# Chapter 15

# Environmental Assessment

# 15. Environmental Assessment

To evaluate the influence of the increased use of urban gas on the environment in the Study area, first of all, it is necessary to grasp the present situation of air pollution sources, across the whole of Indonesia to Java and around the Study area. Information of the fuel consumption in the areas has been collected and analyzed through the Study. In addition, the current situation of air pollutant emissions from fuel use in the area which is nearest to the Study Area, and the amount of reduction in air pollution by the growing use of urban gas in each sector has been projected until 2020.

Estimation of the environmental improvement in future due to urban gas use is calculated by using the emission factor of the fuel being substituted for urban gas in each sector. The degree of improvement in each is estimated by comparing with the case in which urban gas will not increase beyond the present quantity.

## 15.1 General Environment around the Study Area

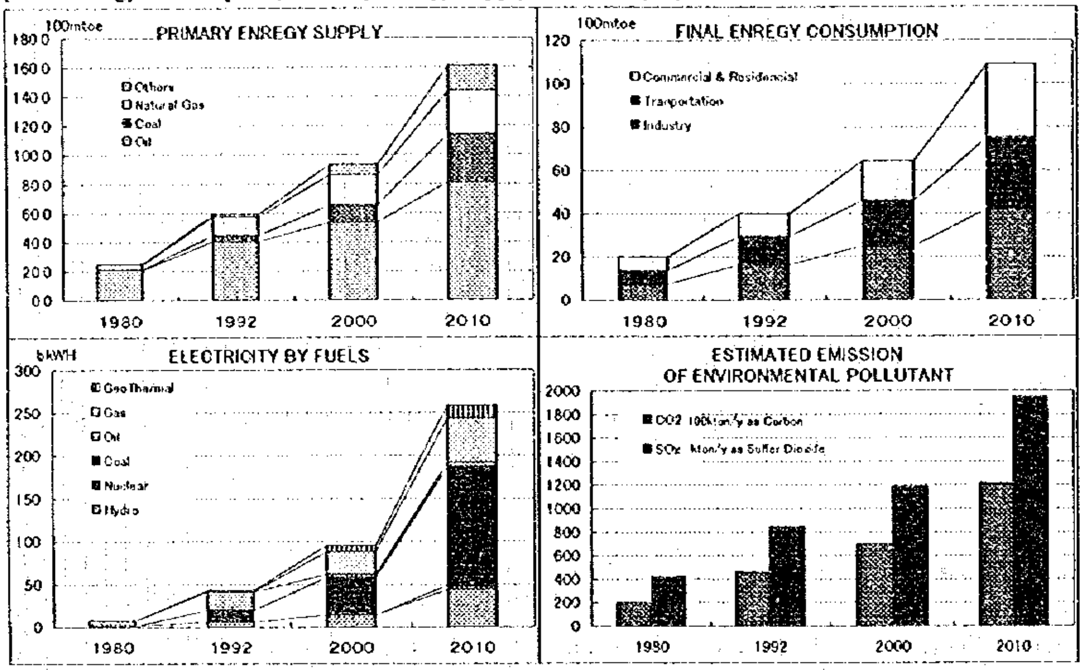
### 15.1.1 Present and Future Environmental Issues in Indonesia

Environmental pollution accompanying economic growth in Indonesia began with water pollution caused by industrial waste water. Next, came air pollution which accompanied the rapid increase in energy consumption in the electric power sector and basic industries. Later, it expanded with the increase in traffic volume and population in the urban areas.

Looking to the energy demand in the future, the use of petroleum product will increase with economic development. Expected that energy consumption in the residential and commercial sectors will also increase as the standard of living improves. In the electric power sector which requires large fuel consumption, it is also expected that most fuel sources will be shifted to coal with the growth of electricity demand.

As for the gross air pollution and green house gas, such as sulfur oxide and carbon dioxide, in this presupposition, Indonesia is expected to become the fourth largest pollution-discharging country among the developing countries in the Asian region, following China, India and Korea. That is, for sulfur oxide, it will represent about 7% of the whole Asia, and about 5% of the total carbon dioxide emissions.(Figure15.1.1)

**Figure 15-1-1 Indonesia's Long-range Energy Outlook**
(Final energy consumption, Primary energy supply, Electricity by fuels)




*Source :Long range energy investigation by MITI*

### 15.1.2 Current Situation of Air Pollution

In addition to the present situation of air pollution in Indonesia and in the Study area , we have evaluated the emission of each air pollutant from each type of fuel consumption, and determined the quantity of air pollutant when natural gas is used among all fuels.

The current energy balance in Indonesia has been detailed in several sources, such as BPS, MME (Ministry of Mining and Energy) and IEA statistics. This time, we have briefly evaluated the above three data sources. We adopted the MME statistics for this estimation because of its suitability and consistency of each parameter which will be used in our environmental assessment. (Table 15.1.1)

The major source of air pollution in Indonesia, according to this estimation, is the use of oil products as fuels, followed by coal. The estimation reveals that more than 80% of the total pollution is caused by the industrial sector, including electric power, and the transportation sector. In particular, 65% of nitrogen oxide is from the transportation sector and 32% is from industries including the electric power sector.

Natural gas accounts for 13% of carbon dioxide, less than 4% nitrogen oxides and negligible share of sulfur oxides. (Figure 15.1.2)

**Table 15-1-1 Energy Balance in Indonesia (1994)**

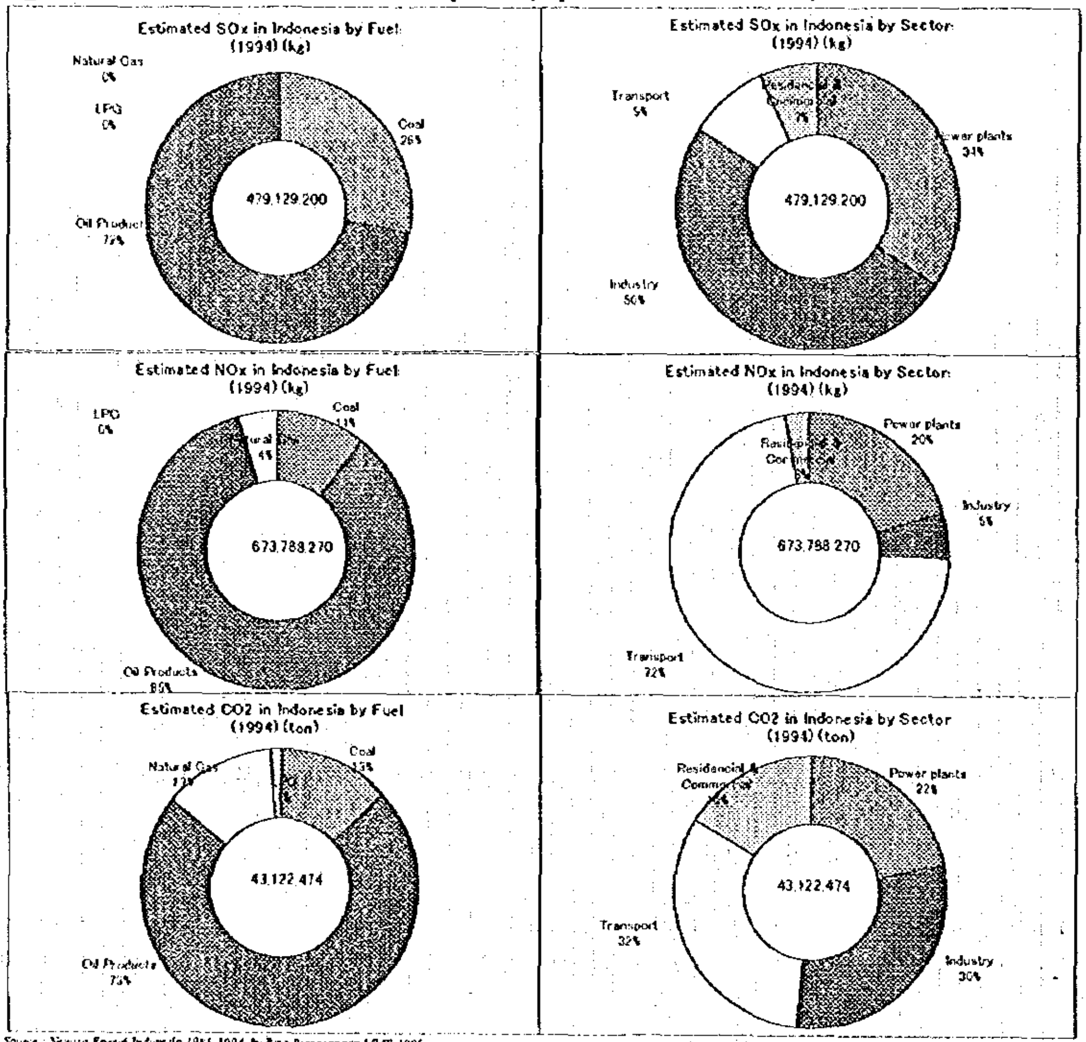
| Energy Balance in 1994 by MME 1995 | Coal | Crude Oil | Oil Products | Natural Gas | LPG | Hydro-power | Geo-thermal | Elect-ricity (Million BOE) | Total |
|---|---|---|---|---|---|---|---|---|---|
| Prodiuction | 129.5 | 548.8 | | 421.6 | | 20.9 | 2.6 | | 1123.4 |
| Imports | 4.3 | 64 | 38.1 | | 1.1 | | | | 107.5 |
| Exports | 100.9 | 322.4 | 0.2 | 245.7 | 21.9 | | | | 691.1 |
| Intl. Marine Bankers | | | 4 | | | | | | 4 |
| Stock change | | | | | | | | | 0 |
| Primary Supply | 32.9 | 290.4 | 33.8 | 175.8 | 20.7 | 20.9 | 2.6 | | 577.1 |
| Refineries | | 293.9 | 206.6 | 0 | 3.7 | | | | 504.2 |
| Power plants | 21.6 | | 25.5 | 30.1 | | 20.9 | 2.6 | 35.4 | 136.1 |
| Others | 0 | | | 56.2 | 20.8 | | | | 77 |
| Transformation | 21.6 | 293.9 | 181.1 | 86.3 | 24.5 | 20.9 | 2.6 | 35.4 | 666.3 |
| Own Use and Losses | 0.1 | 0.6 | 4.4 | 101.5 | 0 | | | 5.4 | 112 |
| Stat. Difference | 4.4 | 4.2 | 14.9 | 62.8 | 1 | | | 0 | 87.3 |
| Final Consumption | 15.6 | | 225.5 | 50.9 | 4.7 | | | 30 | 326.7 |
| Final Energy Use | 15.3 | | 225.5 | 28.6 | 4.7 | | | 30 | 304.1 |
| Industry | 15.3 | | 62.2 | 28.4 | 1.4 | | | 16.7 | 124 |
| Transport | | | 111.1 | 0.1 | | | | 0 | 111.2 |
| Residencial & Commercia | 0 | | 52.2 | 0.1 | 3.3 | | | 13.2 | 68.8 |
| Non-energy Use | 0.3 | | | 22.3 | | | | | 22.6 |

*Source :Negara Energy Indonesia 1985-1991, by Biro Perencanaan MME 1995*

On the other hand, it can be seen that air pollution from the use of oil products represents 75% - 85% of all air pollution. Thus substituting urban gas for petroleum products will significantly contribute to the improvement of air quality.

The estimation procedure is shown in Table 15.1.2. The amount of pollution caused by each type of fuel is estimated in this table and the average emission factor will be used later for estimation of the influence of the growth of urban gas use on air pollution in the future.

## Figure 15-1-2 Air Pollutant Emission by Fuels, by Sectors in Indonesia, 1994




*Source : Neraca Energi Indonesia 1955-1994, by Biro Perencanaan SDME 1995*
*Making Estimation of Air Pollution by JICA Urban Gas Project, 1996*

# Table 15-1-2 Fuel Consumption by Sectors and Estimation of Air Pollutants in Indonesia, 1994

Fuel Consumption by Sector and Estimation of Air Pollutants in Indonesia in 1994

| Fuel | Consumption | $SO_x$ EF | $SO_x$ Sulfer % | $SO_x$ Estimate | $NO_x$ EF | $NO_x$ Estimate | $CO_2$ EF | $CO_2$ Density/Factor | $CO_2$ Estimate |
|---|---|---|---|---|---|---|---|---|---|
| **Electricity** | | | | kg | | kg | | | ton |
| Oil Products | 3,700,223 ton | 20 Skg/ton | 0.34 | 25,463,287 | 18.685 kg/ton | 69,138,672 | 0.86 ton/toe | | 3,182,192 |
| Coal | 4,611,909 ton | 19.5 Skg/ton | 1.07 | 96,227,472 | 9.95 kg/ton | 45,888,490 | 1.065 ton/toe | 0.680 toe/ton | 3,338,037 |
| Natural gas | 4,499 10^10kcal | 0.0092 kg/10^10cal | | 41,388 | 4.4 kg/10^10cal | 19,794,482 | 0.631 Kg/10^4kcal | | 2,838,709 |
| LPG | 0 ton | 0.0136 kg/ton | | 0 | 3.74 kg/ton | 0 | 0.823 ton/toe | 1.150 toe/ton | 0 |
| Total | | | | 121,732,147 | | 134,821,645 | | | 9,358,938 |
| **Industry** | | | | | | | | | |
| Oil Products | 9,025,643 ton | 20 Skg/ton | 1.20 | 217,054,067 | 0.00 kg/ton | 0 | 0.86 ton/toe | | 7,762,053 |
| Coal | 3,266,769 ton | 15.5 Skg/ton | 1.07 | 54,179,357 | 7.5 kg/ton | 24,500,764 | 1.065 ton/toe | 0.680 toe/ton | 2,364,443 |
| Natural gas | 4,245 10^10kcal | 0.0092 kg/10^10cal | | 39,051 | 2.24 kg/10^10cal | 9,508,047 | 0.631 kg/10^4kcal | | 2,678,383 |
| LPG | 176,637 ton | 0.0136 kg/ton | | 2,402 | 2.63 kg/ton | 464,555 | 0.823 ton/toe | 1.150 toe/ton | 167,192 |
| Total | | | | 271,274,877 | | 34,473,367 | | | 12,972,070 |
| **Transportation** | | | | | | | | | |
| Gasolene | 10,101,186 ton | 20 Skg/ton | 0.01 | 2,020,237 | 31.7 kg/ton | 320,207,610 | 0.86 ton/toe | | 8,687,020 |
| Diesel | 6,020,179 ton | 20 Skg/ton | 0.399 | 48,041,025 | 27.4 kg/ton | 164,952,894 | 0.86 ton/toe | | 5,177,354 |
| Natural gas | 15 10^10kcal | 0.0092 kg/10^10cal | | 138 | 5.5 kg/10^10cal | 82,203 | 0.631 kg/10^4kcal | | 9,431 |
| Total | | | | 50,061,400 | | 485,242,707 | | | 13,873,805 |
| **Residencial & Commercial** | | | | | | | | | |
| Oil Products | 7,574,575 ton | 20 Skg/ton | 0.24 | 36,054,976 | 2.49 kg/ton | 18,860,691 | 0.86 ton/toe | | 6,514,134 |
| Natural gas | 15 10^10kcal | 0.0092 kg/10^10cal | | 138 | 1.57 kg/10^10cal | 23,465 | 0.631 kg/10^4kcal | | 9,431 |
| LPG | 416,358 ton | 0.0136 kg/ton | | 5,662 | 0.88 kg/ton | 366,395 | 0.823 ton/toe | 1.150 toe/ton | 394,096 |
| Total | | | | 36,060,776 | | 19,250,552 | | | 6,917,661 |

Estimated Air Pollutants by Fuels in Indonesia in 1994

| Fuel | Consumption | $SO_x$ kg as $SO_2$ | $NO_x$ kg as $NO_2$ | $CO_2$ ton as C |
|---|---|---|---|---|
| Oil Products | 36,421,806 ton | 326,633,592 | 573,159,867 | 31,322,753 |
| Coal | 7,878,677 ton | 150,406,829 | 70,389,255 | 5,702,479 |
| Natural gas | 8,773 10^10kcal | 80,714 | 29,408,198 | 5,535,954 |
| LPG | 592,995 ton | 8,065 | 830,950 | 561,288 |
| Total | | 479,129,200 | 673,788,270 | 43,122,474 |

Estimated Air Pollutants by Sectors in Indonesia in 1994

| Sector | $SO_x$ kg as $SO_2$ | $NO_x$ kg as $NO_2$ | $CO_2$ ton as C |
|---|---|---|---|
| Electricity | 121,732,147 | 134,821,645 | 9,358,938 |
| Industry | 271,274,877 | 34,473,367 | 12,972,070 |
| Transport | 50,061,400 | 485,242,707 | 13,873,805 |
| Residenial & Commercial | 36,060,776 | 19,250,552 | 6,917,661 |
| Total | 479,129,200 | 673,788,270 | 43,122,474 |

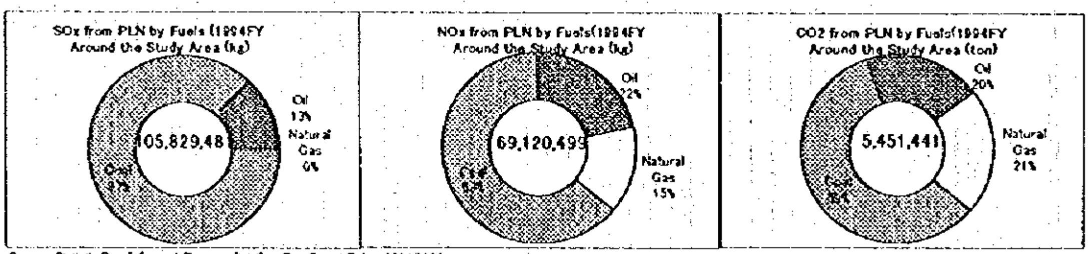
*Source : Negara Energi Indonesia 1985-1994, by Biro Perencanaan MME 1995*
*Adding Estimation of Air Pollution by JICA Urban Gas Project, 1996*

### 15.1.3 Air Pollution from the Electric Power Sector

To understand the discharge sources of air pollutants in the Study area, we have evaluated electric power which discharges large quantities of pollutants, based on the statistical data of PLN fuel consumption. The amount of air pollutant emissions from the power generating facilities of PLN by region and by fuel were calculated. And since the location of power plants in Java are noted on that table, the amount of air pollutants discharged by the power plants around the Study area was also discerned.

According to the results, most pollutant emissions come from the fuel use of coal in those power plants, and sulfur oxide emissions from natural gas use are quite small. But for nitrogen oxide, the emission by the use of natural gas has become much greater because of the recently growing use of gas combined cycle systems around the DKI area. (Figure 15.1.3)

**Figure 15-1-3 Air Pollution by Fuels from Power Generation around the Study Area, 1994**




*Source : Statistic Dan Informasi Ketenagalistrikan Dan Energi Tahun 1994 1995*
*Direktorat Jenderal Listrik Dan Pengembangan Energi JAKARTA, Maret 1995 (MOE)*
*Adding Estimation of Air Pollution by JICA Urban Gas Project, 1996*

Table 15.1.3 and Table 15.1.4 show this estimation procedure. Power plants located from Central Java to West Java will influence air pollutant emissions in the area. The electricity produced by power plants located around the Study area was 27,949,148MWh in 1994, 38% of by coal-fired, 23% by natural gas combined cycle units, 16% oil fired thermal power and 21% hydropower & Geo.-thermal.

