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DD/10/04

Efficiency Analysis for Peruvian electricity distribution sector: Inefficiency's explicative factors. A study for 2000 – 2008

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Elaborado por José Luis Bonifaz y Miguel Jaramillo.

Diciembre 2010

Resumen

This paper estimates the inefficiency of Peruvian electricity distribution companies to determine if the expected results from the 90's reform were met. To do this, we used data for 19 distribution companies for the period 2000 – 2008 using a Cost Stochastic Frontier approach and estimating inefficiency in a one-step procedure. The analysis suggests that private utilities are less inefficient than public Utilities because of better management practices. In other words, private management and investments had been favorable in terms of efficiency for the period studied. Also, regulation changes, especially in 2005, have increased distribution costs and geographical characteristics impact negatively on efficiency, especially in public Utilities. This can be explained by the fact that State investment in difficult areas, with public Utilities operating, imposes additional costs (management and operational) that makes them inefficient. Future investigations should focus in a Region Analysis, for the sake of a bigger Panel sample.

Key words: Distribution sector, Utilities, Inefficiency, Ranking, Stochastic Frontier, Reform.
JEL -Classification: L51, L52, C33

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Relative Efficiency Analysis for Peruvian electricity distribution sector: Inefficiency's explicative factors

A study for 2000 - 2008

José Luis Bonifaz
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First draft, December 2010

Abstract

This paper estimates the inefficiency of Peruvian electricity distribution companies to determine if the expected results from the 90's reform were met. To do this, we used data for 19 distribution companies for the period 2000 – 2008 using a Cost Stochastic Frontier approach and estimating inefficiency in a one-step procedure. The analysis suggests that private utilities are less inefficient than public Utilities because of better management practices. In other words, private management and investments had been favorable in terms of efficiency for the period studied. Also, regulation changes, especially in 2005, have increased distribution costs and geographical characteristics impact negatively on efficiency, especially in public Utilities. This can be explained by the fact that State investment in difficult areas, with public Utilities operating, imposes additional costs (management and operational) that makes them inefficient. Future investigations should focus in a Region Analysis, for the sake of a bigger Panel sample.

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I. Introduction and Motivation

The Electricity Concessions Law (No. 25844), in order to encourage private investment, disintegrated the market vertically into four sectors: generation, transmission, distribution and commercialization (Fernandez-Baca, 2004). This caused the distribution sector to operate as monopolies because of their natural monopoly characteristics. Furthermore, the above process was part of a series of privatization measures[1]. Naturally, since the rules of the game were changed, the result also changed.

This research will focus on the electricity distribution sector. It will assess its performance in recent years to confirm whether if, after a decade, the expected results with disintegration were met or not. An important aspect in the evaluation of the sector is the analysis of Utilities' efficiency. In this line, there have been several studies that attempt to measure the efficiency level of distributors. Bonifaz and Rodriguez (2001) analyze the relative efficiency and the cost-saving technological change, and develop a ranking of distribution companies in Peru. Their results showed that for the analyzed period (1995 - 1998) there were no signs of catching-up in the sector.

Alva and Bonifaz (2003) also reach the final conclusion of the previous study analyzing the State vs. private performance. Additionally, they find that the privatization process of the 90, per se, has not improved efficiency with respect to State owned enterprises. However, Perez-Reyes and Tovar (2009), using DEA and Tobit (two-stage) procedures, found that the privatization process itself has been beneficial especially in the years immediately following the implementation of reforms; therefore, this issue is still under discussion. This paper provides an estimation of inefficiency by using a one-step procedure, for distribution Utilities of the sector using a Stochastic Frontier approach, with 19 enterprises between 2000 and 2008.

The paper is organized as follows. Section 2 summarizes some background history and the reform of the distribution sector. Section 3 presents the empirical model in which all variable and its expected effects are explained. Section 4 shows the empirical model results. Finally, Section 5 summarizes the analysis and reports conclusions and future recommendations.

[1] Also, there were auctions for shares of Compañía Peruana de Teléfonos (CPT) and Empresa Nacional de Telecomunicaciones del Peru (ENTEL PERÚ). The amount collected and the investment commitment made Telefónica de España the beneficiary of the process. That same year also experienced the sale of the Distribution Companies, like EdeChancay and EdeCañete.

The privatization of electricity and telecommunication sectors in Peru was accompanied by the creation of new, independent bodies, in order to regulate the operation of the privatized companies.

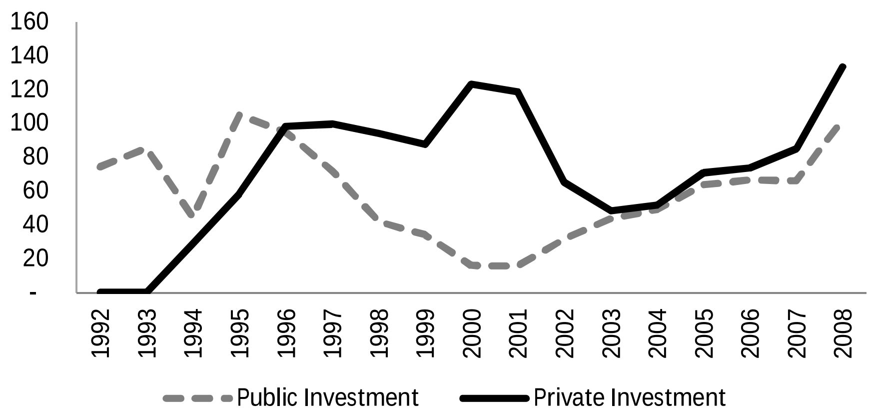
II. Evolution of the sector

The reform process began in 1992 with the disintegration of the electricity sector in the city of Lima[2] (Electro Peru was the State controlled enterprise that managed the electricity system), to later concession companies in the rest of the country in 1997 and 1998. Previously, results and indicators were not promising: In 1990, there was an energy deficit that reached 26%, the electrification rate was 47%, distribution companies' losses were increasing, etc. (Ruiz, 2002).

Likewise, on December 31th, 1996, Law No. 26 734 created a Public Organization, under the name of Supervisory Body for Energy Investment (OSINERG), responsible for overseeing and monitoring compliance with laws and techniques of activities of electricity and hydrocarbons Utilities, as well as compliance with legal rules concerning the conservation and environmental protection. In addition, the Agency absorbed the Electricity Tariffs Commission (CTE), which would later become the Deputy Manager of Tariff regulation (GART). In 2007, OSINERG was renamed as the Supervisory Body for Investment in Energy and Mining (OSINERGMIN) to assume the functions of supervision and safety issues for environment in the mining sector.

With this series of reforms to establish an independent regulatory commission, State participation decreased its level of intervention with regard to revision of tariffs, methodologies to be used, tariff review periods, among others. Also, one of the motivations for the concessions was to attract private investments to replace assets for new technologies, expand coverage (which implies investment in distribution networks), etc. Private investments can be seen in Figure 1, and, as shown, they practically did not exist before the privatization process.

