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Efficiency Analysis of Electric Cooperatives in the Philippines

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The efficiency of electricity distribution in remote areas of the Philippines by 120 electric cooperatives (ECs) is examined using data envelopment analysis (DEA). Using data from 2001 to 2006, the study finds that most ECs can reduce all their inputs proportionately by up to 18 percent and still produce the same level of output. Productivity in the sector has not improved significantly despite the reforms instituted in 2001 as shown by a flat trend that is discernible from the Malmquist index. The study shows that efficiency of ECs rises with size. This result is robust with respect to how size is defined. The study finds that, unsurprisingly, levels of inefficiency are inversely related to system losses. The study also shows that structural and operational characteristics significantly affect EC efficiency. ECs are likewise found to be inefficient in the non-technical component of their distribution costs vis-à-vis their line operations and maintenance costs.

Keywords: Data envelopment analysis, Malmquist index, Electric cooperatives, Philippines

1 Introduction

Since the passage of the Electric Power Industry Reform Act (EPIRA) in 2001, the Philippines embarked on a comprehensive restructuring of its power industry. From a vertically integrated, extensively publicly owned utility business, the industry was envisioned to be broken down into its main components with a deregulated and effectively privatized generation and supply sectors. Despite the reform efforts through the EPIRA enactment however, power rates in the Philippines continue to be among the highest in Asia and remain a source of concern for industries in the country struggling to remain competitive with their regional counterparts. One of the issues, which has not been addressed adequately by industry players and the Energy Regulatory Commission (ERC), is the observed high levels of inefficiency with which Philippine electricity distribution utilities operate. The distribution of electricity in the country is handled mostly by investor-owned utilities (IOUs) and by consumer-owned electric cooperatives (ECs), both of which are under rate-setting regimes (the return on rate base or RORB methodology for the IOUs and a cash reimbursement methodology for the ECs) that do not really promote efficiency in the sector.

Previous attempts to measure productive efficiency in the Philippine electricity distribution sector include Pacudan and Guzman (2002), who use a cross-section of 13 IOUs and 2 municipal-owned utilities and the data envelopment analysis (DEA) methodology to simulate the effects of demand side management and systems loss initiatives in the sector on technical efficiency. Lavado (2004) estimates the cost efficiency of electric cooperatives using DEA and stochastic frontier analysis (SFA) on panel data from 1990 to 2002 and finds that cooperatives were 34-42% away from the cost frontier. Valderrama (2006) estimates the cost efficiency of 19 IOUs and 119 ECs during the period 2000 to 2004 using SFA to determine whether efficiency is a significant financial performance driver in the sector. Posadas and Cabanda (2007) use panel data from 1999 to 2003 of 117 ECs and finds that productivity in the sector during the period, calculated using a DEA-Malmquist approach, is driven mostly by technological change. Fabella and Aldaba (2004) provide an extensive review of regulatory reform in the Philippine energy sector that began in the later part of the 1980s.

Studies on electricity distribution in other countries are few. Von Hirschhausen (2006) did an efficiency analysis of electricity distribution in Germany, while Hattori, Jamasb and Pollitt (2005) conducted a comparison of electricity distribution between UK and Japan.

This paper adds to the literature by using post-EPIRA data from 2001 to 2006 to determine the levels of productive efficiency of electric cooperatives in the Philippines. More importantly, it fills a gap in the literature by identifying structural, environmental and operational factors that significantly affected EC efficiency. Any intervention to improve EC efficiency will be better informed if these factors are determined.

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This paper attempts to analyze several problems pertaining to the efficiency of Philippine ECs. It tries to determine if EC efficiency is affected by size, sales density, customer profile, and systems loss. EC efficiency is believed to be affected by its location and that differences among ECs are more pronounced the more diverse is the geography and terrain of the area they service. Hence, regional differences in EC efficiency are also analyzed. The study also asks the following questions: Are ECs more efficient in the technical (operations and maintenance costs of distribution lines) than in the non-technical (customer-related, general and administrative costs) component of their distribution costs? Are grid-connected ECs more efficient than ECs not connected to the main transmission systems? The study makes use of DEA to analyze these issues.