Total sulfur oxide emissions were 105,829tons, of which 87% is from coal-fired and 12% oil-fired thermal power. As for nitrogen oxide, the total amount of emissions was 69,120tons, of which of 63% is from coal-fired, 17% oil-fired and 14% gas combined cycle units. As for carbon dioxide, which is said to cause global warming, the total amount of emissions was 5,415,447tons, 59% coal-fired, 18% oil-fired, 20% gas combined cycle units.

# Table 15-1-3 Estimation of Fuel Consumption by Power Plants around the Study Area

**PLN Specific Fuel Consumption in 1994/1995 (SFC)**

| | | | | Steam PP | | Diesel PP | Gas Turbine PP | | Combined Cycle PP | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hydro | thermal | St-Oil | St-Gas | St Coal | Diesel PP | Gt Oil | Gt Gas | CC Oil | CC Gas |
| Dist. of EastJava | | | | | | 0.343 | | | | |
| Dist. of Central Java | | | | | | | | | | |
| Dist. of West Java | | | | | | 0.327 | | | | |
| DKI JAYA | | | | | | | | | | |
| G & T Eastern Part of JAVA | | | 0.286 | 0.0094 | 0.383 | 0.268 | 0.414 | 0.0206 | 0.259 | 0.0088 |
| G & T Western Part of JAVA | | | 0.279 | 0.0103 | 0.43 | 0.297 | 0.435 | 0.0153 | 0.347 | 0.0113 |
| JAVA | | | 0.28 | 0.0094 | 0.42 | 0.275 | 0.417 | 0.0154 | 0.345 | 0.0099 |
| Indonesia | | | 0.283 | 0.0095 | 0.431 | 0.274 | 0.458 | 0.0156 | 0.342 | 0.0099 |

Coal (kg)
Oil (lt)
Natural Gas (1000SCF)

**Production of the PLN Electric Energy by Type and Province in 1994/1995 (MWh)**

| | | Geo- | | Steam PP | | | Gas Turbine PP | | Combined Cycle PP | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hydro | thermal | St-Oil | St-Gas | St Coal | Diesel PP | Gt Oil | Gt Gas | CC Oil | CC Gas |
| Dist. of EastJava | 483 | | | | | 5,898 | | | | |
| Dist. of Central Java | 1,596 | | | | | | | | | |
| Dist. of West Java | 1,727 | | | | | 6,744 | | | | |
| DKI JAYA | | | | | | | | | | |
| G & T Eastern Part of JAVA | 949,087 | | 494,022 | 2,173,505 | 2,705,409 | 105,020 | 274,846 | 1,626 | 9,566 | 7,740,234 |
| G & T Western Part of JAVA | 3,957,002 | 1,934,968 | 4,482,415 | 45,664 | 10,257,937 | 1,446 | 25,445 | 319,147 | 389,031 | 6,527,622 |
| Around the Study Area | 3,958,729 | 1,934,968 | 4,482,415 | 45,664 | 10,257,937 | 8,190 | 25,415 | 319,147 | 389,031 | 6,527,622 |
| JAVA | 4,909,895 | 1,934,968 | 4,976,437 | 2,219,169 | 12,963,346 | 119,108 | 300,291 | 320,773 | 398,597 | 14,267,856 |
| Indonesia | 6,044,210 | 1,934,968 | 5,990,541 | 2,302,223 | 13,933,163 | 4,681,078 | 898,848 | 522,462 | 425,513 | 15,577,572 |

**PLN Fuel Consumption in 1994/1995**

| | | | | Steam PP | | Diesel PP | Gas Turbine PP | | Combined Cycle PP | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hydro | Jeo-therma | St-Oil | St-Gas | St Coal | Diesel PP | Gt Oil | Gt Gas | CC Oil | CC Gas |
| | | | kL | MSCF | ton | kL | kL | MSCF | kL | MSCF |
| Dist. of EastJava | | | | | | 2,023 | | | | |
| Dist. of Central Java | | | | | | | | | | |
| Dist. of West Java | | | | | | 2,205 | | | | |
| DKI JAYA | | | | | | | | | | |
| G & T Eastern Part of JAVA | | | 141,290 | 20,431 | 1,036,172 | 28,145 | 113,786 | 33 | 2,478 | 68,114 |
| G & T Western Part of JAVA | | | 1,250,594 | 470 | 4,410,913 | 429 | 11,069 | 4,883 | 134,994 | 73,762 |
| Around the Study Area | | | 1,250,594 | 470 | 4,410,913 | 2,635 | 11,069 | 4,883 | 134,994 | 73,762 |
| JAVA | | | 1,393,402 | 20,860 | 5,444,605 | 32,755 | 125,221 | 4,940 | 137,516 | 141,252 |
| Indonesia | | | 1,695,323 | 21,871 | 6,005,193 | 1,282,615 | 411,672 | 8,150 | 145,525 | 154,218 |

Source : Statistic Dan Informasi Ketenagalistrikan Dan Energi Tahun 1994/1995
Direktorat Jenderal Listrik Dan Pengembangan Energi JAKARTA, Maret 1995 (MME)

**PLN Fuel Consumption in 1994/1995**

| | ton | 10^10kcal | ton | ton | ton | 10^10kcal | ton | 10^10kcal |
|---|---|---|---|---|---|---|---|---|
| Dist. of EastJava | | | | 1,846 | | | | |
| Dist. of Central Java | | | | | | | | |
| Dist. of West Java | | | | 2,013 | | | | |
| DKL JAYA | | | | | | | | |
| G & T Eastern Part of JAVA | 128,945 | 475 | 1,036,172 | 25,686 | 103,844 | 1 | 2,261 | 1,584 |
| G & T Western Part of JAVA | 1,141,319 | 11 | 4,410,913 | 392 | 10,101 | 114 | 123,198 | 1,715 |

## Table 15-1-4 Estimation of Air Pollution from Power Plants around the Study Area

**Estimation of Air Pollution**

| | | Hydro | Geo-thermal | St-Oil | St-Gas | St Coal | Diesel PP | Gt Oil | Gt Gas | CC Oil | CC Gas |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **SOx** | | | | S*kg/ton | kg/10^10cal | S*kg/ton | S*kg/ton | S*kg/ton | kg/10^10cal | S*kg/ton | kg/10^10cal |
| SOx Emmission Factor | | | | 20 | 0.0092 | 19.5 | 20 | 20 | 0.0092 | 20 | 0.0092 |
| Sulfer Content | % | | | 0.54 | | 1.07 | 0.27 | 0.54 | | 0.54 | |
| | | | | (as IDO) | | | (as HSD) | | | | |
| Around the Study Area | kg | | | 12,336,241 | 101 | 92,033,658 | 12,981 | 109,095 | 1,043 | 1,332,549 | 15,222 |
| JAVA | kg | | | 13,733,807 | 4,462 | 113,601,690 | 161,420 | 1,234,220 | 1,057 | 1,355,400 | 30,213 |
| Indonesia | kg | | | 16,709,631 | 4,678 | 125,298,357 | 6,320,928 | 4,057,571 | 1,743 | 1,434,344 | 32,986 |
| **NOx** | | | | kg/ton | kg/10^10cal | kg/ton | kg/ton | kg/ton | kg/10^10cal | kg/ton | kg/10^10cal |
| NOx Emmission Factor | | | | 10 | 4.4 | 9.95 | 27.37 | 27.37 | 5.5 | 27.37 | 5.5 |
| Around the Study Area | kg | | | 11,415,186 | 48,114 | 41,888,593 | 65,812 | 276,476 | 624,385 | 3,311,934 | 9,432,008 |
| JAVA | kg | | | 12,716,488 | 2,133,924 | 54,173,823 | 818,162 | 3,127,835 | 631,669 | 3,434,935 | 18,061,949 |
| Indonesia | ton | | | 15,471,881 | 2,237,338 | 59,751,673 | 32,037,740 | 10,282,937 | 1,042,197 | 3,635,000 | 19,719,943 |
| **$CO_2$** | | | | ton/toe | kg/10^4kcal | ton/toe | ton/toe | ton/toe | kg/10^4kcal | ton/toe | kg/10^4kcal |
| $CO_2$ Emmission Factor | | | | 0.86 | 0.631 | 1.065 | 0.86 | 0.86 | 0.631 | 0.86 | 0.631 |
| Around the Study Area | ton-C | | | 981,534 | 6,900 | 3,192,559 | 2,068 | 8,687 | 31,631 | 105,950 | 1,082,103 |
| JAVA | ton-C | | | 1,093,618 | 306,024 | 3,940,731 | 25,708 | 98,281 | 72,470 | 107,930 | 2,072,198 |
| Indonesia | ton-C | | | 1,330,582 | 320,855 | 4,346,477 | 1,006,666 | 323,103 | 119,568 | 114,216 | 2,262,415 |

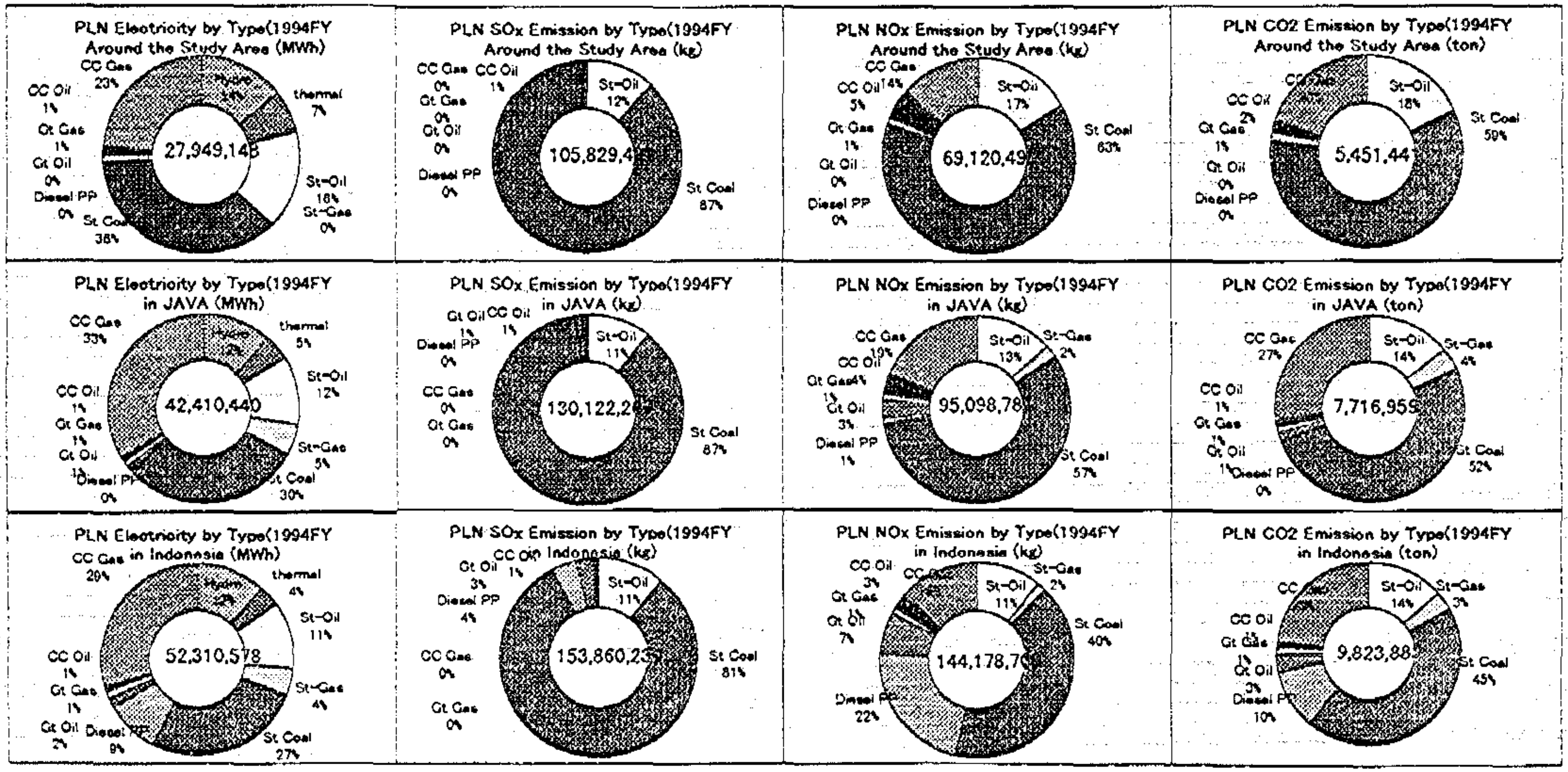
**Air Pollutant Emission from PLN by Fuels 1994/1995**

| | | Coal | Oil | Natural Gas | Total | Emission/MWh |
|---|---|---|---|---|---|---|
| **SOx** | | | | | | |
| Around the Study Area | kg | 92,033,698 | 13,778,861 | 16,922 | 105,829,481 | 4.798 |
| JAVA | kg | 113,601,690 | 16,484,847 | 35,731 | 130,122,269 | 3.659 |
| Indonesia | kg | 125,298,357 | 28,522,474 | 39,407 | 153,860,239 | 3.471 |
| **NOx** | | | | | | |
| Around the Study Area | kg | 43,588,583 | 15,127,408 | 10,104,507 | 69,120,497 | 3.134 |
| JAVA | kg | 54,173,823 | 20,097,419 | 20,827,542 | 95,098,783 | 2.674 |
| Indonesia | kg | 59,751,673 | 61,427,557 | 22,999,479 | 144,178,709 | 3.252 |
| **$CO_2$** | | | | | | |
| Around the Study Area | ton-C | 3,192,559 | 1,098,240 | 1,160,643 | 5,451,441 | 0.241 |
| JAVA | ton-C | 3,940,731 | 1,325,536 | 2,450,692 | 7,716,959 | 0.217 |
| Indonesia | ton-C | 4,346,477 | 2,774,567 | 2,702,838 | 9,823,883 | 0.222 |

*Source : Statistic Dan Informasi Ketenagalistrikan Dan Energi Tahun 1994/1995*
*Direktorat Jenderal Listrik Dan Pengembangan Energi JAKARTA, Maret 1995 (MME)*
*adding Estimation of Air Pollution by JICA Urban Gas Project, 1996*

The current situation of air pollutant emissions from the electrical power sector in Indonesia by region is shown in (Figure 15.1.4).

## Figure 15-1-4 Fuel Consumption and Air Pollution by PLN in Each District of Indonesia, 1994FY




*Source : Statistic Dan Informasi Ketenagalistrikan Dan Energi Tahun 1994/1995*
*Direktorat Jenderal Listrik Dan Pengembangan Energi JAKARTA, Maret 1995 (MME)*
*Adding Estimation of Air Pollution by JICA Urban Gas Project, 1996*

### 15.1.4 Air Pollution around the Study Area

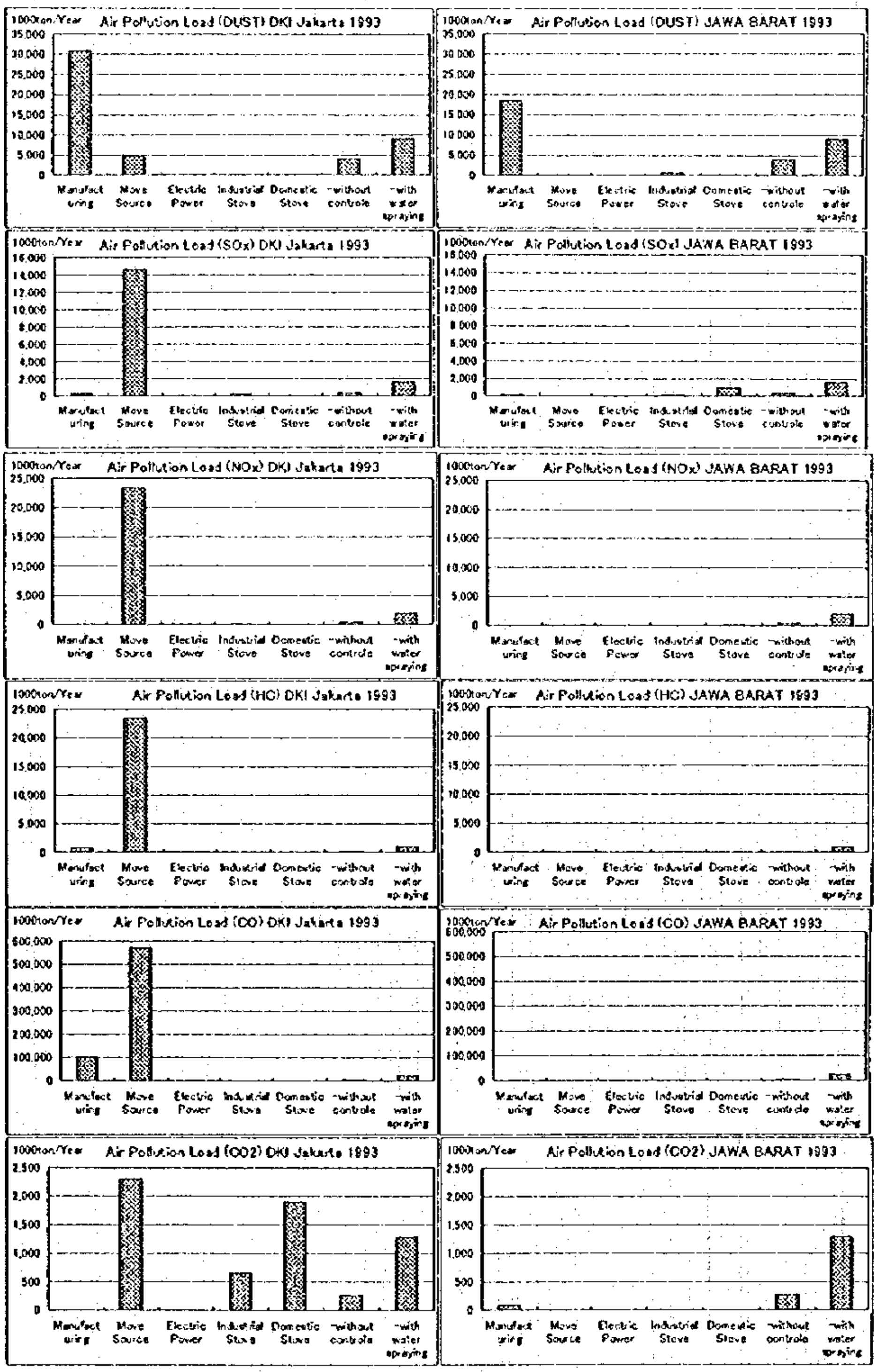
The present situation of air pollution around the Study area is shown in Figure 15.1.5. This data is from statistics published by BPS. It does not include the data on fuel use in the electric power sector. So except for air pollution from electricity, air pollutants from the transportation sector are the major cause of environmental problems around the Study area. Dust is from industry, especially from cement factories in the DKI area, but the other air pollution mainly comes from emissions by moving sources (motor vehicles). And air pollution from the city incinerator is also significant.

