ECONOMIC APPRAISAL ON THE USE OF GAS FOR POWER GENERATION

Sukanto Reksohadiprodjo
Universitas Gadjah Mada

ABSTRAK

Permintaan listrik di Indonesia meningkat dari waktu ke waktu. Artikel ini membahas penggunaan bagi pembangkitan tenaga listirk sebagai alternatif pemenuhan kebutuhan tersebut. Pembahasan juga mencakup sumberdaya gas, cadangan gas, ekspor gas, konsumsi domestik, penentuan harga, dan berbagai proyek di terkait Indonesia. Fokus pembahasan terutama pada penilaian ekonomis penggunaan gas bagi pembangkitan tenaga listrik.

INTRODUCTION

It is understood that the projected demand for electricity in the year 2003/04 or at the end of repelita vii would be 41.000 MW and in the year 2008/09 or at the end of repelita VIII would be 58,060 MW). The electricity demand would be fulfilled by several types of generation, i.e. Hydropower, Coal, Combine Cycle, Steam, Geothermal, Diesel, and Gas.

This paper will discuss the use of gas for power generation and its ramification ranging from gas resources, gas reserves, gas production, gas exports, domestic consumption and pricing, and gas-fired power projects in Indonesia. The discussion would especially focus on the economic appraisal of the use of gas for power generation.

GAS RESOURCES IN INDONESIA

Indonesia's estimated gas reserves are 212.4 TCF of which 114.2 TCF are proven and probable. Two thirds of the reserves are found in three areas: Northern Sumatra, Eastern Kalimantan and the Natuna sea. In addition, other accumulations in the Northwest Java sea, offshore East Java, North of Bali, and the Bird's head area of Irian Jaya. However, the region that consumes most of the gas is in Java. Therefore, problems of transporting gas become prevalent.

GAS PRODUCTION IN INDONESIA

Indonesia's natural gas production in 1995 was 2,999 BCF or 8.2 BCF per day). This was the energy equivalent of 1.42 million barrels of oil per day, or slightly less than the country's 1995 crude oil production).

The production of gas in Indonesia is under-taken by:

(1) MOBIL company which operates arun gas field in North Sumatra and supplies:
   (a) arun LNG plant
   (b) two fertilizers plants
   (c) pulp & paper factory MOBIL production was 1,181 BCF
(2) VICO company which operates Badak gas field in East Kalimantan with 536 BCF and supplies Bontang
   (a) LNG plant
   (b) LPG plant
   (c) fertilizer plant
(3) ARCO which operates fields offshore near Java with production of 300 BCF and supplies natural gas in East Java for:
   (a) power generation
   (b) city gas
   (c) petrochemical plants

   Arco is the largest supplier of gas for domestic use.
(4) TOTAL which operates in East Kalimantan and supplies Bontang LNG plant. Its production is 1 BCF per day.
(5) UNOCAL which also operates in East Kalimantan and supplies Bontang LNG plant.
(6) CONOCO operates in Natuna Sea
(7) MARATHON operates in Natuna Sea
(8) CALTEX produces gas for its own uses, i.e. for power production and enhanced oil recovery (eor) operations.

Indonesia is the world's largest supplier of LNG for export. The major domestic use of gas has been largely as feedstock for fertilizer plants.

The lack of an integrated pipeline grid and lack of sufficiently high "well head" prices to provide necessary return to enable oil contractors to develop gas field have been the obstacle to greater use of gas.

Gas Exports

Most of the gas produced in Indonesia is for export (LNG & LPG amounting to 58 percent), domestic sales (16 percent), own use (21 percent) and flared (5 percent).

LNG exports were mostly to Japan and in 1995 it amounted to 17.6 million tons; to Korea 5.26 million tons and to Taiwan 1.94 million tons; LNG exports in 1995 totaled 25.97 million tons. In 1977 it was only 0.60 million tons. LPG exports were also mostly to Japan and in 1995 it was 2.107.66 thousand tons; to others 281,85 thousand tons, to Hongkong 104,91 thousand tons, and to Singapore 1,79 thousand tons. LPG exports in 1995 totaled 2,496.20 thousand tons, hi 1977 it was only 197.69 thousand tons.

Domestic Gas Utilization and Pricing

The gas produced is utilized for fuel and feedstock. Table 1 shows domestic gas utilization and pricing (pre - 1989 contracts). Subsidies from Pertamina to the industries were involved here.

