 | 534.487 | 602.026 | 673.230 |
| Cokes | 68.250 | 97.130 | 39.120 | 132.561 | 161.664 | 94.556 |
| Tar | 5.577 | 8.547 | 14.652 | 17.051 | 23.190 | 27.634 |
| Total | 290.411 | 570.175 | 608.106 | 684.099 | 786.880 | 795.420 |
| 2. Cost of Sales. | 164.472 | 418.775 | 421.454 | 375.454 | 506.428 | 607.729 |
| Initial inventory | ( 11.827) | ( 23.219) | ( 4.254) | ( 17.250) | ( 685) | ( 2.448) |
| Production Cost | (175.864) | (399.810) | (434.450) | (358.889) | (504.191) | (627.852) |
| Final inventory | ( 23.219) | ( 4.254) | ( 17.250) | ( 685) | ( 2.448) | ( 22.571) |
| Gross profit on Sales | 125.939 | 151.400 | 186.652 | 308.645 | 280.452 | 187.691 |
| 3. Distribution & Selling loss | 46.122 | 105.749 | 139.063 | 155.097 | 158.607 | 186.832 |
| 4. General & administrative profit | 65.434 | 13.564 | 4.273 | 65.722 | 38.937 | 112.799 |
| 5. Installation & appliance Sales | 8.069 | 15.397 | 20.180 | 20.766 | 31.063 | 58.643 |
| 6. Installation & appliance Cost | 2.937 | 5.132 | 5.872 | 7.783 | 12.620 | 19.932 |
| Operation profit | 70.566 | 23.829 | 10.015 | 78.705 | 57.380 | ▲ 74.088 |
| 7. Non operating Revenue | - | 9.496 | 8.324 (46.578) | 7.706 (39.771) | 14.678 ( 40.115) | 10.149 (62.452) |
| 8. Non operating expense | - | 6.578 | 47.632 | 39.806 | 41.722 | 62.960 |
| Recurring profit | 70.566 | 26.747 | 29.293 | 46.605 | 30.336 | ▲126.899 |
| 9. Extra ordinary items (profit) | 4.029 | 5.368 | 3.070 | 1.633 | 1.523 | 13.749 |
| Net profit (before tax) | 74.595 | 32.115 | ▲26.223 | 48.238 | 31.859 | ▲113.150 |

[APPENDIX 6]

(1) Analysis of Financial Statement of PGN

| | | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|---|---|---|
| 1 | Operating profit rate to gross capital (%) | 24.7 | 6.1 | 1.0 | 5.8 | 2.4 | * 2.9 |
| 2 | Gross capital turnover ratio | 1.02 | 1.45 | 0.61 | 0.50 | 0.33 | 0.31 |
| 3 | Sales profit rate to total products sales | 24.3 | 4.2 | 1.6 | 11.5 | 7.3 | * 9.3 |
| 4 | Recurring profit rate to gross capital | 24.7 | 6.8 | * 2.9 | 3.4 | 1.3 | * 2.9 |
| 5 | Recurring profit rate to net worth | 41.9 | 9.3 | * 5.8 | 4.5 | 1.8 | * 6.4 |
| 6 | Fixed assets ratio to capital | 8.9 | 19.6 | 66.6 | 77.5 | 81.2 | 94.1 |
| 7 | Gas production per employee (1000 $m^3$) | 22.7 | 20.7 | 19.4 | 17.4 | 21.0 | 26.0 |
| 8 | Gas sales volume per employee (1000 $m^3$) | 17.2 | 15.5 | 14.7 | 14.1 | 17.1 | 20.1 |
| 9 | Fixed assets per employee (1000 rupiah) | 8.5 | 31.7 | 192.5 | 466.7 | 865.6 | 1,270.5 |
| 10 | Production cost ratio (%) | 56.6 | 73.4 | 69.3 | 54.9 | 64.4 | 76.4 |
| 11 | Other operating cost ratio | 20.8 | 24.2 | 31.4 | 35.5 | 30.7 | 37.8 |
| 12 | Consumers per employee | 14.8 | 13.7 | 13.2 | 13.0 | 14.1 | 14.9 |
| 13 | Gas sales per employee(1,000 rupiah) | 123.3 | 261.5 | 312.5 | 311.1 | 388.1 | 459.5 |
| 14 | Totals sales per employee(1,000 rupiah) | 170.0 | 329.7 | 360.7 | 410.3 | 527.4 | 583.0 |

* minus figures

[APPENDIX]

(2) Financial comparison between PGN and the smaller gas companies in Japan during the 1972 fiscal year

| Items | Formulae | PGN | Smaller gas companies in Japan | | |
|---|---|---|---|---|---|
| | | | Average of 6 companies serv-ing around 10,000 customers | Average of 4 companies serv-ing around 20,000 customers | Average of 4 companies serv-ing around 100,000 customers |
| Rate of return against gross capital | (Sales income) ÷ (Total assets) x 100,% | -2.89 | 5.67 | 7.91 | 8.08 |
| Turnaround rate against gross capital | (Product Sales) ÷ (Total assets) x 100 | 0.31 | 0.43 | 0.44 | 0.44 |
| Sales profit against sales income | (Sales profit ) ÷ (Product sales) x 100,% | -9.31 | 13.13 | 18.01 | 18.32 |
| Recurring profit against gross capital | (Running revenue) ÷ (Total assets) x 100,% | -4.44 | 4.89 | 3.34 | 4.19 |
| Rate of cost against sales | (Sales cost) ÷ (Product sales) x 100,% | 76.40 | 35.87 | 35.27 | 33.82 |
| Rate of marketing and administration costs | (Marketing and administration costs) ÷ (Product sales) x 100,% | 37.78 | 53.43 | 54.96 | 49.59 |
| Rate of sharing labor costs | (Total labor cost) ÷ (Product sales) x 100,% | 33.25 | 11.99 | 15.55 | 12.42 |
| Rate of sharing ammortization | (Ammortizing costs) ÷ (Product sales) x 100,% | 1.59 | 17.26 | 15.50 | 15.28 |
| Rate of sharing interests | (Interest for borrowed loans) ÷ (Product sales) x 100,% | 7.30 | 8.22 | 7.90 | 7.37 |
| Gas sales per employee | (Gas sales (in 1,000 kilocalories) ÷ (Number of employees), 1,000 cubic meters | 72 | 997 | 972 | 1,100 |
| Total sales per employee | (Product sales) ÷ (Number of employees), 1,000 rupiahs | 543 | 7,716 | 7,486 | 8,326 |
| Rate of internal capital | (Total assets) ÷ (Gross capital),% | 77.14 | 21.33 | 26.99 | 30.72 |
| Rate of external capital | (Total liabilities) ÷ (Gross capital),% | 22.86 | 78.67 | 73.01 | 69.28 |
| Rate of fluid assets | (Fluid assets) ÷ (Gross capital) x 100,% | 27.39 | 28.64 | 30.50 | 17.99 |
| Rate of fixed assets | (Total fixed assets) ÷ (Total assets),% | 72.61 | 71.36 | 69.50 | 82.01 |
| Turn-around cycle of tangible fixed assets | (Tangible fixed assets) ÷ (Product sales) 12, months | 28.0 | 19.0 | 17.28 | 19.24 |
| Rate of fixed assets per employee | (Tangible fixed assets) ÷ (Number of employees), 1,000 rupiahs | 1,270 | 12,225 | 10,781 | 13,348 |
| Number of customers per employee | (Number of customers at year-end) ÷ (Number of employees) | 15 | 251 | 302 | 266 |

[APPENDIX 7]

## Estimation of Gas Demand for 8 Stations

Explanation of the Programme:

1. Population and Permanent Houses

    1) Estimation of population in 2000 from the past growth rate (primary regression coefficient), demand forecast data, and municipal data.

    2) Population estimation for each year on the basis of the above data.

    3) Estimation of the future number of permanent houses on the basis of the future population data obtained from the present number of permanent houses and population.

        a) Existing condition (population per permanent house).

        b) Estimation of future population per permanent house.

        c) Calculation of the future number of permanent houses.

    4) Calculation of the density of permanent houses and values at 20%, 30%, 40% and 50% of the calculated density.

2. Demand Estimate

    1) The gas volume and the number of customers are extrapolated assuming that their increase will be small in the early rehabilitation period.

    2) The growth rate of gas volume per customer is taken at 2%.

    3) The annual growth rate of the number of customers is taken at 10%.

    4) The number of customers of permanent houses is included because it will be limited.

5) If there would be any large demand as in Cirebon, it is added.

6) The sum total is obtained to calculate the saturation rate against population and against the number of permanent houses.

Explanation of Abbreviations used in output data

1. Effective Demand for City Gas

| | | |
|---|---|---|
| POP | : | Population (unit: thousand persons) |
| PER.H | : | Permanent house |
| H.DENS | : | Permanent house density (house/ha) |
| PP/PH | : | Population per permanent house (person/house) |
| 20P | : | 20% of permanent houses (thousand houses) |
| 30P | : | 30% " " |
| 40P | : | 40% " " |
| 50P | : | 50% " " |

2. Number of Consumers and Gas Sale

| | | |
|---|---|---|
| UNI.VOL | : | Gas sales per consumer ($m^3$/year) |
| GAS VOL | : | Total gas sales (thousand $m^3$/year) |
| ADD | : | Gas sales for industry use (Cirebon only) (thousand $m^3$/year) |
| TOTAL | : | Grand total including ADD (thousand $m^3$/year) |
| COV.P | : | Saturation against population ($= \frac{\text{number of consumers}}{\text{population}}$ : %) |
| COV.H | : | Saturation against permanent house ($= \frac{\text{number of consumers}}{\text{number of permanent houses}}$ : %) |

EFFECTIVE DEMAND FOR CITY GAS (JAKARTA)

| YEAR | POP. | PER.H | P.DENS | H.DENS | PP/PH | 20P | 30P | 40P | 50P |
|---|---|---|---|---|---|---|---|---|---|
| 1972 | 4353.9 | 135.3 | 86.3 | 2.6 | 32.1 | 27.0 | 40.5 | 54.1 | 67.6 |
| 1973 | 4501.9 | 142.3 | 89.3 | 2.8 | 31.6 | 28.4 | 42.7 | 56.9 | 71.1 |
| 1974 | 4650.0 | 149.6 | 92.2 | 2.9 | 31.0 | 29.9 | 44.8 | 59.8 | 74.8 |
| 1975 | 4798.1 | 157.2 | 95.2 | 3.1 | 30.5 | 31.4 | 47.1 | 62.8 | 78.6 |
| 1976 | 4946.2 | 165.0 | 98.1 | 3.2 | 29.9 | 33.0 | 49.5 | 66.0 | 82.5 |
| 1977 | 5094.2 | 173.2 | 101.0 | 3.4 | 29.4 | 34.6 | 51.9 | 69.2 | 86.6 |
| 1978 | 5242.3 | 181.7 | 104.0 | 3.6 | 28.8 | 36.3 | 54.5 | 72.6 | 90.8 |
| 1979 | 5390.4 | 190.4 | 106.9 | 3.7 | 28.2 | 38.0 | 57.1 | 76.1 | 95.2 |
| 1980 | 5538.5 | 199.6 | 109.8 | 3.9 | 27.7 | 39.9 | 59.8 | 79.8 | 99.8 |
| 1981 | 5686.5 | 209.1 | 112.8 | 4.1 | 27.1 | 41.8 | 62.7 | 83.6 | 104.5 |
| 1982 | 5834.6 | 219.0 | 115.7 | 4.3 | 26.6 | 43.8 | 65.7 | 87.6 | 109.5 |
| 1983 | 5982.7 | 229.4 | 118.7 | 4.5 | 26.0 | 45.8 | 68.8 | 91.7 | 114.7 |
| 1984 | 6130.8 | 240.2 | 121.6 | 4.7 | 25.5 | 48.0 | 72.0 | 96.0 | 120.1 |
| 1985 | 6278.8 | 251.4 | 124.5 | 4.9 | 24.9 | 50.2 | 75.4 | 100.5 | 125.7 |
| 1986 | 6426.9 | 263.2 | 127.5 | 5.2 | 24.4 | 52.6 | 78.9 | 105.3 | 131.6 |
| 1987 | 6575.0 | 275.5 | 130.4 | 5.4 | 23.8 | 55.1 | 82.6 | 110.2 | 137.7 |
| 1988 | 6723.1 | 288.4 | 133.3 | 5.7 | 23.3 | 57.6 | 86.5 | 115.3 | 144.2 |
| 1989 | 6871.1 | 302.0 | 136.3 | 5.9 | 22.7 | 60.4 | 90.6 | 120.8 | 151.0 |
| 1990 | 7019.2 | 316.2 | 139.2 | 6.2 | 22.1 | 63.2 | 94.8 | 126.5 | 158.1 |
| 1991 | 7167.3 | 331.2 | 142.2 | 6.5 | 21.6 | 66.2 | 99.3 | 132.4 | 165.6 |
| 1992 | 7315.4 | 346.9 | 145.1 | 6.8 | 21.0 | 69.3 | 104.0 | 138.7 | 173.4 |
| 1993 | 7463.4 | 363.5 | 148.0 | 7.2 | 20.5 | 72.7 | 109.0 | 145.4 | 181.7 |
| 1994 | 7611.5 | 381.0 | 151.0 | 7.5 | 19.9 | 76.2 | 114.3 | 152.4 | 190.5 |
| 1995 | 7759.6 | 399.5 | 153.9 | 7.9 | 19.4 | 79.9 | 119.8 | 159.8 | 199.7 |
| 1996 | 7907.7 | 419.1 | 156.8 | 8.3 | 18.9 | 83.8 | 125.7 | 167.6 | 209.5 |
| 1997 | 8055.7 | 439.9 | 159.8 | 8.7 | 18.3 | 87.9 | 131.9 | 175.9 | 219.9 |
| 1998 | 8203.8 | 462.0 | 162.7 | 9.1 | 17.7 | 92.4 | 138.6 | 184.8 | 231.0 |
| 1999 | 8351.9 | 485.5 | 165.7 | 9.6 | 17.2 | 97.1 | 145.6 | 194.2 | 242.7 |
| 2000 | 8500.0 | 510.6 | 168.6 | 10.1 | 16.6 | 102.1 | 153.1 | 204.2 | 255.3 |