The current situation of air pollution caused by transportation is shown in Figure 15.1.6. This reveals much of the air pollution is from motorcycles around the DKI area, followed by passenger cars, and the amount of those pollutants has increased during the last two years. The Government of Indonesia has already recognized the necessity of countermeasures to reduce air pollution caused by the traffic.

There are several reports on air pollution from transportation in the DKI area, and counter measures are being implemented through regulations. However, the improvement of traffic systems should be given the first priority. Increase of public transportation systems and increased provisions for crosscuts which will give the main road a supplementary role, will ease traffic congestion. It is also expected to reduce the number of cars going into the city center.

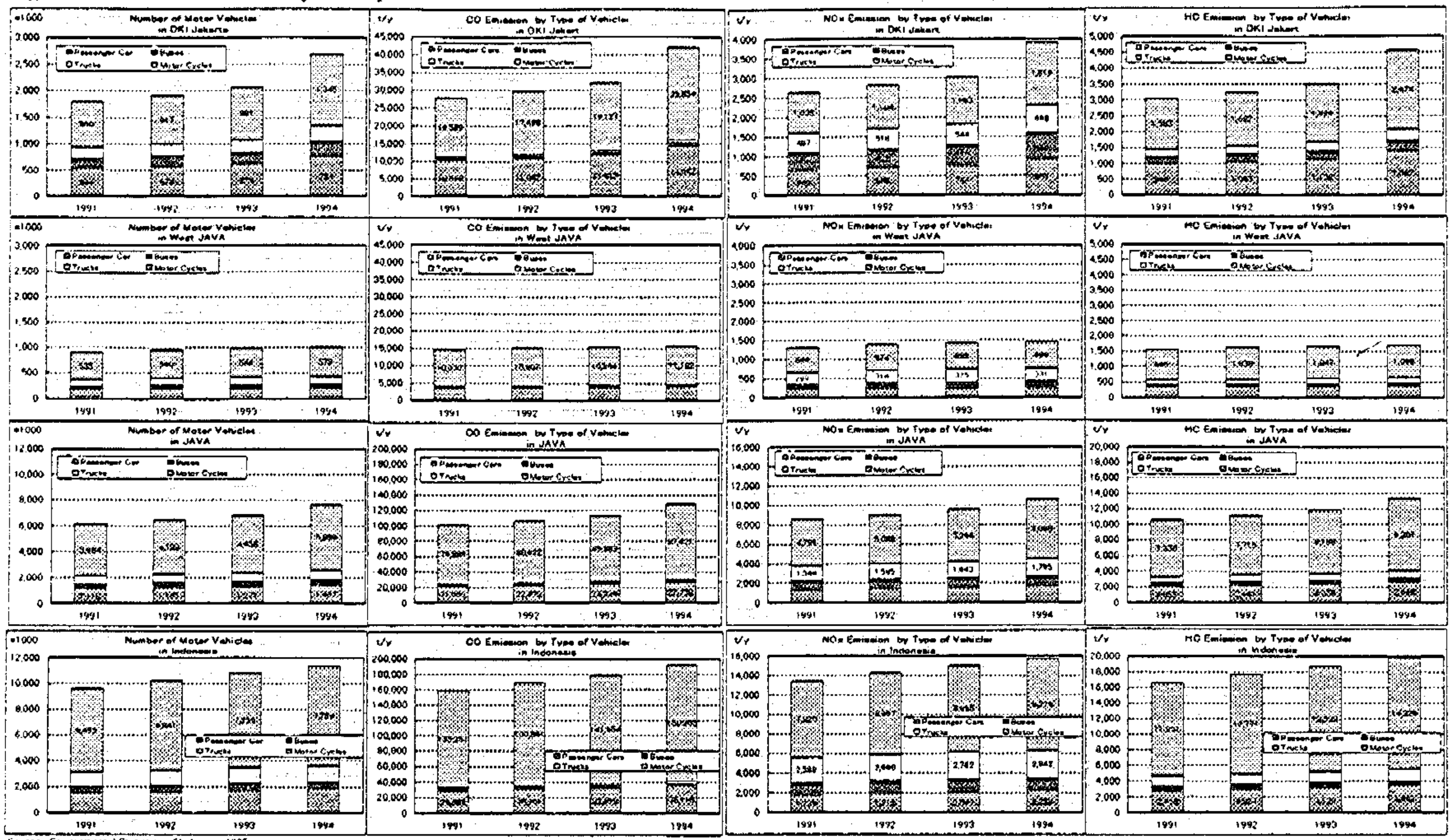
Nitrogen oxide is also increasing year by year. The increase in the air pollution in Jakarta has been especially significant in the last two years. (Figure 15.1.7).

## Figure 15-1-5 Situation of Air Pollutant in West Java and DKI



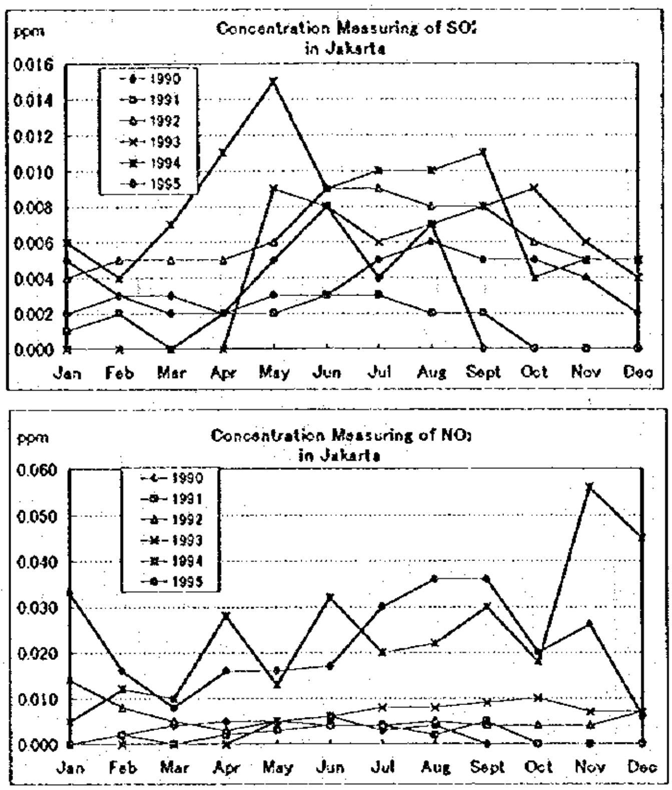

*Source :Environmental Statistic of Indonesia 1995, Regional Account of Quality environmental*

Figure 15-1-6 Air Pollution by Transportation Sector in Each District of Indonesia




Source: Environmental Statistics of Indonesia 1995

**Figure 15-1-7 Concentration Measuring of Air Pollution in Jakarta**




*Source : Environmental Statistic of Indonesia*
*Department of Communications, Meteorological and Geophysical Agency*
*Note : Threshold value SO2: 0.10 ppm/24hours NOx: 0.05 ppm/24hours*

**Table 15-1-5 Air Pollution in Several Locations in Jakarta**

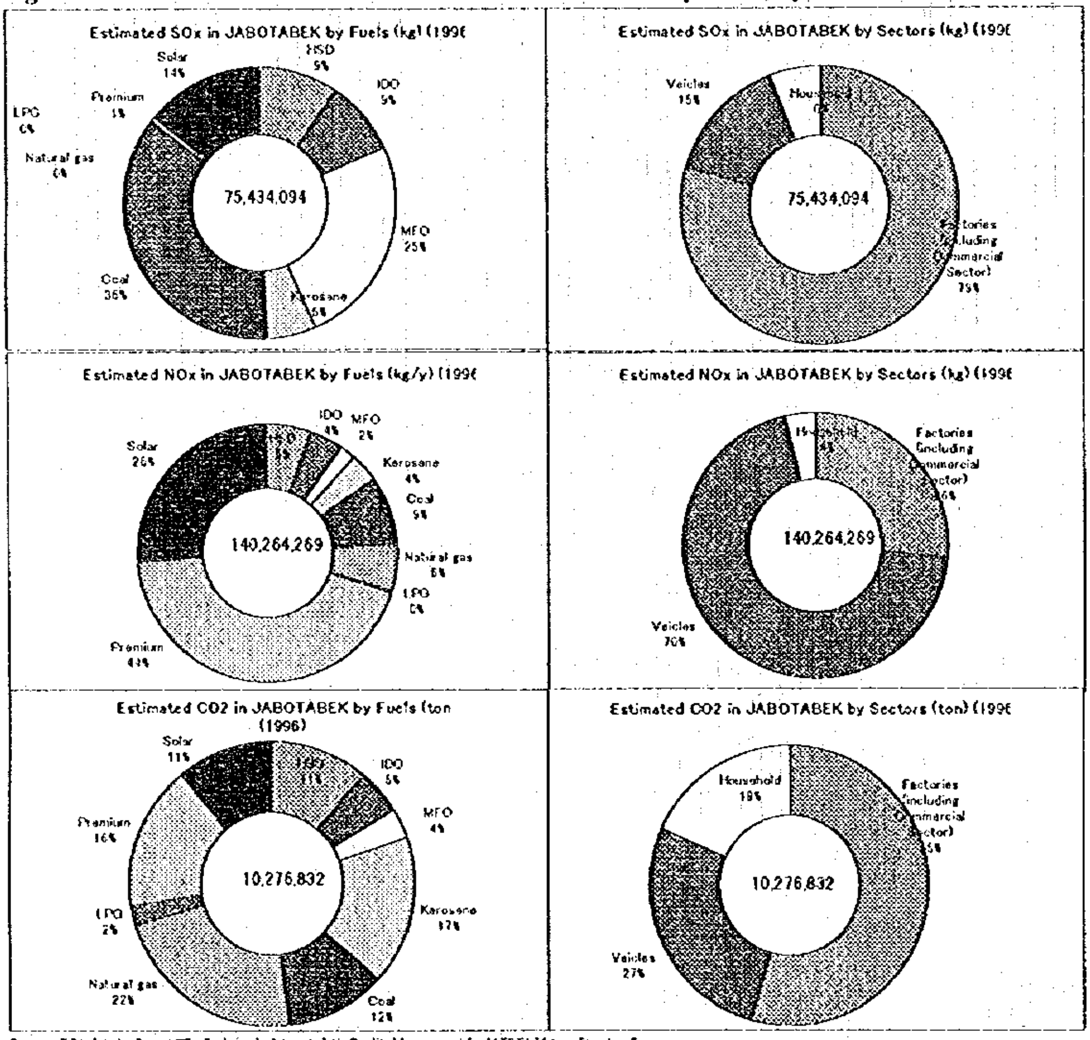
Air Pollutant in Several Location of Jakarta

| | SO2 ppm | NO2 ppm | Debu mmg/m3 | Pb mmg/m3 | Cd mmg/m3 | Cr ppm | Ni mmg/m3 | Mn mmg/m3 | Fe mmg/m3 | Cu mmg/m3 | Zn mmg/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Road side station | | | | | | | | | | | |
| Thamrin | 0.013 | 0.083 | 74 | tp | tp | tp | tp | tp | tp | tp | tp |
| Bus station | 0.002 | 0.052 | 369 | 1.28 | 4.91 | 29 | 0.02 | 0.37 | 10.65 | 0.17 | 1.82 |
| Pasar Baru | 0.002 | 0.062 | 376 | 1.58 | 1.95 | 15.72 | 0.01 | 0.19 | 7.17 | 0.82 | 0.75 |
| Senen | 0.002 | 0.046 | 284 | 1.1 | 2.44 | 15.38 | 0.01 | 0.17 | 6.46 | 0.21 | 0.98 |
| Bandengan | 0.003 | 0.069 | 546 | 1.54 | 2.26 | 31.37 | 0.03 | 0.35 | 13.55 | 0.2 | 0.92 |
| General ambient station | | | | | | | | | | | |
| Radio Dalam | 0.001 | 0.041 | 184 | 0.83 | 1.65 | 15.47 | 0.03 | 0.09 | 3.5 | 0.14 | 0.35 |
| Pondok Gede | 0.001 | 0.043 | 213 | 1.82 | 2.13 | 11.93 | 0.01 | 0.13 | 3.46 | 0.09 | 0.64 |
| Sawah Besar | 0.002 | 0.034 | 225 | 0.66 | 1.74 | 16.82 | 0.12 | 0.12 | 4.54 | 0.22 | 0.35 |
| Tebet | 0.005 | 0.026 | 246 | 0.85 | 1.96 | 23.23 | 0.04 | 0.15 | 4.97 | 0.24 | 0.34 |
| Pulo Gadung | 0.001 | 0.047 | 246 | 1.46 | 2.25 | 23 | 0.01 | 0.14 | 4.57 | 0.26 | 0.41 |

*Source : Environmental Statistic of Indonesia*
*Urban Recitation and Environment Ofice of DKI Jakarta, 1994/1995 Report of Air Environment in Jakarta*

A JICA Study on the management of air pollution in the Jakarta Metropolitan Area is separately ongoing. To supplement this, we tried to estimate the environmental pollutant load by fuels and by sector according to fuel consumption data from each published statistical source. As a result of this estimate, it has been concluded that the influence on the environment of using natural gas (including urban gas) is quite negligible. It has also been found that the improvement of air quality can be expected by increasing natural gas use relative to energy consumption.

**Figure 15-1-8 Estimated Air Pollutants in JABOTABEK by Fuels, by Sector (1996)**




*Source : JICA, Interim Report "The Study on the Integrated Air Quality Management for JAKARTA Metropolitan Area"*
*Making Estimation of Air Pollution by JICA Urban Gas Project, 1996*

The procedure for this estimation is shown in Table 15.1.6. And the parameters used in this estimation also will be used in later estimations of the environmental influences of growing urban gas use.

## Table 15-1-6 Fuel Consumption by Sector and Emission of Air Pollutants in JABOTABEK, 1996

**Fuel Consumption by Sector and Estimation of Air Pollutants in JABOTABEK in 1996**

| Factories & Commercial Sector | | SOx | | | | NOx | | | $CO_2$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fuel | Consumption | EF | Sulfer % | Density | Estimate | EF | Density | Estimate | EF | Density/Factor | Estimate |
| | | | | | kg | | | kg | | | ton |
| HSD | 1,616,856 kl/y | 20 S*Dkg/kl | 0.27 | 0.813 | 7,098,321 | 5.84 kg/ton | 0.813 | 7,676,703 | 0.86 ton/toe | 0.813 kg/l | 1,130,473 |
| IDO | 790,660 kl/y | 20 S*Dkg/kl | 0.54 | 0.8 | 6,831,302 | 9.62 kg/ton | 0.8 | 6,084,919 | 0.86 ton/toe | 0.8 kg/l | 543,974 |
| MFO | 441,952 kl/y | 20 S*Dkg/kl | 2.23 | 0.947 | 18,666,373 | 5.84 kg/ton | 0.947 | 2,444,207 | 0.86 ton/toe | 0.947 kg/l | 359,935 |
| Kerosene | 19,520 kl/y | 20 S*Dkg/kl | 0.11 | 0.867 | 37,232 | 7.46 kg/ton | 0.867 | 126,252 | 0.86 ton/toe | 0.867 kg/l | 14,555 |
| Coal | 1,647,263 ton/y | 15.5 Skg/ton | 1.07 | | 27,319,857 | 7.5 kg/ton | | 12,354,473 | 1.065 ton/toe | 0.680 toe/ton | 1,192,267 |
| Natural gas | 4,059,741 1000m3/y | 0.0092 kg/10^10cal | | | 33,017 | 2.24 kg/10^10cal | | 8,038,937 | 0.631 kg/10^4kc | 8,840 kcal/m3 | 2,264,540 |
| LPG | 84,057 ton/y | 0.0136 kg/ton | | | 1,143 | 2.63 kg/ton | | 221,070 | 0.823 ton/toe | 1.150 toe/ton | 79,562 |
| Total | | | | | 59,987,246 | | | 36,946,560 | | | 5,585,305 |
| **Veicles** | | | | | | | | | | | |
| Premium | 2,641,600 kl/y | 20 S*Dkg/kl | 0.01 | 0.735 | 388,315 | 31.7 kg/ton | 0.735 | 61,547,959 | 0.86 ton/toe | 0.735 kg/l | 1,669,755 |
| Solar | 1,574,360 kl/y | 20 S*Dkg/kl | 0.40 | 0.85 | 10,678,884 | 27.4 kg/ton | 0.85 | 36,666,844 | 0.86 ton/toe | 0.85 kg/l | 1,150,857 |
| Total | | | | | 11,067,199 | | | 98,214,804 | | | 2,820,613 |
| **Household** | | | | | | | | | | | |
| Kerosene | 2,294,932 kl | 20 S*Dkg/kl | 0.11 | 0.867 | 4,377,353 | 2.49 kg/ton | 0.867 | 4,954,368 | 0.86 ton/toe | 0.867 kg/l | 1,711,147 |
| LPG | 168,792 ton | 0.0136 kg/ton | | | 2,296 | 0.88 kg/ton | | 148,537 | 0.823 ton/toe | 1.150 kg/l | 159,767 |
| Total | | | | | 4,379,649 | | | 5,102,905 | | | 1,870,914 |

**Estimated Air Pollutants by Fuels in JABOTABEK in 1996**

| Fuel | Consumption | SOx kg as $SO_2$ | NOx kg as $NO_2$ | $CO_2$ ton as C |
|---|---|---|---|---|
| HSD | 1,616,856 kl/y | 7,098,321 | 7,676,703 | 1,130,473 |
| IDO | 790,660 kl/y | 6,831,302 | 6,084,919 | 543,974 |
| MFO | 441,952 kl/y | 18,666,373 | 2,444,207 | 359,935 |
| Kerosene | 2,314,452 kl/y | 4,414,586 | 5,080,620 | 1,725,702 |
| Coal | 1,647,263 ton/y | 27,319,857 | 12,354,473 | 1,192,267 |
| Natural gas | 4,059,741 1000m3/y | 33,017 | 8,038,937 | 2,264,540 |
| LPG | 252,849 ton/y | 3,439 | 369,607 | 239,329 |
| Premium | 2,641,600 kl/y | 388,315 | 61,547,959 | 1,669,755 |
| Solar | 1,574,360 kl/y | 10,678,884 | 36,666,844 | 1,150,857 |
| Total | | 75,434,094 | 140,264,269 | 10,276,832 |

*Source : JICA, Interim Report "The Study on the Integrated Air Quality Managemant for JAKRTA Metropolitan Area"*
*Adding Estimation of Air Pollution by JICA Urban Gas Project, 1996*

## 15.2 Environmental Assessment for Demand Projection of Urban Gas Use

The Study estimates the amount of environmental improvement according to the projection of urban gas demand in each sector until 2020. Essential factors used in the estimation of pollutants were edited by the Science and Technology Agency of Japan. Also, the detailed emission factors by fuels and by sector which are included in the Interim Report of the JICA Environmental Investigation around the JABOTABEK area were used.