Table 1. Domestic Gas Utilization and Pricing

FUEL	PRICE ($)	PRICE per MMBTU (Rp.)
FERTILIZER (-)	1.00-1.50	-
STEEL INDUSTRY	2.00	-
* ELECTRICTY (43%)	2.45 - 3.00	-
CEMENT INDUSTRY	2.70 - 3.00	-
PAPER	1.30	-
REFINERY (LPG 11%)	1.40	
PLYWOOD (Irian Jaya)	0.97	-
CITY GAS (5%)	-	2,500-4,150
FEEDSTOCK		
FERTILIZER (33%)	1.00-1.50	-
STEEL INDUSTRY	0.65	-

Source: American Embassy, Petroleum Report: Indonesia, p.78

In 1995, for the first time, electricity became the largest user of domestic gas. In 1994, a 420-kilometer pipeline began transporting gas from Arco fields north of Bali to Gresik. A 1,500 mw combined cycle plant will use more than half of the gas. Two other gas-fired combined cycle plants near Jakarta began operating.

Electricity production from natural gas has exploded from 969 gwh in 1990 to 13,424 gwh in 1994. During the same period the amount of gas used for electricity generation increased from 7.4 bcf to 95.9 bcf per year. In 1995, it jumped to 210 bcf.

Gas Projects

There are two types of gas projects:

(1) pipeline projects, and (2) gas fired power projects.

The pipeline projects were undertaken by

(a) PGN - the integrated transmission system (but not for power generation)

(a.l.) Trans Central Sumatra {corridor block/asamera (South Sumatra)} toward Duri and the branch to Batam islands;

(a.2.) Trans South Sumatra (Prabumulih lane to Cilegon, West Java);

(a.3) Trans South Sulawesi: Sengkang lane to Pare-pare and Ujung Pandang.

(b) East Java - West Java interconnection (Surabaya to Semarang to Cilamaya);

(c) East Java grid (Mobil oil, Arco Bali north Pertamina);

(d) Cilamaya - Jakarta.

The gas-fired projects consist of projects by:

(a)) the energy equity of Australia bot 134 mw gas fired combined cycle power plant in sengkang (south Sulawesi).

(b) enron development corporation builds a 500 mw combined cycle gas fired power project near grati in east Java; also a 136 mw combined cylce plant near samarinda in east kalimantan.

Both had signed power purchase agreement

Estimation of Electricity Demand in Indonesia

In 1993/1994 electricity sold to customers is depicted in table 2. Table 3 shows that in 1993/94 the supply of electricity may come not only from gas, but also from other sources of energy, i.e. Hydropower, coal, geothermal, and fossil fuel. It also shows the usage of electricity in Java and outside Java which is 80 percent and 20 percent, respectively. In table 4 one can see the installed capacity during 1973/74 to 1993/94 period, and the projected growth of installed capacity and projected energy demand during the 1993/94 - 2008/09 period.

Table 5 shows that the type of purely gas generation could be relatively small compared with use of coal which would be dominant (from 16.2 percent in 1993/94 to 53.5 percent in 2008/09 with its environmental consequences).

Table 6, 7 and 8 shows the electricity production during 1973/74 - 1993/94 period and the projected growth of production, projected electricity consumption. 1993/94 -2008/09, and electricity production and supply 1973/74 to 1993/94 according to type of generation stations. It seems that supply of electricity would always be greater than demand for electricity. Indonesia would be very fortunate in the future to have that kind of situation, if and only if there is adequate fund available for investment.

Table 2. Energy (electricity) sold to customers in GWh by 1993/1994

Customers	**Java**	**%**	**Outside Java**	**%**	**Total**
Residential	9,678.4	31.0	3,462.3	44.7	13.140,7
Industry	16,816.3	53.9	2,744.7	35.4	19,561.0
Commercial	2,960.5	9.5	814.5	10.5	3,745.0
Social Institutions	633.9	2.0	211,5	2.7	845.4
Government Office Buildings	876.8	2.8	321.1	4.2	1,197.9
Public Street Lighting	247.1	0.8	194.9	2.5	442.0
Total	31,213.1	80	7,748.9	20	38,962.0

Sumber : American Embassy, op.cit.p.35

Tabel 3. Total Supply and Usage of Electricity in Indonesia by 1993/1994 (in GWh)