Figure 1
Electrical distribution sector investment 1992-2008
(Millions US$)



Source: Ministry of Energy and Mines. Statistical Memories.

As for the evolution of some variables of electricity distribution sector for the period of study, Table 1 shows that per capita consumption (kWh per habitant) increased from 668 in

[2] Electro Lima supplied Lima, Peru's Capital City. After the reform, it was divided in two generation enterprises (Etevensa and Edegel), four distribution companies (Edelnor, Edelsur, EdeChancay, which would be taken over by Edelnor in 1999, and Edecañete) and its transmission assets belonged to Etecen.

2000 to 1,001 in 2008. Other variables also experienced a similar growth. For example, sales and number of customers increased from 10,763 GWh and 3,352 thousands in 2000 to 16,297 and 4,625 in 2008, respectively. By contrast, distribution losses have been reduced in more than 3%, possibly as a result of regulation; they established annual goals for reducing losses to boost Utilities' efficiency.

Table 1
Peruvian electricity distribution sector evolution

Indicator	2000	2001	2002	2003	2004	2005	2006	2007	2008	% Var 2000-2008
Per capita consumption (KW.h/Habitant)	668.00	691.00	712.00	734.00	773.00	823.00	872.00	947.00	1,001.00	5.2%
Turnover (Millions US$)	866.07	862.63	862.23	901.10	986.87	1,147.78	1,222.41	1,305.45	1,501.00	7.3%
N° Customers (Thousands)	3,352.21	3,462.85	3,614.48	3,727.27	3,860.52	3,977.10	4,165.27	4,359.86	4,624.79	4.1%
Distribution Losses (% of Sales)	10.40	9.70	9.10	9.10	8.70	8.40	8.60	8.20	8.00	-3.2%
Regulated Tariffs (US$ Cents /kW.h)	8.80	8.80	8.30	8.40	8.70	9.40	9.20	9.10	9.56	1.1%
Sales (GW.h)	10,763.20	10,522.40	11,113.50	11,303.60	12,001.30	12,914.30	14,043.60	15,032.20	16,297.18	5.4%

Source: Ministry of Energy and Mines. Statistical Memories.

Appendix 1 shows that, for all the companies, customers and total sales have increased for the period of analysis. Furthermore, some companies have reduced or have not changed dramatically the number of workers, mainly due to outsourcing in various activities of operation and maintenance of networks; however, there is a big range in terms of percentage variation. For example, Electro Ucayali has increased in 20% the number of workers, but Edelnor decreased it in 0.2%. Also, personnel expenditures have experienced a mean reduction of 0.6% between 2000 and 2008. By contrast, on average, there has been an increase in fixed asset investment, which is in line the sector's increment in investment in the last years.

Partial productivity indicators can be very useful for evaluation efficiency in the electricity distribution sector. Table 2 shows the 2000 – 2008 average for each distribution company under analysis. Some State companies[3], such as Electro Sur Medio, do not show substantial improvement in the partial productivity indicators reported, with an increment of 0.9% for distribution losses, respectively. Electro Ucayali, on the other hand, obtained a different result with a reduction of 3.9% in distribution losses.

In contrast, most private companies (including those returned to the State)[4] show improvements in productivity indicators (Edelnor, Electronoroeste, Electronorte, and Luz del Sur and Hidrandina), like average reductions in distribution losses and increases in customers / workers ratio (Electrocentro, Electronoroeste, Electronorte and Luz del Sur).

However, distribution companies should also be ranked according to typical sector to highlight the differences between firms operating in different contexts (urban high density, medium density urban, low-density urban, rural and urban rural), so these differences could affect previous results[5].

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[3] For more details about ownership, see appendix 2
[4] In 2002, Hidrandina, Electronorte, Electrocentro and Electronoroeste were returned to the State
[5] For more information, see appendix 3

Despite the usefulness of these partial productivity indicators (among others), and although they are commonly used, they only reflect partial evidence on the achieved efficiency by companies during the evaluated time period. In addition, the Customers/Workers ratio is strongly dependent on the level of substitution between capital and workers of each enterprise, and, on the client side, it depends largely on the consumer density of the concession area. It is therefore recommendable to use other methods to analyze the efficiency of each company, since these indicators do not show conclusive evidence companies' efficiency.

Table 2
Partial productivity indicators for Peruvian electricity distribution sector

Company	2000		2004		2008		% Var 2000 - 2008	
	C/W	Losses	C/W	Losses	C/W	Losses	C/W	Losses
Coelvisac	10	5%	43	2%	94	2%	44.2%	-11.5%
Edecañete	1,177	9%	1,009	8%	1,091	9%	-0.3%	0.6%
Edelnor	3,383	9%	1,612	9%	1,816	8%	-4.0%	-2.2%
Electro Oriente	1,290	18%	649	13%	881	10%	-0.9%	-6.3%
Electro Puno	1,167	15%	948	13%	1,192	12%	1.0%	-0.6%
Electro Sur Este	926	14%	957	10%	1,297	10%	4.6%	-2.9%
Electro Sur Medio	406	11%	433	13%	685	12%	7.7%	0.9%
Electro Tocache	471	39%	274	17%	278	17%	-2.7%	-8.4%
Electro Ucayali	1,083	12%	543	9%	798	8%	1.1%	-3.9%
Electrocentro	1,100	8%	1,246	10%	1,436	9%	3.5%	1.4%
Electronoroeste	1,173	11%	1,012	10%	1,333	10%	2.3%	-1.5%
Electronorte	873	14%	925	10%	1,202	9%	5.0%	-5.4%
Electrosur	925	12%	743	9%	797	8%	-1.2%	-4.3%
Emsemsa	389	30%	437	22%	508	19%	3.5%	-4.9%
Emseusa	404	15%	823	15%	262	11%	7.4%	-3.7%
Hidrandina	1,927	13%	1,060	9%	1,375	9%	-1.8%	-3.5%
Luz del Sur	1,144	8%	1,142	7%	1,214	6%	0.9%	-2.9%
Seal	1,158	23%	1,275	13%	1,540	10%	4.6%	-8.9%
Sersa	888	17%	1,022	16%	802	14%	-0.9%	-2.2%

C/W accounts for Customer/Worker ratio.

Source: OSINERGMIN. Statistical Memories.

III. Empirical Model

This paper will determine the explicative factors of inefficiency in a one-step procedure. First, we will model a frontier where agents minimize costs (maximize profits). By this procedure, we will get the level of inefficiency as a residual (different than the error term). At the same time, this residual will be modeled to find the determinants of inefficiency in the electrical distribution sector in Peru.

Frontier researches are important because, unlike other methods[6], do not assume that all firms are efficient (Coelli, et al. 1998). These studies try to estimate a frontier from the best practices observed.