EFFECTIVE DEMAND FOR CITY GAS (MEDAN)

| YEAR | POP. | PER.H | P.DENS | H.DENS | PP/PH | 20P | 30P | 40P | 50P |
|---|---|---|---|---|---|---|---|---|---|
| 1972 | 614.5 | 17.5 | 122.6 | 3.4 | 35.1 | 3.5 | 5.2 | 7.0 | 8.7 |
| 1973 | 624.3 | 18.1 | 124.6 | 3.6 | 34.4 | 3.6 | 5.4 | 7.2 | 9.0 |
| 1974 | 634.1 | 18.7 | 126.5 | 3.7 | 33.7 | 3.7 | 5.6 | 7.5 | 9.3 |
| 1975 | 643.9 | 19.4 | 128.5 | 3.8 | 33.1 | 3.8 | 5.8 | 7.7 | 9.7 |
| 1976 | 653.7 | 20.1 | 130.4 | 4.0 | 32.4 | 4.0 | 6.0 | 8.0 | 10.0 |
| 1977 | 663.5 | 20.8 | 132.4 | 4.1 | 31.8 | 4.1 | 6.2 | 8.3 | 10.4 |
| 1978 | 673.3 | 21.6 | 134.4 | 4.3 | 31.1 | 4.3 | 6.4 | 8.6 | 10.8 |
| 1979 | 683.1 | 22.4 | 136.3 | 4.4 | 30.4 | 4.4 | 6.7 | 8.9 | 11.2 |
| 1980 | 692.9 | 23.2 | 138.3 | 4.6 | 29.8 | 4.6 | 6.9 | 9.2 | 11.6 |
| 1981 | 702.7 | 24.0 | 140.2 | 4.8 | 29.1 | 4.8 | 7.2 | 9.6 | 12.0 |
| 1982 | 712.6 | 24.9 | 142.2 | 4.9 | 28.5 | 4.9 | 7.4 | 9.9 | 12.4 |
| 1983 | 722.4 | 25.9 | 144.1 | 5.1 | 27.8 | 5.1 | 7.7 | 10.3 | 12.9 |
| 1984 | 732.2 | 26.9 | 146.1 | 5.3 | 27.1 | 5.3 | 8.0 | 10.7 | 13.4 |
| 1985 | 742.0 | 27.9 | 148.1 | 5.5 | 26.5 | 5.5 | 8.3 | 11.1 | 13.9 |
| 1986 | 751.8 | 29.0 | 150.0 | 5.8 | 25.8 | 5.8 | 8.7 | 11.6 | 14.5 |
| 1987 | 761.6 | 30.2 | 152.0 | 6.0 | 25.2 | 6.0 | 9.0 | 12.0 | 15.1 |
| 1988 | 771.4 | 31.4 | 153.9 | 6.2 | 24.5 | 6.2 | 9.4 | 12.5 | 15.7 |
| 1989 | 781.2 | 32.7 | 155.9 | 6.5 | 23.8 | 6.5 | 9.8 | 13.0 | 16.3 |
| 1990 | 791.0 | 34.0 | 157.9 | 6.7 | 23.2 | 6.8 | 10.2 | 13.6 | 17.0 |
| 1991 | 800.9 | 35.4 | 159.8 | 7.0 | 22.5 | 7.0 | 10.6 | 14.1 | 17.7 |
| 1992 | 810.7 | 37.0 | 161.8 | 7.3 | 21.9 | 7.4 | 11.1 | 14.8 | 18.5 |
| 1993 | 820.5 | 38.6 | 163.7 | 7.7 | 21.2 | 7.7 | 11.5 | 15.4 | 19.3 |
| 1994 | 830.3 | 40.3 | 165.7 | 8.0 | 20.5 | 8.0 | 12.1 | 16.1 | 20.1 |
| 1995 | 840.1 | 42.1 | 167.6 | 8.4 | 19.9 | 8.4 | 12.6 | 16.8 | 21.0 |
| 1996 | 849.9 | 44.1 | 169.6 | 8.8 | 19.2 | 8.8 | 13.2 | 17.6 | 22.0 |
| 1997 | 859.7 | 46.2 | 171.6 | 9.2 | 18.6 | 9.2 | 13.8 | 18.4 | 23.1 |
| 1998 | 869.5 | 48.4 | 173.5 | 9.6 | 17.9 | 9.6 | 14.5 | 19.3 | 24.2 |
| 1999 | 879.3 | 50.8 | 175.5 | 10.1 | 17.2 | 10.1 | 15.2 | 20.3 | 25.4 |
| 2000 | 889.2 | 53.5 | 177.4 | 10.6 | 16.6 | 10.7 | 16.0 | 21.4 | 26.7 |

EFFECTIVE DEMAND FOR CITY GAS (BOGOR)

| YEAR | POP. | PER.H | P.DENS | H.DENS | PP/PH | 20P | 30P | 40P | 50P |
|---|---|---|---|---|---|---|---|---|---|
| 1972 | 196.8 | 10.1 | 91.1 | 4.6 | 19.4 | 2.0 | 3.0 | 4.0 | 5.0 |
| 1973 | 199.9 | 10.3 | 92.5 | 4.8 | 19.2 | 2.0 | 3.1 | 4.1 | 5.1 |
| 1974 | 203.0 | 10.6 | 94.0 | 4.9 | 19.0 | 2.1 | 3.1 | 4.2 | 5.3 |
| 1975 | 206.2 | 10.9 | 95.4 | 5.0 | 18.8 | 2.1 | 3.2 | 4.3 | 5.4 |
| 1976 | 209.3 | 11.2 | 96.9 | 5.1 | 18.6 | 2.2 | 3.3 | 4.4 | 5.6 |
| 1977 | 212.5 | 11.5 | 98.3 | 5.3 | 18.4 | 2.3 | 3.4 | 4.6 | 5.7 |
| 1978 | 215.6 | 11.8 | 99.8 | 5.4 | 18.2 | 2.3 | 3.5 | 4.7 | 5.9 |
| 1979 | 218.8 | 12.1 | 101.2 | 5.6 | 18.0 | 2.4 | 3.6 | 4.8 | 6.0 |
| 1980 | 221.9 | 12.4 | 102.7 | 5.7 | 17.8 | 2.4 | 3.7 | 4.9 | 6.2 |
| 1981 | 225.0 | 12.7 | 104.2 | 5.9 | 17.6 | 2.5 | 3.8 | 5.0 | 6.3 |
| 1982 | 228.2 | 13.0 | 105.6 | 6.0 | 17.4 | 2.6 | 3.9 | 5.2 | 6.5 |
| 1983 | 231.3 | 13.4 | 107.1 | 6.2 | 17.2 | 2.6 | 4.0 | 5.3 | 6.7 |
| 1984 | 234.5 | 13.7 | 108.5 | 6.3 | 17.0 | 2.7 | 4.1 | 5.5 | 6.8 |
| 1985 | 237.6 | 14.1 | 110.0 | 6.5 | 16.8 | 2.8 | 4.2 | 5.6 | 7.0 |
| 1986 | 240.8 | 14.4 | 111.4 | 6.7 | 16.6 | 2.8 | 4.3 | 5.7 | 7.2 |
| 1987 | 243.9 | 14.8 | 112.9 | 6.8 | 16.4 | 2.9 | 4.4 | 5.9 | 7.4 |
| 1988 | 247.0 | 15.2 | 114.3 | 7.0 | 16.2 | 3.0 | 4.5 | 6.0 | 7.6 |
| 1989 | 250.2 | 15.6 | 115.8 | 7.2 | 16.0 | 3.1 | 4.6 | 6.2 | 7.8 |
| 1990 | 253.3 | 16.0 | 117.3 | 7.4 | 15.8 | 3.2 | 4.8 | 6.4 | 8.0 |
| 1991 | 256.5 | 16.4 | 118.7 | 7.6 | 15.6 | 3.2 | 4.9 | 6.5 | 8.2 |
| 1992 | 259.6 | 16.8 | 120.2 | 7.7 | 15.4 | 3.3 | 5.0 | 6.7 | 8.4 |
| 1993 | 262.8 | 17.2 | 121.6 | 7.9 | 15.2 | 3.4 | 5.1 | 6.9 | 8.6 |
| 1994 | 265.9 | 17.7 | 123.1 | 8.2 | 15.0 | 3.5 | 5.3 | 7.0 | 8.8 |
| 1995 | 269.0 | 18.1 | 124.5 | 8.4 | 14.8 | 3.6 | 5.4 | 7.2 | 9.0 |
| 1996 | 272.2 | 18.6 | 126.0 | 8.6 | 14.6 | 3.7 | 5.5 | 7.4 | 9.3 |
| 1997 | 275.3 | 19.1 | 127.4 | 8.8 | 14.4 | 3.8 | 5.7 | 7.6 | 9.5 |
| 1998 | 278.5 | 19.6 | 128.9 | 9.0 | 14.1 | 3.9 | 5.8 | 7.8 | 9.8 |
| 1999 | 281.6 | 20.1 | 130.3 | 9.3 | 13.9 | 4.0 | 6.0 | 8.0 | 10.0 |
| 2000 | 284.8 | 20.6 | 131.8 | 9.5 | 13.7 | 4.1 | 6.1 | 8.2 | 10.3 |