The paper is organized into five sections. The distribution sector in the Philippines is described briefly in the next section. The methodology of the study is discussed in the third section. The data used and the results of the empirical analysis are presented in the fourth section. The conclusion and areas for further study are given in the last section.

2 The Distribution of Electricity in the Philippines: An Overview

The distribution of power in the Philippines is a regulated activity wherein the right to distribute electricity is granted by a franchise covering a particular geographical area[1]. Distribution Utilities (DUs) have the exclusive right to sell electricity to end users connected to their respective distribution networks subject to the entry of qualified third party providers in unviable areas of a franchise area. As of 2006, there are 144 DUs in the country, of which 16 are investor-owned utilities (PUs), eight (8) are local government-run and 120 are customer-owned electric cooperatives (ECs).

The largest electricity distributor in the Philippines is MERALCO, which holds the distribution franchise for Metro Manila and urban and rural areas surrounding the capital. About a quarter of the total population of the Philippines lives within the consolidated MERALCO franchise area. MERALCO supplies electricity to over four million customers in 25 cities and 86 municipalities[2]. Its electricity sales in 2006 were 25,078 GW h, or about 55% of nationwide sales in that year. MERALCO is a public company listed on the Philippine Stock Exchange.

The ECs are generally small, with all 120 ECs accounting for only 21% of total electricity sales in the country in 2006. Only 38 ECs sold more than 100,000 MW h in 2006 and almost half of the sector had sales of less than 50,000 MW h. Being customer owned and controlled by locally elected boards, they have proven to be susceptible to local political volatility and poor management. ECs are presently regulated on a so-called "cash reimbursement basis"—i.e., they are given rates sufficient to cover purchased power cost, operating costs, loan payment, and an amount (5% of the rate) as reinvestment fund. Customers are initially required to contribute a token amount as their "equity". The lack of a substantial equity interest and of a profit incentive is likely the root cause for the financially compromised operations of many ECs.

The ECs operate under the general oversight of the National Electrification Administration (NEA), which provides technical and managerial support and loan financing for grid augmentation projects. Under EPIRA, the NEA is also mandated to strengthen the ECs' technical and financial viability and to prepare them to operate in a deregulated electricity market. The ECs' distribution infrastructure was financed almost completely by public money through the NEA. Most of these loans were subsequently mandated by EPIRA to be absorbed by a government entity, the Power Sector Assets and Liabilities Management Corporation.

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[1] As in other countries, presence of monopoly characteristics leads to heavy regulation of the electricity distribution sector. However, unlike in other jurisdictions where the franchise or license to operate is granted by local governments or the regulatory agency, in the Philippines, investor-owned distribution utilities need to secure a congressional franchise to run a distribution business.

[2] Source: www.meralco.com.ph

3 Methodology

There are two general approaches to measure efficiency – the econometric approach and the mathematical programming approach. The DEA used in this study belongs to the latter group of techniques and is the more popular approach. This procedure to measure efficiency is based on the canonical hull of input-output vectors of the production possibilities set. The measure makes use of information from all members of a group of firms (ECs in this study) and hence is a relative measure of efficiency.[3]

