Operational Performance of Regional Electricity Distribution in Indonesia

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abstract

After three decades of sustained growth, the Indonesian electricity industry has been enduring a difficult phase, as an adverse impact of the country's economic crisis. Since 1999, the industry has endeavored to improve efficiency. To present the overall picture of the state of electricity distribution and the effects of the efficiency drive program, this study evaluates the changes in operational performance of regional electricity distribution in Indonesia. The target companies are 22 regional electricity distributors, and the period of observation is from 2002 to 2005. Most companies targeted in this study tended to improve their efficiency from 2002 to 2004. However, their efficiency improvement speed slowed in 2005 due to low revenues in real prices as compared to 2004. This decrease in revenue may have been caused by high inflation and high oil prices while the tariff on electricity remained constant in 2005. We determined that the main variables that improve electricity distribution efficiency are system loss and company location. Based on this result, we suggest that business specialization be pursued by undertaking corporate restructuring to separate the electric systems by generation, transmission and distribution outside of Java.

1. Introduction

After three decades of sustained growth, the Indonesian electricity industry has been enduring a difficult phase, as an adverse impact of the country's economic crisis. The collapse of Indonesia's currency (Indonesia Rupiah, IDR) in 1997 plunged regulated electricity selling prices from about 7 cents to fewer than 3 cents USD per kWh (PLN Annual Report, 2002). In 1998, the Perusahaan Listrik Negara (PLN)[(1)] reported that its revenue stream could not cover the cost of supplying electricity.

Despite the prolonged economic and political crises triggered by the 1997 Asian financial crisis, Indonesia is still experiencing high growth in electricity demand. This demand was predicted to increase at a rate of 6-8 percent annually through 2010. The relatively high demand growth is associated with the country's low electrification ratio, low electricity consumption per capita and positive economic growth after the 1997 crisis (see Table1). As recommended by the results of a government audit, efforts to improve efficiency in electric utilities have been implemented since 1999 (PLN Annual Report, 2002).

Most utilities in the world have been liberalized by government to improve efficiency in the electricity sector. The main objective of liberalization or electricity reform is to improve the efficiency and performance of the sector and reduce the fiscal burden on the government (Newbery, 2002). Indonesia is no exception. Since 1990, the electricity sector has been deregulating through the introduction of independent power producers (IPPs). Most reforms have involved restructuring, privatization and sometimes transferring ownership. In 1998, efforts to restructure the sector were initiated through an International Monetary Fund economic assistance program for Indonesia. In the reform transition process, an additional type of efficiency program was applied to improve the performance of the sector.

Table 1. Electricity sector development and economic conditions

	Before crisis (1990-1997)	Crisis (1998-1999)	After crisis (2001-2005)
Electricity Growth	14%	1.5%	6.6%
GDP Growth	6.2%	1.5%	4.8%
Electrification Ratio	40%	51%	58%

Source: PLN Annual Report, 2005

Since 2000, PLN has implemented an Efficiency Drive Program (EDP) to improve efficiency. This program is aimed at reducing operational costs, increasing income and improving system reliability through improvement in the efficiency of generators, distribution and electricity retail and through improvement in the efficiency of support functions, such as human resources, finance and management information systems. EDP is a target program whose goals should be achieved by optimizing operation patterns, optimizing maintenance, minimizing individual use, innovating in operation and improving each plant's capabilities.

The EDP distribution target is to minimize losses and to increase income. These goals are met by optimizing operation patterns and maintenance, increasing the electricity tariff, and other efficiency improvement activities. To minimize losses resulting from technical problems, repairs are performed and distribution networks are built. Meanwhile, electricity theft by customers or non-customers results in lower income for utility companies. To reduce both non-technical losses and electricity theft, inspections and continuous control of illegal usages of electricity are conducted. Income is also increased through regulated tariff adjustments and reducing billing cycles. While the government of Indonesia has increased the electricity tariff a number of times following the 1997 crisis, in reality, the tariff adjustment has been rather slow. These limited increases reduced or even eliminated the PLN's ability to invest in new capacity expansion.

2. Literature review and objective

Traditional performance measurement systems provide an unbalanced picture of performance that can lead managers to miss important opportunities for improvement. The most common method of performance evaluation is ratio analysis. Ratio analysis involves selecting two significant figures and expressing their relationship as a proportion or fraction. The most common types are return to investment, inventory turnover, debt ratio and productivity per person, among others. These measures are often inadequate due to the existence of multiple inputs and outputs related to different resources, activities and environmental factors.