EFFECTIVE DEMAND FOR CITY GAS (BANDUNG)

| YEAR | POP. | PER.H | P.DENS | H.DENS | PP/PH | 20P | 30P | 40P | 50P |
|---|---|---|---|---|---|---|---|---|---|
| 1972 | 1204.5 | 30.8 | 148.7 | 3.8 | 39.1 | 6.1 | 9.2 | 12.3 | 15.4 |
| 1973 | 1223.7 | 31.9 | 151.0 | 3.9 | 38.2 | 6.3 | 9.5 | 12.7 | 15.9 |
| 1974 | 1242.9 | 33.1 | 153.4 | 4.0 | 37.4 | 6.6 | 9.9 | 13.2 | 16.5 |
| 1975 | 1262.1 | 34.4 | 155.8 | 4.2 | 36.6 | 6.8 | 10.3 | 13.7 | 17.2 |
| 1976 | 1281.4 | 35.7 | 158.1 | 4.4 | 35.8 | 7.1 | 10.7 | 14.3 | 17.8 |
| 1977 | 1300.6 | 37.1 | 160.5 | 4.5 | 35.0 | 7.4 | 11.1 | 14.8 | 18.5 |
| 1978 | 1319.8 | 38.6 | 162.9 | 4.7 | 34.1 | 7.7 | 11.5 | 15.4 | 19.3 |
| 1979 | 1339.1 | 40.1 | 165.3 | 4.9 | 33.3 | 8.0 | 12.0 | 16.0 | 20.0 |
| 1980 | 1358.3 | 41.7 | 167.6 | 5.1 | 32.5 | 8.3 | 12.5 | 16.6 | 20.8 |
| 1981 | 1377.5 | 43.4 | 170.0 | 5.3 | 31.7 | 8.6 | 13.0 | 17.3 | 21.7 |
| 1982 | 1396.7 | 45.1 | 172.4 | 5.5 | 30.9 | 9.0 | 13.5 | 18.0 | 22.5 |
| 1983 | 1416.0 | 47.0 | 174.8 | 5.8 | 30.0 | 9.4 | 14.1 | 18.8 | 23.5 |
| 1984 | 1435.2 | 49.0 | 177.1 | 6.0 | 29.2 | 9.8 | 14.7 | 19.6 | 24.5 |
| 1985 | 1454.4 | 51.1 | 179.5 | 6.3 | 28.4 | 10.2 | 15.3 | 20.4 | 25.5 |
| 1986 | 1473.7 | 53.3 | 181.9 | 6.5 | 27.6 | 10.6 | 15.9 | 21.3 | 26.6 |
| 1987 | 1492.9 | 55.6 | 184.3 | 6.8 | 26.8 | 11.1 | 16.7 | 22.2 | 27.8 |
| 1988 | 1512.1 | 58.1 | 186.6 | 7.1 | 25.9 | 11.6 | 17.4 | 23.2 | 29.0 |
| 1989 | 1531.3 | 60.8 | 189.0 | 7.5 | 25.1 | 12.1 | 18.2 | 24.3 | 30.4 |
| 1990 | 1550.6 | 63.6 | 191.4 | 7.8 | 24.3 | 12.7 | 19.0 | 25.4 | 31.8 |
| 1991 | 1569.8 | 66.6 | 193.8 | 8.2 | 23.5 | 13.3 | 20.0 | 26.6 | 33.3 |
| 1992 | 1589.0 | 69.9 | 196.1 | 8.6 | 22.7 | 13.9 | 20.9 | 27.9 | 34.9 |
| 1993 | 1608.3 | 73.4 | 198.5 | 9.0 | 21.9 | 14.6 | 22.0 | 29.3 | 36.7 |
| 1994 | 1627.5 | 77.1 | 200.9 | 9.5 | 21.0 | 15.4 | 23.1 | 30.8 | 38.5 |
| 1995 | 1646.7 | 81.2 | 203.3 | 10.0 | 20.2 | 16.2 | 24.3 | 32.5 | 40.6 |
| 1996 | 1665.9 | 85.6 | 205.6 | 10.5 | 19.4 | 17.1 | 25.7 | 34.2 | 42.8 |
| 1997 | 1685.2 | 90.4 | 208.0 | 11.1 | 18.6 | 18.0 | 27.1 | 36.1 | 45.2 |
| 1998 | 1704.4 | 95.7 | 210.4 | 11.8 | 17.8 | 19.1 | 28.7 | 38.2 | 47.8 |
| 1999 | 1723.6 | 101.4 | 212.7 | 12.5 | 16.9 | 20.2 | 30.4 | 40.5 | 50.7 |
| 2000 | 1742.9 | 107.8 | 215.1 | 13.3 | 16.1 | 21.5 | 32.3 | 43.1 | 53.9 |

EFFECTIVE DEMAND FOR CITY GAS (CIREBON)

| YEAR | POP. | PER.H | P.DENS | H.DENS | PP/PH | 20P | 30P | 40P | 50P |
|---|---|---|---|---|---|---|---|---|---|
| 1972 | 162.5 | 13.4 | 45.0 | 3.7 | 12.1 | 2.6 | 4.0 | 5.3 | 6.7 |
| 1973 | 165.0 | 13.7 | 45.7 | 3.7 | 12.0 | 2.7 | 4.1 | 5.4 | 6.8 |
| 1974 | 167.6 | 14.0 | 46.4 | 3.8 | 11.9 | 2.8 | 4.2 | 5.6 | 7.0 |
| 1975 | 170.2 | 14.3 | 47.1 | 3.9 | 11.8 | 2.8 | 4.2 | 5.7 | 7.1 |
| 1976 | 172.8 | 14.6 | 47.8 | 4.0 | 11.8 | 2.9 | 4.3 | 5.8 | 7.3 |
| 1977 | 175.4 | 14.9 | 48.6 | 4.1 | 11.7 | 2.9 | 4.4 | 5.9 | 7.4 |
| 1978 | 178.0 | 15.2 | 49.3 | 4.2 | 11.6 | 3.0 | 4.5 | 6.1 | 7.6 |
| 1979 | 180.6 | 15.6 | 50.0 | 4.3 | 11.5 | 3.1 | 4.6 | 6.2 | 7.8 |
| 1980 | 183.2 | 15.9 | 50.7 | 4.4 | 11.4 | 3.1 | 4.7 | 6.3 | 7.9 |
| 1981 | 185.8 | 16.2 | 51.4 | 4.5 | 11.4 | 3.2 | 4.8 | 6.5 | 8.1 |
| 1982 | 188.4 | 16.6 | 52.1 | 4.6 | 11.3 | 3.3 | 4.9 | 6.6 | 8.3 |
| 1983 | 191.0 | 16.9 | 52.9 | 4.6 | 11.2 | 3.3 | 5.0 | 6.7 | 8.4 |
| 1984 | 193.6 | 17.3 | 53.6 | 4.7 | 11.1 | 3.4 | 5.1 | 6.9 | 8.6 |
| 1985 | 196.2 | 17.6 | 54.3 | 4.8 | 11.1 | 3.5 | 5.3 | 7.0 | 8.8 |
| 1986 | 198.8 | 18.0 | 55.0 | 4.9 | 11.0 | 3.6 | 5.4 | 7.2 | 9.0 |
| 1987 | 201.3 | 18.4 | 55.7 | 5.0 | 10.9 | 3.6 | 5.5 | 7.3 | 9.2 |
| 1988 | 203.9 | 18.7 | 56.5 | 5.2 | 10.8 | 3.7 | 5.6 | 7.5 | 9.3 |
| 1989 | 206.5 | 19.1 | 57.2 | 5.3 | 10.7 | 3.8 | 5.7 | 7.6 | 9.5 |
| 1990 | 209.1 | 19.5 | 57.9 | 5.4 | 10.7 | 3.9 | 5.8 | 7.8 | 9.7 |
| 1991 | 211.7 | 19.9 | 58.6 | 5.5 | 10.6 | 3.9 | 5.9 | 7.9 | 9.9 |
| 1992 | 214.3 | 20.3 | 59.3 | 5.6 | 10.5 | 4.0 | 6.0 | 8.1 | 10.1 |
| 1993 | 216.9 | 20.7 | 60.0 | 5.7 | 10.4 | 4.1 | 6.2 | 8.2 | 10.3 |
| 1994 | 219.5 | 21.1 | 60.8 | 5.8 | 10.3 | 4.2 | 6.3 | 8.4 | 10.5 |
| 1995 | 222.1 | 21.5 | 61.5 | 5.9 | 10.3 | 4.3 | 6.4 | 8.6 | 10.7 |
| 1996 | 224.7 | 21.9 | 62.2 | 6.0 | 10.2 | 4.3 | 6.5 | 8.7 | 10.9 |
| 1997 | 227.3 | 22.3 | 62.9 | 6.1 | 10.1 | 4.4 | 6.7 | 8.9 | 11.1 |
| 1998 | 229.9 | 22.8 | 63.6 | 6.3 | 10.0 | 4.5 | 6.8 | 9.1 | 11.4 |
| 1999 | 232.5 | 23.2 | 64.4 | 6.4 | 9.9 | 4.6 | 6.9 | 9.3 | 11.6 |
| 2000 | 235.0 | 23.6 | 65.1 | 6.5 | 9.9 | 4.7 | 7.1 | 9.4 | 11.8 |

EFFECTIVE DEMAND FOR CITY GAS (SEMARANG)

| YEAR | POP. | PER.H | P.DENS | H.DENS | PP/PH | 20P | 30P | 40P | 50P |
|---|---|---|---|---|---|---|---|---|---|
| 1972 | 614.3 | 22.6 | 61.8 | 2.2 | 27.1 | 4.5 | 6.7 | 9.0 | 11.3 |
| 1973 | 624.1 | 23.3 | 62.7 | 2.3 | 26.7 | 4.6 | 6.9 | 9.3 | 11.6 |
| 1974 | 633.9 | 24.0 | 63.7 | 2.4 | 26.3 | 4.8 | 7.2 | 9.6 | 12.0 |
| 1975 | 643.7 | 24.7 | 64.7 | 2.4 | 25.9 | 4.9 | 7.4 | 9.9 | 12.3 |
| 1976 | 653.5 | 25.5 | 65.7 | 2.5 | 25.5 | 5.1 | 7.6 | 10.2 | 12.7 |
| 1977 | 663.3 | 26.3 | 66.7 | 2.6 | 25.2 | 5.2 | 7.8 | 10.5 | 13.1 |
| 1978 | 673.1 | 27.1 | 67.7 | 2.7 | 24.8 | 5.4 | 8.1 | 10.8 | 13.5 |
| 1979 | 682.9 | 27.9 | 68.7 | 2.8 | 24.4 | 5.5 | 8.3 | 11.1 | 13.9 |
| 1980 | 692.7 | 28.8 | 69.6 | 2.9 | 24.0 | 5.7 | 8.6 | 11.5 | 14.4 |
| 1981 | 702.5 | 29.7 | 70.6 | 2.9 | 23.6 | 5.9 | 8.9 | 11.8 | 14.8 |
| 1982 | 712.3 | 30.6 | 71.6 | 3.0 | 23.2 | 6.1 | 9.2 | 12.2 | 15.3 |
| 1983 | 722.1 | 31.6 | 72.6 | 3.1 | 22.8 | 6.3 | 9.4 | 12.6 | 15.8 |
| 1984 | 731.9 | 32.6 | 73.6 | 3.2 | 22.4 | 6.5 | 9.7 | 13.0 | 16.3 |
| 1985 | 741.7 | 33.6 | 74.6 | 3.3 | 22.0 | 6.7 | 10.0 | 13.4 | 16.8 |
| 1986 | 751.6 | 34.7 | 75.6 | 3.4 | 21.6 | 6.9 | 10.4 | 13.8 | 17.3 |
| 1987 | 761.4 | 35.8 | 76.6 | 3.6 | 21.2 | 7.1 | 10.7 | 14.3 | 17.9 |
| 1988 | 771.2 | 36.9 | 77.5 | 3.7 | 20.8 | 7.3 | 11.0 | 14.7 | 18.4 |
| 1989 | 781.0 | 38.1 | 78.5 | 3.8 | 20.4 | 7.6 | 11.4 | 15.2 | 19.0 |
| 1990 | 790.8 | 39.4 | 79.5 | 3.9 | 20.0 | 7.8 | 11.8 | 15.7 | 19.7 |
| 1991 | 800.6 | 40.7 | 80.5 | 4.0 | 19.6 | 8.1 | 12.2 | 16.2 | 20.3 |
| 1992 | 810.4 | 42.0 | 81.5 | 4.2 | 19.2 | 8.4 | 12.6 | 16.8 | 21.0 |
| 1993 | 820.2 | 43.4 | 82.5 | 4.3 | 18.8 | 8.6 | 13.0 | 17.3 | 21.7 |
| 1994 | 830.0 | 44.9 | 83.5 | 4.5 | 18.4 | 8.9 | 13.4 | 17.9 | 22.4 |
| 1995 | 839.8 | 46.4 | 84.4 | 4.6 | 18.0 | 9.2 | 13.9 | 18.5 | 23.2 |
| 1996 | 849.6 | 48.0 | 85.4 | 4.8 | 17.6 | 9.6 | 14.4 | 19.2 | 24.0 |
| 1997 | 859.4 | 49.7 | 86.4 | 5.0 | 17.2 | 9.9 | 14.9 | 19.8 | 24.8 |
| 1998 | 869.2 | 51.4 | 87.4 | 5.1 | 16.8 | 10.2 | 15.4 | 20.5 | 25.7 |
| 1999 | 879.0 | 53.2 | 88.4 | 5.3 | 16.4 | 10.6 | 15.9 | 21.3 | 26.6 |
| 2000 | 888.8 | 55.2 | 89.4 | 5.5 | 16.0 | 11.0 | 16.5 | 22.0 | 27.6 |