In addition, the applied methodology will also depend on the form the frontier is specified, which may be based on a production function (which shows the quantities produced according to the inputs used) or a cost function (which reflects the total cost as a function of the product and price of inputs). For the purpose of this paper, we have chosen a cost function specification because, in the electricity sector, supply must equal demand at all times, as a result of not being able to save electric production as a stock. Also, minimizing costs is consistent with model firm regulation adopted in Peru (Dammert, Garcia Carpio and Molinelli, 2008).

There are several approaches for frontier calculation in literature. Nonparametric approach of mathematical programming: Data Envelopment Analysis - DEA (Charnes, Cooper and Rhodes, 1978) and parametric approaches: Deterministic Frontier (DF) and Stochastic Frontier (SF). A frontier without assumptions about the distribution of inefficiency can also be estimated for panel data (Rodríguez, Ruzzier, and Rossi, 1999).

Therefore, we chose the Stochastic Frontier approach via Maximum Likelihood estimation, with panel data for 19 Utilities in 2000 - 2008. However, several other authors have chosen different methodologies and different variables. For example, Söderberg (2007) uses a Stochastic Frontier model whose dependent variable is total costs and whose regressors are the price of electricity purchased, the price of labor and capital, among others. Bonifaz and Rodriguez (2001) use the distribution costs as dependent variable and the number of consumers, wages, and market structure as explicative factors. Perez Reyes and Tovar (2009) use DEA, with a Tobit estimation in a second stage for technical efficiency under variable returns to scale for period 1996 - 2006. The decision to use SFA responds to DEA's problems. For example the inefficiency indicators are strongly affected by the number of observations, thus, if this number grew, the method would lose the ability to differentiate between efficient and inefficient firms. Furthermore, this method is sensitive to the presence of outliers, biasing efficiency measures (Bonifaz and Rodriguez, 2001).

[6] Productivity indexes, production functions, etc.

1. A brief review of existing literature

There is vast international literature on studies of efficiency in the electricity distribution sector. The research topics usually tend to be the development of efficiency rankings, comparisons of performance among private and public companies, and the effect of regulatory reforms in different countries.

Miliotis (1992) evaluates 45 Divisions of Greek Public Power Corporation, through the impact of geography, size and population density, concluding that the Divisions that operate in urban centers have higher rates of efficiency than those operating in areas where population is more dispersed. Pollitt (1994) applies a DEA approach and OLS model to analyze 145 distribution and transmission companies from the USA and UK. This research concluded that there was not enough evidence for significant differences in technical efficiency between public and private companies. Similarly, Bagdadioglu et al. (1996) use a DEA model for 70 companies in Turkey and come to the same previous conclusion: the rejection of the null hypothesis of difference in efficiency between public and private companies.

Rodriguez, Ruzzier and Rossi (1999) evaluated the consistency between different methods for estimating the efficiency of distribution companies. They found that their results were consistent with each other in terms of mean results, rankings and the distinction between best and worst practices observed. Scarsi (1999) used DEA methodology to evaluate the efficiency of local electricity distribution companies in Italy and concluded that it is feasible to apply a method of Yardstick Competition in this industry.

Sanhueza (2003) studies the performance of the Chilean distribution reforms after 1982 and, by using DEA, determined the efficient Capital base for companies. The author found that 57% of companies in the sample can be considered technically efficient as they can identify actions and strategies to increase business productivity. Soderberg (2007) uses the stochastic frontier model for Swedish companies for 2000-2005 and concluded that the regulator should be aware that cost and quality efficiency are contradictory, as well as the fact that private ownership do not have a big impact per se, but accompanied by other influence factors.

On the Peruvian side, Bonifaz and Santin (2000), through DEA, estimated the economic efficiency of 18 electricity distribution companies in Peru between 1995-1998, and conclude that privatized firms do not outperform state enterprises, arguing that privatization has not meant an improvement in terms of efficiency. Bonifaz and Rodriguez (2001) use stochastic frontier for 16 distribution companies in Peru from 1995 to 1998 (post reform) and conclude that there is insufficient evidence to argue that there is technical change or significant savings associated with technological improvements in the sector. Perez Reyes and Tovar (2009) analyzed 14 Peruvian distribution companies in the period 1996-2006 with a DEA model and Malmquist index. They conclude that privatization proved to be advantageous especially the first years after the reform, even for those returned to the State. For more information, table 3 shows many investigations.

Our investigation differs from similar previous studies through a more robust period, in which changes in the reforms of the 90s have settled in the sector. Furthermore, efficiency is going to be explained with a different approach, and its explicative factors include companies' management variables and not just geographic issues and the difference between private and State ownership.