In the estimation, fuels to be replaced by increased urban gas use are shown below. For industry, they are based on actual fuel consumption. For the residential sector, they are based on forecast fuel composition, and for the commercial sector, respectively according to each facility, LPG for the kitchen, HSD for boilers and with the substitution fuel for air-conditioners being electric power. The quantity of improvement of the air pollutants are estimated and the Study's total estimated amount of improvement is shown below.

**Table 15-2-1**

**Improvement in Air Pollution by Urban Gas Use around the Study Area**

*(Based on 1995, Estimated for the Growth of Urban Gas Use since 1995)*

| Area | Item | | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| **Amount of Improvement** | | | | | | | | |
| Base Case | SOx | kg | 0 | 29,670,084 | 47,438,483 | 73,813,187 | 128,448,102 | 219,333,916 |
| | NOx | kg | 0 | 7,115,788 | 11,575,523 | 18,197,845 | 31,672,680 | 53,931,023 |
| | CO2 | ton | 0 | 331,947 | 529,914 | 820,753 | 1,424,737 | 2,430,298 |
| High Case | SOx | kg | 0 | 31,458,046 | 51,046,786 | 85,015,841 | 177,174,318 | 373,069,548 |
| | NOx | kg | 0 | 7,507,696 | 12,361,254 | 20,781,466 | 43,191,394 | 90,504,678 |
| | CO2 | ton | 0 | 352,970 | 572,182 | 948,298 | 1,971,139 | 4,147,866 |
| Low Case | SOx | kg | 0 | 27,613,292 | 42,887,822 | 61,692,768 | 88,009,297 | 121,441,441 |
| | NOx | kg | 0 | 6,592,431 | 10,410,174 | 15,195,819 | 21,863,590 | 30,337,449 |
| | CO2 | ton | 0 | 309,705 | 480,529 | 687,414 | 976,582 | 1,343,001 |
| **Rough Total of Air Pollution** | | | | | | | | |
| Base Case | SOx | kg | 34,719,536 | 54,892,080 | 85,484,032 | 137,449,349 | 235,692,695 | 427,127,836 |
| | NOx | kg | 16,790,254 | 26,230,528 | 39,921,858 | 61,825,849 | 102,570,643 | 181,306,903 |
| | CO2 | kg | 3,542,421 | 5,235,066 | 7,463,644 | 10,700,035 | 16,424,098 | 27,130,808 |
| High Case | SOx | kg | 34,794,293 | 56,045,624 | 90,774,984 | 155,569,559 | 317,441,707 | 715,199,917 |
| | NOx | kg | 16,820,389 | 26,527,276 | 41,899,249 | 68,989,697 | 135,628,508 | 298,218,386 |
| | CO2 | kg | 3,546,242 | 5,295,933 | 7,768,719 | 11,706,873 | 20,793,431 | 42,262,660 |
| Low Case | SOx | kg | 34,619,211 | 53,661,721 | 79,653,987 | 118,891,761 | 170,755,808 | 249,305,167 |
| | NOx | kg | 16,824,623 | 25,650,898 | 37,482,095 | 54,231,207 | 76,190,579 | 109,155,282 |
| | CO2 | kg | 3,544,481 | 5,153,736 | 7,115,234 | 9,654,765 | 12,927,992 | 17,721,614 |
| **Ratio of Improvement by Urban Gas Use (Base Case)** | | | | | | | | |
| Base Case | SOx | | | 35.1% | 35.7% | 34.9% | 35.3% | 33.9% |
| | NOx | | | 21.3% | 22.5% | 22.7% | 23.6% | 22.9% |
| | CO2 | | | 6.0% | 6.6% | 7.1% | 8.0% | 8.2% |
| High Case | SOx | | | 36.0% | 36.0% | 35.3% | 35.8% | 34.3% |
| | NOx | | | 22.1% | 22.8% | 23.1% | 24.2% | 23.3% |
| | CO2 | | | 6.2% | 6.9% | 7.5% | 8.7% | 8.9% |
| Low Case | SOx | | | 34.0% | 35.0% | 34.2% | 34.0% | 32.8% |
| | NOx | | | 20.4% | 21.7% | 21.9% | 22.3% | 21.7% |
| | CO2 | | | 5.7% | 6.3% | 6.6% | 7.0% | 7.0% |

*Source : Estimated Air Pollution by JICA Urban Gas Project, 1996*

The improved quantity of air pollutants caused by urban gas use is estimated as well as air pollutants from other fuels that are to be replaced. Incidentally, in the commercial sector, the environment load in the power sector decreases, which accompanies the decrease of electricity due to electrical air-conditioners to be replaced by gas absorption air-conditioners.

### 15.2.1 Assessment of Urban Gas Use in the Residential Sector

**Table 15-2-2**

**Improvement in Air Pollution from Residential Sector by Urban Gas Use around the Study Area**

(Based on 1995, Estimated for the Growth of Urban Gas Use since 1995)

| Area | Item | | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| **Amount of Improvement** | | | | | | | | |
| Base Case | SOx | kg | 0 | 1,985 | 6,234 | 9,352 | 12,396 | 15,229 |
| | NOx | kg | 0 | 5,101 | 19,181 | 30,566 | 42,607 | 54,686 |
| | CO2 | ton | 0 | 1,651 | 6,137 | 9,921 | 14,161 | 18,745 |
| High Case | SOx | kg | 0 | 2,056 | 6,057 | 9,133 | 11,879 | 14,323 |
| | NOx | kg | 0 | 5,133 | 18,395 | 29,812 | 41,112 | 52,654 |
| | CO2 | ton | 0 | 1,753 | 6,221 | 10,298 | 14,642 | 19,591 |
| Low Case | SOx | kg | 0 | 1,715 | 5,683 | 8,810 | 12,025 | 15,139 |
| | NOx | kg | 0 | 4,311 | 17,092 | 28,082 | 40,210 | 52,749 |
| | CO2 | ton | 0 | 1,414 | 5,463 | 9,030 | 13,082 | 17,423 |
| **Rough Total of Air Pollution** | | | | | | | | |
| Base Case | SOx | kg | 1,170,713 | 1,287,524 | 1,308,790 | 1,345,891 | 1,385,035 | 1,422,911 |
| | NOx | kg | 2,217,469 | 3,174,273 | 4,106,278 | 4,595,714 | 5,042,991 | 5,472,796 |
| | CO2 | ton | 787,415 | 1,084,873 | 1,376,427 | 1,608,000 | 1,870,862 | 2,190,079 |
| High Case | SOx | kg | 1,170,669 | 1,246,067 | 1,245,070 | 1,253,884 | 1,266,373 | 1,205,906 |
| | NOx | kg | 2,217,162 | 2,977,698 | 3,880,921 | 4,302,285 | 4,708,159 | 4,943,624 |
| | CO2 | ton | 787,354 | 1,076,020 | 1,377,668 | 1,619,692 | 1,909,447 | 2,235,416 |
| Low Case | SOx | kg | 1,145,206 | 1,285,504 | 1,332,284 | 1,397,199 | 1,479,708 | 1,580,720 |
| | NOx | kg | 2,282,287 | 3,101,379 | 4,071,935 | 4,618,849 | 5,201,622 | 5,864,724 |
| | CO2 | ton | 793,357 | 1,074,826 | 1,357,347 | 1,577,424 | 1,829,466 | 2,138,321 |
| **Ratio of Improvement by Urban Gas Use (Base Case)** | | | | | | | | |
| Base Case | SOx | | | 0.2% | 0.5% | 0.7% | 0.9% | 1.1% |
| | NOx | | | 0.2% | 0.5% | 0.7% | 0.8% | 1.0% |
| | CO2 | | | 0.2% | 0.4% | 0.6% | 0.8% | 0.8% |
| High Case | SOx | | | 0.2% | 0.5% | 0.7% | 0.9% | 1.2% |
| | NOx | | | 0.2% | 0.5% | 0.7% | 0.9% | 1.1% |
| | CO2 | | | 0.2% | 0.4% | 0.6% | 0.8% | 0.9% |
| Low Case | SOx | | | 0.1% | 0.4% | 0.6% | 0.8% | 0.9% |
| | NOx | | | 0.1% | 0.4% | 0.6% | 0.8% | 0.9% |
| | CO2 | | | 0.1% | 0.4% | 0.6% | 0.7% | 0.8% |

*Source : Estimated Air Pollution by JICA Urban Gas Project, 1996*
*Estimated by using forecast rate of fuels in each year*

In the residential sector, the amount of air pollutant improvement in DKI, Tangeran and Bekasi is estimated according to the urban gas demand in the residential sector forecast in the Study (Table 15.2.2),(Table 15.2.3). As for the fuels to be replaced by urban gas, basically kerosene is a major fuel in the residential sector, however, in recent years, economic growth has accelerated the use of LPG. With the improvement of the standard of living, the share of fuels in residential areas is changing year by year, so we can suppose the conversion estimation will be done by the weighted average of fuel composition every year in future. The amount of improvement will be estimated for the increment of urban gas use in future from the present quantity of gas use. (Figure 15.2.1)

**Table 15-2-3**

**Urban Gas Demand Projection of Residential Sector in the Study Area (DKI, Bekasi, Tangerang)**

| Item | Unit | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Population | Thousand | 13,164 | 14,634 | 16,313 | 18,237 | 20,447 | 22,994 |
| Family Size | Member | 4.81 | 4.81 | 4.5 | 4.5 | 4.48 | 4.42 |
| Number of Households | Thousand | 2,737 | 3,042 | 3,625 | 4,053 | 4,564 | 5,202 |
| **Base Case** | | | | | | | |
| GRDP(Constant 1993 Price) | $10^9$Rp | 67,478 | 99,147 | 135,841 | 186,114 | 249,062 | 333,303 |
| Total of Energy Demand | $10^9$kcal | 8,707 | 10,246 | 12,666 | 14,746 | 17,187 | 20,238 |
| Total of Electricity Demand | $10^6$kWh | 8,156 | 11,421 | 15,816 | 20,907 | 27,192 | 35,589 |
| Energy Consumption per Household | $10^3$kcal | 3,181 | 3,368 | 3,494 | 3,639 | 3,766 | 3,890 |
| Electricity Consumption per Household | kWh | 2,980 | 3,754 | 4,363 | 5,159 | 5,958 | 6,841 |
| LPG | $10^9$kcal | 1,783 | 3,018 | 4,701 | 6,509 | 8,686 | 11,518 |
| Kerosene | $10^9$kcal | 4,860 | 4,849 | 4,361 | 4,322 | 4,360 | 4,457 |
| Other Fuels | $10^9$kcal | 2,041 | 1,791 | 2,180 | 2,327 | 2,356 | 2,231 |
| Urban Gas | $10^9$kcal | 22.67 | 588 | 1,422 | 1,589 | 1,786 | 2,033 |
| Number of Customers of City Gas | Thousand | 7.13 | 174.60 | 406.84 | 436.57 | 474.15 | 522.46 |
| Urban Gas Consumption per Household | $m^3$ | 362 | 383 | 397 | 413 | 428 | 442 |
| **High Case** | | | | | | | |
| GRDP(Constant 1993 Price) | $10^9$Rp | 67,478 | 101,934 | 146,340 | 210,089 | 294,662 | 413,278 |
| Total of Energy Demand | $10^9$kcal | 8,707 | 10,303 | 12,857 | 15,108 | 17,777 | 21,130 |
| Total of Electricity Demand | $10^6$kWh | 8,156 | 11,687 | 16,818 | 23,105 | 31,238 | 42,499 |
| Energy Consumption per Household | $10^3$kcal | 3,181 | 3,386 | 3,547 | 3,728 | 3,895 | 4,062 |
| Electricity Consumption per Household | kWh | 2,980 | 3,841 | 4,639 | 5,701 | 6,844 | 8,169 |
| LPG | $10^9$kcal | 1,783 | 3,105 | 5,022 | 7,183 | 9,825 | 13,479 |
| Kerosene | $10^9$kcal | 4,860 | 4,803 | 4,235 | 4,117 | 4,075 | 4,086 |
| Other Fuels | $10^9$kcal | 2,041 | 1,596 | 1,907 | 1,890 | 1,513 | 1,040 |
| Urban Gas | $10^9$kcal | 22.67 | 799 | 1,694 | 1,919 | 2,188 | 2,526 |
| Number of Customers of City Gas | Thousand | 7.13 | 235.94 | 477.49 | 514.63 | 561.62 | 621.78 |
| Urban Gas Consumption per Household | $m^3$ | 362 | 385 | 403 | 424 | 443 | 462 |
| **Low Case** | | | | | | | |
| GRDP(Constant 1993 Price) | $10^9$Rp | 67,478 | 96,425 | 126,025 | 164,709 | 210,214 | 268,293 |
| Total of Energy Demand | $10^9$kcal | 8,707 | 10,189 | 12,477 | 14,389 | 16,613 | 19,377 |
| Total of Electricity Demand | $10^6$kWh | 8,156 | 11,165 | 14,866 | 18,902 | 23,642 | 29,755 |
| Energy Consumption per Household | $10^3$kcal | 3,181 | 3,349 | 3,442 | 3,551 | 3,640 | 3,725 |
| Electricity Consumption per Household | kWh | 2,980 | 3,670 | 4,101 | 4,664 | 5,180 | 5,720 |
| LPG | $10^9$kcal | 1,783 | 2,930 | 4,393 | 5,879 | 7,604 | 9,791 |
| Kerosene | $10^9$kcal | 4,668 | 4,896 | 4,502 | 4,545 | 4,679 | 4,886 |
| Other Fuels | $10^9$kcal | 2,234 | 1,982 | 2,424 | 2,693 | 2,922 | 3,123 |
| Urban Gas | $10^9$kcal | 22.67 | 381 | 1,159 | 1,273 | 1,409 | 1,578 |
| Number of Customers of City Gas | Thousand | 7.13 | 113.77 | 336.59 | 358.40 | 386.95 | 423.52 |
| Urban Gas Consumption per Household | $m^3$ | 362 | 381 | 391 | 403 | 414 | 423 |

*Source: By JICA Urban Gas Project Team 1996*

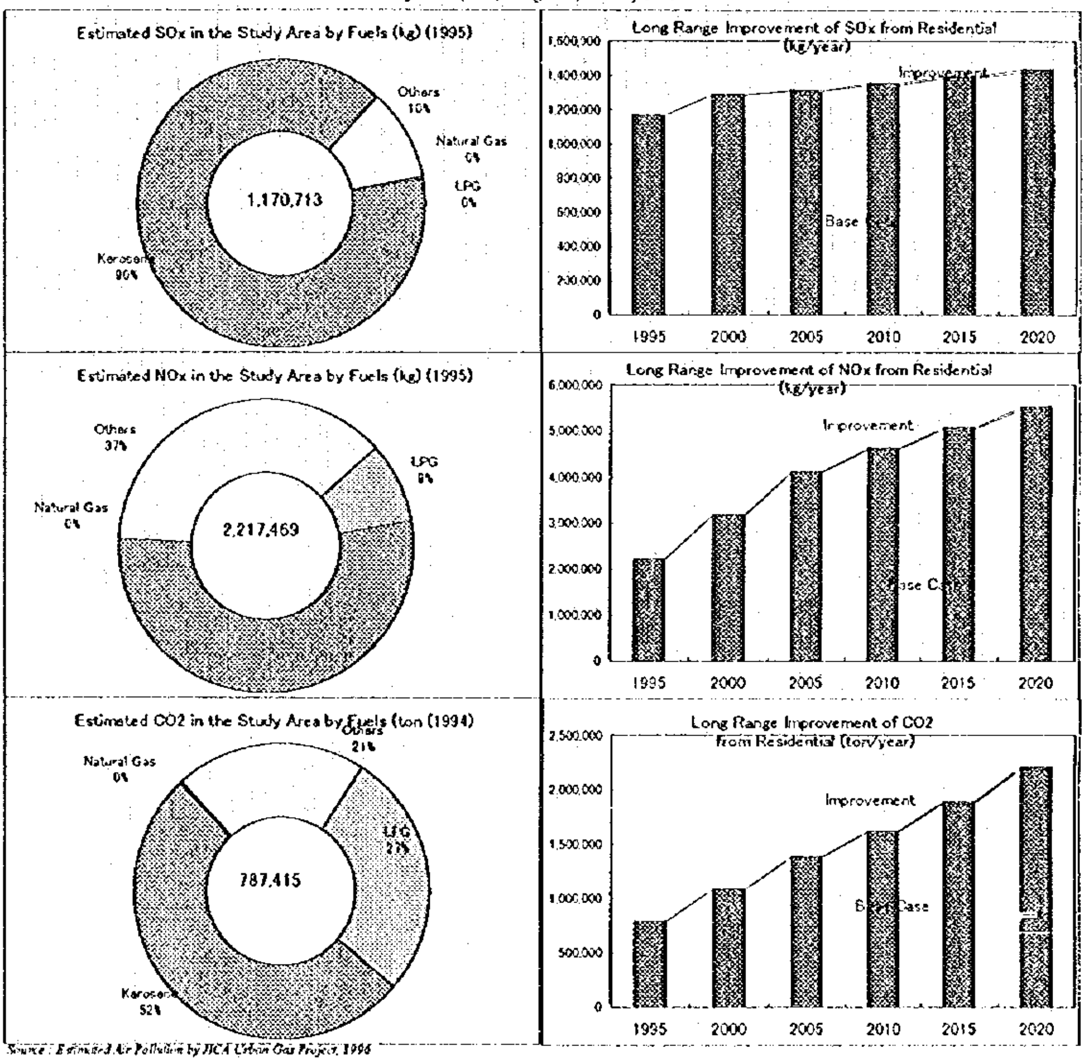
**Share of Each Fuel in Residential Sector (Base Case)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| LPG | | 29.5% | 35.0% | 39.2% | 43.9% | 48.9% | 54.2% |
| Kerosene | | 54.3% | 40.1% | 28.7% | 24.1% | 20.6% | 17.7% |
| Other Fuels | | 15.9% | 23.4% | 28.4% | 27.0% | 24.4% | 21.1% |
| Urban Gas | | 0.3% | 1.5% | 3.7% | 5.0% | 6.1% | 6.9% |

The share of the urban gas use in total fuel consumption in the residential sector is estimated to be 7% in 2020. In those years, the amount of kerosene and its share of the whole decreases gradually including other fuels, such as non-commercial fuels like fire wood, because of the growth of LPG use. So emission of sulfur oxide remains stable or rather decreases, including the conversion to LPG and urban gas, and the improvement is significant.

**Figure 15-2-1**

Air Pollutants Estimation from Residential in the Study Area (DKI, Tangeran, Bekasi) 1995




Source : Estimated Air Pollution by JICA Urban Gas Project, 1996

In the above figure, "Others" means undefined fuels such as non-commercial fuels including fuels used in urban slums, and the emission factor for fire wood is used for its estimation of air pollutant emissions. As for air pollution in households, in small rooms, the influence of the improvement of substituting non-sulfur fuels such as LPG and urban gas for kerosene is quite remarkable.