EFFECTIVE DEMAND FOR CITY GAS (SURABAYA)

| YEAR | POP. | PER.H | P.DENS | H.DENS | PP/PH | 20P | 30P | 40P | 50P |
|---|---|---|---|---|---|---|---|---|---|
| 1972 | 2190.4 | 61.7 | 97.6 | 2.7 | 35.5 | 12.3 | 18.5 | 24.6 | 30.8 |
| 1973 | 2225.3 | 63.9 | 99.2 | 2.8 | 34.8 | 12.7 | 19.1 | 25.5 | 31.9 |
| 1974 | 2260.3 | 66.1 | 100.7 | 2.9 | 34.1 | 13.2 | 19.8 | 26.4 | 33.0 |
| 1975 | 2295.3 | 68.5 | 102.3 | 3.0 | 33.4 | 13.7 | 20.5 | 27.4 | 34.2 |
| 1976 | 2330.2 | 71.0 | 103.8 | 3.1 | 32.8 | 14.2 | 21.3 | 28.4 | 35.5 |
| 1977 | 2365.2 | 73.6 | 105.4 | 3.2 | 32.1 | 14.7 | 22.0 | 29.4 | 36.8 |
| 1978 | 2400.2 | 76.3 | 107.0 | 3.4 | 31.4 | 15.2 | 22.8 | 30.5 | 38.1 |
| 1979 | 2435.1 | 79.1 | 108.5 | 3.5 | 30.7 | 15.8 | 23.7 | 31.6 | 39.5 |
| 1980 | 2470.1 | 82.0 | 110.1 | 3.6 | 30.0 | 16.4 | 24.6 | 32.8 | 41.0 |
| 1981 | 2505.1 | 85.1 | 111.6 | 3.7 | 29.4 | 17.0 | 25.5 | 34.0 | 42.5 |
| 1982 | 2540.0 | 88.3 | 113.2 | 3.9 | 28.7 | 17.6 | 26.5 | 35.3 | 44.1 |
| 1983 | 2575.0 | 91.7 | 114.8 | 4.0 | 28.0 | 18.3 | 27.5 | 36.6 | 45.8 |
| 1984 | 2610.0 | 95.2 | 116.3 | 4.2 | 27.3 | 19.0 | 28.5 | 38.1 | 47.6 |
| 1985 | 2644.9 | 98.9 | 117.9 | 4.4 | 26.7 | 19.7 | 29.6 | 39.5 | 49.4 |
| 1986 | 2679.9 | 102.8 | 119.4 | 4.5 | 26.0 | 20.5 | 30.8 | 41.1 | 51.4 |
| 1987 | 2714.9 | 106.9 | 121.0 | 4.7 | 25.3 | 21.3 | 32.0 | 42.7 | 53.4 |
| 1988 | 2749.8 | 111.3 | 122.5 | 4.9 | 24.6 | 22.2 | 33.4 | 44.5 | 55.6 |
| 1989 | 2784.8 | 115.9 | 124.1 | 5.1 | 24.0 | 23.1 | 34.7 | 46.3 | 57.9 |
| 1990 | 2819.8 | 120.7 | 125.7 | 5.3 | 23.3 | 24.1 | 36.2 | 48.3 | 60.3 |
| 1991 | 2854.7 | 125.9 | 127.2 | 5.6 | 22.6 | 25.1 | 37.7 | 50.3 | 62.9 |
| 1992 | 2889.7 | 131.3 | 128.8 | 5.8 | 21.9 | 26.2 | 39.4 | 52.5 | 65.6 |
| 1993 | 2924.7 | 137.1 | 130.3 | 6.1 | 21.3 | 27.4 | 41.1 | 54.8 | 68.5 |
| 1994 | 2959.6 | 143.3 | 131.9 | 6.3 | 20.6 | 28.6 | 43.0 | 57.3 | 71.6 |
| 1995 | 2994.6 | 149.9 | 133.5 | 6.6 | 19.9 | 29.9 | 44.9 | 59.9 | 74.9 |
| 1996 | 3029.6 | 157.0 | 135.0 | 6.9 | 19.2 | 31.4 | 47.1 | 62.8 | 78.5 |
| 1997 | 3064.5 | 164.5 | 136.6 | 7.3 | 18.6 | 32.9 | 49.3 | 65.8 | 82.2 |
| 1998 | 3099.5 | 172.7 | 138.1 | 7.7 | 17.9 | 34.5 | 51.8 | 69.0 | 86.3 |
| 1999 | 3134.5 | 181.4 | 139.7 | 8.0 | 17.2 | 36.2 | 54.4 | 72.5 | 90.7 |
| 2000 | 3169.5 | 190.9 | 141.3 | 8.5 | 16.5 | 38.1 | 57.2 | 76.3 | 95.4 |

EFFECTIVE DEMAND FOR CITY GAS (UJUN PANDANG)

| YEAR | POP. | PER.H | P.DENS | H.DENS | PP/PH | 20P | 30P | 40P | 50P |
|---|---|---|---|---|---|---|---|---|---|
| 1972 | 434.6 | 22.0 | 206.9 | 10.4 | 19.7 | 4.4 | 6.5 | 8.8 | 11.0 |
| 1973 | 441.5 | 22.5 | 210.2 | 10.7 | 19.5 | 4.5 | 6.7 | 9.0 | 11.2 |
| 1974 | 448.4 | 23.1 | 213.5 | 11.0 | 19.3 | 4.6 | 6.9 | 9.2 | 11.5 |
| 1975 | 455.4 | 23.8 | 216.8 | 11.3 | 19.1 | 4.7 | 7.1 | 9.5 | 11.9 |
| 1976 | 462.3 | 24.4 | 220.1 | 11.6 | 18.9 | 4.8 | 7.3 | 9.7 | 12.2 |
| 1977 | 469.2 | 25.0 | 223.4 | 11.9 | 18.7 | 5.0 | 7.5 | 10.0 | 12.5 |
| 1978 | 476.2 | 25.7 | 226.7 | 12.2 | 18.5 | 5.1 | 7.7 | 10.2 | 12.8 |
| 1979 | 483.1 | 26.4 | 230.0 | 12.5 | 18.2 | 5.2 | 7.9 | 10.5 | 13.2 |
| 1980 | 490.1 | 27.1 | 233.3 | 12.9 | 18.0 | 5.4 | 8.1 | 10.8 | 13.5 |
| 1981 | 497.0 | 27.8 | 236.6 | 13.2 | 17.8 | 5.5 | 8.3 | 11.1 | 13.9 |
| 1982 | 503.9 | 28.5 | 239.9 | 13.5 | 17.6 | 5.7 | 8.5 | 11.4 | 14.2 |
| 1983 | 510.9 | 29.2 | 243.3 | 13.9 | 17.4 | 5.8 | 8.7 | 11.7 | 14.5 |
| 1984 | 517.8 | 30.0 | 246.6 | 14.2 | 17.2 | 6.0 | 9.0 | 12.0 | 15.0 |
| 1985 | 524.8 | 30.8 | 249.9 | 14.6 | 17.0 | 6.1 | 9.2 | 12.3 | 15.4 |
| 1986 | 531.7 | 31.5 | 253.2 | 15.0 | 16.8 | 6.3 | 9.4 | 12.6 | 15.7 |
| 1987 | 538.6 | 32.4 | 256.5 | 15.4 | 16.6 | 6.4 | 9.7 | 12.9 | 16.2 |
| 1988 | 545.6 | 33.2 | 259.8 | 15.8 | 16.4 | 6.6 | 9.9 | 13.3 | 16.6 |
| 1989 | 552.5 | 34.1 | 263.1 | 16.2 | 16.2 | 6.8 | 10.2 | 13.6 | 17.0 |
| 1990 | 559.5 | 34.9 | 266.4 | 16.6 | 15.9 | 6.9 | 10.4 | 13.9 | 17.4 |
| 1991 | 566.4 | 35.8 | 269.7 | 17.0 | 15.7 | 7.1 | 10.7 | 14.3 | 17.9 |
| 1992 | 573.3 | 36.8 | 273.0 | 17.5 | 15.5 | 7.3 | 11.0 | 14.7 | 18.4 |
| 1993 | 580.3 | 37.7 | 276.3 | 17.9 | 15.3 | 7.5 | 11.3 | 15.1 | 18.8 |
| 1994 | 587.2 | 38.7 | 279.6 | 18.4 | 15.1 | 7.7 | 11.6 | 15.4 | 19.3 |
| 1995 | 594.2 | 39.7 | 282.9 | 18.9 | 14.9 | 7.9 | 11.9 | 15.9 | 19.8 |
| 1996 | 601.1 | 40.7 | 286.2 | 19.4 | 14.7 | 8.1 | 12.2 | 16.3 | 20.3 |
| 1997 | 608.0 | 41.8 | 289.5 | 19.9 | 14.5 | 8.3 | 12.5 | 16.7 | 20.9 |
| 1998 | 615.0 | 42.9 | 292.8 | 20.4 | 14.3 | 8.5 | 12.8 | 17.1 | 21.4 |
| 1999 | 621.9 | 44.0 | 296.1 | 20.9 | 14.1 | 8.8 | 13.2 | 17.6 | 22.0 |
| 2000 | 628.8 | 45.2 | 299.4 | 21.5 | 13.9 | 9.0 | 13.5 | 18.0 | 22.6 |

NUMBER OF CONSUMERS AND GAS VOLUME (JAKARTA)

| YEAR | CONSUMERS | UNI VOL. | GAS VOL. | ADD. | TOTAL | COV.P. | COV.H. |
|---|---|---|---|---|---|---|---|
| 1972 | 6156. | 1500. | 9234. | 0. | 9234. | 0.1 | 4.5 |
| 1973 | 6214. | 1427. | 8867. | 0. | 8867. | 0.1 | 4.3 |
| 1974 | 6132. | 1554. | 9529. | 0. | 9529. | 0.1 | 4.0 |
| 1975 | 6134. | 1599. | 9808. | 0. | 9808. | 0.1 | 3.9 |
| 1976 | 6136. | 1644. | 10087. | 0. | 10087. | 0.1 | 3.7 |
| 1977 | 6443. | 1683. | 10843. | 0. | 10843. | 0.1 | 3.7 |
| 1978 | 6765. | 1729. | 11696. | 0. | 11696. | 0.1 | 3.7 |
| 1979 | 7441. | 1763. | 13123. | 0. | 13123. | 0.1 | 3.9 |
| 1980 | 8185. | 1798. | 14724. | 0. | 14724. | 0.1 | 4.1 |
| 1981 | 9004. | 1834. | 16521. | 0. | 16521. | 0.1 | 4.3 |
| 1982 | 9904. | 1871. | 18536. | 0. | 18536. | 0.1 | 4.5 |
| 1983 | 10895. | 1908. | 20798. | 0. | 20798. | 0.1 | 4.7 |
| 1984 | 11984. | 1947. | 23335. | 0. | 23335. | 0.1 | 4.9 |
| 1985 | 13183. | 1986. | 26182. | 0. | 26182. | 0.2 | 5.2 |
| 1986 | 14501. | 2025. | 29376. | 0. | 29376. | 0.2 | 5.5 |
| 1987 | 15951. | 2066. | 32960. | 0. | 32960. | 0.2 | 5.7 |
| 1988 | 17546. | 2107. | 36981. | 0. | 36981. | 0.2 | 6.0 |
| 1989 | 19301. | 2149. | 41493. | 0. | 41493. | 0.2 | 6.3 |
| 1990 | 21231. | 2192. | 46555. | 0. | 46555. | 0.3 | 6.7 |
| 1991 | 23354. | 2236. | 52235. | 0. | 52235. | 0.3 | 7.0 |
| 1992 | 25690. | 2281. | 58608. | 0. | 58608. | 0.3 | 7.4 |
| 1993 | 28259. | 2327. | 65758. | 0. | 65758. | 0.3 | 7.7 |
| 1994 | 31084. | 2373. | 73781. | 0. | 73781. | 0.4 | 8.1 |
| 1995 | 34193. | 2421. | 82782. | 0. | 82782. | 0.4 | 8.5 |
| 1996 | 37612. | 2469. | 92882. | 0. | 92882. | 0.4 | 8.9 |
| 1997 | 41373. | 2518. | 104213. | 0. | 104213. | 0.5 | 9.4 |
| 1998 | 45511. | 2569. | 116927. | 0. | 116927. | 0.5 | 9.8 |
| 1999 | 50062. | 2620. | 131192. | 0. | 131192. | 0.5 | 10.3 |
| 2000 | 55053. | 2672. | 147156. | 0. | 147156. | 0.6 | 10.7 |