Table 3
Some empirical evidence on electricity distribution subject

Authors	Methodology	Input	Output	Other factors	Efficiency explaining factors
Pérez Reyes and Tovar (2009)	DEA and Malmquist Index	N° of workers, Distribution losses (MWh), Monetary value of active Capital, Medium-voltage and low-voltage network kilometres, and Number of substations.	Sales (GWh), N° of Customers	N.A.	Reform, Property, Mountains, Jungle
Soderberg (2007)	SFA with random effects (Costs)	Price of purchased electricity,Capital price, Labor price	Distributed Energy (KWh)	Population Density, Average Energy Consumption, Proportion of urban area, Jungle area, Agriculture area, Proportion of Low voltage customers, Wind speed, Year	Companies' ownership, Average customers outage minutes (minutes), Transforming Capacity (MVA), Share of overhead lines.
Goto and Tsutsui (2008)	SFA with random effects	Capital index, N° of workers	Distributed Energy, N° of customers	N.A.	Exogenous factors
Cronin and Motluk (2007)	DEA	Quantity and price of: Labor, Capital, Materials, Losses	Distributed Energy, N° of customers	N.A.	N.A.
Hirschhausen et al. (2006)	DEA and SFA (Production)	N° of workers, Size of distribution area, Load Factor in peak hours, Losses, Wiring type, Geographic differences	Distributed Energy, N° of customers (residential and industrial), Density	N.A.	N.A.
Nemoto and Goto (2006)	SFA with fixed effects	Price of labor, Price of capital, N° of workers, Capital Stock	Distributed Energy	Proportion of industrial use, Proportion of high voltage lines	N.A.
Pombo and Taborda (2006)	DEA (Production)	N° of workers, N° of transformers, Size of distribution area, Regional per capita GDP, National capacity for electricity generation	Distributed Energy, N° de consumidores, Urban area	N.A.	Exogenous factors
Berg et al. (2005)	DEA and SFA with random effects (Production)	Purchased electricity, Operation costs and Size of distribution area	Distributed Energy, N° of customers	N.A.	Exogenous factors
Hattori et al. (2005)	DEA and SFA with random effects (Costs)	Total Cost	Distributed Energy, N° of customers	N.A.	Exogenous factors
Kwoka (2005a)	Squared average cost	Labor price, Capital price, Price of purchased energy	Distributed Energy, N° of Customers, Service area	Proportion of underground lines, Proportion of high voltage lines, Energy auto-generation	N.A.
Kwoka (2005b)	Squared total cost	Labor price, Capital price, Price of purchased energy	Distributed Energy, Generated electricity	N° of customers, Type of electricity generation, Member of a Holding company, Ownership, Outages	N.A.
Lowry et al. (2005)	SFA (Costs)	Labor price, Capital price, N° of workers, Operation and Maintenance expenditures	Distributed Energy, N° of Customers, Service area	Gas Consumers, Average rainfall, System age, Proportion of lines , Plant value, Proportion of different kind of customers, Average temperature	N.A.
Farsi and Filippini (2004)	SFA with fixed and random effects (Costs)	Labor price, Capital price, Price of purchased energy	Distributed Energy	Load factor, Service area, N° of customers, High voltage indicator	N.A.
Filippini et al. (2004)	SFA with random effects (Costs)	Price of Labor, Price of Capital	Distributed Energy	Density, Load factor	N.A.
Fraquelli et al. (2004)	SFA with random effects (Costs)	Price of Labor, Price of other inputs	Distributed quantity of Gas, Water and Electricity	N.A.	N.A.
Ida and Kuwahara (2004)	Translog cost function with fixed effects	Price of labor, Price of capital, Price of fuel	Generated, transfered and distributed energy	N.A.	N.A.
Edvarsen and Forsund (2003)	DEA (Production)	Operation and maintenance costs, Replacement value, Losses	Distributed Energy, N° of customers	N.A.	N.A.
Bonifaz and Rodriguez (2001)	SFA with random effects (Costs)	Price of labor	N° of customers, Energy sales	Density, Estructure of the sector, Time	N.A.
Rodriguez , Rossi and Ruzzier (1999)	SFA, DFA, DEA	N° of employees, Total sales, Market estructure, Transforming capacity	N° of customers	N.A.	N.A.
Scarsi (1999)	DEA	N° of employees, Kilometers of distribution lines	Distributed Energy (GWh), N° of customers	N.A.	N.A.
Bagdadioglu, Waddams and Weyman - Jones (1996)	DEA	N° of workers, Transforming capacity (MVA), Network size (kilometers), General expenditure, Losses (MWh)	N° of customers, Supplied Electricity (MWh), Max Demand (MW), Service area (Km2)	N.A.	N.A.
Pollit (1994)	DEA, OLS	N° of workers, N° of transformers, Circuit kilometers	N° of Customers, Offered electricity (KWh), Service area	N.A.	N.A.
Miliotis (1992)	DEA (Costs)	Length of lines (Km.), Installed capacity, Techinical and administrative work (hours)	Sales, N° of customers	N.A.	Input management, Supply design, Unquantifiable environmental factors*

*The author comments about posible reasons for efficiency but does not estimates them

2. The Model

Before specifying the empirical model, it is important to decide the relevant variables for the estimation. In fact, as shown in Table 3, there is no definitive consensus about the inputs and outputs chosen for Frontier estimation in electricity distribution sector; so, the choice depends on what the researcher is looking for and availability of information. Also, distinction of which variable can be considered as a product, or which can be considered as an input for the distribution company, accompanied with exogenous regressors or controls, is very important.

In general terms, the cost frontier models typically include production inputs such as the price of capital, and the price of labor, and in some cases, the price of electricity purchased. Furthermore, the product is determined as the number of customers or sales, which should have a positive effect on the costs of the distributor (more customers or more sales, higher production and hence higher costs). On the other hand, some authors like Söderberg (2007) and Neuberg (1977) usually add control variables to take into account other factors such as market size, available infrastructure, and environmental conditions, among others.

We propose the following model with inputs, outputs, and other exogenous variables (whose inclusion will be explained later.) Also, it is worthy to note that the study is done for the case of technical efficiency, due to the difficulty of isolating allocative efficiency (Álvarez, 2001):

$$Costs = \beta_0 + \beta_1 Clients + \beta_2 OH + \beta_3 Losses + \beta_4 P_L + \beta_5 P_K + \beta_6 REG2001 + \beta_7 REG2005 + \beta_8 trend + v_{it} + \mu_{it}$$

Costs is a variable that represents the distribution costs which are calculated by Osinergmin once every four years, PL and PK indicate the cost of labor and capital respectively (Perez Reyes and Tovar, 2009). Variable Clients is a product proxy and represents the Utility's number of clients. Sales could have been another proxy, but it was not included because of the fact that Clients and Sales suffer of multicollinearity. The variable OH are kilometers of overhead lines per customer, Losses are the losses that occur during the energy transportation and exchange. REG2001 and REG2005 are dummy variables which gather the effect of regulation changes in distribution costs calculation. Finally, a trend is included so it could represent technological changes (Bonifaz and Rodriguez, 2001).

There are several reasons to include these exogenous variables. First, inclusion of Clients responds to a product approximation. Theoretically and intuitively one would expect higher distribution costs with more clients. OH implicates more costs, if more overhead lines are required per customer. For example, operation and maintenance costs of 20 kilometers of distribution lines per 5 clients are higher than 10 kilometers per 5 clients (Neuberg, 1977).

Losses are included due to the energy robbery during it transportation and exchange. This is justified by the fact that the distributor has to incur in higher costs to cover the energy lost (Pérez Reyes and Tovar, 2009). Inputs P_L and P_K, are measured by wages and (depreciation + financial expenses)/net fixed assets respectively. Its inclusion responds to include Utilities' production costs, which should impact positively on distribution costs.

Finally, REG2001 and REG2005 were included to control regulation changes in the analysis. The objective is to recall the effect of OSINERGMIN in the distribution costs determination and actualization. In consequence, and following Söderberg (2007), dummy variables are included (REG2001 and REG2005) that represent the regulation changes in 2001 and 2005. However, REG2001 was taken out due to non-significance.

3. A Inefficiency Model

Battese and Coelli (1995) extended the model of Kumbhakar, Ghosh and McGukin (1991) and Reifschneider and Stevenson (1991), to a case of panel data where inefficiency effects are defined as a function of firm-specific variables.

In this case, any variation in technical efficiency over time will be specific to the firms, as it depends on variables for each company. According to Alvarez (2001), inefficiency is an independent and identically-distributed random variable, and is obtained by truncating the normal distribution N (μ_{it}, σ^2).

$$\mu_{it} = z_{it}\delta$$

Where

Z_{it}: Is a matrix of explanatory variables that usually has firm-specific effect.
δ: Is a vector of unknown parameters.