Since Data Envelopment Analysis (DEA) was first introduced by Charnes et al. (1978), this methodology has been widely applied to the efficiency measurement of many organizations. A number of studies have examined efficiency benchmarking and productivity analysis of electric utilities using DEA models. Pacudan and Elaine (2002) employed DEA to 1998 data for the Philippines. They evaluated technical efficiency and simulated the effects of Demand Side Management (DSM) and losses to the efficiency in distribution utilities. They found that the main source of technical inefficiency is scale inefficiency. Their other findings, with DSM and system loss reduction based on target settings, demonstrated an improvement in efficiency.

Pombo and Taborda (2005) evaluated the performance and productivity of Colombia's power distribution utilities and measured the effect of reform by a panel tobit model. They applied dynamic analysis for 1985-2001 data. The input variables assessed in this study were labor, grid size (km), transformer (MVA), and its outputs were the number of customers and sales (GWh). They found that efficiency and productivity increased mainly in the largest utilities following the reform, while the less efficient firms did not improve. Econometric results suggested a positive effect of reform. In evaluating efficiency determinants, they modeled efficiency scores as a function of utility characteristics, performance, environment, ownership structure, and regulatory-related policy dummies.

Thakur et al. (2005) evaluated the performance of 26 Indian state-owned electricity utilities (SOEUs). They evaluated the impact of scale on the efficiency scores using DEA. The results indicated that the performance of several SOEUs was sub-optimal, suggesting the potential for significant cost reductions. Separate benchmarks were derived for possible reductions in the number of employees.

Estache et al. (2008) assessed the performance changes following reforms in the late 1990 in 12 Southern African countries and focused on the change in TFP in each country for the period 1998-2005. Although the companies did not make significant improvements during the period of analysis in their use of capital and human assets, they improved performance by adopting better technologies and commercial practices. No significant correlation could be associated with the adoption of reforms.

Many studies in the past decade have investigated electricity distribution performance, but none of this research focused on Indonesian electric distribution companies. Because Indonesia has the fourth largest population in the world after China, India and the United States, the country's economic growth has a substantial impact on the world market. Additionally, electrification is one of the most important factors necessary for economic development through manufacturing and service sector growth. Thereby, understanding how electricity distribution efficiency (EDE)[(2)] was changed after the EDP was implemented in Indonesia is an important area of study. Determining which factors improve EDE has important policy implications. Based on this idea, the objective of this study is (1) to evaluate the changes in performance of 22 regional electricity distribution companies with data from 2002 to 2005 using DEA, and (2) to clarify which factors affect the EDE in Indonesia by applying panel tobit analysis.

3. Methodology

DEA is a non-parametric method that uses mathematical linear programming based techniques to measure the relative performance of organizational units known as Decision Making Units (DMU). DEA can be applied to analyze multiple inputs and outputs without imposing any functional form on the relationships between input and output. The technique was originally suggested by Charnes et al. (1978) and is built on the ideas of Farrell (1957).

In the DEA model, efficiency is defined as the ratio of the weighted sum of output to the weighted sum of input. Assuming that the chosen sample has z utilities (called DMUs), each with M input and N output, the EDE measure of a DMU k is defined by:

$$EDE = Max\ \theta = \frac{\sum_{k=1}^{n} v_p y_{p,k}}{\sum_{j=1}^{m} u_q x_{q,k}} \tag{1}$$

subject to

$$\frac{\sum_{k=1}^{n} v_p y_{p,i}}{\sum_{j=1}^{m} u_q x_{q,i}} \leq 1 \quad \forall i \quad (1 \leq i \leq z) \tag{2}$$

$$v_p \geq 0,\ u_q \geq 0, \quad \forall p,\ q \tag{3}$$

Where i is the DMU number, p is the output variable name, and q is the input variable name. θ ($0 \leqq \theta \leqq 1$) is the efficiency score, where θ equals one represents efficient performance, and θ is less than one denotes inefficient performance. v_p is the weight for output p; u_q is the weight for input q; y_p is output data, and x_q is input data.