NUMBER OF CONSUMERS AND GAS VOLUME (MEDAN)

| YEAR | CONSUMERS | UNI VOL. | GAS VOL. | ADD. | TOTAL | COV.P. | COV.H. |
|---|---|---|---|---|---|---|---|
| 1972 | 1501. | 1572. | 2359. | 0. | 2359. | 0.2 | 8.5 |
| 1973 | 1442. | 1510. | 2177. | 0. | 2177. | 0.2 | 7.9 |
| 1974 | 1336. | 1600. | 2137. | 0. | 2137. | 0.2 | 7.1 |
| 1975 | 1243. | 1600. | 1988. | 0. | 1988. | 0.1 | 6.3 |
| 1976 | 1149. | 1600. | 1838. | 0. | 1838. | 0.1 | 5.7 |
| 1977 | 1160. | 1616. | 1874. | 0. | 1874. | 0.1 | 5.5 |
| 1978 | 1172. | 1632. | 1912. | 0. | 1912. | 0.1 | 5.4 |
| 1979 | 1289. | 1664. | 2146. | 0. | 2146. | 0.1 | 5.7 |
| 1980 | 1418. | 1697. | 2407. | 0. | 2407. | 0.2 | 6.1 |
| 1981 | 1559. | 1731. | 2701. | 0. | 2701. | 0.2 | 6.4 |
| 1982 | 1715. | 1766. | 3031. | 0. | 3031. | 0.2 | 6.8 |
| 1983 | 1887. | 1801. | 3401. | 0. | 3401. | 0.2 | 7.2 |
| 1984 | 2076. | 1837. | 3815. | 0. | 3815. | 0.2 | 7.7 |
| 1985 | 2283. | 1874. | 4281. | 0. | 4281. | 0.3 | 8.1 |
| 1986 | 2512. | 1912. | 4803. | 0. | 4803. | 0.3 | 8.6 |
| 1987 | 2763. | 1950. | 5389. | 0. | 5389. | 0.3 | 9.1 |
| 1988 | 3039. | 1989. | 6047. | 0. | 6047. | 0.3 | 9.6 |
| 1989 | 3343. | 2029. | 6785. | 0. | 6785. | 0.4 | 10.2 |
| 1990 | 3677. | 2069. | 7611. | 0. | 7611. | 0.4 | 10.7 |
| 1991 | 4042. | 2111. | 8533. | 0. | 8533. | 0.5 | 11.3 |
| 1992 | 4440. | 2153. | 9563. | 0. | 9563. | 0.5 | 11.9 |
| 1993 | 4876. | 2196. | 10710. | 0. | 10710. | 0.5 | 12.6 |
| 1994 | 5350. | 2240. | 11988. | 0. | 11988. | 0.6 | 13.2 |
| 1995 | 5868. | 2285. | 13410. | 0. | 13410. | 0.6 | 13.9 |
| 1996 | 6432. | 2330. | 14993. | 0. | 14993. | 0.7 | 14.5 |
| 1997 | 7046. | 2377. | 16752. | 0. | 16752. | 0.8 | 15.2 |
| 1998 | 7713. | 2425. | 18706. | 0. | 18706. | 0.8 | 15.9 |
| 1999 | 8439. | 2473. | 20876. | 0. | 20876. | 0.9 | 16.5 |
| 2000 | 9228. | 2523. | 23282. | 0. | 23282. | 1.0 | 17.2 |

NUMBER OF CONSUMERS AND GAS VOLUME (Bandung)

| YEAR | CONSUMERS | UNI VOL. | GAS VOL. | ADD. | TOTAL | COV.P. | COV.H. |
|---|---|---|---|---|---|---|---|
| 1972 | 5574. | 1111. | 6192. | 0. | 6192. | 0.4 | 18.0 |
| 1973 | 5568. | 1122. | 6247. | 0. | 6247. | 0.4 | 17.4 |
| 1974 | 5514. | 1170. | 6451. | 0. | 6451. | 0.4 | 16.6 |
| 1975 | 5491. | 1208. | 6621. | 0. | 6621. | 0.4 | 15.9 |
| 1976 | 5448. | 1247. | 6793. | 0. | 6793. | 0.4 | 15.2 |
| 1977 | 5687. | 1279. | 7273. | 0. | 7273. | 0.4 | 15.3 |
| 1978 | 5937. | 1313. | 7795. | 0. | 7795. | 0.4 | 15.3 |
| 1979 | 6498. | 1339. | 8703. | 0. | 8703. | 0.4 | 16.1 |
| 1980 | 7108. | 1366. | 9710. | 0. | 9710. | 0.5 | 17.0 |
| 1981 | 7769. | 1393. | 10825. | 0. | 10825. | 0.5 | 17.8 |
| 1982 | 8484. | 1421. | 12058. | 0. | 12058. | 0.6 | 18.7 |
| 1983 | 9258. | 1449. | 13422. | 0. | 13422. | 0.6 | 19.6 |
| 1984 | 10095. | 1478. | 14927. | 0. | 14927. | 0.7 | 20.5 |
| 1985 | 10997. | 1508. | 16586. | 0. | 16586. | 0.7 | 21.5 |
| 1986 | 11970. | 1538. | 18415. | 0. | 18415. | 0.8 | 22.4 |
| 1987 | 13018. | 1569. | 20428. | 0. | 20428. | 0.8 | 23.3 |
| 1988 | 14146. | 1600. | 22641. | 0. | 22641. | 0.9 | 24.3 |
| 1989 | 15358. | 1632. | 25073. | 0. | 25073. | 1.0 | 25.2 |
| 1990 | 16659. | 1665. | 27742. | 0. | 27742. | 1.0 | 26.1 |
| 1991 | 18056. | 1698. | 30669. | 0. | 30669. | 1.1 | 27.0 |
| 1992 | 19553. | 1732. | 33876. | 0. | 33876. | 1.2 | 27.9 |
| 1993 | 21158. | 1767. | 37388. | 0. | 37388. | 1.3 | 28.8 |
| 1994 | 22875. | 1802. | 41232. | 0. | 41232. | 1.4 | 29.6 |
| 1995 | 24714. | 1838. | 45437. | 0. | 45437. | 1.5 | 30.4 |
| 1996 | 26681. | 1875. | 50035. | 0. | 50035. | 1.6 | 31.1 |
| 1997 | 28785. | 1912. | 55060. | 0. | 55060. | 1.7 | 31.8 |
| 1998 | 31036. | 1951. | 60552. | 0. | 60552. | 1.8 | 32.4 |
| 1999 | 33443. | 1990. | 66555. | 0. | 66555. | 1.9 | 32.9 |
| 2000 | 36020. | 2029. | 73116. | 0. | 73116. | 2.0 | 33.4 |

NUMBER OF CONSUMERS AND GAS VOLUME (BOGOR)

| YEAR | CONSUMERS | UNI VOL. | GAS VOL. | ADD. | TOTAL | COV.P. | COV.H. |
|---|---|---|---|---|---|---|---|
| 1972 | 1110. | 980. | 1087. | 0. | 1087. | 0.5 | 10.9 |
| 1973 | 1103. | 1053. | 1161. | 0. | 1161. | 0.5 | 10.6 |
| 1974 | 1074. | 1074. | 1153. | 0. | 1153. | 0.5 | 10.0 |
| 1975 | 1051. | 1051. | 1104. | 0. | 1104. | 0.5 | 9.6 |
| 1976 | 1029. | 1029. | 1058. | 0. | 1058. | 0.4 | 9.1 |
| 1977 | 1080. | 1080. | 1166. | 0. | 1166. | 0.5 | 9.3 |
| 1978 | 1134. | 1284. | 1456. | 0. | 1456. | 0.5 | 9.6 |
| 1979 | 1247. | 1309. | 1633. | 0. | 1633. | 0.5 | 10.2 |
| 1980 | 1371. | 1335. | 1832. | 0. | 1832. | 0.6 | 11.0 |
| 1981 | 1507. | 1362. | 2054. | 0. | 2054. | 0.6 | 11.8 |
| 1982 | 1655. | 1389. | 2300. | 0. | 2300. | 0.7 | 12.6 |
| 1983 | 1816. | 1417. | 2575. | 0. | 2575. | 0.7 | 13.5 |
| 1984 | 1991. | 1445. | 2880. | 0. | 2880. | 0.8 | 14.4 |
| 1985 | 2182. | 1474. | 3218. | 0. | 3218. | 0.9 | 15.4 |
| 1986 | 2388. | 1504. | 3593. | 0. | 3593. | 0.9 | 16.5 |
| 1987 | 2611. | 1534. | 4007. | 0. | 4007. | 1.0 | 17.5 |
| 1988 | 2853. | 1565. | 4465. | 0. | 4465. | 1.1 | 18.7 |
| 1989 | 3113. | 1596. | 4970. | 0. | 4970. | 1.2 | 19.9 |
| 1990 | 3393. | 1628. | 5526. | 0. | 5526. | 1.3 | 21.1 |
| 1991 | 3695. | 1660. | 6137. | 0. | 6137. | 1.4 | 22.5 |
| 1992 | 4018. | 1694. | 6808. | 0. | 6808. | 1.5 | 23.8 |
| 1993 | 4364. | 1728. | 7542. | 0. | 7542. | 1.6 | 25.2 |
| 1994 | 4734. | 1762. | 8345. | 0. | 8345. | 1.7 | 26.7 |
| 1995 | 5128. | 1797. | 9221. | 0. | 9221. | 1.9 | 28.2 |
| 1996 | 5548. | 1833. | 10174. | 0. | 10174. | 2.0 | 29.7 |
| 1997 | 5993. | 1870. | 11211. | 0. | 11211. | 2.1 | 31.3 |
| 1998 | 6464. | 1907. | 12334. | 0. | 12334. | 2.3 | 32.9 |
| 1999 | 6963. | 1946. | 13550. | 0. | 13550. | 2.4 | 34.5 |
| 2000 | 7488. | 1985. | 14864. | 0. | 14864. | 2.6 | 36.2 |

NUMBER OF CONSUMERS AND GAS VOLUME (CIREBON)

| YEAR | CONSUMERS | UNI VOL. | GAS VOL. | ADD. | TOTAL | COV.P. | COV.H. |
|---|---|---|---|---|---|---|---|
| 1972 | 603. | 1073. | 647. | 0. | 647. | 0.3 | 4.5 |
| 1973 | 598. | 1070. | 639. | 0. | 639. | 0.3 | 4.3 |
| 1974 | 589. | 1106. | 651. | 0. | 651. | 0.3 | 4.2 |
| 1975 | 581. | 1131. | 657. | 3000. | 3657. | 0.3 | 4.0 |
| 1976 | 574. | 1156. | 663. | 10000. | 10663. | 0.3 | 3.9 |
| 1977 | 631. | 1178. | 743. | 20000. | 20743. | 0.3 | 4.2 |
| 1978 | 695. | 1200. | 834. | 30000. | 30834. | 0.3 | 4.5 |
| 1979 | 764. | 1224. | 935. | 40000. | 40935. | 0.4 | 4.8 |
| 1980 | 840. | 1248. | 1049. | 50000. | 51049. | 0.4 | 5.2 |
| 1981 | 925. | 1273. | 1177. | 60000. | 61178. | 0.4 | 5.6 |
| 1982 | 1017. | 1298. | 1321. | 60000. | 61321. | 0.5 | 6.1 |
| 1983 | 1119. | 1324. | 1482. | 60000. | 61482. | 0.5 | 6.5 |
| 1984 | 1231. | 1351. | 1663. | 60000. | 61663. | 0.6 | 7.1 |
| 1985 | 1354. | 1378. | 1866. | 60000. | 61866. | 0.6 | 7.6 |
| 1986 | 1489. | 1405. | 2094. | 60000. | 62094. | 0.7 | 8.2 |
| 1987 | 1638. | 1434. | 2350. | 60000. | 62350. | 0.8 | 8.9 |
| 1988 | 1802. | 1462. | 2636. | 60000. | 62636. | 0.8 | 9.6 |
| 1989 | 1982. | 1492. | 2958. | 60000. | 62958. | 0.9 | 10.3 |
| 1990 | 2180. | 1521. | 3318. | 60000. | 63318. | 1.0 | 11.1 |
| 1991 | 2396. | 1552. | 3719. | 60000. | 63719. | 1.1 | 12.0 |
| 1992 | 2630. | 1583. | 4165. | 60000. | 64165. | 1.2 | 12.9 |
| 1993 | 2886. | 1615. | 4661. | 60000. | 64661. | 1.3 | 13.9 |
| 1994 | 3163. | 1647. | 5211. | 60000. | 65211. | 1.4 | 14.9 |
| 1995 | 3463. | 1680. | 5820. | 60000. | 65820. | 1.5 | 16.0 |
| 1996 | 3789. | 1713. | 6494. | 60000. | 66494. | 1.6 | 17.2 |
| 1997 | 4140. | 1748. | 7238. | 60000. | 67238. | 1.8 | 18.5 |
| 1998 | 4519. | 1783. | 8058. | 60000. | 68058. | 1.9 | 19.8 |
| 1999 | 4927. | 1818. | 8961. | 60000. | 68961. | 2.1 | 21.1 |
| 2000 | 5364. | 1855. | 9952. | 60000. | 69952. | 2.2 | 22.6 |