The aim of such a design is based on the search for the determinants of inefficiency. In addition, time-variant technical efficiency values are obtained for each company. To find the determinants of inefficiency, consider the next regression equation.

$$\mu_{it} = \delta_0 + \delta_1 Num\_Outage + \delta_2 Dur\_Outage + \delta_3 CW + \delta_4 Jungle + \delta_5 Mountains + \delta_6 Ownership + e_{it}$$

Ownership is a dummy variable activated when the distribution companies are private or has been privatized. The inclusion of this variable seeks to differentiate the management of a private and a public company and thus give an indication of who is more efficient. CW is a Clients / Workers ratio, which represents another proxy for companies' management. Num_Outage and Dur_Outage indicate the number and duration of outages that occurred; these variables are also related to the management and operation of the company[7]. Finally, Jungle and Mountains are dummies that are activated if the company is located in the mountains or the jungle, distinguishing the geographical effects on enterprises' efficiency[8].

Empirical studies (Pit and Lee, 1981) have estimated stochastic frontiers and predicted efficiencies of firms using cost or production functions. Then, in a second step, such efficiencies are modeled against a number of explanatory variables related to management of the same company, or controlled aspects by distribution companies (such as management expertise, characteristics of the firm, if private owned or not, etc.) in an attempt to identify the reasons why firms differ by their efficiency.

This procedure has been considered useful for a long time. However, this type of two-stage estimates can generate inconsistent results with the assumptions regarding the

[7] Söderberg (2007) includes these variables as a proxy for quality of service. Companies diminish quality (the number of breaks is the quality attribute most valued by customers) to reduce its costs, however, this creates inefficiency regarding service, use of inputs, etc.
[8] A summary of these variables and its descriptive statistics is detailed in Appendix 4.

independence of inefficiency. The calculation in two steps, then, would not provide results as appropriate as those obtained using one-step estimation.

This problem was solved by Kumbhakar, Ghosh and McGukin (1991) and Reifschneider and Stevenson (1991), who proposed a stochastic frontier model that included effects associated with inefficiency, expressed as a function of a set of explanatory variables. Under this premise, the model will be held in a single step.

On the other hand, Battese and Corra (1977) proposed an expression of the inefficiency term related to its variance. The authors found the relationship $\sigma^2 = \sigma_\mu^2 + \sigma_v^2$ (where σ_μ^2 is the variance of the inefficiency and σ_v^2 is the residual variance) and derived a parameter $\gamma = \sigma_\mu^2 /(\sigma_\mu^2 + \sigma_v^2)$, which must be between 0 and 1. A value of 1 for γ would indicate that there are inefficiencies in the model and that the movements of the frontier are due to inefficiency, and not by the error term v. This representation will allow a test of non-existence of inefficiencies in the model, i.e. $\gamma = 0$.

IV. Results

1. The Model

The model presented in the previous section was estimated by Maximum Likelihood (its results are shown in the next table). The first group of variables corresponds to the Stochastic Cost Frontier, the inefficiency regressors are presented in the second group.

As expected, Clients impacts positively on distribution cost, just like Losses, which is consistent with the fact that the utility is forced to increase its costs to compensate the distribution energy losses. OH's coefficient has the expected sign; it implies that is less expensive to distribute energy in a more populated area than in a less populated area.

Both inputs, PL and PK, have positive coefficients, which evidence the expected effect on distribution cost. This is intuitively correct for it implies the following: (1) the greater the wages, greater the costs incurred and (2) as time goes by, financial expenses (interests and depreciation) are generated and the Utility would have to restock capital which means greater costs.

The trend variable was included to measure technological changes. In consequence its coefficient should be positive because Utilities become more efficient and its costs decrease as technology advances. Nevertheless, the estimation indicates that the effect is negative. This result could be explained by the fact that the State is responsible for investing in remote areas where there is no concessions (inefficient investment). Nevertheless, this would be an interest subject for future investigations.

Finally, the dummy variable REG2005 has a positive coefficient. This implies that OSINERGMIN distributional cost revision in 2005 has lead to an increase in distribution costs. According to information presented in the Distribution Energy Tariff Fixation for 2005, the impact shown is consequence of differences between market and projected distribution costs, the last ones included also an increase in distributions networks. Thus, the dummy variable controlled regulation changes[9].

Table 4
Frontier and Inneficiency Estimation

Variable	Coefficient	(S.E)
Constant	23.05*	(1.59)
Clients	5.74E-06*	(9E-07)
OH	0.14*	(0.03)
Losses	10.43*	(1.33)
Trend	0.43*	(0.15)
Ln (D+F / FNA)	0.45**	(0.30)
Ln Wages	0.61**	(0.39)
Reg 2005	4.49*	(0.78)
Constant	-11.33*	(3.84)
N_Outages	0.15*	(0.05)
D_Outages	0.15*	(0.03)
CW	-0.01*	(0.00)
Mountains	0.19***	(1.01)
Jungles	4.02*	(1.52)
Ownership	-10.31*	(3.00)
Sigma-squared	33.35	(7.25)
Gamma	0.93	(0.02)

*, **, Significance level at 5%, 10% respectevely

*** not Significant

Inefficiency determinants need to be analyzed closely. Firstly, results shown that private utilities are less inefficient than public utilities. In consequence, private administration has been favorable in the analysis period. This result agrees with Perez-Reyes and Tovar (2009), even though the different methods. However, it contrasts with Bonifaz and Santin (2000). These differences are probably caused by different time period in the studies, as private administration contribution to reduce inefficiency takes time and investments need to settle. In fact, some Utilities were privatized between 1997 and 1998, Electro Norte, Electro Noroeste, Hidrandina and Electro Centro. Thus, studies with periods closer to privatization process, like Bonifaz an Santin, could imply that between 1995-1998 private administration had no effect in efficiency, but in the long run, this paper prove it does improve efficiency.

In second place, Clients/Worker ratio has manifested the expected results: the fewer workers needed to supply concession clients, the less inefficient the utility. In third term, both number and duration of outages have a positive relation with inefficiency, which is intuitively correct, reflecting Utilities' inadequate outages management and, in consequence, greater inefficiency. Söderberg (2007) proposed that Utilities tend to decrease service quality (measured by number and duration of outages) so they could reduce distribution costs.

[9] These regulatory changes are due to costs review of involved companies to fix tariffs for a period of four years.

Dummy variables Mountains and Jungle present a positive relation with inefficiency, which implies that these conditions are counterproductive in efficiency terms. Usually, clients in these areas are more disperse and geography complicates distribution. However, Mountains was not significant, thus this condition is not so relevant to explain inefficiency.

Several authors propose hypothesis tests to justify the estimates of efficiency. These tests start by estimating an OLS model (the restricted model) and then compare it to a Maximum Likelihood model. These comparisons are made by contrasting the generalized likelihood ratio with a critical value. The critical values correspond to the tables reported in the work of Kodde and Palm[10] (1986).