Time series panel data also allow performance trends of electricity distribution to be calculated using Pooled DEA. EDE is calculated the distance between the performance on the production frontier line and each company's performance. EDE in t year are decided individually by the performance in t year, and not affected by t-1 year performance. Therefore, it is possible to achieve high EDE value if the EDE in the previous year was low. This approach can be used to see the performance trends of a DMU or firm over time. In Pooled DEA, the same DMU is compared not only with the performance of other DMUs in the same time period but also against itself across other time periods. The efficiency scores from Pooled DEA will be used as dependent variables in panel tobit modeling to find factors that contribute to efficiency. According to Cooka and Seiford (2009), Pooled DEA analyses have advantages over other analysis methods in evaluating the efficiency of time-series data and allow for the application of standard regression concepts to study efficiency changes.

Panel tobit analysis can be used to measure the effects of an operating environment. The principal aim of the analysis is to produce measures of technical efficiency and identify aspects of efficiency that may be related to performance. The efficiency scores from Pooled DEA are used as dependent variables in the panel tobit model. Panel tobit modeling was proposed by John G. Cragg in 1971 (Cragg, 1971). This model is employed when the dependent variable is censored and limited (here, the efficiency score is defined from 0 to 1).

4. Data and model

4-1. Data

This study compares the performance of 22 regional electricity distributors in Indonesia. The monetary and physical data for this study were obtained from PLN Statistical Data for the period 2002 to 2005.(3) Some economic data for the panel tobit model were obtained from the Indonesia Statistical Bureau for this same time period. There are 88 total samples in the 4 year analysis. A summary of the data for DEA and panel tobit modeling are shown in Table 2.

Table 2. Summary of data for DEA (Averages from 2002 to 2005)

Variables	# of distribution companies	2002	2003	2004	2005
Labor (People)	22	1,339	1,334	1,331	1,310
Grid size (km)	22	24,358	24,873	25,650	25,886
Transformer (MVA)	22	1,351	1,375	1,389	1,316
Units sold (GWh)	22	3,958	4,111	4,545	4,860
Number of customers (connection)	22	1,406,996	1,459,844	1,515,417	1,569,400
Revenue (Million Rp, 2000 Price)	22	1,772,606	2,152,982	2,369,329	2,230,879

Source: PLN Statistical Data for the period 2002 to 2005

4-2. DEA model

To model the efficiency of electricity distribution in Indonesia, this study applies three inputs and three outputs. The choice of variables was based on previous studies, data availability, and characteristics of electricity distribution. The input variables are the total number of laborers involved in distribution (person), the length of the existing electric cables (grid size, km) and transformer capacity (MVA). The output variables are the amount of electricity distributed to end users (unit sold, GWh), total number of customers (connection) and the total revenue or turnover in a year (Million Rp, real price). The Pooled DEA model for calculating DMU k's efficiency is represented as follows.

$$EDE = Max\ \theta = \frac{\sum_{t=2002}^{2005}\sum_{k=1}^{n} v_{pt} y_{pt,k}}{\sum_{t=2002}^{2005}\sum_{j=1}^{m} u_{qt} x_{qt,k}} \tag{4}$$

subject to

$$\frac{\sum_{t=2002}^{2005}\sum_{k=1}^{n} v_p y_{p,i}}{\sum_{t=2002}^{2005}\sum_{j=1}^{m} u_q x_{q,i}} \leq 1 \qquad 1 \leq i \leq 22 \tag{5}$$

$$u_q \geq 0,\ v_p \geq 0,\ \forall q, p \tag{6}$$

p = units sold, number of customers, revenue
q = labor, grid size, transformer

where, i is the DMU number, θ ($0 \leqq \theta \leqq 1$) is the efficiency score, v_p is the weight for output p, u_q is the weight for input q, y_p is the output data, x_q is the input data, and t shows the year. Where θ equals one, the company achieved efficient performance, and where θ is below 1, the company is inefficient, which could be improved by referring the efficient company.

The PLN is comprised by two main sectors: the power generation part and the distribution part. In this study, we focus on the distribution side and try to evaluate EDE by using only distribution sector data, which is not included in the power generation sector data. As shown in Table 2, the DEA shows the utilization efficiency of the electricity distribution infrastructure. Therefore, we believe the variables selected are consistent with our research objective.

4-3. Panel tobit regression model

To model efficiency determinants in panel tobit analysis, several variables are considered. The principal aim is to produce a measure of efficiency and identify whether that aspect of efficiency is related to managerial performance. To conduct this analysis, exogenous operating environment factors that may contribute to efficiency differentials need to be measured.