It is conspicuous that LPG consumption has increased mainly in the boomtown development areas like BSD, in recent years. But in the case of LPG use, each cylinder is placed underneath the cooking table without any fire protection. It is possible that the gas leakage will generate an explosion. So, it will be necessary for LPG cylinders to be put outdoors or the distribution method should be employed to avoid such explosions. As for centralized distribution, it will be easy to substitute urban gas for LPG.

A question is why LPG cylinders are put directly below the cooking table. Supposing that the decrease of the initial stage investment will make new estate selling prices lower, it will also have a big influence on the new habitants. Thus the problem will be how to process the cost load to avoid such disasters.
Incidentally, as for this point, some concern has been shown by the consumer side in the field survey of the residential sector.

## Table 15-2-4

**Fuel Consumption in Residential and Estimation of Air Pollutants in the Study Area (DKI, Tangeran, Bekasi) in 1995**

| Fuel | Consumption | kcal/kg | SOx EF | SOx Sulfur % | SOx Density | SOx Estimate | NOx EF | NOx Density | NOx Estimate | $CO_2$ EF | $CO_2$ Density/Factor | $CO_2$ Estimate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kerosene | 486 10^10kcal | 10,196 | 20 Skg/ton | 0.11 | 0.867 | 1,048,638 | 2.49 kg/ton | 0.867 | 1,186,868 | 0.86 ton/toe | 1.000 | 409,922 |
| Natural Ga | 2 10^10kcal | | 0.0092 kg/10^10cal | | | 21 | 1.57 kg/10^10cal | | 3,560 | 0.631 kg/10^4kcal | | 1,431 |
| Others | 204 10^10kcal | | 0.86 kg/toe | | | 170,441 | 6 kg/toe | | 1,189,122 | 1.19 ton/toe | | 235,843 |
| LPG | 178 10^10kcal | 11,846 | 0.0136 kg/ton | | | 2,047 | 0.88 kg/ton | | 132,453 | 0.823 ton/toe | 1.150 | 142,467 |
| Total | | | | | | 1,221,147 | | | 2,512,003 | | | 789,662 |

Estimated Air Pollution by JICA Urban Gas Project, 1996

**Calorie Base**

| | |
|---|---|
| Kerosene | 486 10^10kcal |
| Natural Ga | 2 10^10kcal |
| Others | 204 10^10kcal |
| LPG | 178 10^10kcal |
| | 871 10^10kcal |

**Average Emission from Residential by Using Fuels**

| | |
|---|---|
| SOx | 1,402 kg/10^10kcal |
| NOx | 2,885 kg/10^10kcal |
| $CO_2$ | 907 ton/10^10kcal |

## 15.2.2 Assessment of Urban Gas Use in the Commercial Sector

As for the commercial sector, the substitution of urban gas for fuels is limited according to the usage. For cooking, LPG is at present the main fuel, so LPG will be substituted by urban gas.

Table 15-2-5
**Improvement in Air Pollution from Commercial Sector, by Urban Gas Use around the Study Area**
(Based on 1995, Estimated for the Growth of Urban Gas Use since 1995)

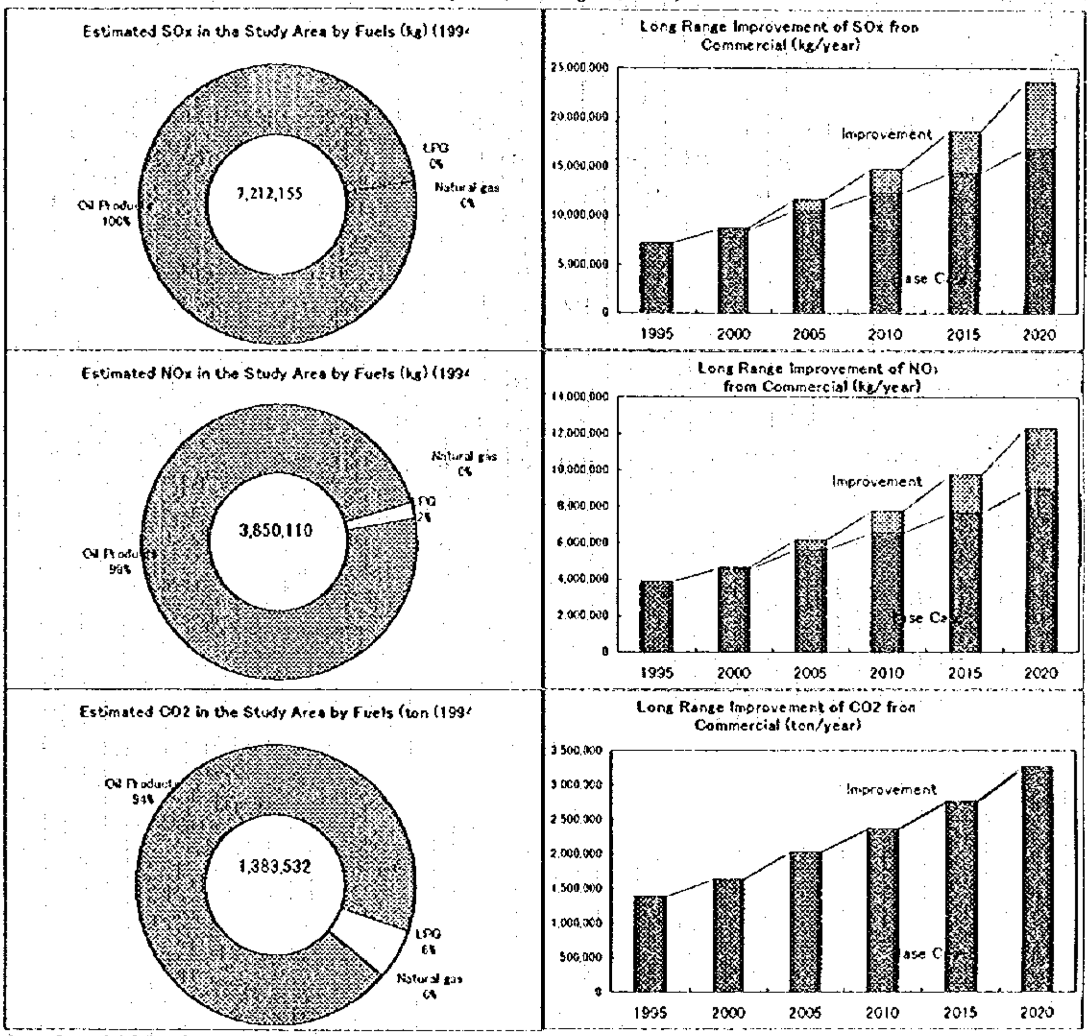
| Area | Item | | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| | | | | **Amount of Improvement** | | | | |
| Base Case | SOx | kg | 0 | 209,131 | 1,085,110 | 2,430,614 | 4,293,458 | 6,797,151 |
| | NOx | kg | 0 | 103,496 | 532,083 | 1,190,246 | 2,101,253 | 3,325,373 |
| | CO2 | ton | 0 | 1,367 | 6,280 | 13,901 | 24,443 | 38,605 |
| High Case | SOx | kg | 0 | 74,817 | 796,560 | 2,107,923 | 4,011,843 | 6,824,308 |
| | NOx | kg | 0 | 38,150 | 391,641 | 1,033,119 | 1,964,200 | 3,339,321 |
| | CO2 | ton | 0 | 824 | 4,950 | 12,379 | 23,153 | 39,056 |
| Low Case | SOx | kg | 0 | 74,817 | 760,079 | 1,963,219 | 3,542,176 | 5,572,008 |
| | NOx | kg | 0 | 38,150 | 373,811 | 962,396 | 1,734,657 | 2,727,276 |
| | CO2 | ton | 0 | 824 | 4,744 | 11,562 | 20,501 | 31,986 |
| | | | | **Improvement in SOx by Each Facilities (Base Case)** | | | | |
| Base Case | Cooking | kg | 0 | 5 | 24 | 54 | 96 | 153 |
| | Boiler | kg | 0 | 13,560 | 48,543 | 101,677 | 174,290 | 270,633 |
| | Air Con. | kg | 0 | 195,566 | 1,036,543 | 2,328,883 | 4,119,072 | 6,526,365 |
| High Case | Cooking | kg | 0 | 4 | 20 | 49 | 92 | 156 |
| | Boiler | kg | 0 | 9,919 | 40,376 | 92,224 | 166,384 | 274,751 |
| | Air Con. | kg | 0 | 64,893 | 756,164 | 2,015,650 | 3,845,367 | 6,549,400 |
| Low Case | Cooking | kg | 0 | 4 | 19 | 46 | 82 | 127 |
| | Boiler | kg | 0 | 9,919 | 39,002 | 86,776 | 148,700 | 227,600 |
| | Air Con. | kg | 0 | 64,893 | 721,057 | 1,876,397 | 3,393,395 | 5,344,280 |
| | | | | **Rough Total of Air Pollution** | | | | |
| Base Case | SOx | kg | 7,245,945 | 8,526,697 | 10,540,615 | 12,271,586 | 14,302,980 | 16,842,015 |
| | NOx | kg | 3,868,148 | 4,551,860 | 5,626,963 | 6,551,018 | 7,635,450 | 8,990,879 |
| | CO2 | ton | 1,390,014 | 1,635,705 | 2,022,042 | 2,354,100 | 2,743,789 | 3,230,861 |
| High Case | SOx | kg | 7,245,945 | 8,574,132 | 10,699,565 | 12,572,841 | 14,793,977 | 17,584,335 |
| | NOx | kg | 3,868,148 | 4,577,183 | 5,711,816 | 6,711,839 | 7,897,562 | 9,387,157 |
| | CO2 | ton | 1,390,014 | 1,644,805 | 2,052,534 | 2,411,891 | 2,837,979 | 3,373,263 |
| Low Case | SOx | kg | 7,245,945 | 8,479,261 | 10,383,330 | 11,974,491 | 13,825,299 | 16,125,493 |
| | NOx | kg | 3,868,148 | 4,526,538 | 5,542,998 | 6,392,418 | 7,380,417 | 8,608,374 |
| | CO2 | ton | 1,390,014 | 1,626,605 | 1,991,869 | 2,297,107 | 2,652,154 | 3,093,408 |
| | | | | **Ratio of Improvement by Urban Gas Use (Base Case)** | | | | |
| Base Case | SOx | | 0 | 2.4% | 9.3% | 16.5% | 23.1% | 28.8% |
| | NOx | | 0 | 2.2% | 8.6% | 15.4% | 21.6% | 27.0% |
| | CO2 | | 0 | 0.1% | 0.3% | 0.6% | 0.9% | 1.2% |
| High Case | SOx | | 0 | 0.9% | 6.9% | 14.4% | 21.3% | 28.0% |
| | NOx | | 0 | 0.8% | 6.4% | 13.3% | 19.9% | 26.2% |
| | CO2 | | 0 | 0.1% | 0.2% | 0.5% | 0.8% | 1.1% |
| Low Case | SOx | | 0 | 0.9% | 6.8% | 14.1% | 20.4% | 25.7% |
| | NOx | | 0 | 0.8% | 6.3% | 13.1% | 19.0% | 24.1% |
| | CO2 | | 0 | 0.1% | 0.2% | 0.5% | 0.8% | 1.0% |

*Source : Estimated Air Pollution by JICA Urban Gas Project, 1996*

In the same way, for boilers, the replaced will be HSD and for air-conditioners, electricity. As for electricity which is defined as the energy conversion sector, it should be evaluated in the whole electric power sector, but in this estimation, the influence of urban gas substitution is the object, and the improvement quantity of electricity decrease in the Study area is quite large, so we include the improvement effect which will be caused by the substitution of gas air-conditioning for electrical air-conditioning. Therefore, on the effect side, the air pollutant decrease by the electricity decrease in air-conditioning only is contained in the estimation of the improvement ratio.

**Figure 15-2-2**

**Air Pollutants Estimation from Commercial Sector in the Study Area (DKI, Tangeran, Bekasi) 1994**




*Source : Estimated Air Pollution by JICA Urban Gas Project, 1996*

By this substitution of urban gas in the Base Case, present sulfur oxide will be decreased by 2.4% in 2000, 16.5% in 2010 and 28.8% in 2020. As for nitrogen oxide, it will be decreased by 2.2% in 2000, 15.4% in 2010 and 27%in 2020. Also, as for carbon dioxide it will be decreased by 0.1% in 2000, 0.6% in 2010 and 1.2% in 2020.

### 15-2-3 Assessment of Urban Gas Use in the Industrial Sector

The estimated improvement of air pollution with the increased use of urban gas in the industrial sector around the Study area is shown in Table 15.2.6, Table 15.2.7 and Figure 15.2.3.

For the fuels to be substituted with urban gas, we adopted the weighted average of actual oil product consumption around the Study area (from Purwakarta to Tangeran) in 1994, which was specially extracted from the BPS data base during the second Study mission.

The improvement in air pollution is based on an estimate of the increment of urban gas use in future over the present quantity of gas use. As a result, improvement can be expected in cutting sulfur oxide emissions.

As for nitrogen oxide, the emission factor of fuel use is originally different depending on the usage or facilities. The Environment Project conducted by JICA has obtained a more accurate emission factor by the measurement of each facility. But in this Study, we are not estimating the fuel consumption by each facility, but basically use the industrial average emission factor edited by the Science and Technology Agency of the Japanese government. The procedure for estimation is shown in Table 15.2.8.

**Table 15-2-6 Improvement in Air Pollution from Industry with Urban Gas Use around the Study Area**

(Factory Use, Based on 1995, Estimated for the Growth of Urban Gas Use since 1995)

| Area | Item | | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| **DKI Jakarta** | | | | | | | | |
| Base Case | SOx | kg | 0 | 6,460,245 | 7,463,797 | 11,024,459 | 15,398,291 | 21,472,892 |
| | NOx | kg | 0 | 1,536,652 | 1,775,359 | 2,622,308 | 3,662,680 | 5,107,602 |
| | CO2 | ton | 0 | 72,133 | 83,338 | 123,096 | 171,932 | 239,759 |
| High Case | SOx | kg | 0 | 6,596,250 | 7,772,510 | 11,894,738 | 18,223,513 | 28,347,868 |
| | NOx | kg | 0 | 1,569,002 | 1,848,791 | 2,829,315 | 4,334,695 | 6,742,903 |
| | CO2 | ton | 0 | 73,652 | 86,785 | 132,813 | 203,478 | 316,523 |
| Low Case | SOx | kg | 0 | 6,324,240 | 7,104,504 | 10,022,877 | 12,596,893 | 15,523,941 |
| | NOx | kg | 0 | 1,504,301 | 1,689,897 | 2,384,069 | 2,996,332 | 3,692,568 |
| | CO2 | ton | 0 | 70,614 | 79,327 | 111,912 | 140,653 | 173,335 |
| **Tangerang** | | | | | | | | |
| Base Case | SOx | kg | 0 | 8,409,652 | 10,055,886 | 13,608,170 | 18,583,345 | 25,360,072 |
| | NOx | kg | 0 | 2,000,343 | 2,391,921 | 3,236,877 | 4,420,286 | 6,032,217 |
| | CO2 | ton | 0 | 93,900 | 112,281 | 151,945 | 207,496 | 283,163 |
| High Case | SOx | kg | 0 | 8,681,663 | 10,585,392 | 14,959,364 | 22,523,561 | 33,890,796 |
| | NOx | kg | 0 | 2,065,044 | 2,517,871 | 3,558,276 | 5,357,517 | 8,061,359 |
| | CO2 | ton | 0 | 96,937 | 118,193 | 167,032 | 251,491 | 378,414 |
| Low Case | SOx | kg | 0 | 8,137,642 | 9,454,453 | 12,142,330 | 14,880,380 | 18,222,566 |
| | NOx | kg | 0 | 1,935,642 | 2,248,862 | 2,888,208 | 3,539,489 | 4,334,470 |
| | CO2 | ton | 0 | 90,862 | 105,565 | 135,577 | 166,150 | 203,467 |
| **Bekasi** | | | | | | | | |
| Base Case | SOx | kg | 0 | 10,676,405 | 16,051,492 | 25,317,553 | 42,252,608 | 69,967,450 |
| | NOx | kg | 0 | 2,539,519 | 3,818,052 | 6,022,104 | 10,050,323 | 16,642,652 |
| | CO2 | ton | 0 | 119,209 | 179,226 | 282,688 | 471,779 | 781,234 |
| High Case | SOx | kg | 0 | 11,696,444 | 17,502,529 | 29,568,047 | 58,533,781 | 115,291,818 |
| | NOx | kg | 0 | 2,782,149 | 4,163,200 | 7,033,138 | 13,923,008 | 27,423,632 |
| | CO2 | ton | 0 | 130,599 | 195,428 | 330,147 | 653,570 | 1,287,312 |
| Low Case | SOx | kg | 0 | 9,656,366 | 14,472,144 | 20,981,218 | 28,970,285 | 39,577,784 |
| | NOx | kg | 0 | 2,296,890 | 3,442,384 | 4,990,651 | 6,890,952 | 9,414,082 |
| | CO2 | ton | 0 | 107,820 | 161,591 | 234,270 | 323,473 | 441,913 |
| **Karawang** | | | | | | | | |
| Base Case | SOx | kg | 0 | 2,806,489 | 5,202,996 | 8,919,429 | 18,639,905 | 37,220,192 |
| | NOx | kg | 0 | 667,559 | 1,237,599 | 2,121,600 | 4,433,740 | 8,853,298 |
| | CO2 | ton | 0 | 31,336 | 58,095 | 99,592 | 208,127 | 415,589 |
| High Case | SOx | kg | 0 | 3,024,097 | 5,821,125 | 10,908,037 | 27,264,061 | 67,925,278 |
| | NOx | kg | 0 | 719,320 | 1,384,629 | 2,594,616 | 6,485,105 | 16,156,895 |
| | CO2 | ton | 0 | 33,766 | 64,997 | 121,796 | 304,422 | 758,432 |
| Low Case | SOx | kg | 0 | 2,588,881 | 4,548,930 | 6,990,674 | 10,947,933 | 16,962,204 |
| | NOx | kg | 0 | 615,798 | 1,082,021 | 1,662,821 | 2,604,106 | 4,034,677 |
| | CO2 | ton | 0 | 28,907 | 50,792 | 78,056 | 122,241 | 189,395 |
| **Purwakarta** | | | | | | | | |
| Base Case | SOx | kg | 0 | 1,106,175 | 7,572,968 | 12,503,609 | 29,268,097 | 58,500,930 |
| | NOx | kg | 0 | 263,118 | 1,801,327 | 2,974,143 | 6,961,791 | 13,915,194 |
| | CO2 | ton | 0 | 12,351 | 84,557 | 139,611 | 326,798 | 653,203 |
| High Case | SOx | kg | 0 | 1,382,719 | 8,562,613 | 15,568,599 | 46,605,680 | 120,775,158 |
| | NOx | kg | 0 | 328,897 | 2,036,727 | 3,703,190 | 11,085,757 | 28,727,915 |
| | CO2 | ton | 0 | 15,439 | 95,607 | 173,834 | 520,384 | 1,348,537 |
| Low Case | SOx | kg | 0 | 829,631 | 6,542,029 | 9,583,639 | 17,059,605 | 25,567,800 |
| | NOx | kg | 0 | 197,338 | 1,556,105 | 2,279,591 | 4,057,845 | 6,081,628 |
| | CO2 | ton | 0 | 9,263 | 73,046 | 107,008 | 190,482 | 285,482 |