Table 5
Hypothesis tests

Null Hypothesis	Log Likelihood	Critic Value*	Statistic	Decision
H_o: $\mu = \sigma^2_u = 0$	-424.41	5.14	14.86	Reject Ho
H_o: $\gamma = \delta_0 = \delta_1 = .. = \delta_6 = 0$	-409.69	14.85	44.31	Reject Ho
H_o: $\gamma = 0$	-424.53	2.71	14.62	Reject Ho

** Represents 5% critical values*

The first test has the null hypothesis that the inefficiency is distributed as half normal ($\mu = \sigma^2_u = 0$). When the OLS model is restricted to a zero inefficiency (μ) we can say that the distribution is assumed to be half normal (Battese and Coelli, 1995). In this case, the likelihood ratio is greater than the critical value (14.86 vs. 5.14), thus rejecting the null hypothesis that the inefficiency is zero and therefore distributed as half normal. By contrast, this case can be taken as if the inefficiency were truncated normal.

The second null hypothesis (Ho: $\gamma = \delta_0 = \delta_1 = ... = \delta_5 = 0$) assumes that there is no inefficiency effects. As you can see, the likelihood ratio exceeds the critical value, so it can be concluded that there is no statistical evidence to suggest that there is no inefficiency effects in the model.

Finally, the third hypothesis indicates that deviations from the efficiency frontier are due to statistical noise. In the estimated model, the parameter γ (ratio of variances proposed by Battese and Corra, 1977) is close to one (approximately 0.93), indicating that inefficiency effects are highly likely to be significant in the analysis of stochastic frontier.

This was corroborated with the generalized likelihood ratio, where the calculated statistic is 14.62. This is higher than the critical value reported in the tables Kodde and Palm (1986), which assumes 5% significance and one restriction.

[10] According Coelli, Rao and Battese (1998) the number of degrees of freedom used for choosing the critical value equals the number of constraints posed by the null hypothesis.

2. Inefficiency Ranking

The inefficiency terms were extracted after performing the single step methodology. This responds to the relatively easy possibility to build inefficiency rankings and compare them with other measures, such as those used by the regulator, OSINERGMIN.

The next table shows the results of technical efficiency by Utilities. A value of one would denote that the company is fully efficient, while a value of 1.5, for example, denotes that the company incurs in a 50% increase from its efficient cost value.

The results obtained using Stochastic Frontier estimation differs from partial productivity indicators (As stated before, these indicators are incomplete, mainly because they only consider one dimension, related to a specific issue. However, efficiency rankings from the SFA approach take into account many variables for a more accurate estimation). According to the estimated inefficiency, the first and last companies from the rankings are Edelnor and Emseusa, respectively. Meanwhile, the ratio of clients over employees shows that those companies are Edelnor and Coelvisac. However, if efficiency were measured by distribution losses, the best ranked company would be Coelvisac, while the least efficient Emsemsa. Clearly, the results, even among the partial indicators are not consistent with each other.

Table 6
Efficiency ranking comparison[11]

Utility	Efficiency		C/W		Losses	
Edelnor	**1.023**	**(1)**	**1,822**	**(1)**	0.086	(3)
Seal	1.027	(2)	1,228	(4)	0.147	(16)
Hidrandina	1.028	(3)	1,452	(2)	0.103	(10)
Luz del Sur	1.029	(4)	1,153	(5)	0.071	(2)
Electronoroeste	1.044	(5)	1,118	(6)	0.099	(6)
Electro Sur Medio	1.047	(6)	459	(15)	0.116	(11)
Electrosur	1.055	(7)	856	(12)	0.102	(8)
Electronorte	1.056	(8)	971	(10)	0.102	(9)
Coelvisac	1.059	(9)	**50**	**(19)**	**0.026**	**(1)**
Edecañete	1.063	(10)	1,043	(8)	0.094	(5)
Electro Ucayali	1.068	(11)	644	(14)	0.100	(7)
Electro Oriente	1.069	(12)	788	(13)	0.127	(13)
Electro Tocache	1.074	(13)	356	(18)	0.215	(18)
Electrocentro	1.080	(14)	1,256	(3)	0.090	(4)
Electro Sur Este	1.100	(15)	1,015	(9)	0.120	(12)
Electro Puno	1.120	(16)	1,061	(7)	0.144	(15)
Emsemsa	1.141	(17)	455	(16)	**0.249**	**(19)**
Sersa	1.159	(18)	959	(11)	0.156	(17)
Emseusa	**1.200**	**(19)**	436	(17)	0.142	(14)

C/W accounts for Clients / Workers ratio

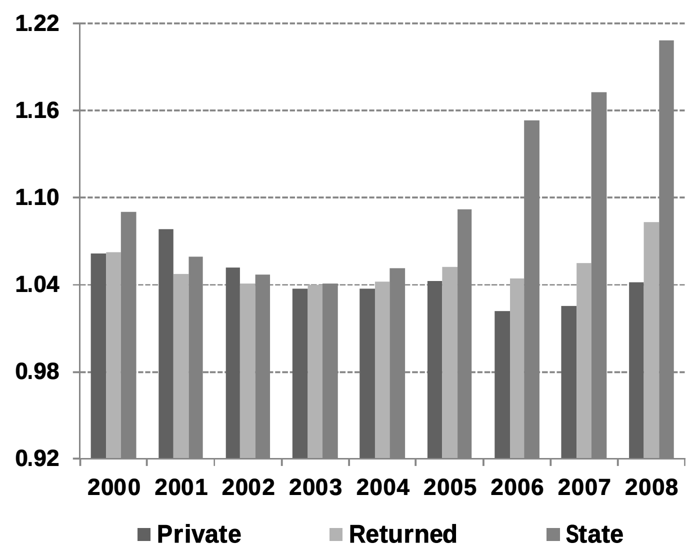
To test the consistency of this ranking, we performed the Spearman's rank correlation test. The results showed that there is a low to medium correlation between the ranking of inefficiency and partial indicators, with a -0.519 correlation between the ranking and the variable Clients/ Worker and 0.515 in relation to the variable Losses.

[11] A graphic for efficiency ranking is presented in Appendix 5

Even though Edelnor is the first company listed in the ranking, we must take into account that it operates under better and ideal conditions, with accessible areas of higher density, unlike other companies located in the mountains or jungle, places where the energy is hard to distribute. Emseusa belongs to this case.

The following chart shows that private companies, even those that were returned to the state, have a lower average inefficiency with respect to public enterprises. Thus, on the basis of the last eight years, one might conclude that the privatization process of the 90's has been beneficial in terms of efficiency, especially in the first half of the new millennium.

Figure 2
Average inefficiency by type of ownership, 2000 - 2008



Appendix 6 contains a ranking categorized by region and Typical Sector (where 1 accounts for higher density and 5 for lower density)[12]. As can be seen, most of the efficient companies operate in the coast, with higher density populations than other Utilities. Moreover, companies operating in the mountains and / or forest have lower performance, a fact that had already been verified with the estimation of the previous section.