NUMBER OF CONSUMERS AND GAS VOLUME (SEMARANG)

| YEAR | CONSUMERS | UNI VOL. | GAS VOL. | ADD. | TOTAL | COV.P. | COV.H. |
|---|---|---|---|---|---|---|---|
| 1972 | 2053. | 952. | 1954. | 0. | 1954. | 0.3 | 9.0 |
| 1973 | 2013. | 930. | 1872. | 0. | 1872. | 0.3 | 8.6 |
| 1974 | 1947. | 944. | 1837. | 0. | 1837. | 0.3 | 8.1 |
| 1975 | 1890. | 945. | 1786. | 0. | 1786. | 0.2 | 7.6 |
| 1976 | 1834. | 945. | 1733. | 0. | 1733. | 0.2 | 7.1 |
| 1977 | 1953. | 954. | 1863. | 0. | 1863. | 0.2 | 7.4 |
| 1978 | 2080. | 964. | 2005. | 0. | 2005. | 0.3 | 7.6 |
| 1979 | 2288. | 983. | 2249. | 0. | 2249. | 0.3 | 8.1 |
| 1930 | 2516. | 1002. | 2524. | 0. | 2524. | 0.3 | 8.7 |
| 1981 | 2768. | 1023. | 2832. | 0. | 2832. | 0.3 | 9.3 |
| 1982 | 3045. | 1043. | 3177. | 0. | 3177. | 0.4 | 9.9 |
| 1983 | 3349. | 1064. | 3565. | 0. | 3565. | 0.4 | 10.5 |
| 1984 | 3682. | 1085. | 3998. | 0. | 3998. | 0.5 | 11.2 |
| 1985 | 4046. | 1107. | 4480. | 0. | 4480. | 0.5 | 12.0 |
| 1986 | 4442. | 1129. | 5018. | 0. | 5018. | 0.5 | 12.7 |
| 1987 | 4874. | 1152. | 5616. | 0. | 5616. | 0.6 | 13.6 |
| 1988 | 5344. | 1175. | 6280. | 0. | 6280. | 0.6 | 14.4 |
| 1989 | 5855. | 1198. | 7018. | 0. | 7018. | 0.7 | 15.3 |
| 1990 | 6409. | 1222. | 7836. | 0. | 7836. | 0.8 | 16.2 |
| 1991 | 7010. | 1247. | 8742. | 0. | 8742. | 0.8 | 17.2 |
| 1992 | 7661. | 1271. | 9744. | 0. | 9744. | 0.9 | 18.2 |
| 1993 | 8364. | 1297. | 10851. | 0. | 10851. | 1.0 | 19.2 |
| 1994 | 9123. | 1323. | 12073. | 0. | 12073. | 1.0 | 20.3 |
| 1995 | 9941. | 1349. | 13419. | 0. | 13419. | 1.1 | 21.3 |
| 1996 | 10822. | 1376. | 14900. | 0. | 14900. | 1.2 | 22.5 |
| 1997 | 11769. | 1404. | 16528. | 0. | 16528. | 1.3 | 23.6 |
| 1998 | 12785. | 1432. | 18314. | 0. | 18314. | 1.4 | 24.8 |
| 1999 | 13874. | 1461. | 20271. | 0. | 20271. | 1.5 | 26.0 |
| 2000 | 15038. | 1490. | 22412. | 0. | 22412. | 1.6 | 27.2 |

NUMBER OF CONSUMERS AND GAS VOLUME (SURABAYA)

| YEAR | CONSUMERS | UNI VOL. | GAS VOL. | ADD. | TOTAL | COV.P. | COV.H. |
|---|---|---|---|---|---|---|---|
| 1972 | 4444. | 1567. | 6963. | 0. | 6963. | 0.2 | 7.2 |
| 1973 | 4358. | 1483. | 6462. | 0. | 6462. | 0.1 | 6.8 |
| 1974 | 4267. | 1555. | 6635. | 0. | 6635. | 0.1 | 6.4 |
| 1975 | 4181. | 1584. | 6622. | 0. | 6622. | 0.1 | 6.0 |
| 1976 | 4096. | 1613. | 6606. | 0. | 6606. | 0.1 | 5.7 |
| 1977 | 4342. | 1644. | 7138. | 0. | 7138. | 0.1 | 5.8 |
| 1978 | 4602. | 1675. | 7708. | 0. | 7708. | 0.1 | 6.0 |
| 1979 | 5062. | 1708. | 8648. | 0. | 8648. | 0.2 | 6.3 |
| 1980 | 5568. | 1742. | 9703. | 0. | 9703. | 0.2 | 6.7 |
| 1981 | 6125. | 1777. | 10887. | 0. | 10887. | 0.2 | 7.1 |
| 1982 | 6737. | 1813. | 12216. | 0. | 12216. | 0.2 | 7.6 |
| 1983 | 7411. | 1849. | 13706. | 0. | 13706. | 0.2 | 8.0 |
| 1984 | 8152. | 1886. | 15378. | 0. | 15378. | 0.3 | 8.5 |
| 1985 | 8967. | 1924. | 17254. | 0. | 17254. | 0.3 | 9.0 |
| 1986 | 9864. | 1962. | 19359. | 0. | 19359. | 0.3 | 9.5 |
| 1987 | 10851. | 2001. | 21721. | 0. | 21721. | 0.3 | 10.1 |
| 1988 | 11934. | 2041. | 24368. | 0. | 24368. | 0.4 | 10.7 |
| 1989 | 13119. | 2082. | 27323. | 0. | 27323. | 0.4 | 11.3 |
| 1990 | 14414. | 2124. | 30620. | 0. | 30620. | 0.5 | 11.9 |
| 1991 | 15827. | 2166. | 34295. | 0. | 34295. | 0.5 | 12.5 |
| 1992 | 17370. | 2210. | 38390. | 0. | 38390. | 0.6 | 13.2 |
| 1993 | 19051. | 2254. | 42947. | 0. | 42947. | 0.6 | 13.8 |
| 1994 | 20882. | 2299. | 48016. | 0. | 48016. | 0.7 | 14.5 |
| 1995 | 22874. | 2345. | 53650. | 0. | 53650. | 0.7 | 15.2 |
| 1996 | 25042. | 2392. | 59908. | 0. | 59908. | 0.8 | 15.9 |
| 1997 | 27397. | 2440. | 66853. | 0. | 66853. | 0.8 | 16.6 |
| 1998 | 29955. | 2488. | 74556. | 0. | 74556. | 0.9 | 17.3 |
| 1999 | 32730. | 2538. | 83094. | 0. | 83094. | 1.0 | 18.0 |
| 2000 | 35740. | 2589. | 92550. | 0. | 92550. | 1.1 | 18.7 |

NUMBER OF CONSUMERS AND GAS VOLUME (UJUN PANDANG)

| YEAR | CONSUMERS | UNI VOL. | GAS VOL. | ADD. | TOTAL | COV.P. | COV.H. |
|---|---|---|---|---|---|---|---|
| 1972 | 405. | 1605. | 650. | 0. | 650. | 0.0 | 1.8 |
| 1973 | 416. | 1675. | 696. | 0. | 696. | 0.0 | 1.8 |
| 1974 | 413. | 1660. | 685. | 0. | 685. | 0.0 | 1.7 |
| 1975 | 415. | 1654. | 686. | 0. | 686. | 0.0 | 1.7 |
| 1976 | 417. | 1649. | 687. | 0. | 687. | 0.0 | 1.7 |
| 1977 | 439. | 1664. | 730. | 0. | 730. | 0.0 | 1.7 |
| 1978 | 461. | 1679. | 774. | 0. | 774. | 0.0 | 1.7 |
| 1979 | 507. | 1712. | 868. | 0. | 868. | 0.1 | 1.9 |
| 1980 | 557. | 1746. | 974. | 0. | 974. | 0.1 | 2.0 |
| 1981 | 613. | 1781. | 1093. | 0. | 1093. | 0.1 | 2.2 |
| 1982 | 674. | 1817. | 1226. | 0. | 1226. | 0.1 | 2.3 |
| 1983 | 742. | 1853. | 1376. | 0. | 1376. | 0.1 | 2.5 |
| 1984 | 816. | 1890. | 1544. | 0. | 1544. | 0.1 | 2.7 |
| 1985 | 898. | 1928. | 1732. | 0. | 1732. | 0.1 | 2.9 |
| 1986 | 988. | 1967. | 1943. | 0. | 1943. | 0.1 | 3.1 |
| 1987 | 1087. | 2006. | 2181. | 0. | 2181. | 0.2 | 3.3 |
| 1988 | 1195. | 2046. | 2447. | 0. | 2447. | 0.2 | 3.5 |
| 1989 | 1315. | 2087. | 2745. | 0. | 2745. | 0.2 | 3.8 |
| 1990 | 1446. | 2129. | 3080. | 0. | 3080. | 0.2 | 4.1 |
| 1991 | 1591. | 2171. | 3456. | 0. | 3456. | 0.2 | 4.4 |
| 1992 | 1750. | 2215. | 3878. | 0. | 3878. | 0.3 | 4.7 |
| 1993 | 1925. | 2259. | 4351. | 0. | 4351. | 0.3 | 5.0 |
| 1994 | 2118. | 2304. | 4882. | 0. | 4882. | 0.3 | 5.4 |
| 1995 | 2330. | 2351. | 5478. | 0. | 5478. | 0.3 | 5.8 |
| 1996 | 2563. | 2398. | 6146. | 0. | 6146. | 0.4 | 6.2 |
| 1997 | 2819. | 2445. | 6896. | 0. | 6896. | 0.4 | 6.7 |
| 1998 | 3101. | 2494. | 7737. | 0. | 7737. | 0.5 | 7.2 |
| 1999 | 3411. | 2544. | 8681. | 0. | 8681. | 0.5 | 7.7 |
| 2000 | 3752. | 2595. | 9740. | 0. | 9740. | 0.5 | 8.2 |

[APPENDIX 8]

## Combustion Characteristics and Interchangeability of Gas

The gas appliance is capable of meeting the change of gas components to some extent in order to attain the optimum combustion. This allowable range of change in the gas characteristics is called the gas interchangeability.

The optimum combustion must satisfy all the following conditions

(1) Predetermined heat of combustion is produced (Constant input).

(2) Flame is free from "lift" and light-back (Stability of flame).

(3) Neither soot nor carbon monoxide is generated (Complete combustion).

(4) Flame has the specified temperature, length and red heat.

When a certain predetermined gas appliance is used, these combustion characteristics vary according to the change of the supplied gas components, and are also affected largely by the gas characteristics listed below.

(1) Calorific value.

(2) Specific gravity.

(3) Flame speed.

(4) Theoretical (stoichiochemical) air requirement.

(5) Flammable limits.

(6) Sooting index.

(7) Spontaneous ignition temperature.

(8) Supply pressure.

It is preferable that the combustion characteristics of supplied gas be individually reviewed on the basis of the above-listed characteristic values or the indices obtained by their combination. Ordinarily, however, the review is made using the gas interchangeability diagram in which the longitudinal axis represents WI and the horizontal axis the index relating to flame speed.

CP (Derbourg's combustion potential) which is an index related to the flame speed of gas supplied by PGN was obtained by the following simplified equations and plotted in the gas interchangeability diagram shown in Fig. A-1.

$$\text{WI (Wobbe Index)} = \frac{\text{Calorific value}}{\sqrt{\text{Specific gravity}}} \quad \text{..... (Input index)}$$

$$CP = K \frac{H_2 + 0.6\ (CO + C_nH_m) + 0.3CH_4}{\sqrt{d}}$$

where, CP : Combustion potential.

