BEHAVIOURAL PERFORMANCE MODELING FOR ELECTRICITY DISTRIBUTION COMPANIES

Mohamed ELSOBKI
Cairo University – Egypt
sobki54@yahoo.com

Mohamed ABDELRAHMAN
Ain Shams University – Egypt
m_abdel_rahmanca@yahoo.com

ABSTRACT

Benchmarking of electricity distribution companies differs significantly from benchmarking of any other industries. Even companies, which seem to have similar operational environments, could have very different cost structures. When benchmarking is used as a regulatory tool it has direct effects on companies profits. The paper presents a methodology to model distribution utilities performance, whether from reliability or efficiency perspective. The model makes use of data accumulated in a database. It depends on calculating the correlation coefficients among the performance indicators and specifying a threshold for those coefficients to indicate proportionality relation. This implies that linear relations can be fitted for the data under consideration. Finally the utility model is expressed in set of linear relations. Those relations provide a tool for assessing the regulatory actions impact on incumbent companies.

INTRODUCTION

Benchmarking of electricity distribution companies differs significantly from benchmarking of any other industries. For example the operational environments of companies vary greatly from one company to another. The costs of electricity distribution vary greatly depending on geographic and demographic issues. Even companies, which seem to have similar operational environments, could have very different cost structures. When benchmarking is used as a regulatory tool it has direct effects on companies profits [1].

Furthermore, quality demands for electricity have risen. There are industrial processes that would suffer greatly due to electricity disruptions. Besides the requirement needed by the industry, also the level of service to which the residential customers have accustomed has risen. This has forced electricity sector regulators to consider quality aspects when deciding proper regulatory measures for electricity distribution monopoly [2].

In conclusion, regulatory actions impact distribution companies performance from both service quality and profit aspects. Since both issues are crucially important to consider in taking regulatory decisions, the impact of any regulatory action should be quantitatively assessed beforehand. This quantitative assessment requires the establishment of a model for the company under research, a question that has been addressed in a previous publication.

The objective of this paper is to propose a methodology for modelling distribution companies based upon historical performance indices. The paper is organized in five sections including this section. Section II describes the statistical model established for a test distribution company. Section III Section presents a case study. Section IV discusses performance contracting. Section V is the conclusions section.

STATISTICAL MODEL DESCRIPTION

It is customary in regulatory agencies to establish a framework of a database to ensure the availability of historical data. This database is necessary to monitor the trend of the performance of all licensed entities including distribution utilities. Numerous entities including regulatory agencies and utilities themselves have a common interest in monitoring the performance. Efforts are spent to build and agree to the performance indicators, their definition, calculation methodology, etc. For distribution utilities, the performance assessment includes technical, financial, customer service, and management indices. Definitely, technical, financial, customer service, and management indices are related together. Table 1 shows the reliability indicators for five distribution companies, A, B, C, D, and E [3]. Table 2 shows installed network components characteristics for the same companies. Table 3 shows some measures of efficiency, viz., network losses, energy sales and labour productivity.

Table 4 shows the correlation coefficients between indicators for reliability, efficiency and network components. The higher the absolute value of the correlation coefficients the stronger the relation between the performance indicators. It is assumed that if the absolute value of correlation coefficients is more than 0.6, this means a proportionality relation between the indices. Consequently, it is assumed that the relationship between this subset of indicators can be approximated by linear functions. The shaded cells in TABLE 4 are all those correlation coefficients that satisfy this criteria, while ignoring the correlation coefficients between an indicator and itself since it scores the highest possible value of “1”, which is logical. However, comparing those coefficients with those of another pool of utilities working in another environment would be indicative of the relative performance between both groups of utilities rather than comparing indicators in absolute terms. The comparison will raise questions about the reason behind discrepancies, if any.

CASE STUDY

Assume that it has been agreed to pick the median of a performance indicator as the benchmark for that indicator. Distribution companies are obliged under a mechanism compliant with the legislative framework in force to reach that benchmark. Considering Customer Average Interruption Duration Index (CAIDI) to represent the reliability of the companies and considering the percentage losses to represent the utility efficiency, both are strongly related to network component utilization indicators, viz., Medium Voltage Over Head transmission Lines length per 100 customers, and number of distribution transformers per 100 customers.

The benchmark for CAIDI is 33.23 minutes/customer. The benchmark for losses is 8.49%. The fitted linear functions between those indices and network parameters are

Losses = -6.885 X MV OHL/100 Customers + 0.762 X # Transformers/100 Customers + 12.1977 (1)

CAIDI = 300 X MV OHL/100 Customers – 185.4106 X # Transformers/100 Customers + 72.8366 (2)

For the abovementioned benchmarks; the losses characteristic line is

-3.7077 = -6.885 X MV OHL/100 Customers + 0.762 X # Transformers/100 Customers

the CAIDI characteristic line is

-39.6066 = 300 X MV OHL/100 Customers – 185.4106 X # Transformers/100 Customers

The objective of the utility is to be below those characteristics with minimum cost. This is a typical linear programming problem. The minimum or maximum cost will occur at the intersection point, i.e., MV OHL/100 Customers = 0.685 and # Transformers/100 Customers = 1.3231. However, the cost function itself is unknown and it depends on the capital investment required, penalties and incentives offered by the regulatory regime.