The second part of the table contains the typical sectors for each distributor. While most companies distributes to various typical sector, OSINERGMIN assigns weights for each of them. These weights, according to Article 5 of the Directorial Resolution N ° 015-2004 EM / DGE, are conformed by sales of energy for each electrical system (either medium or low voltage) in the period November 2005 - October 2009. Thus, the first ranked company, Edelnor, distributes primarily to the typical sector 1 (urban area of high density). On the other side, Emseusa distributes energy to rural-urban areas only.

[12] For more details about the sectors, Appendix 7 shows more information.

V. Conclusions

With this one step procedure, we found that on average private companies are more efficient than the State. Also, the number and duration of customer interruptions and the ratio C/W, proxies for companies' management, had the expected impact on inefficiency. An increase in the number of interruptions affects positively the inefficiency, while the more customers per employee, the less the inefficiency.

The impact of rough geographical conditions and difficult access, characteristics of the mountains and forests, affects positively inefficiency. Thus, companies like Electro Puno or Sersa show negative results in terms of efficiency, possibly due to the conditions under which they operate: the geographical nature, concession areas of low density, among others.

We have also found that inefficiency has increased since 2005 (especially in State companies). One possible answer could be the interrelations with other sectors, like Generation. In 2004, the spot price diverged from the regulated price in the Generation sector (due to excess in demand). Thus, these enterprises would not sell at this price and Distribution companies had to withdraw energy without a contract. Even though this could be a possible explanation, this issue is still open for more questions and answers.

The estimation of a ranking of efficiency through this methodology can be quite useful to the regulator. The ranking showed that Edelnor, Seal, Hidrandina (privatized but later returned to the State) and Luz del Sur were the least inefficient. In general, the results show that, on average, privatization was positive in terms of efficiency. Thus, it was found that the inefficiency of privatized enterprises remained below the inefficiency of state enterprises. Even companies that were privatized and returned to the state showed lower inefficiency levels than that those who remained public all the time. This would provide evidence for the continuation of the privatization process, especially in the southern companies like Electro Sur Este or Electro Puno, among others.

Finally, although this estimations is more robust than those found in previous researches, it is recommended to make a country analysis in Latin America for the sake of obtaining more degrees of freedom for the estimation.

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VII. Appendix

Appendix 1
Main variables of Peruvian electricity distribution companies (2000 - 2008)

Utility	Total Customers 1/.		Total Sales 2/.		Workers		Net Fixed Assets 3/.		Personnel Expenditure 4/.	
	Mean	% Var.	Mean	% Var.	Mean	% Var.	Mean	% Var.	Mean	% Var.
Coelvisac	818.2	46.1%	56.7	30.0%	16	0.3%	17,782.6	16.5%	24.30%	-4.2%
Edecañete	25,611.6	3.0%	65.3	6.1%	25	4.8%	36,174.2	5.7%	17.48%	1.4%
Edelnor	927,385.9	1.9%	4,136.8	5.3%	574	-0.2%	1,931,346.2	1.1%	10.52%	0.3%
Electro Oriente	128,780.4	6.1%	235.6	9.0%	225	22.9%	326,509.2	0.9%	26.78%	-4.8%
Electro Puno	117,412.9	6.0%	138.7	8.2%	116	8.4%	184,652.5	-1.5%	17.07%	-1.2%
Electro Sur Este	230,596.6	5.7%	252.7	8.5%	240	2.8%	318,888.7	4.7%	21.20%	-3.0%
Electro Sur Medio	124,842.3	4.7%	435.8	5.5%	280	-1.3%	192,839.0	3.8%	13.97%	1.0%
Electro Tocache	7,017.7	14.2%	6.7	23.1%	22	28.5%	808.8	-3.5%	16.55%	5.5%
Electro Ucayali	41,342.1	6.6%	120.5	9.2%	75	20.1%	107,420.5	-1.4%	17.28%	-1.3%
Electrocentro	365,698.7	6.4%	466.8	4.8%	300	3.7%	478,456.3	0.6%	19.63%	-3.1%
Electronoroeste	237,088.9	5.8%	514.7	9.3%	216	5.1%	262,151.4	-1.1%	16.48%	-2.1%
Electronorte	214,743.2	6.4%	345.0	9.3%	229	3.2%	178,825.4	1.7%	18.49%	-3.3%
Electrosur	96,569.1	4.3%	186.6	7.4%	117	6.9%	115,228.5	2.4%	17.48%	0.9%
Emsemsa	5,827.7	4.4%	5.8	9.7%	13	1.0%	272.4	22.9%	22.73%	5.0%
Emseusa	5,176.9	6.3%	5.4	8.8%	15	25.8%	3,747.2	n.a.	16.05%	n.a.
Hidrandina	405,296.9	5.7%	855.3	5.9%	303	15.5%	645,668.7	6.5%	18.12%	3.0%
Luz del Sur	729,217.4	2.4%	4,255.5	5.3%	633	1.8%	1,504,494.5	5.9%	12.08%	-2.0%
Seal	238,246.6	3.9%	546.2	0.6%	216	3.0%	204,561.4	2.6%	15.49%	5.1%
Sersa	4,118.3	3.9%	3.8	6.1%	4	5.6%	84.5	19.1%	12.16%	-0.1%
Average		**7.8%**		**9.6%**		**9.1%**		**3.4%**		**-0.6%**

1/. Total customers comprises medium and low voltage

2/. Total sales comprises medium and low voltage sales. Expressed in GWh.

3/. Expressed in Thousands of Soles in 1994.

4/. Personnel expenditures are represented by the sum of personnel and outsorcing expenditures divided by total income.

Source: OSINERGMIN. Statistical Memories.

Appendix 2
Companies' ownership

Company	Ownership		
	2000	**2002**	**2008**
Coelvisac	Private	Private	Private
Edecañete	Private	Private	Private
Edelnor	Private	Private	Private
Electrocentro	Private	State	State
Electronoroeste	Private	State	State
Electronorte	Private	State	State
Hidrandina	Private	State	State
Electro Oriente	State	State	State
Electro Puno	State	State	State
Electrosur	State	State	State
Electro Sur Este	State	State	State
Electro Sur Medio	Private	Private	Private
Electro Ucayali	State	State	State
Emsemsa	State	State	State
Luz del Sur	Private	Private	Private
Seal	State	State	State
Sersa	State	State	State
Electro Tocache	State	State	State
Emseusa	State	State	State