* PRODUCTION of PLN	JAVA	OUTSIDE JAVA	TOTAL INDONESIA
1. Hydropower	6,654.8	1,204.2	7,859.0
2. Steam	20,037.0	1,747.2	21,784.2
3. Gas Turbine	1,123.9	1,485.0	2,609.4
4. Combined Cycle	7,628.6	166.2	7,794.8
5. Geothermal	-	1,090.0	1,090.0
6. Diesel	4,132,2	199,0	4,331.2
* TOTAL PLN PRODUCTION	36,733.2	8,735.4	45.468
* PURCHASED by PLN	1,202.0	48.2	1,250.2
* TOTAL SUPPLY	37,935.2	8,783.6	46,718.8
* USAGE			
1. Own use	1,526.1 (-)	375.1 (-)	1,901.2 (-)
2. Transmission Losses	982.3 (-)	206.6 (-)	1,198.0 (-)
3. Distribution Losses	3,535.8 (-)	1,131.2 (-)	4,667.1 (-)
Total Usage	6,044.2	1,712.9	7,766.3
* ENERGY SOLD	31,213.0	7,748.9	38,962.0
	(rounded	(rounded)	(rounded)

Sumber : American Embassy, op.cit.p.34

Table 4. Installed Capacity (MW) during 1973/74-1993/94, Projected of Installed Capacity (MW), and Projected Energy Demand (MW) during 1993/94-2008/09

	INSTALLED	PROJECTED GROWTH OF INSTALLED CAPACITY (MW)	% Δ YEAR	% Δ YEAR	PROJECTED ENERGY DEMAND (MW)	% Δ 5 YEARS	% YEAR
1973/74	776.06	-	-	-	-	-	-
1978/79	2,288.38	-	-	-	-	-	-
1984/84	3,938.99	-	-	-	-	-	-
1988/89	8,529.22	-	-	-	-	-	-
1993/94	lJ3,600.05	12,987.0	-	-	13,580	-	-
1998/99	-	24,308.0	87.2	17.4	25.855	90.4	-
2003/04	-	35,314.0	45.3	9.1	41,000	56.6	11.7
2008/09	-	50,772.0	43.8	8.8	58.060	41.6	8.3

Source: Ibid, p.36

Table 5. Type of Power Generation in relation to Projected Energy Demand (MW)

Type of Power Generation	End of Repelita V (1993/94)	End of Repelita VI (1998/99)	End of Repelita VII (2003/04)	End of Repelita VIII (2008/09)
Hydro	2,365	4,331	6,269	8,954
Coal	2,195	11,403	18,566	31,059
*) Combine Cycle	3,388	4,557	6,090	7,342
*) Steam	2,210	2,085	1,860	1,090
Gas	1,414	678	5,602	6,901
Geothermal	273	688	714	714
Diesel	1,735	2,413	1,899	2,000
Total	13,580	25,855	41,000	58,060

Source: Ibid. p. 36.

*) assumed using gas.

Table 6. Electricity Production (GWh) 1973/74 -1993/94 and Projected Growth of Production

1993/94 to 2008/09

	Production (include purchase)	Estimated Production (include purchase)
1973/74	3,005.98	NA
1978/79	5,722.82	NA
1983/84	13,391.83	NA
1988/89	25.622.75	NA
1993/94	46,718.78	49,225
1998/99	NA	105,818
2003/04	NA	164,778
2008/09	NA	242,693

Source: Ibid. p. 37.

Table 7. Projected Electricity Consumption and Production 1993/94 - 2008/09

Consumption			Production	Projected
	kWh/capacity	(GWh)	(GWh)	(thousand)
1993/94	220	41,833	49,225	190.150
1998/99	426	88,335	105,818	207,360
2003/04	612	137,002	164,778	223,860
2008/09	844	202,010	242,693	239,350

Source: Ibid, p.37, recalculated.

The Type Of Generating Stations Chosen gas and Determined The Fuels That Are Posible To Be Used:

(1) hydro plant utilized water;

(2) traditional steam turbine plant and gas plant utilized natural gas, heavy oils, coals, oils; wood and plant

(3) combined cycle plant utilizes natural gas and oil;

(4) simple cycle plant utilizes natural oil;

(5) (5) geothermal plant utilizes geothermal source;

(6) diesel plant utilizes diesel oil and heavy

(7) coal plant utilizes coal and heavy oils

Table 8. Electricity Production and Supply (Gwh) 1993/74-1993/94

Type of Generating Station	EndofRepelita 1973/74	End of Repelita 1978/79	End of Repelita 1983/84	End of Repelita 1988/89	End of Repelita 1993/94
- Hydro	NA	NA	NA	NA	7,859.0
- Steam (coal?)	713.45	1,523.10	7,365.49	14,218.38	21,784.23
- Gas	158.32	1,156.73	1,065.60	1,581.98	2,609.44
- Combine	-	-	-	-	7,794.75
- Geothermal	-	-	209.31	1,011.96	1,090.00
- Diesel	467.90	845.53	1,654.13	2,900.87	4,331.51
Production	2,369.25	4,909.63	12,110.81	24,940.05	45,468.59
Purchased	636.73	813.18	1,281.02	682.71	1,250.17
Total Supply	3,005.98	5,722.82	13,391.83	25,622.75	46,718.78