Suppose there are N firms each producing M outputs using K inputs. The DEA method essentially tries to determine for each firm, what set of output and input weights yields maximum efficiency given the outputs and inputs of the other firms in the sector. Because this is best expressed as a linear programming (LP) problem, a primal or a dual formulation can be used. The dual formulation, which is the easiest to compute numerically, can be written as:

$$\max_{\phi_i,\lambda} : \phi_i \qquad \text{for } i = 1, \ldots, N$$

$$\begin{aligned} s.t. \quad \mathbf{Y}\lambda - \phi_i y_i &\geq 0 \\ x_i - \mathbf{X}\lambda &\geq 0 \\ \lambda &\geq 0 \\ \textstyle\sum_{j=1}^{N} \lambda_j &= 1 \end{aligned} \tag{1}$$

where $\mathbf{X}$ and $\mathbf{Y}$ are the K x N input and M x N output matrices, respectively; x_i and y_i are the input and output vectors of firm i. λ is an N x 1 vector of constants and ϕ_i is the efficiency index of firm i. This output–oriented DEA formulation assumes variable returns to scale (VRS). A constant returns to scale (CRS) formulation can be obtained by simply removing the last constraint.[4] Note that $1 < \phi_i < \infty$ is an index whose inverse, E_i, is a measure of the technical efficiency of firm i relative to the most efficient firm in the group:

$$0 < E_i = \frac{1}{\phi_i} \leq 1 \tag{2}$$

$E_i = 1$ indicates that firm i is at the boundary of the technical frontier and hence, is the most efficient among the group of firms to which it belongs. Note that the LP program is applied N times, once for each firm.

Färe et al. (1994) proposed a model of productivity change based on the Malmquist productivity index (MPI). Basically, this index measures productivity by determining the feasible combination of outputs and inputs that yields the maximum output as represented by their efficiency scores in two successive time periods. The computation of scores makes use of the same base period reference technology. The ratio of these scores in the 2 successive periods produces the MPI. For example, the MPI for firm i using period t and t + 1 reference technology, respectively, is:

$$MPI_{i,t} = \frac{E_{i,t}(t+1)}{E_{i,t}(t)} \quad \text{and} \quad MPI_{i,t+1} = \frac{E_{i,t+1}(t+1)}{E_{i,t+1}(t)} \tag{3}$$

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[3] This section draws heavily from Coelli (1996). These methods to arrive at a quantitative measure of productivity have been applied widely in the productivity analysis of other industries like banking, telecommunications and mutual funds industries. See for example, Uri (2001), Haslem et al. (1999) and Murthi et al. (1997).

[4] In the empirical section below, both scale assumptions are used. The results however are not very different from each other. Hence, only the VRS formulation is reported.

where the time variable in parenthesis indicates the time period of the input output combination used in computing the efficiency score and the time variable in the subscripts indicates the base period reference technology. The Malmquist productivity change index (MPCI) that is computed below for the ECs is simply the geometric mean of the two MPIs given in equation (3):

$$MPCI_{i,t} = \sqrt{MPI_{i,t} MPI_{i,t+1}} \quad (4)$$

Coelli (1996) provides further discussion and a computer program to compute equations (1) to (4).

4 Data and Empirical Results

This study measures efficiency using the DEA method outlined above. Given the absence of reliable data on cost of capital inputs, the study limits itself to the analysis of technical efficiency. The study uses the average of financial and operating data from 2001 to 2006 for 118 Philippine ECs in computing the efficiency scores and indices discussed in the previous section. The computation of the Malmquist index makes full use of the panel data to determine productivity trends in the sector. Of the 118 ECs, 97 are connected to the grid while the remaining 21 ECs operate in very remote areas not covered by the grid.[5] The data were culled from submissions of the cooperatives to the NEA, the government agency tasked with the supervision of the sector. The variables used in the empirical analysis are identified and defined in Table 1. Table 2 describes the sample based on some of these variables.