Distribution loss and average real price were highlighted as determinants of efficiency. Those variables are targeted by the EDP and directly affect the plant efficiency and income of distribution companies. The other variables considered were the electrification ratio, GDP per capita and the Java dummy. We arrived at these variables based upon previous studies and specific conditions of regional electricity distribution in Indonesia. We included the Java dummy to examine the effect of business specialization. Java is specialized in the distribution sector and shows better performance, while other areas remain vertically integrated. All variables were selected as potentially having an important impact on efficiency.

Distribution loss is an indicator for plant efficiency. This measurement is a standard control for electricity distribution plant efficiency. The expected sign of this variable is negative because it has an adverse effect on efficiency. Average price is an indicator of profitability and sales diversification. The expected sign for this variable is positive. The average price value channels more profitability and tends to increase in business and industrial sales. The electrification ratio represents the degree of electrification coverage, demand growth, and population density. Within the context of power distribution activity, this variable is as an indicator of demand growth and market density. The expected sign for this variable is positive because greater density allows the utility to exploit its networks. GDP per capita is an indicator of the economic conditions and the affordability of people to subscribe and pay for electricity. The expected sign for this variable is positive because GDP per capita reflects the ability of customer to access electricity in a distribution area. The dummies capture business structure and activities, as some utilities are still integrated and some specialize in distribution. The model is presented as follows:

$$y_{it}^* = \beta_0 + \beta_1 \mathrm{Dist}_{it} + \beta_2 \mathrm{Ave}_{it} + \beta_3 \mathrm{Elect}_{it} + \beta_4 \mathrm{GDP}_{it} + \beta_5 \mathrm{Java\ dummy}_i + \eta_i + \mu_t + \varepsilon_{it} \tag{7}$$

$$y_{it} = y_{it}^* \quad if \;\; 1 \geq y_{it}^* \geq 0 \tag{8}$$

$$y_{it} = 0, otherwise \tag{9}$$

where y_i is the efficiency score ($0 \leqq y_i \leqq 1$), Dist is the system losses or percentage of losses (%), Ave is the average real price (Rp/kWh), Elect is the electrification ratio (connections/number of households), GDPper is the GDP per capita (million Rp, real price), and Java dummy is the specialized dummy variable (located in Java=1, others=0)(4). Meanwhile, β_0, β_1, β_2, β_3, β_4 and β_5 are variables to be estimated. η and μ are unobserved firm- and time-specific fixed effects, respectively. ε is an idiosyncratic error term. The summary of the variables and their expected signs are outlined in the Table3:

Table 3. Summary of variables for panel tobit model and expected signs

Variables	Definition	Purpose	Expected sign
Dist	Percentage of system losses (%)	Control for plant efficiency	Negative
Ave	Average real price (Rp/kWh)	Control for profitability and sales diversification	Positive
Elect	Electrification Ratio (# of connections, %)	Control for electrification coverage and demand growth	Positive
GDPper	GDP per capita (Million Rp, real price)	Control for economic and area capability	Positive
Java dummy	Specialized in distribution (located in Java=1, Others=0)	To consider the effect of business specialization on the island of Java	Positive

This study identifies efficiency determinants of 22 regional electricity distributions in Indonesia. The monetary and physical data for this study were obtained from PLN Statistical Data for the time period 2002 to 2005. Some economic data (GDP and Population) for were obtained from the Indonesia Statistical Bureau for the same time period. All monetary data are deflated to their 2000 price. There are 88 total samples in this 4-year analysis. The summary of data is outlined in Table 4.

The variables to which the Pooled DEA model is applied are related to electric distribution and corporate financial performance. These variables can be controlled by distribution companies, and we can recognize these variables as internal factors in electric distribution efficiency. By using these variables, we can evaluate electricity distribution efficiency. However, the variables to which the panel tobit analysis is applied are core performance index (distribution loss) and external factors of electric distribution efficiency, which are not controlled by electric distribution companies.

Table 4. Summary of data for panel tobit in averages, 2002-2005 (22 Distributions, 4 years)

Variable	Samples	2002	2003	2004	2005
Dist	88	15.61	14.92	10.53	10.02
Ave	88	467.75	543.81	537.25	468.73
Elect	88	48.90	49.88	55.77	56.57
GDPper	88	10.31	10.42	10.41	10.66

5. Results and discussion

5-1. Pooled DEA efficiency

This study calculates EDE by applying Pooled DEA. We used Pooled DEA to allow for the comparison of performances with policy analysis where a time-dimension is not used. Because this study deals with time-series panel data, this approach was applied to see performance trends of power distribution over time. The results of this measure are presented in Table 5.