Source: Ibid. p. 37. NA = Data not available

Table 9. Size Range (MW's), Capital Cost and Fuel Efficiency of Each Station Available for Generating Power and The Time to Construct, in 1992.

Type of Generating Stations/Plants	Size Range	Capital Cost for Each MW (in US $)	Fuel Efficiency	Time to Construct (years)
1. Hydro Plant	up to 650	$ 1 - $ 2 million	N/A	5
2. Traditional Steam turbine	up to 1000	$ 600thou - $ 1,5 million	40 - 45 %	3
3. Combine cycle	up to 350	$ 500thou - $ 1.0 million	45 - 58 %	2
4. Simple Cycle	up to 250	$ 250 thou - $ 500 thou	35 - 42 %	1 1/2
5. Geothermal	up to 259	$ 1 - $ 2 million	25%	3
6. Diesel	up to 50	$ 800 thou - $ 1,3 million	40 - 48 %	<1
7. Coal	up to 400	$ 1 - $ 1.7 million	40 - 45 %	3
8. Wind Turbine	up to 10	$ 900 thou - $ 1.7 million	N/A	<1
9. Nuclear	400-1500	$ 1.5 - $ 2.75 million	32 - 37 %	5

Table 9 shows the usual size range (mw), the capital costs for each mw (in us $), fuel efficiency, and time to construct each type of generating station.

Economic Appraisal On The Use Of Gas For Power Generation

it is understood that the uses of gas are for:

(1) exports (58 percent)

(2) domestic sales (16 percent)

(a) fuel

- Fertilizer industry
- Steel industry
- Electricity
- Cement industry
- Paper industry
- Refinery
- Plywood
- City gas

(b) feedstock

- Fertilizer industry
- Steel industry

(3) own use (21 percent)

(4) flared (5 percent)

Since this paper is about economic appraisal on the use of gas for power generation, the discussion would concentrate on efforts that should support the achievement of efficiency in terms of gas utilization for power generation. Efficient use of a resource would implicitly involve the exploitation of such resource from the beginning of the process as seen in figure 1.

(1) determine the least production cost of Ing and lpg both of Pertamina and other companies;

(2) determine the just price of gas, especially gas for fuel in electricity production both PLN and private companies;

(3) determine the least production cost of electricity both PLN and private companies; and

(4) determine the just price of electricity sold/ marketed by PLN and private companies for utilization by industry, residential, commercial, social institutions, government office buildings, and public street lighting.

Research on this had been done and it was argued that technology would determine the efficiency of processes not the economies of scale of operation. Therefore, to reduce (average) cost companies should introduce new technologies in their operations. See figure 2.

If cost of production could be reduced, the price could also be lowered.

The fact is that the demand for electricity is continuing to grow. The projection of demand for electricity is depicted in table 10. Also in figure 1. New generating will have to be built. See table 11. Natural gas fueled power plants are the most efficient, least costly, and emit the least pollutants and greenhouse gases of all the fossil-fueled power plants technologies available). Hesitancy to use natural gas usually is based on the possible shortages. Which is not experienced by Indonesia thus far.

TABLE 11. Projected Additions To Installed Capacity (MW)

TYPE PLANT		1989/99			2003/04		
ADDITIONS BY					ADDITIONS BY		
1993/94		PLN	PRIVATE	TOTAL	PLN	PRIVATE	TOTAL
Hydropower	2,215	821	-	821	3,392	-	3,392
Stream	4,341	2,595	1,630	4,225	1,375	4,520	5,899
Combined Cycle	2,817	3,139	1,098	4,237	66	66	132
Geothermal	250	355	135	490	58	895	953
Gas Turbine	1,413	1,749	-	17,49	1,500	-	1,500
Diesel	2,140	420	-	420	10	120	130
Microhydro	-	123	-	123	-	-	-
Total	13,176	8,712	2,863	11,575	5,061	5,061	10,662

Source: PLN, US Embassy

Since there is no shortages of natural gas at all in Indonesia and relatively low prices for natural gas supplies and proven reserves it is reasonable that the (increase) use of gas for power generation should be taken into consideration seriously. The by-products of gas utilization are many, e.g. The heat from power generation can be used for water heating and industrial steam production so as to materially increase the overall efficiency of fuel use. Gas is also proven as a nox reducing agent for use in pollution reduction in coal-fired power plants. Given all of these technologies, Indonesia can look forward to a period when a signify cant portion of electric power generation comes from the use of natural gas in a clean and economic manner (and if possible abandon program which focus on the use of coal to generate electricity).