*Source : Estimated Air Pollution by JICA Urban Gas Project, 1996*

**Table 15-2-7 Improvement in Air Pollution from Industry, with Urban Gas Use around the Study Area**

(Factory Use, Based on 1995, Estimated for the Growth of Urban Gas Use since 1995)

| Area | Item | | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| **Amount of Improvement** | | | | | | | | |
| Base Case | SOx | kg | 0 | 29,458,967 | 46,347,139 | 71,373,221 | 124,142,247 | 212,521,537 |
| | NOx | kg | 0 | 7,007,192 | 11,024,259 | 16,977,033 | 29,528,820 | 50,550,963 |
| | CO2 | ton | 0 | 328,929 | 517,497 | 796,931 | 1,386,133 | 2,372,948 |
| High Case | SOx | kg | 0 | 31,381,174 | 50,244,170 | 82,898,785 | 173,150,596 | 366,230,917 |
| | NOx | kg | 0 | 7,464,413 | 11,951,218 | 19,718,535 | 41,186,082 | 87,112,704 |
| | CO2 | ton | 0 | 350,392 | 561,010 | 925,622 | 1,933,345 | 4,089,218 |
| Low Case | SOx | kg | 0 | 27,536,761 | 42,122,060 | 59,720,738 | 84,455,096 | 115,854,295 |
| | NOx | kg | 0 | 6,549,970 | 10,019,270 | 14,205,341 | 20,088,724 | 27,557,424 |
| | CO2 | ton | 0 | 307,467 | 470,322 | 666,823 | 942,999 | 1,293,592 |
| **Rough Total of Air Pollution** | | | | | | | | |
| Base Case | SOx | kg | 26,302,879 | 43,826,133 | 71,891,762 | 121,604,751 | 217,201,549 | 405,348,095 |
| | NOx | kg | 10,704,637 | 17,836,179 | 29,258,212 | 49,490,199 | 88,395,789 | 164,966,892 |
| | CO2 | ton | 1,364,992 | 2,274,365 | 3,730,836 | 6,310,700 | 11,271,712 | 21,035,610 |
| High Case | SOx | kg | 26,377,680 | 44,966,069 | 77,060,984 | 139,459,533 | 298,481,736 | 692,738,912 |
| | NOx | kg | 10,735,079 | 18,300,105 | 31,361,961 | 56,756,664 | 121,474,863 | 281,928,019 |
| | CO2 | ton | 1,368,874 | 2,333,522 | 3,999,093 | 7,237,277 | 15,489,762 | 35,949,806 |
| Low Case | SOx | kg | 26,228,061 | 42,651,657 | 66,220,872 | 103,345,890 | 152,740,848 | 228,233,056 |
| | NOx | kg | 10,674,188 | 17,358,195 | 26,950,297 | 42,059,283 | 62,161,839 | 92,885,346 |
| | CO2 | ton | 1,361,110 | 2,213,415 | 3,436,544 | 5,363,153 | 7,926,513 | 11,844,194 |
| **Ratio of Improvement by Urban Gas Use (Base Case)** | | | | | | | | |
| Base Case | SOx | | | 40% | 39% | 37% | 36% | 34% |
| | NOx | | | 28% | 27% | 26% | 25% | 23% |
| | CO2 | | | 13% | 12% | 11% | 11% | 10% |
| High Case | SOx | | | 41% | 39% | 37% | 37% | 35% |
| | NOx | | | 29% | 28% | 26% | 25% | 24% |
| | CO2 | | | 13% | 12% | 11% | 11% | 10% |
| Low Case | SOx | | | 39% | 39% | 37% | 36% | 34% |
| | NOx | | | 27% | 27% | 25% | 24% | 23% |
| | CO2 | | | 12% | 12% | 11% | 11% | 10% |

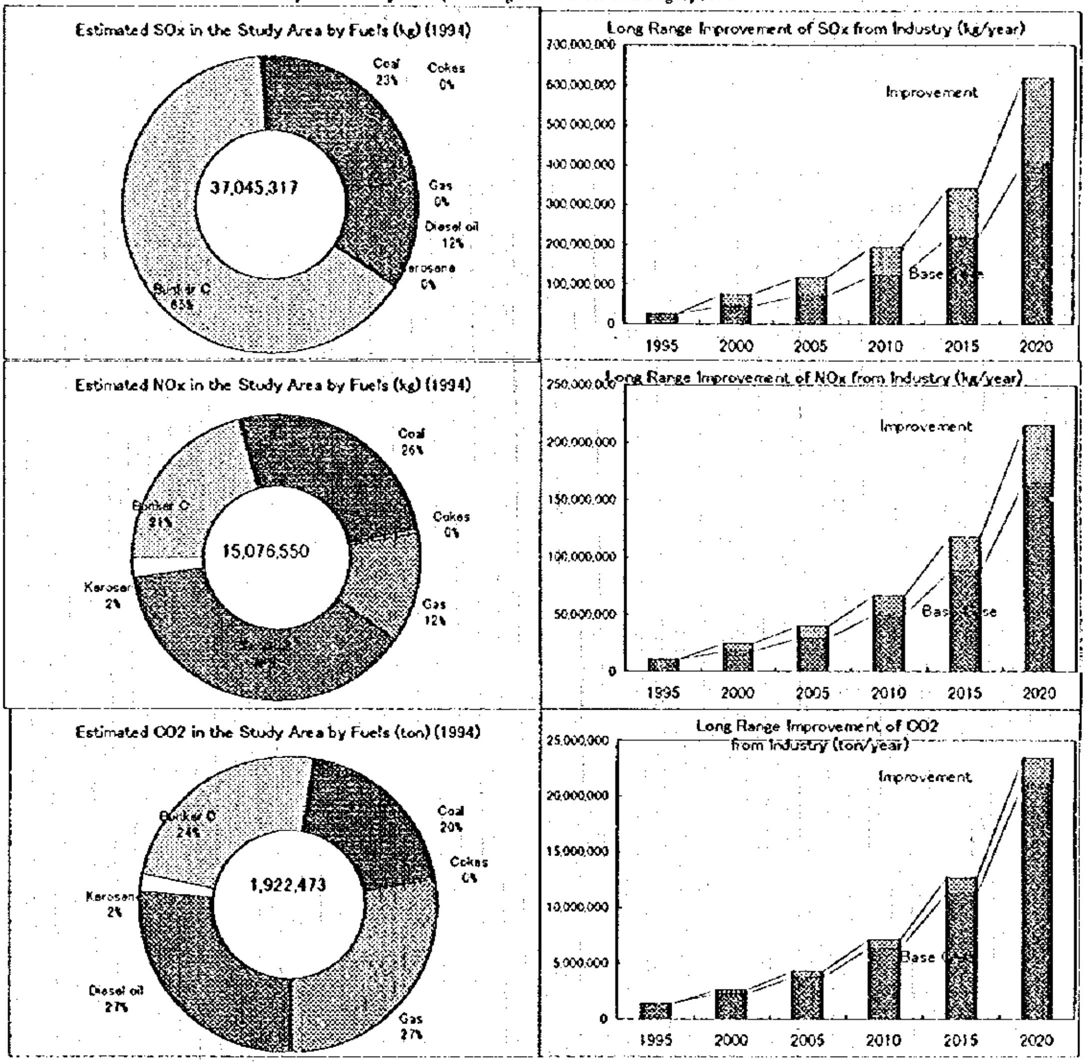
*Source : Estimated Air Pollution by JICA Urban Gas Project, 1996*

The suitability of fuels which can be substituted by gas in industries varies according to type of facilities and purpose of fuel use. In our estimation, however, the weighted average of all fuels will be substituted for by growing urban gas use. As a result, improvement in sulfur oxide and nitrogen oxide will be expected. As for carbon dioxide, improvement will be accomplished according to the carbon ratio of the replaced fuel.

In industry, the measures of environment load reduction will be brought about by the improvement of the process itself in addition to such fuel conversion. Also, considering the comparative increase of coal use in future for Indonesian electric power, the spread of international cooperation will also be expected from the viewpoint of global warming, in addition to countermeasures for decrease of sulfur oxide emission. The result of the estimation is shown in Figure 15.2.1.

**Figure 15-2-3**

Air Pollutants Estimation from Industry in the Study Area (including Purwakarta and Bogor) 1994




Source : Estimated Air Pollution by JICA Urban Gas Project, 1996

In the figure above, air pollutant emissions from the consumption of bunker C oil, which has been increasing rapidly in recent years, became a fairly large part of the air pollution load in 1994. On the other hand, major environmental improvement is expected by substituting urban gas for other fuels. The rate of improvement of sulfur oxide emissions, compared with the case in which urban gas use will not increase more than the present amount, is estimated to be improved by 40% in 2000, 37% in 2010, and 34% in 2020 as a Base Case. As for nitrogen oxides, 28% of the whole is estimated to be improved in 2000, 26% in 2010 and 23% in 2020 in the Base Case. As for carbon dioxide, a 13% reduction is estimated in 2000, 11% in 2010 and 10% in 2020.

## Table 15-2-8

**Fuel Consumption of Industries and Air Pollutants Estimation in the Study Area (including Purwakarta and Bogor) 1994**

| Fuel Consumption | | SOx | | | | NOx | | | $CO_2$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EF | Sulfer % | Density | Estimate | EF | Density | Estimate | EF | Density/Factor | Estimate |
| (A)Transportation | | | | | kg | | | kg | | | ton |
| Gasoline | 52,476 kl | 20 S*Dkg/ton | 0.01 | 0.735 | 7,714 | 31.7 kg/ton | 0.735 | 1,222,665 | 0.86 ton/toe | 0.735 kg/l | 33,170 |
| Diesel fuel | 1,183,859 kl | 20 S*Dkg/ton | 0.40 | 0.85 | 8,030,116 | 27.4 kg/ton | 0.85 | 27,572,076 | 0.86 ton/toe | 0.85 kg/l | 865,401 |
| **Subtotal** | | | | | 8,037,830 | | | 28,794,741 | | | 898,571 |
| (B)Factory | | | | | | | | | | | |
| Gas | 944,156 1000m3 | 0.0092 kg/10^10cal | | | 7,679 | 2.24 kg/10^10cal | | 1,869,580 | 0.631 kg/10^4kcal | 8,840 kcal/m3 | 526,654 |
| Diesel oil | 743,002 kl | 20 S*Dkg/ton | 0.36 | 0.81 | 4,298,822 | 9.62 kg/ton | 0.81 | 5,764,978 | 0.86 ton/toe | 0.81 kg/l | 515,372 |
| Kerosene | 49,799 kl | 20 S*Dkg/ton | 0.11 | 0.867 | 94,987 | 7.46 kg/ton | 0.867 | 322,091 | 0.86 ton/toe | 0.867 kg/l | 37,131 |
| Bunker C | 568,082 kl | 20 S*Dkg/ton | 2.23 | 0.947 | 23,993,625 | 5.84 kg/ton | 0.947 | 3,141,766 | 0.86 ton/toe | 0.947 kg/l | 462,657 |
| Coal | 520,704 ton | 15.5 Skg/ton | 1.07 | | 8,635,876 | 7.5 kg/ton | | 3,905,280 | 1.065 ton/toe | 0.680 toe/ton | 376,878 |
| Cokes | 8,095 ton | 17.7 Skg/ton | 0.1 | | 14,328 | 9 kg/ton | | 72,855 | 0.668 ton/toe | 0.699 toe/ton | 3,780 |
| **Subtotal** | | | | | 37,045,317 | | | 15,076,550 | | | 1,922,473 |
| **Total** | | | | | 45,083,146 | | | 43,871,290 | | | 2,821,044 |

Source : BPS Data Base, extracted and estimated by JICA Urban Gas Project, 1996

**Average Fuel Parameter of Industry in the Study Area**

| | |
|---|---|
| Oil Products Average Sulfer Content | 1.202 % |
| Oil Products Average Caloree | 9,375 kcal/kg |
| Oil Products Average Density | 0.867 ton/kl |
| Oil Products Average Nox EF | 7.818 kg/ton |
| Oil Products Average CO2 EF | 0.860 ton/toe |

## 15.3. Environmental Influence of Absorption Chiller and NGV

### 15.3.1 Apsorption Chiller

#### (1) Background

The turbo chiller has been used as a large-sized air-conditioner and the working fluid is usually CFC-11 (chloro-fluorocarbon, $CCl_3F$ ). CFCs are said to deplete the stratospheric ozone layer and cause global warming. To prevent global environmental aggravation beforehand, the restrictions on the production and the consumption of CFCs are implemented based on " the Montreal Protocol about the substances to deplete an ozone layer ". The Montreal Protocol divides countries into two groups, the advanced countries and the developing countries according to the consumption of restricted substances. In the advanced countries, the production was stopped in January, 1996. The consumption of CFCs in Indonesia is less than 0.3 kilograms/year·people (0.02 kilograms/year·people, 1992 ) and the country is defined as a developing country. The phase out of CFCs in developing countries is scheduled to be completed by 2010. But Indonesia decided to phase out CFC by the end of 1997. The phase out is seemed to be on schedule. Table 15.3-1 shows the consumption of CFCs in each sector in 1992.

**Table 15-3-1 CFC consumption 1992** Unit: ton/year

| Foam | Ref./AC | Fire Ext. | Aerosol | Solvents | Total |
|---|---|---|---|---|---|
| 1,025 | 2,112 | 205 | 2,000 | 2,473 | 7,815 |

*Source : JICA Seminar*

Table 15-3-2 shows the consumption of CFCs in the refrigeration and air-conditioning sector. The consumption in this sector was reportedly reduced to 1,574 tons in 1994.

**Table 15-3-2 Consumption of CFCs in the Refrigeration and Air-conditioning Sector**

Unit: ton/year

| CFC-11 | CFC-12 | CFC-115 | Total |
|---|---|---|---|
| 318 | 1,754 | 40 | 2,112 |

*Source : JICA Seminar*

At present, it seems that HCFC is being used as an alternative refrigerant for CFC in Indonesia. However, HCFC still has an effect to deplete ozone layer and will be phased out by 2040.

Absorption chillers usually use lithium bromide solution ( LiBr solution ) as the working fluid compared to chloro-fluorocarbons ( CFCs ) used in turbo chillers. Greater attention is being drawn to absorption chillers in this regard in the world. In Indonesia, the absorption chiller seems to spread rapidly in the future.

### (2) Amount of CFC Reduced

At present, the turbo chiller uses usually CFC as refrigerant. Air source package chiller and GHP usually use HCFC-22. The amounts of refrigerant are compared as an example for BSD case, the feasibility of which is being studied in this Study. The amounts of refrigerant are calculated for 2 cases for District Cooling and 2 cases for de-centralized cooling ( the detailed descriptions about cases are in Captor 9 ). The results are shown in Table 15.3-3. de-centralized cooling cases ( case A and B ) use absorption chillers and, the amount of CFC and HCFC is zero. De-centralized cooling cases( case C and D ) use turbo chillers and, total amounts of CFC and HCFC are 119 tons and 229 tons.

**Table 15-3-3 Amount of Refrigerant in the Case of BSD**

| | District Cooling | | | | | |
|---|---|---|---|---|---|---|
| | Case A<br>Conventional<br>Steam driven absorption chiller and gas boiler | | | Case B<br>Cogeneration<br>Cogeneration supplies power and steam for absorption chiller | | |
| | RT | CFC ( ton ) | HCFC ( ton ) | RT | CFC ( ton ) | HCFC ( ton ) |
| Absorption Chiller | 82,000 | 0 | 0 | 82,000 | 0 | 0 |
| Gas Heat Pump | | | | | | |
| Turbo-Chiller | | | | | | |
| Package Cooler | | | | | | |
| Total | 82,000 | 0 | 0 | 82,000 | 0 | 0 |

| | Distributed Cooling | | | | | |
|---|---|---|---|---|---|---|
| | Case C<br>Gas & Electrical<br>Combination of gas cooling and electrical driven chiller | | | Case D<br>Electrical<br>Electrical driven chiller | | |
| | RT | CFC ( ton ) | HCFC ( ton ) | RT | CFC ( ton ) | HCFC ( ton ) |
| Absorption Chiller | 36,000 | 0 | 0 | | | |
| Gas Heat Pump | 1,500 | 0 | 4 | | | |
| Turbo-Chiller | 5,000 | 15 | 0 | 41,000 | 125 | 0 |
| Package Cooler | 35,500 | 0 | 100 | 37,000 | 0 | 104 |
| Total | 78,000 | 15 | 104 | 78,000 | 125 | 104 |

*Source: JICA Team*

## 15.3.2. NGV

### (1) Background

The objectives of promoting NGV (Natural Gas Veicle) popularization in Indonesia are said, A: to save petroleum consumption in the transportation sector and B: to reduce air pollution caused by exhaust gas from automobiles. Indonesian government is giving a serious attention to the environment and planning to introduce 30,000 NGVs by 2000.

### (2) Exhaust Gas from Automobile

Table 15.3.-4 shows the influence of the exhaust gas from automobiles to the environment as studied by BAPEDAL ( Board of Environment Effect Control ) in 1992. From this study, it is clear that the influence to the environment is large.

**Table 15-3-4 Influence of the Exhaust Gas from Automobiles**

| Item | Influence( % ) |
|---|---|
| Total Suspended Solid | 44 |
| Hydrocarbon | 89 |
| Lead | 100 |
| NOx | 73 |

*Source: PETROMIER Jan. 15, 1997*

The result of the emission test is shown in Table 15.3-5.

**Table 15-3-5 Result of the Emission Test** Unit: Gram/Mile( 1 Mile = 1.61 km )

| Pollutant | Gasoline | Diesel | CNG |
|---|---|---|---|
| Hydrocarbon | 0.68 | 1.15 | 0.25 |
| Carbon Monoxide | 3.63 | 2.55 | 0.10 |
| Nitrogen Oxide | 1.37 | 1.95 | 0.50 |
| Sulfur Oxide | 0.45 | 0.80 | - |
| Particle | 0.06 | 0.70 | - |
| Total | 6.19 | 7.15 | 0.85 |

*Source: World Bank/Lemigas, GATRA. 15 Feb. 1997*

### (3) Influence on Environment

An estimated fuel consumption for the transportation sector in DKI Jakarta is in Table 15.3.6. The consumption is estimated by JICA Team using the report of the Institute Technology of Bandung.