Table 1. Variable List and Definitions

Variable Name	Unit of Measure	Description
Sales volume	Megawatt-hours (MW h)	Annual sales in MW h
Number of customers/connections	Persons	
Peak Demand	Kilowatts (KW)	Maximum demand on a utility's distribution system
Customer structure*	Percent	Proportion of sales in MW h to non-residential customers, as classified by the respective EC
Length of distribution line	Circuit kilometers (CKM)	
Number of employees	Persons	
Transformer capacity	Megavolt Amperes (MVA)	Total transformer capacity of primary distribution substations
Distribution, supply and metering (DSM) cost	Philippine Pesos	Sum of operations and maintenance, customer accounts, and general and administrative expenses of ECs
Operations and maintenance (OM) cost	Philippine Pesos	Distribution and substation-related expenses such as repairs and maintenance
Administration (ADMIN) costs	Philippine Pesos	Expenses incurred in relation to customer accounts (e.g., meter reading, billing and collection) and utility administration (e.g., office supplies, travel, training, and management salaries)
Sales density	Sales in MW h/CKM	
Customer density	Number of customers/CKM	
Systems loss	Percent	(electricity purchased less DU consumption less electricity sold) divided by electricity purchased

* This variable attempts to capture the proportion of a utility's sales to different types of customers whose cost to serve varies because of each one's load/service requirements. A more precise measure would have been customers classified by type of voltage connection. However, this type of data is not reported by the sector at present.

[5] The latter ECs, collectively termed Small Power Utility Group utilities (SPUG ECs), are described and analyzed separately below as a group. Of the 120 ECs, two have incomplete data and are excluded from the study.

Table 2. Descriptive Statistics from a Sample of 97 Grid-Connected ECs Average Figures (2001 to 2006)

	Mean	Median	Maximum	Minimum	Std. Dev.
Sales volume (MW h)	88,197.85	66,535.53	392,461.30	6,616.69	81,551.10
Number of customers	55,718.36	50,541.83	132,103.70	10,955.67	29,069.14
Peak demand (KW)	22.08	16.61	90.90	1.99	18.32
Customer structure (%)	39.67	38.39	67.06	17.96	11.76
Distribution line length (CKM)	2,249.13	2,051.71	6,225.56	304.56	1,205.85
Number of employees	220.45	199.67	797.50	49.17	117.39
Transformer capacity (MVA)	34.11	30.00	140.00	5.00	26.13
Sales density (kW h sales/CKM)	41.50	29.95	237.45	4.57	35.67
Customer density (customers/CKM)	27.09	24.84	61.09	6.69	11.11
Systems loss (%)	15.51	14.57	54.37	6.31	5.51

The study's empirical strategy is to build a base model that can be extended by adding inputs or outputs one at a time to analyze the effects of the variable of interest on overall efficiency. The inputs and outputs of the base model and six of its extensions are shown in Table 3. The base model has three inputs (distribution line length, number of employees, transformer capacity) and three outputs (sales volume, number of customers and peak demand). The three inputs selected are the most frequently used input variables in 20 benchmarking studies surveyed by Jamasb and Pollitt (2001). The output variables are likewise among the most frequently used variables in the same survey, with sales volume and number of customers being the most often used variables.

Table 3. Specifications of DEA Models

Model Name	BASE	STRUCTURE	DENSITY	SLOSS	DSM	OM	ADMIN
Variable							
Number of customers	O	O	O	O	O	O	O
Sales volume	O	O	O	O	O	O	O
Peak demand	O	O	O	O	O	O	O
Customer Structure		O					
Distribution line length	I	I	I	I	I	I	I
No. of employees	I	I	I	I	I	I	I
Transformer capacity	I	I	I	I	I	I	I
Customer density			I				
Systems loss				I			
DSM cost					I		
Operations & maintenance cost						I	
Administration costs							I

Legend: O – output variable; I – input variable

The model STRUCTURE adds customer structure, defined as the proportion of sales to non-residential customers to total sales, as one of the outputs. The other five extensions add inputs one at a time. These input variables and the corresponding model names in parenthesis are: sales density (DENSITY), system loss (SLOSS), distribution, supply and metering costs (DSM), operations and maintenance (OM), administrative and other costs (ADMIN).