TABLE 12. SOURCE PERFORMANCE STANDARD

SO;

STANDARD

	Coal	1.20 lb./MMBtu and 90% reduction (when over 0.60 lb./MMBtu) 70% reduction (when under 0.60 lb./MMBtu)
	Oil and Gas	0.80 lb./MMBtu and 90% (unless under 0.2 lb./MMBtu)

NOx

	Coal	0.50 lb./MMBtu Subbituminsus Coal
		0.80 lbVMMBtu (if more than 25 % NGP lignite)
		0.60 lb./MMBtu other Coal
	Oil	0.30 lb./MMBtu
Gas		0.20 lbVMMBtu

TPS (particulate)

ALL Fuel	0.03 lb./MMBtu

Source : Steven I. Freedman, op.cit p. 677.

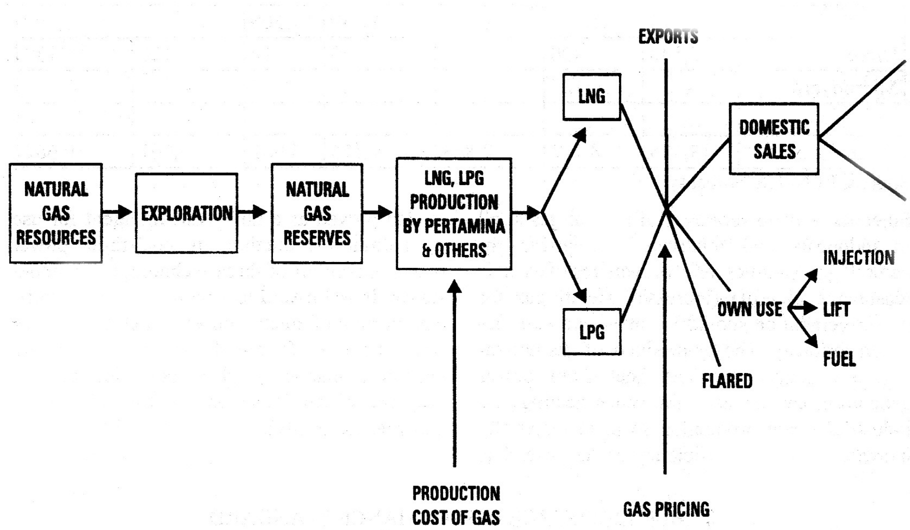

Figure 1. Utilization of Gas for Power Generation

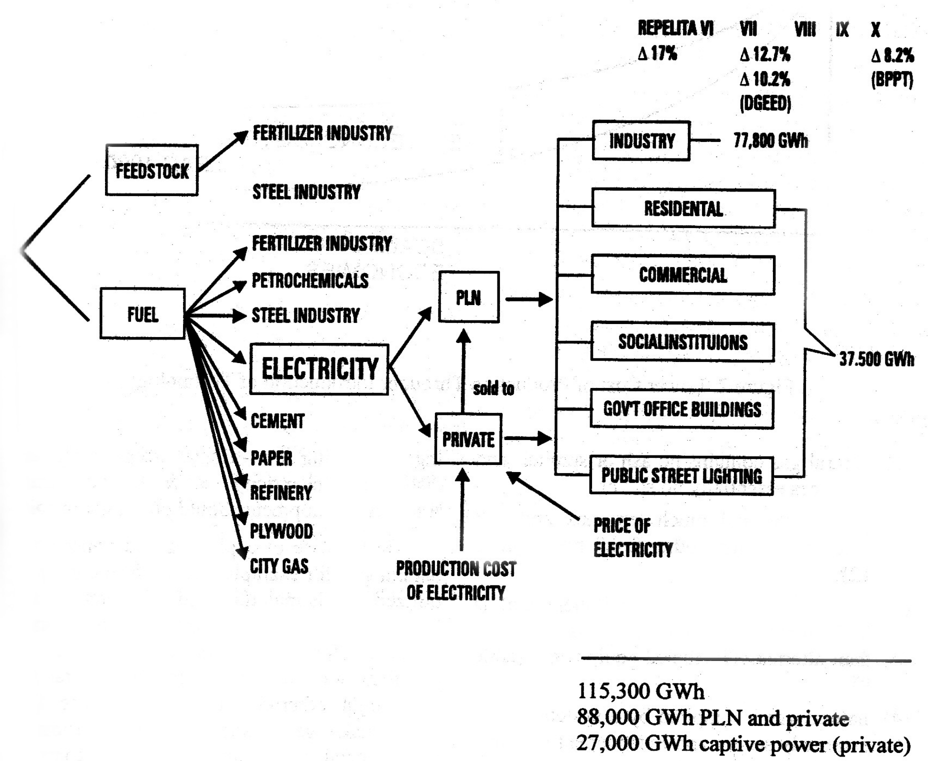

Figure 2. Lower Cost of Production Throught Introduction of Technology

(1) natural gas contains no ash or sulphur, and produces essentially no so2 or

(2) particulates and much less nox and co2 when burned than other fossil fuels (table 12);

(3) natural gas is used in equipment that is both higher in efficiency and less expensive than alternatively fueled equipment (table 9)

(4) natural gas is supplied by a system that is extremely secure and independent of transportation problems;

(5) natural gas is principally domestic; and the price of electricity produced from natural gas generating plant is exactly equal to that produced from coal, i.e. $ 0.04 - $ 0.05/kwh and much lower than that produced from hydro which is $ 0.04 - $ 0.07 /kwh; geothermal $ 0.05 - $ 0.08/kwh; wind $ 0.05 - $ 0.09/kwh; biomass $ 0.06 -$ 0.08/kwh; solar $ 0.10 - $ 0.12/kwh, and photovoltaic $ 0.30 - $ 0.40/kwh.

To increase efficiency and reduce costs one has to make efforts in all phases as to make productive the process of exploiting gas, transporting gas, producing Ing, transporting Ing, producing elec-tricity, transmitting and distributing electricity. R & d and human resource development should play a major role.

In the case of exploiting and transporting natural gas, for example, the Ing fpso concept is utilized; Ing is manufactured on, stored in, and loaded from floating production and storage offshore (fpso) facilities. The fpso is an excellent way to bring to market natural gas that might otherwise not utilized. The fpso could make gas available to new customers with special needs and or to the domestic market. The fpso option could make small scale Ing projects economical for gas fields of at least 0.8 trillion cubic feet.)