**Table 15-3-6**

Estimated Fuel Consumption for Transportation in DKI Jakarta

( kl/year, 1996 Base ) NGV-3

| | Gasoline | Diesel |
|---|---|---|
| Taxi | 159,000 | 28,000 |
| Mikrolet | 41,000 | 1,000 |
| Sedan | 538,000 | 15,000 |
| Others | 1,408,000 | 693,000 |
| Total | 2,146,000 | 737,000 |

*Source: Institute Technology Bandung/JICA Team*

Using Table 15.3-5 and Table 15.3-6, the influence on the environment is calculated, supposing that 50 % of taxis and Mikrolet are converted to CNG from gasoline. The reduced amount of pollutant is estimated to be little smaller than 3 %( Table 15.3-7 ). The reduction in carbon monoxide and sulfur oxide are relatively large. If 50 % of sedan type cars are converted to CNG in addition to taxis and Mikrolet, the reduced amount of pollutant is estimated to be about 10%( Table 15.3.8 ). At the same time, the reduction of petroleum fuel consumption in the transportation sector are estimated to be about 3% and 12% respectively.

**Table 15-3-7 Reduced Amount of Pollutant (1)**

| | | |
|---|---|---|
| Assumption | | NGV-3 |
| Conversion Rate from Gasoline to CNG | | |
| Taxi | 50 % | |
| Mikrolet | 50 % | |
| Sedan | 0 % | |
| Calculated Reduction Rate of Pollutant Materials | | |
| Hydrocarbon | 1.6 % | |
| Carbon Monoxide | 3.2 % | |
| Nitrogen Oxide | 1.7 % | |
| Sulfur Oxide | 2.5 % | |
| Particle | 0.0 % | |
| Total | 2.5 % | |

*Source: JICA Team*

**Table 15-3-8 Reduced Amount of Pollutant (2)**

| | | |
|---|---|---|
| Assumption | | NGV-3 |
| Conversion Rate from Gasoline to CNG | | |
| Taxi | 50 % | |
| Mikrolet | 50 % | |
| Sedan | 50 % | |
| Calculated Reduction Rate of Pollutant Materials | | |
| Hydrocarbon | 6.6 % | |
| Carbon Monoxide | 13.0 % | |
| Nitrogen Oxide | 7.1 % | |
| Sulfur Oxide | 10.3 % | |
| Particle | 0.0 % | |
| Total | 10.2 % | |

*Source: JICA Team*

### (4) Current Situation

As for transportation, it is expected the environment will be improved by the use of NGV in future. During the third field survey, a newspaper reported that BAPEDAL has decided to switch all agency vehicles to NGV from now.
To investigate the present situation of NGV use, we visited a converter kit trader and a NGV filling station in Jakarta. While the government plan is comprehensive, at present nothing concrete has been done to actually execute it and the outline appears to still be under debate.
There are from 10 to 15 CNG filling stations now (it is not clear if all of them are operating or not). To really introduce this for taxis and the mini buses, it is said that 100 or more filling stations must be installed from now on.

Also, the filling time is still long, and the mileage for one CNG filling is not more than 150kM. Added to this, it is possible to say that the impact of the current price difference between gasoline and CNG is still not enough. Because, there are some problems concerning whether the management of filling stations is an attractive business in Jakarta compared with others, the sphere of NGV use will be limited to the neighborhood areas of Jakarta. Without installing many more filling stations, the fuel efficiency will decrease substantially with alternating use of gasoline and CNG.
PGN is also studying details for NGV use, but it seems difficult to create a scenario for introducing it because of the above reasons.

The target of NGV use will be taxis and Mikrolet (Mini Buses), and the air pollutants emitted by those will be 15% or 25% of the total emissions from transportation in the JABOTABEK area. As reported by the JICA Environmental Study in JABOTABEK, the improvement target of air pollution by using NGV will be expected within this range.

## 15.4 Conclusions

As for the total situation of the environmental issues in the Study area, the top priority problem is the securing of drinking water sources because of the river pollution caused by industrial waste water and residential drainage. Next, there is fear of farm product pollution coming from river pollution. Moreover, there is marine produce pollution which accompanies the coastal ocean pollution from the river water contamination. As for air pollution, because of the positive influence of the geographical situation in the Study area, in the pollution whole area pollution is not so obvious. It seems to occur with local air pollution, that is, the exhaust pollution from motor vehicles in the traffic congested areas and the air pollution in the areas near factories from which air pollutants such as PM are emitted. The source of this pollution is often able to be specified.

As for environmental counter measures in the industrial sector, for example, sulfur oxide emissions can be substantially improved by converting to a low sulfur fuel such as natural gas. On the other hand, if they have effective counter measures for air pollutant sources, other fuels can be used in the same air pollutant load as natural gas. Conversion to natural gas from other fuels is not always an indispensable item for air pollution improvement measures. Therefore, the attempt to increase the growth of gas fuel use will be done while making economic and environmental evaluations.

According to the improvement of the standard of living, as for the commercial sector, it is expected that the energy demand of shopping centers and office buildings will increase rapidly. In that situation especially, introducing the absorbing type of air-conditioning using gas in stead of the ordinary one using electricity will be effective from the view point of environmental evaluation. That is, first, electricity consumption (especially in the daytime peak load) growth will be suppressed and the emission quantity of air pollutants from the electric power sector will be reduced. Secondly, double environmental improvement can be expected because of changing the coolant from CFC gas to lithium bromide which is not said to be a green house gas.

As for the residential sector, they have been changing from non commercial fuels such as wood to kerosene and moreover from kerosene to LPG. Especially, in recent years, LPG growth is quite remarkable due to improvement of the standard of living. As a result, the environmental improvement concerning sulfur oxide is big, so it is also expected the quantity of sulfur oxide from households fuel use will be stable in future.

On the other hand, the danger of explosions will increase with the present type of LPG use. It will be necessary that the position of the LPG cylinder should be changed (from indoors to outdoors ), or it will be better to change household fuel to urban gas.
Also, The World Bank reports that respiratory disease occurs with indoor pollution in such households so it is possible to expect that fuel conversion to LPG or urban gas can improve the environment in the residential sector.

From the view point of the environmental issue, evaluating the necessity of increase in the urban gas demand quantitatively is not always the first priority in the present situation of energy supply for urban areas. But it will become a problem in future. We can also say, it is important to investigate in future the problem of consuming energy and avoiding pollution by it in concentrated urban areas .

# Chapter 16

# Assessment and Recommendations on the Master Plan

## 16. Assessment and Recommendations on the Master Plan

### 16.1 Assessment of the Master Plan

(1) Overview

The Team concludes from the analysis of the Master Plan that the gas distribution to smaller customers will be economically feasible and beneficial on the national economic basis subject to conditions. This is judged mainly from the overall EIRR and NPV or NSB (the net social benefit) over the calculation period from 1997 to 2020. The IRR and the NSB values of cash flows are shown in Table 16-1.

**Table 16-1 Economic Results of M/P**

| | IRR (%/y) | NSB (mil. Rp) |
|---|---|---|
| Base case | 34.2 | 970,601 |
| High case | 40.2 | 1,353,508 |
| Low case | 28.1 | 653,777 |

*Source: JICA Team 1997*

We set gas prices at a level competitive with alternative energies in calculating IRR rather than directly determining the economic gas distribution cost in each market sector. There is complexity of the gas market that includes residential, commercial, industrial and new technology sub-sectors which all use the same distribution network. Instead, the residential gas distribution cost is exemplified in a feasibility study that follows later.

The feasibility can be expected when:

a. The price is set at a cost recoverable price, and
b. is still at a level competitive with LPG.
c. The financing is available.
d. All the effort to cut costs is made, and
e. a large market of gas cooling is sought together.

In most cases if the price is set at about 800 Rp/m3, which suffices the "a" and "b" above and is still affordable by many people if higher than the current price, a project of gas distribution to smaller customers will be generally feasible in certain energy consumption density. How high consumption density is required must be checked by the feasibility studies for each region or estate and depends on the kind of use of gas. If a large commercial market is combined the project will be more viable.

(2) We assumed the gas purchase price to gradually increase from the current price of 167 Rp/m3 in 1996 to 268 Rp/m3 in 2020 in real terms reflecting the future gas to be coming from farther gas fields through the South Sumatra-Java pipelines and so on.

(3) Residential gas price increase:

The residential gas price was set at 800 Rp/m3 in real terms in the above economic analysis. This is a level still low enough to compete with LPG and to recover the investment; thus deemed as an economic price. The difference between the purchase price and 800 Rp/m3 represents the distribution cost which is based on efficient operations.

The set price of 800 Rp/m3 is far higher the current residential gas price but has to be realized for the independent feasibility of residential gas distribution. This level is both economically competitive and affordable by many potential customers.

A quick increase of the residential gas price to a level of 800 Rp/m3 is desired since a case of gradual increase over ten years proved not high enough a rate of return for inviting private sector investors.

(4) Concept of Separate Entity:

How to virtually raise the price is a political or corporate theme and we have proposed a concept of "separate entity distribution operation".

In this concept PGN sells gas to a separate distribution entity, PGN's subsidiary or a third party company, at a wholesale price and the rest of the work of gas distribution is handled by such an entity which charges an 800 Rp/m3 level price to residential customers in a designated area.

This is because PGN is currently required by the Government to apply a unique gas price to residential customers in the country regardless of the region and actual cost differences, and it is presumed that a separate company may be allowed to apply a different but economically reasonable price to customers A similar scheme is already applied to apartment buildings, where a landowner charges a price to end customers, though the price is different from such a high level.

To maintain the safety and common gas distribution standards, PGN may still act as a contractor for physical operations and patrols, not really feeling the loss of a market. The estate operator may be rewarded with certain economic returns, keeping privileges and attractiveness of the property.

By this scheme, the final price to the customer could be divided into a distribution charge and a gas price, the latter of which is still in line with the PGN gas tariff.

**Table 16-2 Financial Analysis on the Master Plan**

| | Scenario | | Base | | High | | Low | |
|---|---|---|---|---|---|---|---|---|
| | | | IRR %/y | NPV milRp | IRR %/y | NPV milRp | IRR %/y | NPV milRp |
| 1 | Managed by separate utility. Gas purchased at 315, sold at 800 | PGN side | 27.0 | 432,524 | 31.5 | 727,665 | 20.8 | 194,685 |
| | | Sep. U. | 17.5 | 120,337 | 17.9 | 130,910 | 17.0 | 106,697 |
| 2 | PGN operates. Price up in ten years | | 20.7 | 456,244 | 24.5 | 769,701 | 16.1 | 203,656 |
| 3 | PGN operates. No price hike | | 16.6 | 259,105 | 21.2 | 674,686 | 10.4 | 8,837 |

*Source: JICA Team 1997*

(5) Financial Analysis:

Whether to adopt the separate entity concept and how quickly to raise the price for residential customers affect the economics of the whole Master Plan mildly because of an inherent cross subsidy from more lucrative industrial sectors. The situation is shown in Table 16-2.

Since the portion of the residential gas market in the whole PGN operation is small, less economical element is absorbed, except in the combined cases of current gas price and low demand. This can work as a back-stop element to PGN for venturing into new market sectors, but it is never desirable that the residential gas market operation damage the financial picture of other sectors when PGN requires large investment in transmission lines. Thus an arrangement for self sustainability of the residential gas operation is necessary.

(6) Commercial Air-conditioning:

Gas absorption air-conditioning is mostly feasible in commercial facilities at the current gas and electric prices if the pipelines are located close to the customer facilities. The estimated pay-back is 3 to 4 years. Assuming the electric prices will be raised in the future reflecting the clearly more expensive generation costs, absorption chillers will be feasible in the future, too.

(7) Cogeneration:

High efficiency cogeneration may have some difficulty in attracting investors, who generally want a quick property investment return, due to high capital expenditure and generally low energy prices as well as an insufficient amount of heat demand depending on facilities. Pay-back is 5 to 6 years and the IRR may be in the range of 10 to 13 %/y in a 15 year project period. It is still economical to an investor with enough financial capability and long-term perspective of property operation. It is worth consideration for hotels and hospitals in urban areas. The gas cogeneration is challenged by other cogeneration using low priced oil products if there is no environmental restriction of using oils in urban areas.

(8) Natural Gas Vehicles:

NGV is simply beneficial for the environment in urban areas as long as economics allows it and the policy of the government to spread CNG for taxis, buses and other fleet are appreciated if the price of a conversion kit is maintained at the current level and safety is ensured. There are still barriers of land prices in installing CNG filling stations in urban areas and so the economics are difficult to generalize. A certain density of the number of stations is required for NGVs to take off in a self sustaining market. It may be worth certain cross-subsidy in a transition period.

(9) Industrial market:

There is a large potential in industrial gas market in many industrial estates being developed in the east of Jakarta as well as in Serang. Uncertainty is also large in estimating the potential gas demand since many estates are in a very early stage of development. The Team, nevertheless dared to approximate the potential. There are recent challenges from low cost oil products, so PGN should feel competition and think in advance for possible demand areas. The Team appreciates that PGN well knows the industrial gas sector from abundant experiences.

(10) Environmental and societal effect:

The Team conducted a detailed environmental assessment for the Master Plan projections. As natural gas is environmentally benign, it is essentially to assess how good natural gas is in urban areas. Gas considerably decreases SOx and NOx in urban areas by replacing oil for factories as well as greenhouse gases effective globally. Gas absorption chillers decreases ozone depleting CFCs. The gas is safer than LPG which has recently caused large explosion incidents as well as is more convenient. It is felt by people as having a premium value which, though, changes with income levels and hard to quantitatively determine.

## 16.2 Recommendations

1) It should be recognized in energy policies that gas distribution to smaller customer markets is feasible at economic prices under certain conditions including joint development of residential and commercial markets, and the gas cooling market, too. Mid-income group residents can be better targeted for the residential gas market and so they can be a locomotive for building up the gas energy infrastructure.

2) It is recommended to consider a separate utility concept, if the policy of one gas price by one company continues in the country, since such policy seems to disregard market principles. When the distribution cost in a certain region is different from an other region and such a cost can still compete with other fuels, it is recommended to approve a mechanism to apply a different price through a separate entity establishment

3) The government is recommended to endorse the promotion of gas air-conditioning and cogeneration, when feasible, for commercial or industrial buildings and complexes.

4) NGVs are beneficial and recommended to be promoted in urban areas. More filling stations are necessary for sustainability.

5) It is recommended to continue to watch new industrial estate development, since industrial estates in West Java are growing and early pipeline planning is better for securing the gas market.

# PART III

# FEASIBILITY STUDIES

# Chapter 17

# Common Scheme and Assumptions

# PART III FEASIBILITY STUDIES

## 17. Common Scheme and Assumptions

### 17.1. Overview

The goal of the Urban Gas Development plan is to create a long-term master plan, extending over a period of more than 20 years, along with feasibility studies (F/S), which include short and middle-term concrete plans. From the preliminary survey stage, the Counterpart Team requested that the contents of the feasibility studies be related to future action plans. Based on the results of the first and second field works, the Team suggested four candidate sites to the Counterpart Team for the feasibility study, and the implementation of a study of two cases was approved by the Steering Committee.

Before conducting these, however, the Team brought the price issue to the attention of the counterpart since residential and commercial distribution costs are at a different level from current tariffs and the price has to be effectively raised to be closer to an economic level which is still competitive and eventually beneficial to the people.

For this reason we propose and assume new schemes to develop new smaller customer market in the F/S areas.

### 17.2. Area Selection

In order to select the feasibility study areas, the Team suggested the following four candidate sites to the Counterpart as examples of a residential area, a combined area of residential and commercial, a industrial area and a rehabilitation, along with a summary of the financial evaluation of the PGN side. The major goal of this development plan is to increase gas use in the household sector, and therefore the candidate plans (1) and (2) were approved by the Steering Committee.

**(1) Expansion of Residential Gas Use in Existing Areas -Bekasi Baru**

Currently new residential estates are being developed extensively around Jakarta city. The purpose of purchasing land is sometimes investment for the future, so the rate of occupancy in new residential estates is low. And it will take time for the scale of gas consumption to become proportionate to the scale of estate areas, and the efficiency of PGN's investment in distribution pipelines in such areas is very low. The Team examined existing residential areas where urban gas demand is expected to be proportionate to the land scale immediately after constructing distribution pipelines as a candidate for the feasibility studies.

**(2) Gas Use in Multi-Functional Development Areas -BSD**

Investigation of gas demand in multi-functional development areas has discovered that building construction has not started on many of the properties which have apparently been purchased for speculative purposes. On such properties, therefore, even if PGN invests in pipeline network at an early stage of development, it will take time before houses are fully built and expected gas sales are actually achieved. It was also revealed that these newly developed properties owned by medium to high income groups tend to occupy relatively large land area. This means that the number of houses per unit length of gas pipes is small and, therefore, pipeline investment is less rewarding. Due to such financial disadvantages, PGN has not made aggressive demand development efforts.

**(3) Utility Service Subsidiary in Newly Developed Industrial Complex-Purwakarta**

We proposed to investigate the operation by PGN of a utility service company (for example electricity, urban gas, water telecommunication, sewerage) in a newly developing industrial complex.

Measures for promoting investment from both inside and outside the country will be sought. Investment in pipeline construction from an existing trunk line to the industrial complex and in the distribution system within the complex should be made in good time and with the least financial burden on PGN.

**(4) Rehabilitation Plans for Existing Gas Pipelines**

PGN has many pipelines in central Jakarta constructed during the Dutch rule that now have sprung gas leaks.

Some are being systematically rehabilitated. There are certain areas around Jakarta where gas supply has just started. Since polyethylene pipes are not used in these areas, significant corrosion has developed and unaccounted-for gas amounts to more than 20%. If rehabilitation contributes to future promotion of gas in the area, economics, safety and other issues will be investigated with regard to the pipe replacement in these areas.

## 17.3 Common Scheme and Assumptions

This Study has chosen PERUMNAS BEKASI BARU as the zone for residential gas demand development study and BUMI SERPONG DAMAI (BSD) as the zone for commercial and residential complex demand development study. These two zones have various common points in conducting the feasibility study. But the development of residential housing unit area has mostly been completed in the former zone, while it is still on the midway in the latter zone. Due to this, the obtainable concrete data differ so that the way of conducting the feasibility study becomes a little different. The feasibility study in BSD is inevitably subject to many assumptive factors.

The ratio of gas distribution cost( investment in low pressure pipelines) and user cost ( service pipes, gas meters, collection, meter reading ) to the current gas rate for households is so high that currently the selling price is lower than the cost. To eliminate that structure in the feasibility areas, we studied in detail various measures including items relating to gas business in general, toward the goals of :

- ✧ Adjusting the gas rate by estimating the proper cost level,
- ✧ Reducing the investment cost of pipelines, and
- ✧ Reducing the cost to serves gas to each end user.

The Team also discussed the possibility of independent distribution utility entities to resolve issues mentioned above.

**17.3.1 Common Scheme**

Figure 17-3-1 shows a rough works flow of the feasibility study.

(1) Area Survey
In order to create a realistic F/S result, the survey progresses while simultaneously reviewing the existing development master plan and present situation in each area. In particular, for the survey in BSD, which is now being developed, the F/S will consider the construction plans related to other utilities.

(2) Market Survey
The urban gas demand projection in the area is based on the basic consumption per meter and demand prediction methods used in the Master Plan. In the area near Bekasi Baru, where LPG will be the mainstay, household and small-scale industrial demand can also be expected. Therefore, the target area has been extended to the surrounding region, and the demand near Bekasi Baru is being examined. In order to clarify the barriers to implementing this project, the market survey will include the demand for gas and physical distribution of LPG, which is the main competitor of urban gas.