$H_2$ : Hydrogen content in gas (Vol. %)

CO : Carbon monoxide content in gas (Vol. %)

$C_nH_m$ : Content of hydrocarbons other than methane in gas (Vol. %)

$CH_4$ : Methane content in gas (Vol. %)

d : Specific gravity of gas to air.

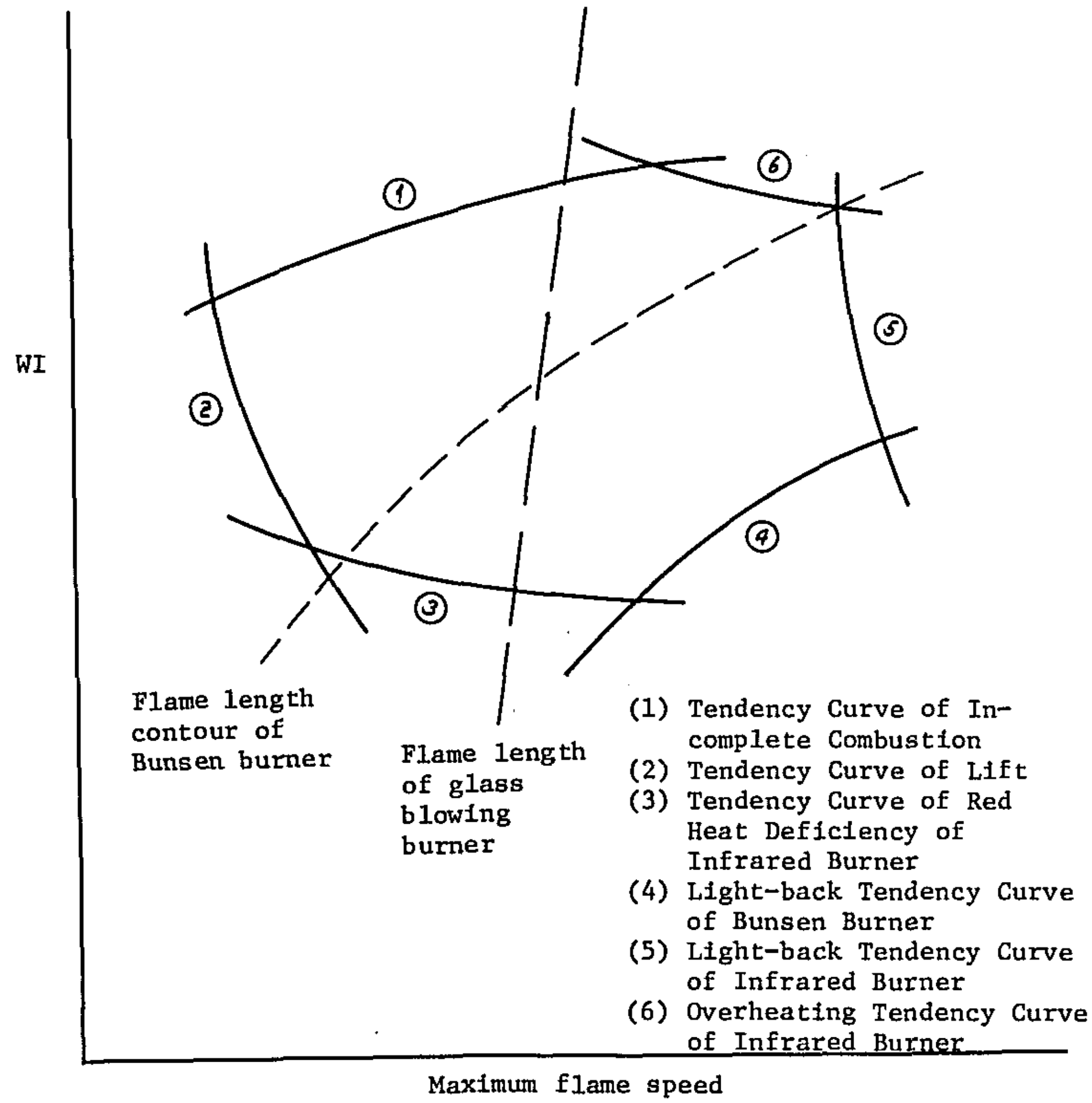
K : Constant determined by the oxygen content in gas, varying according to the values shown in Table A-1.

In the gas interchangeability diagram, the combustion characteristics are expressed by tendency curves shown in Fig. A-1. The area enclosed by these curves is the gas interchangeability region in which good combustion can be attained. The interchangeability region is simplified and surrounded by longitudinal and horizontal lines respresenting WI and CP respectively, and shown in Fig. II-8 (P. 93 ) as interchangeability regions 4A, 6B, 6C and 7C which conform to the respective gas appliances.

Table A-1 Oxygen content in gas

| $O_2$ (%) | K | $O_2$ (%) | K |
|---|---|---|---|
| 1.0 | 1.000 | 9.0 | 1.440 |
| 2 | 05 | 2 | 60 |
| 4 | 10 | 4 | 80 |
| 6 | 12 | 6 | 1.500 |
| 8 | 15 | 8 | 20 |
| 2.0 | 1.020 | 10.0 | 1.540 |
| 2 | 30 | 2 | 60 |
| 4 | 35 | 4 | 80 |
| 6 | 40 | 6 | 1.600 |
| 8 | 50 | 8 | 20 |
| 3.0 | 1.060 | 11.0 | 1.640 |
| 2 | 65 | 2 | 70 |
| 4 | 70 | 4 | 90 |
| 6 | 80 | 6 | 1.710 |
| 8 | 90 | 8 | 30 |
| 4.0 | 1.100 | 12.0 | 1.760 |
| 2 | 05 | 2 | 90 |
| 4 | 10 | 4 | 1.820 |
| 6 | 20 | 6 | 50 |
| 8 | 30 | 8 | 80 |
| 5.0 | 1.150 | 13.0 | 1.920 |
| 2 | 60 | 2 | 60 |
| 4 | 70 | 4 | 2.000 |
| 6 | 80 | 6 | 40 |
| 8 | 90 | 8 | 80 |
| 6.0 | 1.200 | 14.0 | 2.120 |
| 2 | 10 | 2 | 70 |
| 4 | 20 | 4 | 2.220 |
| 6 | 40 | 6 | 60 |
| 8 | 60 | 8 | 2.320 |
| 7.0 | 1.280 | 15.0 | 2.380 |
| 2 | 90 | 2 | 2.440 |
| 4 | 1.310 | 4 | 2.520 |
| 6 | 30 | 6 | 2.600 |
| 8 | 40 | 8 | 680 |
| 8.0 | 1.360 | 16.0 | 2.780 |
| 2 | 80 | 2 | 2.880 |
| 4 | 90 | 4 | 3.000 |
| 6 | 1.410 | 6 | 3.140 |
| 8 | 30 | 8 | 3.300 |
| | | 17.0 | 3.450 |

Fig. A-1 Gas Interchangeability Diagram and Tendency Curves of Combustion Characteristics



At present, gas supplied to urban areas in Japan is classified into 14 kinds by flame speed, as shown in the following table.
If symbol 6B is used, it indicates that WI is in the neighbourhood of 6,000. Flame speed is expressed by symbols A, B and C as follows.

A : Gas with slow flame speed.

B : Gas with medium flame speed.

C : Gas with fast flame speed.

Table A-2 Classification of Gas

| Flame Speed | | |
|---|---|---|
| Slow | Medium | Fast |
| 13A | 6 B | 7 C |
| 12A | 5 B | 6 C |
| 11A | 4 B | 5 C |
| 6A | | 4 C |
| 5A | | |
| 5AN | | |
| 4A | | |

Gas supplied by Tokyo Gas Co., Ltd. is placed under the category of 6B and 13A, and that of Osaka Gas under 6C and 13A. It is rare that supplied gas falls under the category of 4A. Japanese gas industry is planning to revise the existing classification in such a way that WI will exceeds 6,000 for all categories.

Gas interchangeability is calculated by a number of methods such as the one resorting to the index of American Gas Association, as well as Weaver's method and Derbourg's method. However, since none of these methods are accurate enough, experimental effort is made in all countries of the world to raise the accuracy.

Values of SM shown in Table II-8 (P93) are used at the laboratory of Tokyo Gas Co. These values are highly reliable since they were obtained by the "Formula of Maximum Flame Speed of Mixed Gas" which was developed on the basis of a series of continuous experiments.

[APPENDIX 9 ]

## Input and Port Loading of Gas Appliances

Input:

The calorific value consumed by a gas appliance per unit time is called input (Kcal/hr).

The flow rate of gas from a round nozzle is expressed by the following equation.

$$Q = 0.011\ k\ .\ D^2 \sqrt{\frac{P}{d}}$$

where, Q : Gas flow rate ($Nm^3/hr$).

D : Nozzle diameter (mm).

P : Gas pressure (mmAq).

d : Gas specific gravity (air=1).

k : Flow rate coefficient (ratio of the theoretical flow rate to the actual flow rate; see Fig. III-9 (P.96 )).

The input is the product of this gas flow rate and the calorific value.

$$\text{Input} = H \cdot Q = 0.011 \cdot k \cdot \sqrt{P} \cdot \frac{H}{\sqrt{d}}$$

where, H : Calorific value of gas.

$H/\sqrt{d}$ is a characteristic value of gas alone, and called WI (Wobbe index). It is used as an index of gas interchangeability, and the input to gas appliance is directly affected by the change of this index.

Port Loading:

In order to express the size of burner port which attains stable flame and complete combustion, input per unit area of port is employed. This input is called port loading and expressed in $kcal/mm^2 \cdot hr$.

The port loading of Bunsen burners is as shown below:

| | | | |
|---|---|---|---|
| Coal gas | : | 8 ∿ 12 | ($kcal/mm^2 \cdot hr$) |
| Natural gas | : | 5 ∿ 9 | ( " ) |
| LP gas | : | 4 ∿ 8 | ( " ) |

It will be understood from the above values that natural gas calls for a larger port area than coal gas in order to attain stable and complete combustion at the same input.

[APPENDIX 10]

## Natural Gas Conversion

Natural gas conversion need to be carried out according to a detailed plan. PGN has already completed the conversion in its Cirebon area, but it will be difficult to effect the conversion at a time for the whole Jakarta city which is far more extensive than Cirebon area. It will therefore be necessary to divide the area into a number of blocks and carry out the conversion consecutively from one block after another. While the conversion will necessitate the adjustment of gas appliances, this will call for the training of PGN's service personnel, as well as for PR activities to enlighten customers on the characteristics of natural gas.

### 1. Outline of Conversion Plan

Conversion from manufactured gas with a low Wobbe index to natural gas having a high Wobbe index presupposes the adjustment of customers' gas appliances so as to maintain good combustion characteristics.

If it is found not feasible to adjust gas appliances of all customers in a short time, the service area should be divided into a number of blocks (i.e., sectors) and adjustment service in each block should be completed in 2 to 5 days. This method is called the "area zoning system."

Whether the adjustment is to be made by the simultaneous area-wide system or area zoning system can be judged by the following equation:

$$\text{Number of customers} = \frac{\text{Load (Number of appliances/worker/day)} \times \text{Number of workers} \times \text{Number of working days}}{\text{Number of Appliances (Number/customer)}}$$

Assuming that the load is 20, number of workers 20, number of working days 3, and number of appliances per worker 2, the number of customers to be given the adjustment service turns out to be 600. If the number of customers is smaller than 600, it is possible to adopt the simultaneous area-wide system.

In general, natural gas conversion process is divided into "area zoning step" and "appliance adjusting step", and requires the following determinations to be made in advance.