The efficiency score in Table 5 is measured by using pooled data from 2002 to 2005. There are no companies with 100% average efficiency from 2002 to 2005. The most efficient company is Batam (No.18) with an efficiency score of 0.991.

Table 5. Results of Pooled DEA from 2002 to 2005

No.	Company name	2002	2003	2004	2005	Average	No.	Company name	2002	2003	2004	2005	Average
1	NAD	0.858	0.887	0.932	0.943	0.905	12	Sulselra	0.949	0.973	0.956	0.880	0.939
2	Sumut	0.718	0.735	0.777	0.965	0.799	13	Maluku	0.671	0.693	0.772	0.839	0.744
3	Sumbar	1.000	0.912	0.930	0.888	0.932	14	Papua	0.570	0.638	0.678	0.740	0.656
4	Riau	0.658	0.747	0.835	0.850	0.773	15	Dist. Bali	0.750	0.729	0.778	0.798	0.764
5	S2JB	0.601	0.615	0.653	0.739	0.652	16	NTB	1.000	1.000	1.000	0.965	0.991
6	Babel	0.805	0.808	0.820	0.823	0.814	17	NTT	0.656	0.701	0.672	0.668	0.674
7	Lampung	0.674	0.756	0.912	0.883	0.806	18	Batam	0.964	1.000	1.000	1.000	0.991
8	Kalbar	0.728	0.764	0.793	0.746	0.758	19	East Java	0.943	0.958	0.983	1.000	0.971
9	Kalselteng	0.808	0.767	0.857	0.828	0.815	20	Jateng & Yogya	0.953	0.984	1.000	1.000	0.984
10	Kaltim	0.593	0.877	0.858	0.786	0.778	21	West Java & Banten	0.932	0.953	1.000	1.000	0.971
11	Suluttenggo	0.688	0.703	0.746	0.788	0.731	22	Jakarta & Tangerang	0.940	0.990	1.000	1.000	0.982
								Mean value of 22 samples	0.794	0.827	0.861	0.870	0.838

The mean efficiency scores of the 22 samples improved from 2002 to 2005, with especially rapid improvement in efficiency from 2002 to 2004. As Table 5 shows, the majority of the companies improved their efficiency score each year. The slower rate of increase from 2004 to 2005 was due to lower revenues in real price compared to 2004. This decrease in revenue in 2005 might have been caused by high inflation and high oil prices while the electricity tariff remained constant.

In aggregate, the sector's efficiency score is 83.8 percent, and the inefficiency level is 16.2 percent. This efficiency score suggests that the companies have the potential to increase 16.2 percent of their desirable output without increasing input.

5-2. Efficiency determinants

This section reports the results of the panel tobit analyses. Table 6 displays the main panel tobit results for the determinants of DEA efficiency. The first column shows the independent variable used in the panel tobit regression model. The other four columns report the results of the efficiency determinant; these are the coefficient, standard error, t-value and the significant value (P>t). The dependent variable is the efficiency scores from the Pooled DEA.

The analysis of the independent variables in Table 6 shows that all the variables are statistically significant and show the expected sign, except for average price. A positive coefficient demonstrates a positive influence on efficiency. System loss has

Table 6. Panel tobit model regression result

Independent variables	Coefficient	Std. Err.	t-value	P > | t |
Dist	−0.0057	0.0018	−3.24	0.001
Ave	0.0001	0.0002	0.03	0.978
Elect	0.0036	0.0012	2.89	0.004
GDPper	0.0009	0.0018	0.48	0.629
Java dummy	0.1161	0.0578	2.01	0.045
Constant	0.7023	0.1029	6.83	0.000

Number of observations = 88, Wald chi2 = 37.96, Prob > chi2 = 0.0000, Log likelihood = 72.80

a negative influence on efficiency. This result means that the higher the distribution loss, the lower the efficiency level. The result suggests that a 1% increase in system loss would lead to a decrease of efficiency by 0.0057. As a target of the EDP, system losses have an adverse impact on the performance of the electricity companies. This result is consistent with the objectives of the EDP. Based upon our results, we assert that the EDP improved EDE by reducing system losses through the implementation of regular government-monitored evaluations.