(3) Pipeline Plan and Investment Cost Estimation
An optimal gas supply system for mixed commercial and household areas as well as exclusive household areas will be constructed after an examination of the aspects related to security and construction cost. The pipeline will be designed after clarifying the technical standards and the concept of design, and consideration will be given in order to easily apply this design to similar areas.

(4) Business Operation

In order to expand the urban gas supply for household use in the future, the current business system, which centers on industrial use, and the gas tariff system and gas promotion measures have to be significantly reformed. It is also highly probable that certain reforms will be impossible to implement because of regulations surrounding the present business of PGN. Therefore, a new business form, including the establishment of a subsidiary company to allow these reforms to be implemented, will also be referred to.

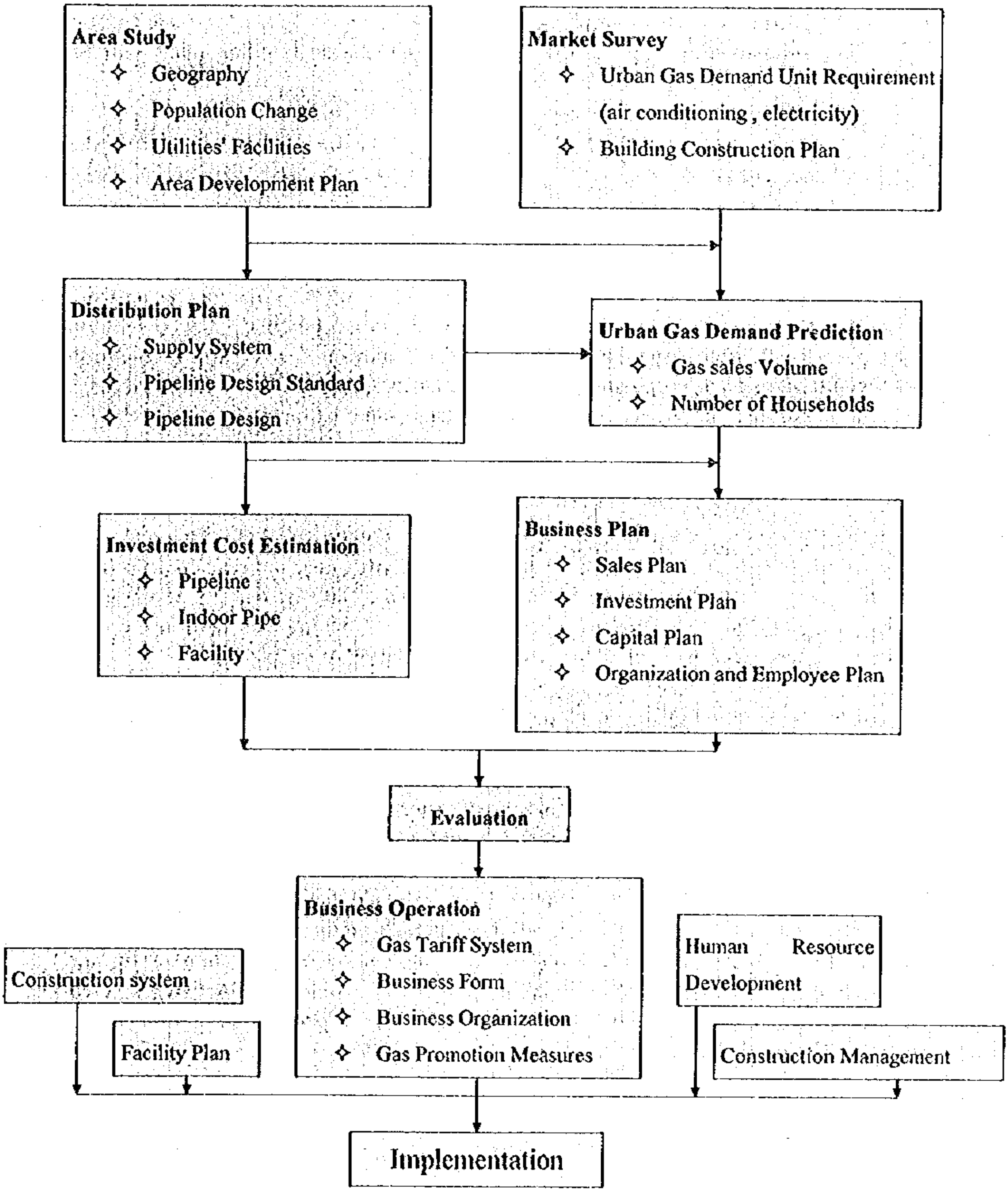
(5) Evaluation

We evaluated the combined cases for what levels the gas price is in, who invests in distribution pipelines and what the business form is through financial analyses.

(6) Business Plan

As part of the examination of the business operation, the restrictive conditions and barriers to expand the household use of urban gas will be summarized, and ways to eliminate these barriers will be pointed out. Based on these results, a proposed business plan will be created including measures to handle the increasing number of customers, development of human resources required to promote urban gas use related to new demands, such as air conditioning, and organizational reform.

Figure 17-3-1 Feasibility Study Plan



### 17.3.2 Common Assumptions of the Feasibility Study (F/S)

Implementation of the two feasibility studies assumes the following preconditions:

- Proper gas price levels will be employed and the investment in gas pipelines described in the plan be implemented
- The infrastructure improvement plans and large-scale building plans will be implemented in the future as planned by developers.
- All-out cooperation to the gas project by the area developers be ensured.
- The work performance capability of contractors be sufficient to fulfill the related works.

1) Gas price and investment described in the business plan scenario:

As mentioned above, the Team formulated two scenarios of gas price increasing from the present level. Additional governmental investment in gas pipelines may be solution to heighten feasibility of the urban gas business. This above is based on the recognition that the current price of urban gas for residential customers is much lower than the gas distribution cost making the gas business unprofitable and unattractive.

2) Implementation of infrastructural improvement and large-scale building plan

The timing of the investment and the demand increase greatly affect the economics. We projected the time of investment for pipelines and the time of gas increase demand from the estimated time of completion of infrastructure (the railway, express ways, main roads ) and the developer's business plans (installation of commercial facilities, public facilities ).These F/S's are subject to steady implementation of the plans.

3) All-out cooperation by the developers

The area developers' cooperation in making use of the lands required for gas pipelines and regulator stations and supply of necessary information on construction of large-scale buildings are indispensable for steady implementation of the F/S plans. Our projection is subject to that the required lands will be offered from the area developers.( According to the National Urban Development Corporation, Perum Perumnas, required lands are small, so these are currently supplied at free cost.) Furthermore, it is very important for the development of the gas market for air conditioning to get construction information as early as possible. Sales activity targeted to facility owners is indispensable in Indonesia where penetration and level of knowledge about absorption chillers are low.

4) Work performance capability of work contractors

As prescribed in the Section of "Master Plan", the present work performance of contractors is insufficient for future implementation. The two feasibility studies do not regard the work capability as a constraint, though the capability is insufficient in actuality.

## 17.4 Gas Price Issues

### 17.4.1 Tariff Levels Competing Other Fuels

In setting tariff levels, it is important to consider the price levels of competing fuels. In the residential sector, we find the competing fuel is LPG, rather than kerosene. The price of LPG, which was set in 1995, is 1000Rp/kg, which is equal to a price of 784Rp/m$^3$ for natural gas. For thinking of competitiveness of natural gas, the tariff for the residential customers could be set at 700-800 Rp/m$^3$.

For commercial customers using gas for cooking, the competing fuel is also LPG. For the commercial customers who use gas for commercial boilers, the competing fuel is kerosene. For a commercial customer who uses gas for air conditioning, the competing fuel is electricity. Here we must take into consideration the fact that all commercial customers will have cooking demand, and some of them have commercial boilers and/or gas air conditioning systems. Net back values of gas estimated in terms of competing fuels and initial costs for hiring each type of energy, are different. Levels of net back values for each type of usage would be Cooking > Air conditioning > Water heating. For those commercial customers who use gas air conditioning, net back value of gas should be calculated from air conditioning using electricity. For those who do not use air conditioning, the net back value of gas should be set from cooking by LPG.

For industrial customers, the net back value of gas is estimated based on which fuel they may want to use other than natural gas. In setting economic benefit/m$^3$ for industrial users in the Master Plan of our report, we are using a basket of competing fuel prices whose shares of competing fuels are those of the existing industrial users in the Jakarta Branch area.

In our feasibility studies, customers are only residential in Bekasi, and commercial and residential in BSD.

### 17.4.2 Allocation of the Distribution Cost to Each Customer Category

Allocation, ideally, should be done based on the actual cost of each category of customer, so that the tariff charged to each category will have fair cost allocation and there are no cross subsidy of costs between customers in an ideal case.

Facility cost should be allocated by percentage of gas flow/hour of each category. As operation hours of residential customer are much lower than that of commercial customers, it will underestimate the cost of facility for residential customers if we allocate it only by gas sales volume.

Service cost that is meter & billing should be allocated by number of times of meter reading in a year in each category of customers. For residential customers, PGN is now reading meters once a month, while for commercial customers once a week, and for industrial customers once a day. High frequency of meter reading is due to the fluctuation of pressure. However this might become more efficient if they introduce better meters.

Maintenance cost of facility would also be allocated in the same way as the facility cost. Material cost, that is the cost of gas purchased from supplier should be allocated by sales volume of gas, assuming the tariff charged by PGN to a separate utility entity would be the same in the course of volume of gas purchased.

### 17.4.3 Two Part Tariff System

We recommend to introduce two part tariff system in the Feasibility Study areas. PGN currently is using a simple tariff system, while PLN is already introducing two part tariff systems. The two part tariff system is such that they separate the tariff into two portions; one is fixed charge to be charged to each customer relative to fixed cost of the project, and the other is variable charge to be charged in terms of variable cost of the project. Fixed cost will include facility cost, personnel expenses and maintenance cost. Variable cost will be the cost of gas.

The two part tariff system will contribute stable collection of the fixed cost and make it financially less vulnerable to the risk of demand fluctuations. Simultaneously, it will motivate each customer to use more gas.

## 17.5 The Case of an Alternative Business Unit

We assume 5 alternative cases of pricing and Business form in the analysis of the Feasibility Study as Table 17-5-1 shows. This assumption of case is exactly same as that of Master Plan.(see section 14.1.1)

**Table 17-5-1 Alternative Cases for Pricing & Business Unit(reproduced)**

| | Gas Price | Investment | Operation |
|---|---|---|---|
| CASE 1 | Keep current price level | PGN | PGN |
| CASE 2 | Raise gas price gradually equivalence to competitive fuels | PGN | PGN |
| CASE 3 | Keep current price level | Government | PGN |
| CASE 4 | Raise gas price gradually equivalence to competitive fuels | Government | PGN |
| CASE 5 | Raise gas price immediately equivalence to competitive fuels | third party (e.g., a subsidiaries of PGN) | third party (e.g., a subsidiaries of PGN) |

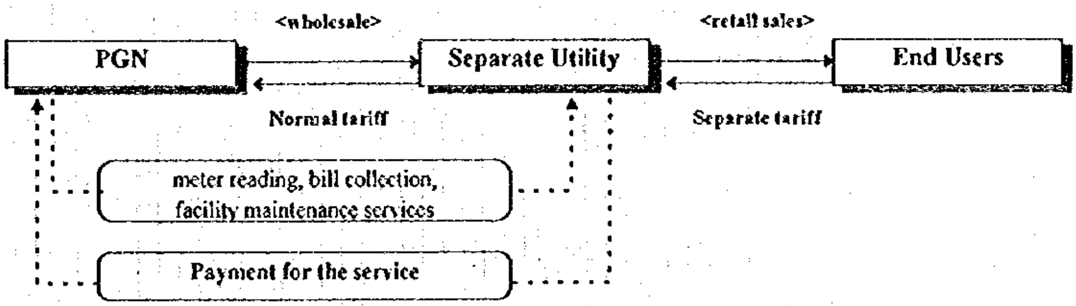
In the case 1, we assume that government keeps rigid gas pricing policy and gives no support to initial investment for distribution pipeline. Therefore, the feasibility may be harder. In the analysis of feasibility study, we will prove what kind of policy is necessary to make the project feasible.

In the case 2, we assume that government approves gradual increase of gas tariff to 800Rp/m$^3$ which is equivalent to competitive fuels such as LPG. However, it may be hard to keep feasibility of the project because PGN is assumed to cover all pipeline cost.

In the case 3 and 4, we assume that initial investment for pipeline is covered by governmental expenditure as an urban infrastructure. In case of Bekasi, it seems realistic to adopt this method as the developer is governmental body, Perum Perumnas. Actually, we can find an example in the water business that initial investment is covered by government.

In the case 5, separate utility established by PGN distributes gas in the F/S area. We assume that immediate increase of gas tariff in this case. Separate utility concept is explained in the section 14.1.1.

**Fig 17-5-1 Separate Utility Entity Concept(reproduced)**



## 17.6 Distribution Pipeline System for Residential Customers

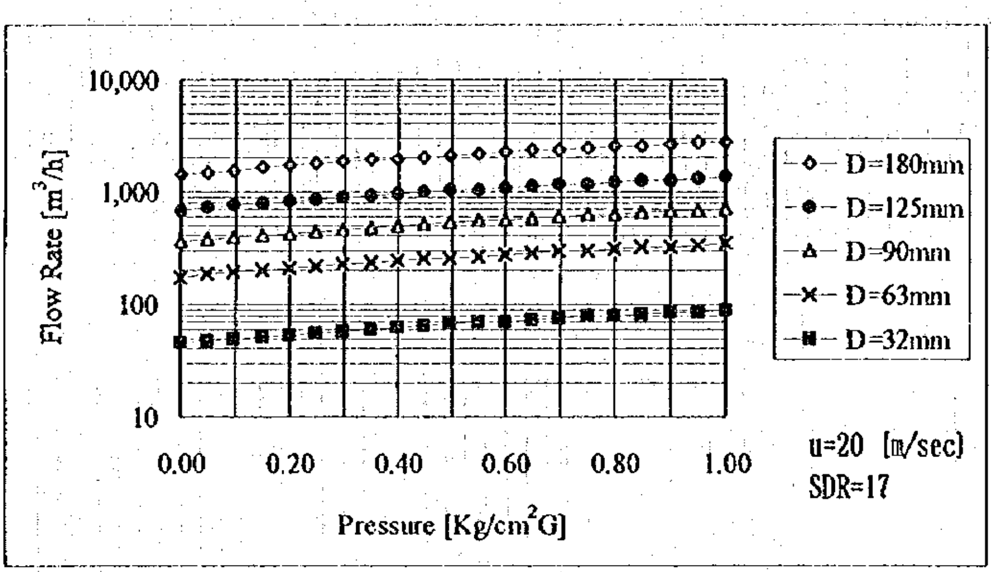
Since the targets of the Feasibility Studies are residential and commercial customers, the distribution network would be either medium pressure system or low pressure system. In order to determine an optimum distribution system for residential customers, construction costs of the following cases were compared using the data of Bekasi Area I. (Detail of Bekasi feasibility study area will be explained in section 18)

**Table 17-6-1 Cases Compared for Finding the Best Distribution System**

| Case | System | Pressure Range | Minimum Diameter to be used |
|---|---|---|---|
| 1 | Low Pressure | 180-230 mmH2O | PE 63 mm |
| 2 | Medium Pressure (1) | 0.1 - 1.0 bar | PE 63 mm |
| 3 | Medium Pressure (2) | 0.1 - 1.0 bar | PE 32 mm |

PGN uses polyethylene (PE) pipes with diameter of 63 mm, 90 mm, 125 mm, and 180 mm for distribution mains. However, the PE 63 mm pipe is too large for conveying gas to a small number of residential customers whose loads are less than 1 $m^3/h$ per customer. Fig. 17-6-1 shows the design load of each diameter pipe at the maximum flow velocity of 20 m/s in the medium pressure system.

**Fig. 17-6-1 Maximum Gas Flow Rate in PE Pipes**

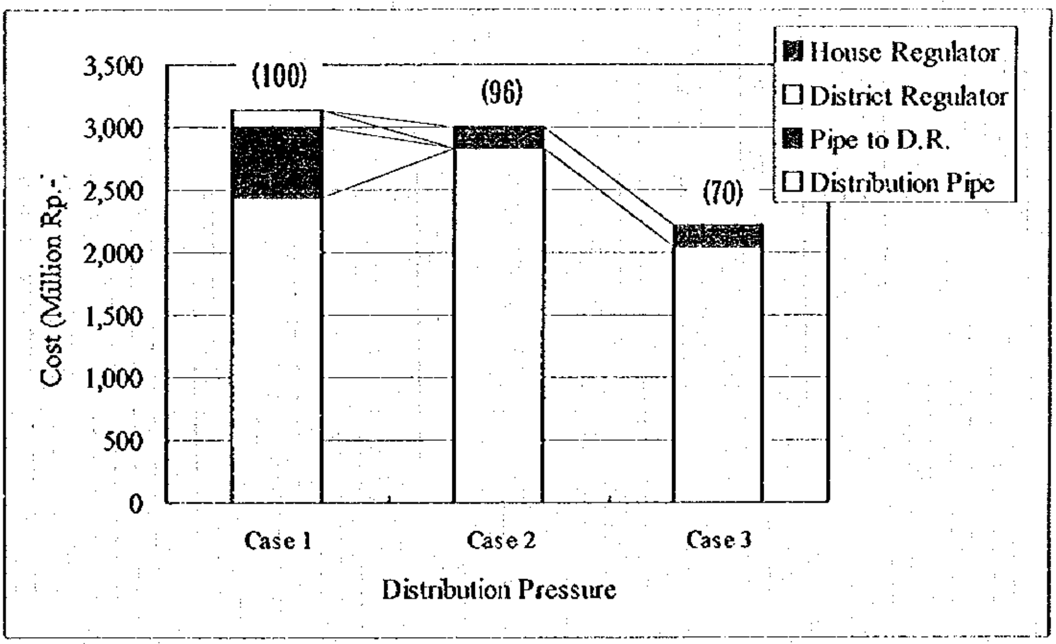



*Source : JICA Team*

From the graph, we understand that the flow rate capacity of PE 32 mm pipe is about 50 $m^3/h$ even at the pressure of 0.10 $Kg/cm^2G$ and this certifies that PE 32 mm pipe can be used for distribution main. A PE 32 mm pipe is usually used for service lines and not for main since it is mechanically weak compared to PE 63 mm pipe. Therefore we use PE 32 mm pipe only under roads narrow enough to avoid third party construction work which may cause damage.

Fig. 17-6-2 shows the cost comparison among 3 distribution systems defined in Table 17-6-1. From the graph, the construction costs of case 1 and case 2 are seen to be almost the same although the construction cost of case 3 is about 30 % lower than the other 2 cases. This means that the introduction of PE 32 mm pipe as distribution main has a good effect on cost reduction. Therefore, we will use the medium pressure distribution system that uses 32 mm pipes for distribution main as the standard distribution system in the Study.

**Fig. 17-6-2 Construction Cost Comparison**




*Source : JICA Team*