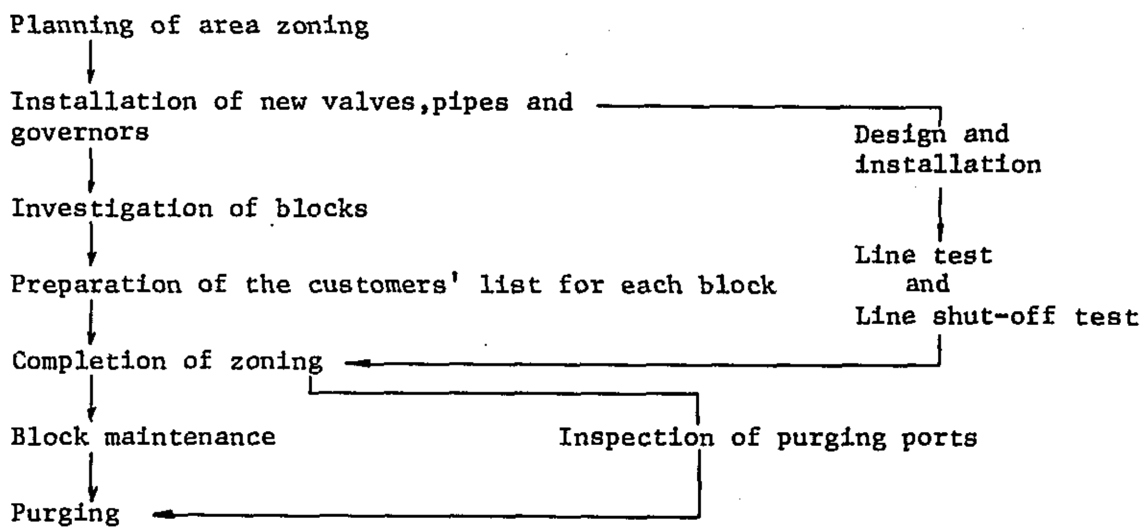
(1) Determination of the calorific value and supply pressure of gas.

(2) Determination of the number of appliances and work load based on the investigation of appliances and study on the method of adjustment.

(3) Determination of the number of workers and the basic number of customers per block.

## 2. Area Zoning

Conversion by the area zoning system is carried out in the following order.



Area Zoning Planning

The distribution network in the area to be covered by the conversion is divided into blocks and the conversion order is determined for each block while confirming that gas supply can be maintained.

Valve and Pipe Installation Planning

Installation of stop valves and temporary connecting lines required for the conversion is planned.

Investigation of Blocks

All customers are checked to determine which block they belong to.

Preparation of the Customers' List

A list of customers classified by blocks is prepared.

Line Test and Line Shut-off Test

When all stop valves and temporary connecting lines are installed, each block is checked to confirm that it is isolated from the surrounding network. Further, the line test is conducted to confirm that the operation of the stop valves according to the conversion sequence does not invite poor supply condition.

Block Maintenance

The list of customers is revised based on the information regarding new installation or abolition of appliances.

3. Gas Appliances Adjustment

The gas appliances adjustment is performed in the following order.

Preliminary survey of gas appliances (sampling survey for examination and determination of the adjustment method)

↓

Examination and determination of adjustment method → Training of workers assinged to adjustment work

↓

Procurement of parts required for adjustment

↓

Appliance Adjustment ← (Training of workers assinged to adjustment work)

↓

Delivery of adjusting parts (leased appliances)

↓

Appliance adjustment (meter inspection)

Gas appliances for household and commercial uses can be adjusted in the sequence described above. However, an overall examination is required for appliances for industrial purposes since their burner is mostly designed to meet the specific purpose of each customer.

4. Fundamentals of Appliance Adjustment

The following are the fundamentals of gas appliances adjustment work:

(1) Since gas appliances are required to exhibit a constant efficiency and functions, the input should be maintained at a suitable fixed value. The nozzle diameter should therefore be adjusted with consideration given to the flow rate coefficent in the nozzle and the change of WI and supply pressure.

(2) The primary air port diameter should be so adjusted that an adequate suction volume of primary air will be maintained.

(3) In certain cases, the burner port must be adjusted to make the flame stable.

[APPENDIX 11]

## Brief History of Japanese Gas Enterprises

Operation of Japanese gas enterprise was started at about the same time as in Indonesia (around 1870) to supply gas to Tokyo and Yokohama for lighting purpose.

In those days, oil lamps were used in most houses for lighting purpose. Although gas lamps excelled in light intensity, general users gave preference for oil lamps because of their simple structure and cheap price. Hence, the development of gas enterprise was very slow until about 1904.

However, with the advent of the 1905 ∿ 1906 boom after the Russo-Japanese war, activities of Japanese industries and enterprises became quite animated and the gas enterprise also made a rapid development, enjoying increasing demand for gas as power and heat sources for industrial and household consumption. In this boom period, moves gained impetus towards establishment of gas companies in large and smaller cities in the country.
Gas companies which numbered only 6 up to 1905 increased to 20 in 1909, and further to 75 in 1911. In 1915, Japanese gas companies registered a phenomenal number of 91, and virtually all of them were private enterprises.

The number of consumers also increased in this growth period and registered 611,000 in 1911, but this could not have been achieved without the streneous effort of gas companies.

Since the general public had little or no knowledge about gas in those days, gas companies conducted positive PR activities. Most consumers used gas experimentally in the beginning, and there were many who used gas in combination with electricity and oil or as supplementary energy source. However, as gas companies exerted continued guidance effort to enlighten the customers, the advantages of gas came to be gradually recognized.

In an attempt to enhance the development of gas enterprise and at the same time to safeguard the interests of gas consumers, the government enacted in 1923 the "Gas Enterprise Law" which served to deepen the knowledge and understanding of general public about gas. The law provided for the approval of gas facilities, gas rates and supply conditions, control measures for safety and security, standard calorific value and components of gas, etc.

In subsequent years, the gas enterprise exerted streneous effort for improving gas quality and expanding gas facilities in order to build a firm foundation for further development. As a result, gas companies numbered 108, and gas consumers totalled 233 households by 1938.

However, the outbreak of the World War II brought about great destruction of the Japanese gas industry. In oarge air-raided cities, such as Tokyo and Osaka, 60 to 90% of consumers were bombed out, and the total number of consumers dropped to 1.4 million or 60% of the pre-war level.

The war brought about a heavy damage upon not only production facilities but also distribution facilities. Some gas companies suffered a percent leakage of more than 50%, and the average percent leakage through the country reached 30%. Distribution system was half paralyzed, and many gas companies had to stop supplying gas,

After the termination of the war, all gas companies immediately started rehabilitation of their plants, holders and pipelines to repair the destruction of war. Rehabilitation entailed extreme difficulties in bombed-out areas because it was not at all easy to locate and repair pipelines laid in such areas.

However, as each gas company used every means to rehabilitate its facilities, gas supply to the remaining consumers was restarted in three months after the end of war, i.e., in December 1945.

Noting the acute need for cutting down the percent leakage, the government conducted a nation-wide leak-preventive campaign. In three months after this campaign, the percent leakage dropped to 15% from the highest of 30%.

The rehabilitation activities were carried out by the united efforts of all gas companies in the face of serious shortage of materials and funds.

It took more than ten years thereafter for the gas enterprise to restore its pre-war level. In order to accelerate the pace of rehabilitation in this period, the government fomulated the Five Year Plan for Rehabilitation of Gas Facilities (First Five Year Plan). In the First Five Year Plan, the following two points were brought to the fore.

1) In view of the advantages of gas as energy source for home consumption, it is of great importance to consolidate and improve the existing gas facilities in a systematic manner for smooth gas supply to general consumers, and to expand such facilities for future augmentation of supply capacity.

2) While Japan is not favoured with natural energy resources, it is very likely that her energy demand will grow rapidly with the population increase, industrial development and improvement of the people's income level. Plans should therefore be mapped out which would enable the gas enterprise to serve for efficient utilization of limited energy resources.

The government was fully cognizant of the advantages of gas and Japan's energy situation which are briefed below.

"Gas is an excellent fuel for home consumption and surpasses other energy sources in handling convenience, economy and calorific value. Since Japan's energy resources are extremely limited, augmented import of fuels is not avoidable even if domestic energy resources are exploited to the full. It is therefore imperative that various energy sources be utilized efficiently according to the purpose of use. Diffusion of gas not only meets this requirement but also serves to expand the scale of Japan's economy by providing coke, tar, benzol and other by-products which are important raw materials required in various industrial fields".

From this conviction, the government encouraged the diffusion of gas. In those days, however, the greater part of energy demand for home consumption was filled by fuels of wood origin including charcoal although gas, kerosene and coal were also used.

The annual cut volume of trees in those days exceeded 18 million $m^3$. This large cut volume threatened the conservation of forest resources voiced strongly from the viewpoint of national economy, and gave an impetus towards shifting from fuels of wood origin to gas.

Japanese gas companies exerted all the endeavours to prompt the diffusion of gas, and achieved the results which surpassed the values envisaged under the Five Year Plan (See the Table A-3). Specifically, the number of consumers increased by 63% and gas sales doubled in the five year period. This means that approximately 5.4 million $m^3$ of forest resources were saved in the same period.

A notable fact about these achievements is that neither the gas rates were raised nor the government subsidy was requested throughout the five year period. This was made possible by the intensive entrepreneurial effort to cut down the prime cost by management rationalization and to promote the sales of gas appliances and by-products.

Completion of the First Five Year Plan was ensued by the formulation of the Second Five Year Plan for Gas Diffusion (November 1957) and the Third Five Year Plan (1963) which were both carried out along the lines laid down in the First Five Year Plan and paved the way to the rapid development of Japanese gas industry.

[Table A-3] The First to Fourch Five Year Plans of Japanese Gas Industry

* thousand gas meters
** million cubic meters

| Years | Number of Consumers * | | | | Quantity of Gas Sales ** | | | | Names of Five Year Plans | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | Planned A | Actual B | B/A | B-A | Planned A | Actual B | B/A | B-A | | |
| 1953 | 2,037 | 2,036 | 100.0 | Δ1 | 1,774 | 1,773 | 99.9 | Δ1 | Five Year Plan for Rehabilitation and Expansion of Town Gas Facilities | • Year: Calendar years<br>• Gas quantity: Actual gas volume |
| 54 | 2,209 | 2,212 | 100.1 | 3 | 2,047 | 2,051 | 100.2 | 4 | | |
| 55 | 2,407 | 2,435 | 101.2 | 28 | 2,315 | 2,277 | 98.4 | Δ38 | | |
| 56 | 2,620 | 2,734 | 104.4 | 114 | 2,596 | 2,608 | 100.5 | 12 | | |
| 57 | 2,848 | 3,087 | 108.4 | 239 | 2,867 | 3,059 | 106.7 | 192 | | |
| 1958 | 3,419 | 3,486 | 102.0 | 67 | 3,453 | 3,285 | 95.1 | Δ168 | Five Year Plan to Propagate Use of Town Gas | |
| 59 | 3,734 | 3,903 | 104.5 | 169 | 3,841 | 3,636 | 94.7 | Δ205 | | |
| 60 | 4,054 | 4,360 | 107.5 | 306 | 4,244 | 4,135 | 97.4 | Δ109 | | |
| 61 | 4,345 | 4,810 | 110.7 | 465 | 4,613 (1,661) | (1,668) | 100.4 | ( 7) | | |
| 62 | 4,623 | 5,296 | 114.6 | 673 | 4.982 (1,794) | (1,857) | 103.5 | ( 63) | | |
| 1963 | 5,903 | 5,885 | 99.7 | Δ18 | 2,093 | 2,126 | 101.6 | 33 | Five Year Plan for Rationalization of Town Gas and to Expand Gas Supply | • Years: Fiscal years<br>• Gas quantity: In terms of 10,000 kcal/$M^3$ |
| 64 | 6,434 | 6,418 | 99.8 | Δ16 | 2,283 | 2,342 | 102.6 | 59 | | |
| 65 | 6,971 | 6,981 | 100.1 | 10 | 2,488 | 2,652 | 106.6 | 164 | | |
| 66 | 7,508 | 7,557 | 100.7 | 49 | 2,700 | 2.985 | 110.6 | 285 | | |
| 67 | 8,089 | 8,172 | 101.0 | 83 | 2,918 | 3,293 | 112.9 | 375 | | |
| 1968 | 8,838 | 8,862 | 100.3 | 24 | 3,852 | 3,591 | 100.3 | 9 | New Five Year Plan of The Town Gas Industry | |
| 69 | 9,632 | 9,605 | 99.7 | Δ27 | 3,932 | 4,097 | 104.2 | 165 | | |
| 70 | 10,404 | 10,371 | 99.7 | Δ33 | 4,294 | 4,571 | 106.5 | 277 | | |
| 71 | 11,235 | 11,121 | 99.0 | Δ114 | 4,688 | 4,963 | 105.9 | 275 | | |
| 72 | 12,119 | 11,892 | 98.1 | Δ227 | 5,105 | 5,417 | 106.1 | 312 | | |

Note) Figures within parentheses in terms of 10,000 kcal/$M^3$.
'Δ' Denotes negative figures.