CONCLUSIONS

1. The demand for electricity in Indonesia would increase over time. This demand would be fulfilled by several types of generation. One of the types of generation is gas.
2. Natural-gas-fueled power plants are the most efficient, least costly, and emit the least pollutants and greenhouse gases of all the fossil-fueled power plant technologies available.
3. Natural gas resource in Indonesia is abundant. It is for export (58 percent), own use (21 percent), domestic sales (16 percent), and flared (5 percent). If production stays the same and exploration does not find new reserves gas production would last 40 years.
4. Domestic sales of gas are for feedstock, and fuel is for industry, city gas and electricity (24 percent).
5. Electricity in Indonesia is produced by PLN and private companies which sell electricity to PLN or direct to business. Electricity is for the use of industry, residential, commercial, social institutions, government office buildings and public street lighting.
6. To lower prices of electricity or reduce Pertamina subsidy of gas to PLN, reduction of gas production and/or transportation costs, electricity produc-tion, transmission and distribution costs is through increase of efficiency throughout the process of delivery.

   The increase of efficiency could be achieved through the empowerment of human resources, use of enhanced technology, and good feasibility study.

REFERENCES

American Embassy, Indonesia's Electric Power Sector 1995, Jakarta, 1995.

HJBaharuddin, IndonesianPerspective on Natural Gas" in Pertambangan dan Energi. Edisi Khusus (special edition) Jakarta 1997, pp. 84-92.

Embassy of the USA, Petroleum Report: Indonesia 1996, Jakarta 1996.

Steven I. Freedman, "The Role of Natural Gas in Electric Power Generation, 1990 to 2020," in Jefferson W. Tester, etal. ed., Energy and the Environment in the 21st Century, MIT, 1991.

Fred R. Glahe and Dwight R. Lee, Microeconomics: Theory and Applications, Harcourt Brace Jovanovick, Publishers, N.Y., 1989.

James M. Griffin and H.B. Steele, Energy Economics and Policy, Academic Press, N.Y., 1980.