Efficiency scores obtained from an application of the DEA on 97 grid-connected ECs ranged from 82 percent (base model) to 87 percent, indicating significant levels of inefficiency in the sector (Table

4). High correlation between the efficiency scores of the base model and the other models tested provides evidence of robustness of results (Table 5).[6] A simple test of equality of means between series indicates that the mean efficiency scores of the different models were significantly different from each other, with a p-value of 0.01.

Table 4. Descriptive Statistics – EC Efficiency Scores

	BASE	STRUCTURE	DENSITY	SLOSS	DSM	OM	ADMIN
Mean	0.82	0.86	0.87	0.82	0.85	0.86	0.84
Median	0.79	0.86	0.87	0.80	0.83	0.85	0.83
Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Minimum	0.40	0.48	0.50	0.40	0.61	0.51	0.59
Std. Dev.	0.14	0.13	0.12	0.14	0.12	0.12	0.12

Table 5. Correlation of Efficiency Scores Using Different Models

	BASE	STRUCTURE	DENSITY	SLOSS	DSM	OM	ADMIN
BASE	1.00	0.85	0.78	0.99	0.96	0.92	0.95
STRUCTURE		1.00	0.55	0.82	0.82	0.83	0.80
DENSITY			1.00	0.81	0.79	0.79	0.77
SLOSS				1.00	0.95	0.92	0.93
DSM					1.00	0.95	0.98
OM						1.00	0.88
ADMIN							1.00

Table 6, which has nine panels (from A to I), shows the breakdown of efficiency scores from the base model according to various criteria. In panel A, it appears that small-sized ECs, which have annual sales of less than 100,000 MW h and constitute 72 percent of total ECs, are relatively inefficient, having an average score of 0.79. This can be compared with the weighted average score of 0.87 for the remaining ECs. Panel B classifies ECs according to the number of customers. Again, it is clear that larger ECs have higher efficiency scores. Panel C shows that ECs with longer distribution lines are less efficient than those with shorter lines. As expected, the larger ECs in terms of sales volume and number of customers and those with higher sales density are more efficient than their counterparts (Panels D, E, F, and G).

DEA efficiency scores tend to increase with the inclusion of more variables. Hence, comparing the base model with the extended models (each of which is just the base model with one additional input or output variable) yields biased results in favor of the latter. To avoid the bias, one has to compare models with the same number of variables. Looking at Table 4 once more, it is seen that the SLOSS model which accounts for system losses yields the lowest efficiency scores among the six extended models, all of which have the same number of variables. In the base model, when ECs are grouped by systems loss levels, results show that average efficiencies decline with increasing levels of systems loss (Table 6, Panel H). Results also show that there are regional differences in technical efficiency. As shown in Panel I, the more efficient ECs are located in Luzon, while most of the inefficient ECs are in Mindanao.

[6] To check for robustness of the DEA-estimated efficiency scores, parametric methods—Corrected Ordinary Least Squares (COLS) and SFA—were also employed. The SFA and COLS efficiency scores had high correlations with the DEA base model scores, confirming the results of the latter. Due to space constraints the details of the COLS and SFA estimation are not presented in the paper anymore but are available upon request.

Table 6. Breakdown of Mean Efficiency Scores

	Number of ECs	Mean Efficiency Score	Std. Dev.	SE of Mean
A. Annual sales in MW h				
[0, 100000)	70	0.79	0.14	0.02
[100000, 200000)	21	0.86	0.13	0.03
[200000, 300000)	1	0.77	NA	NA
[300000, 400000)	5	0.94	0.14	0.06
B. Number of customers				
[0, 50000)	47	0.78	0.14	0.02
[50000, 100000)	39	0.83	0.13	0.02
[100000, 150000)	11	0.91	0.12	0.04
C. Distribution line length in CKM				
[0, 2000)	46	0.83	0.14	0.02
[2000, 4000)	43	0.81	0.14	0.02
[4000, 6000)	7	0.77	0.16	0.06
[6000, 8000)	1	0.77	NA	NA
D. Sales Density (kW h sales per circuit km of line)				
[0, 50)	73	0.79	0.14	0.02
[50, 100)	18	0.88	0.11	0.03
[100, 150)	5	0.99	0.02	0.01
[200, 250)	1	1	NA	NA
E. Percentage of sales to non-residential customers				
[0, 20)	1	1	NA	NA
[20, 40)	50	0.84	0.13	0.02
[40, 60)	41	0.77	0.15	0.02
[60, 80)	5	0.94	0.09	0.04