Source: OSINERGMIN

Appendix 3
Electrical systems by typical sector

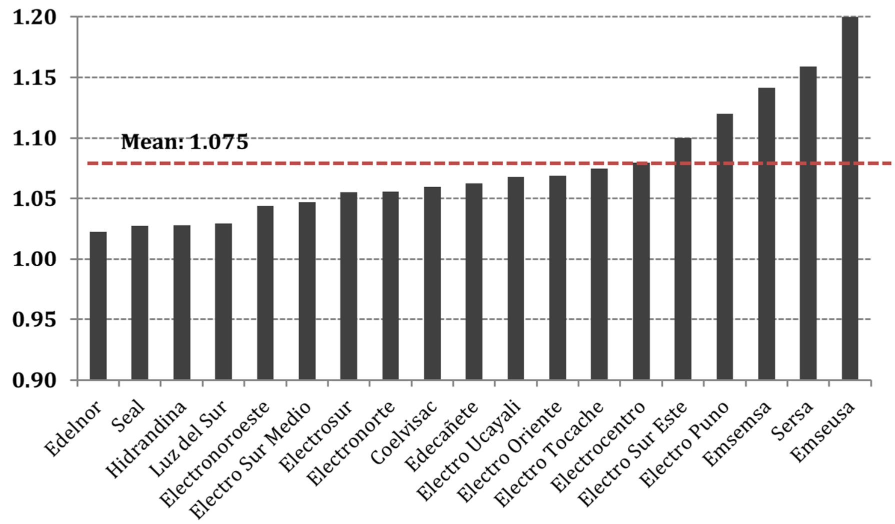
Typical Sector		Electrical Distribution System (Model Company)	Responsible Electrical Distribution Company
1	Urban - High Density	Lima Sur	Luz del Sur
2	Urban - Medium Density	Huancayo	Electrocentro
3	Urban - Low Density	Caraz-Carhuaz-Huaraz	Hidrandina
4	Rural - Urban	Chulucanas	Electronoroeste
5	Rural	Valle Sagrado (Calca, Urubamba and Písac)	Electro Sur Este
Special	Villacuri's electrical distribution system 1/.	Villacurí	Coelvisac

1/. Agriculture system with a particular configuration and charge levels
Source: OSINERGMIN, 2005

Appendix 4
Descriptive Statistics of Variables

Variable	Description	Mean	Standard Deviation	Maximum	Minimum
Costs	Distribution Costs measured in Nuevos Soles per Kwh.	35.08	5.61	52.90	19.91
Clients	Utilities number of clients	205,567.96	249,156.20	1,027,840.00	173.00
OH	Kilometers of Overhead distribution lines per client	6.05	7.93	52.67	0.82
Losses	Distribution losses / Sales	12.05%	5.44%	38.80%	1.54%
Ln (D+F / FNA)	Price of capital, express as the sum of interest an acumulative depreciation divided for Fixed Net Active	0.86	0.61	4.20	0.08
Ln Wages	Natural Logarithm of utility's expenses in workers, in other words, the sum of all wages	4.55	0.64	5.81	2.85
Reg 2001	Dummy variable that activates in 2002, year which OSINERGMIN new costs tarification becomes valid	-	-	1.00	0.00
Reg 2005	Dummy variable that activates in 2006, year which OSINERGMIN new costs tarification becomes valid	-	-	1.00	0.00
N_Outages	Natural Logarithm of Mean frequency outages per user (SAIFI, its Spanish abbreviation)	3.01	0.61	4.23	1.38
D_Outages	Natural Logarithm of Mean duration of outages per user (SAIDI, its Spanish abbreviation)	2.97	1.75	4.92	-4.91
CW	Clients per worker ratio	901.13	462.62	3,383.00	10.00
Mountains	Dummy variable that activates when the utilities distributes energy in the mountains	-	-	1.00	0.00
Jungles	Dummy variable that activates when the utilities distributes energy in the jungle	-	-	1.00	0.00
Ownership	Dummy variable that activates when the utility ownership is private or has been privatized	-	-	1.00	0.00

Appendix 5
Average Inefficiency by Utility (2000 – 2008)



Appendix 6
Electrical systems by typical sector

Company	Mean Inefficiency		Region	Typical Sector	Principal Sector	
Edelnor	1.023	(1)	Coast	1, 2, 3 y 5	1	95%
Luz del Sur	1.029	(4)	Coast	1	1	100%
Electro Sur Medio	1.047	(6)	Coast	2, 3, 4 y 5	2	96%
Electronoroeste	1.044	(5)	Coast	2, 3, 4 y 5	2	83%
Electrosur	1.055	(7)	Coast	2 y 5	2	95%
Coelvisac	1.059	(9)	Coast	3 y Esp*	Esp*	53%
Edecañete	1.063	(10)	Coast	2 y 4	2	88%
Emsemsa	1.141	(17)	Coast	3	3	100%
Electro Ucayali	1.068	(11)	Jungle	2, 3 y 4	2	92%
Electro Oriente	1.069	(12)	Jungle	2, 3, 4 y 5	2	80%
Electro Tocache	1.074	(13)	Jungle	3	3	100%
Sersa	1.159	(18)	Jungle	3	3	100%
Emseusa	1.200	(19)	Jungle	4	4	100%
Seal	1.027	(2)	Sierra	2, 3, 4 y 5	2	85%
Electrocentro	1.080	(14)	Sierra	2, 3, 4 y 5	2	56%
Electro Puno	1.120	(16)	Sierra	2, 3, 4 y 5	2	54%
Electro Sur Este	1.100	(15)	Sierra	2, 3 y 5	2	54%
Hidrandina	1.028	(3)	Coast & Sierra	2, 3, 4 y 5	2	84%
Electronorte	1.056	(8)	Coast, Sierra & Jungle	2, 3, 4 y 5	2	75%

**Agriculture system with a particular configuration and charge levels*

Appendix 7
Weight factor for VAD by typical sector

Utility	Weights by Typical Sector							Total
	1	2	3	4	5	Special	SER*	
Coelvisac			47.38%			52.62%		100%
Edecañete		87.87%		12.13%				100%
Edelnor	94.95%	4.68%	0.34%		0.03%			100%
Electro Oriente		80.48%	6.14%	2.28%	11.03%		0.07%	100%
Electro Pangoa		100.00%						100%
Electro Puno		53.72%	18.84%	1.72%	24.74%		0.98%	100%
Electro Sur Este		53.53%	19.58%		26.37%		0.52%	100%
Electro Sur Medio		96.13%	0.82%	0.06%	2.14%		0.85%	100%
Electro Tocache			99.56%				0.44%	100%
Electro Ucayali		91.71%	6.94%	1.35%				100%
Electrocentro		55.60%	16.85%	8.88%	18.01%		0.66%	100%
Electronoroeste		83.31%	5.61%	8.67%	2.36%		0.05%	100%
Electronorte		75.33%	15.45%	3.93%	4.89%		0.40%	100%
Electrosur		94.93%			5.07%			100%
Emsemsa			100.00%					100%
Emseusa				100.00%				100%
Hidrandina		83.59%	9.78%	2.51%	3.62%		0.50%	100%
Luz del Sur	100.00%							100%
Seal		85.19%	8.30%	1.17%	5.27%		0.07%	100%
Sersa			100.00%					100%

** Weigths for Low Voltage VAD in Rural Electric Systems (Sistemas Eléctricos Rurales in spanish)*
Source: OSINERGMIN (2009)