The electrification ratio has a positive influence on efficiency, suggesting that a distributor with a higher electrification ratio is more efficient than one with a lower electrification ratio. This finding implies that the greater the number of customers that subscribe to a distribution company, the higher its efficiency will be. In particular, a 1% increase in the electrification ratio will raise efficiency by 0.0036. The Java dummy, which indicates whether a distribution company is still vertically integrated or is fully specialized on power distribution, has a positive effect. This finding means that business area specialization has an important impact on efficiency. Overall, there was a 0.1161 efficiency loss resulting from not being fully specialized.

We found that average price did not significantly affect EDE. This result may have been influenced by the fact that some utilities that were considered benchmarks did not show improvements in their average price due to the application of a uniform tariff to the customers. The tariff applied to the customers is a uniform tariff throughout Indonesia. This tariff system decreases the incentive to improve financial performance of PLN because tariff cover the financial loss of PLN. Customer choice impacts the average price through people's response to the tariff. If the applied tariff was higher than expected, customers might use electricity more efficiently. Further, industrial customers can use their own captive power (CEPS, 2004).

We also did not observe a significant relationship between GDP per capita and EDE. This result implies that EDE did not automatically improve with economic development. Thus, we concluded that the government policy focus on the electricity price and monitoring system is an improvement that may help achieve high EDE in Indonesia.

6. Conclusion and policy implications

This study analyzed the performance of electricity distribution in Indonesia using DEA and panel tobit regression analysis. It evaluated changes in the performance of 22 regional electricity distribution companies with input and output data from 2002 to 2005. Most companies in this study improved their electricity distribution efficiency each year from 2002 to 2004. The efficiency improvement speed slowed in 2005 due to revenue decreases, which were caused by the high inflation ratio and oil price increases while the electricity tariff remained constant.

The econometric analysis using a panel tobit model provided evidence regarding the determinants of electricity distribution efficiency. The results showed that system losses, electrification ratio, and the Java dummy significantly affected electricity distribution efficiency. Meanwhile, the average price and GDP per capita did not have a significant relationship with electricity distribution efficiency.

Based on the data analysis and empirical findings, this research suggests three policy implications for the EDP to improve electricity distribution efficiency. (1) System losses have an adverse effect on electricity distribution performance. This result is consistent with an objective of the efficiency drive program aimed at stemming such losses. The efficiency drive program decreases system losses if the company's performance is regularly evaluated. Improvement of distribution efficiency can be achieved through regular monitoring by the efficiency drive program. (2) Business specialization may require corporate restructuring to separate systems for generation, transmission and distribution outside of Java, where they are already separate. This distribution mechanism change is one of the important objectives of the efficiency drive program. We suggest the government make the appropriate resource allocation for such specialization not only on the island of Java but also throughout

Indonesia. (3) The uniform tariff system should be reviewed. There should be tariff differentiation based upon demography (population density), geography (location) and economy (regional income per capita). Other aspects that should be considered in the implementation of a regional tariff system include the type of plant, including the type of fuel used and its availability, and supporting infrastructures. The efficiency drive program should design a new legal framework to support such restructuring and a regional tariff policy.

Notes

(1) The electric power industry in Indonesia is solely managed by Perusahaan Listrik Negara (PLN), a state-owned monopoly. PLN has various business units, in the form of generation, transmission and distribution companies, that carry out their specified functions.

(2) In this study, we define electricity distribution efficiency by the following three components: (1) system loss of electricity, (2) electricity connection (electrification) spread speed, and (3) the financial performance of distribution companies.

(3) It is difficult to evaluate the impact of the efficiency drive program (EDP) without performance data from prior to 2002. Because of the limits on information disclosure through PLN statistical reports, we can only use data from 2002 onward. Electric distribution requires substantial infrastructure such as transformer stations, power poles, and electrical power cables. To comprehensively establish such infrastructure takes a long period of time. We recognize there is time lag from the start of the EDP to performance improvement. Taking this lag into account, we determined that the efficiency analysis from 2002 to 2005 is a complete enough period in which to evaluate the effect of the EDP.

(4) Four companies (East Java, Jateng & Yogya, West Java & Banten, and Jakarta & Tangerang) are located on the island of Java.

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