	Number of ECs	Mean Efficiency Score	Std. Dev.	SE of Mean
F. Customers per CKM of distribution line				
[0, 20)	28	0.73	0.15	0.03
[20, 40)	55	0.82	0.12	0.02
[40, 60)	13	0.95	0.08	0.02
[60, 80)	1	1	NA	NA
G. Customers per Employee				
[100, 200)	18	0.72	0.15	0.03
[200, 300)	59	0.8	0.12	0.02
[300, 400)	17	0.94	0.08	0.02
[400, 500)	3	1	-	-
H. Systems Loss in %				
[0, 10)	10	0.86	0.13	0.04
[10, 20)	73	0.82	0.14	0.02
[20, 30)	13	0.78	0.18	0.05
[50, 60)	1	0.76	NA	NA
I. Regional Location of EC				
Luzon	43	0.87	0.12	0.02
Visayas	28	0.79	0.15	0.03
Mindanao	26	0.76	0.14	0.03
All ECs	97	0.82	0.14	0.01

The Malmquist productivity change index and its components are presented in Table 7. The trend of the indices from 2001 to 2006 can be seen as flat, and fluctuates near the value of one with very small standard deviations. These trends suggest little or no efficiency improvements in electricity distribution despite the reforms that were instituted in 2001 when the EPIRA was passed. Philippine ECs' distribution expenses consist of operations and maintenance expenses (e.g., repairs and maintenance of distribution lines), customer-related expenses (e.g., billing and collection), and general and administrative expenses (e.g., training and employee development costs), with the latter two non-technical components of costs accounting for almost 70 percent, on average, of total distribution expenses (Table 8). A comparison of the efficiency scores separately considering the technical and non-technical portions of distribution cost as inputs found them not to differ much from each other (see DSM, OM and ADMIN model results in Table 4).

Table 7. Malmquist Index Summary of Annual Means

year	pure efficiency change	scale efficiency change	total efficiency change	technical change	total factor productivity change
	[1]	[2]	[3]=[1]x[2]	[4]	[5]=[3]x[4]
01 to 02	1.029	1.068	1.099	0.844	0.928
02 to 03	0.999	1.007	1.006	0.978	0.983
03 to 04	0.868	0.940	0.816	1.236	1.008
04 to 05	1.103	1.063	1.173	0.803	0.941
05 to 06	0.949	0.969	0.920	1.069	0.984
Mean	0.99	1.01	1.00	0.99	0.97
Std dev	0.09	0.06	0.14	0.18	0.03

Table 8. Breakdown of ECs' Total DSM Cost (2001 to 2006)

	O&M	Customer Accounts	Gen&Admin
Mean	32%	25%	43%
Median	31%	25%	43%
Maximum	55%	44%	63%
Minimum	16%	11%	10%

The existence of electric cooperatives is largely a result of the government's efforts to bring electricity to the areas that private utilities do not find profitable enough to enter. Thus, between the private, investor-owned utilities and the electric cooperatives, it is the latter that is operating in the more rural and remote areas in the Philippines. Within the EC sector, however, there is a sub-group of ECs—the Small Power Utility Group utilities or SPUG ECs—that provides electricity to areas in the country that are not reached by the main grids operated by the Transmission Corporation in the three supra regions of the Philippines (i.e., Luzon, Visayas, and Mindanao). As Table 9 shows, grid-connected and SPUG ECs differ significantly in size, cost and operating characteristics (all differences are significant with p-values of almost zero). Means testing shows that SPUG ECs were significantly more inefficient than grid-connected ECs (Table 10). However, the size, density and structure impact on efficiency detected in the sample of grid-connected ECs disappeared when only the SPUG ECs are considered. Although the differences in mean efficiency are not statistically significant, curiously, the small SPUG ECs appear to be more efficient than large-sized SPUG ECs (Table 11).

Table 9. Differences Between Grid-Connected and SPUG ECs (average figures over the period 2001 to 2006)

	Grid-connected	SPUG	All
N	97	21	118
Annual sales in MW h	86,812.74	18,471.65	74,853.05
number of customers	54,983.12	17,165.61	48,365.06
Peak demand in KW	21,896.51	5,419.09	19,012.96
Length of distribution line in circuit km	2,221.94	840.51	1,980.19
Annual distribution cost in Php	73,233.51	24,198.53	64,652.39
Average distribution cost (Php cost per kW h)	1.10	1.79	1.22
Number of employees	218.55	88.63	195.82
Percentage of sales to residential customers	0.61	0.66	0.61
MW h sales per circuit km of distribution line	40.86	18.88	37.02

Table 10. Mean Efficiency Scores: Grid-Connected Versus SPUG ECs

	Count	Mean Efficiency Score
SPUG ECs	21	0.66
Grid-connected ECs	97	0.76
All	118	0.75

Table 11. Mean Efficiency Scores of SPUG ECs by Size*

Size	Count	Mean
Small	8	0.70
Medium	5	0.69
Large	6	0.56
Extra Large	1	0.58
Mega Large	1	0.80
All	21	0.66

* Categories here are based on a classification scheme implemented by the NEA for the cooperatives. The ECs are classified based on a 3-year rolling average of the following factors: sales volume, number of service connections, and length of distribution line.

5 Conclusions and Areas for Further Study

This study confirms that electric cooperatives in the Philippines are operating with significant levels of technical inefficiency. The estimates of the study show that for the same level of output, ECs should be able to proportionally reduce their inputs by up to 18 percent. The productivity of the sector as a whole seems to have stagnated during the post-EPIRA period. A possible reason for this is that demand in the last three years (2004 to 2006) had been flat (the compound annual growth rate is 1.1%, with 37 ECs experiencing negative growth) compared with the 21.7% sales growth rate the cooperatives experienced during the period 2001 to 2003. As a reversal in the demand growth trend is not foreseeable given present economic conditions, efficiency improvements in the sector have become more of an imperative than ever.

This study has shown that a number of structural as well as operational factors significantly affect the efficiency of grid-connected ECs. These are sales and customer density, customer structure, size (as measured by sales volume and number of customers), systems loss and number of customers per employee. These are not totally surprising results. What they imply, however, is that ECs should resist external pressure (usually from local politicians) to expand in areas with low density so as not to sacrifice their efficiency even more. The study also identifies two initiatives ECs can undertake to improve their technical efficiency—reduce systems loss and personnel. The most efficient ECs had, on average, 303 customers per employee, while the least efficient ones had only 221 customers per employee.

Areas for further study include an investigation into the factors that affect the efficiency of the SPUG ECs. It is well accepted that the cost of power in the SPUG areas is higher, but this should mainly be because of the generation component of the service, not the distribution side. The lack of factors to explain the higher inefficiency levels of the SPUG ECs is a puzzle that is clearly worth looking into. Finally, the estimation of the levels and drivers of cost efficiency of the ECs is work that should be seriously pursued. Unfortunately, having been regulated under a cash reimbursement basis and given the weak financial reporting practices of the sector, reliable data on the cost of capital inputs are not yet available. Initiatives to address this information deficiency must be undertaken so that analysis that can inform interventions to improve the cost efficiency of the ECs can be done.

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