Those relations therefore have the potential to be utilized to provide a guidance about the impact of regulatory actions on company investments.

TABLE 1-Reliability indicators.

	SAIFI	SAIDI	CAIDI	ASAI
A	0.77	33	43	0.99
B	0.96	5.7	30	1
C	0.55	0.33	33.23	1
D	2.44	1.8	25.74	1
E	0.52	46.29	167.25	0.99

TABLE 2-Installed Network components characteristics.

	O.H.L. M.V./100 Cust.	U.C. M.V./100 Cust.	# of trans. /100 Cust.	O.H.L. L.V. /100 Cust.	U.G L.V. /100 Cust.
A	0.05	0.36	0.37	0.1	0.84
B	0.03	0.44	0.35	0.14	0.31
C	0.29	0.11	0.48	0.64	0.02
D	0.47	0.57	0.92	1.1	0.45
E	0.95	0.24	1.13	1.04	0.15

TABLE 3- Measures of efficiency.

	Energy Sales/km	Losses	Labor Productivity
A	0.26	15.7	1.09
B	0.33	12.63	0.39
C	0.17	6.57	0.64
D	0.2	7.75	0.66
E	0.13	8.49	0.55

PERORMANCE CONTRACTING

Finally, in order to affect the companies decisions on investment there must be a tool that carry financial consequences. In many domains, the tool is a performance contract Indeed, it would have made a complete sense if instead of delivering a report to distribution licensees, they received a material bonus or a penalty if the legislative framework allows such measures. One proposal is to provide incentives to operating companies. The challenge is to finance those incentives. However, the issue remains a bottle neck for the whole process.

A performance agreement is generally thought of as a legally binding contract between a regulatory authority and a licensee; freely entered into by each party. Under normal circumstances such an agreement would require the Agency to reward a licensee on the basis of the licensee's achievement of one or more specifically identified performance standards. It would also require the Agency to penalize licensees that failed to do so.

In the absence of tariff-setting and fining authorities, the regulator's powers appear to be limited to its ability to reduce (or increase) license fees. Given that license fees are usually nominal, it would seem that the regulator has very little ability to financially reward a licensee by reducing license fees. However, the regulator will have more leverage for penalizing a licensee as increases in license fees can be much more substantial. It is recommended that using whatever power it may be able to acquire, that the regulator take whatever steps forward it can using the performance agreement mechanism. By employing this tool as a kind of halter today, it may well be that the licensees will not bridle at such a bit when stronger powers are accorded to the regulator.

CONCUSIONS

The paper presented a methodology to model distribution utilities performance, whether from reliability or efficiency perspective. The model makes use of data accumulated in a data base. It depends on calculating the correlation coefficients among the performance indicators and specifying a threshold for those coefficients to indicate proportionality relation. This implies that linear relations can be fitted for the data under consideration. Finally the utility model is expressed in set of linear relations. Those relations provide a tool for assessing the regulatory actions impact on incumbent companies.

REFERENCES

[1] Pahwa, A.; Xiaoming Feng; Lubkeman, D, 2003, "Performance evaluation of electric distribution utilities based on data envelopment analysis;Power Systems, IEEE Transactions on ,Volume: 18 , Issue: 1 ,Pages:400 – 405

[2] Feng-Yu Lo; Chen-Fu Chien; Lin, J.T. 2001;"A DEA study to evaluate the relative efficiency and investigate the district reorganization of the Taiwan Power Company Power Systems, IEEE Transactions on , Volume: 16 , Issue: 1 , Pages:170 -
178

[3] M.S. Elsobki (jr.) and M. Abdel-Rahman, "Incentive Based Performance Enhancement of Distribution Companies", *CIRED 2005, Turin, Italy*

TABLE 4-Correlation coefficients among performance indicators.

	SAIFI	SAIDI	CAIDI	ASAI	Energy Sales/km	Losses	O.H.L. M.V. /100Cust.	U.C. M.V. /100 Cust.	# of transf. /100 Cust.	O.H.L. L.V./100 Cust.	U.G L.V./100 Customers	Labor Prod. uctivity
SAIFI	1	-0.48	-0.43	0.46	0.09	-0.2	-0.01	0.83	0.28	0.41	0.27	-0.03
SAIDI	-0.48	1	0.83	-0.97	-0.32	0.34	0.49	-0.23	0.4	0.05	0.24	0.32
CAIDI	-0.43	0.83	1	-0.68	-0.61	-0.18	0.84	-0.37	0.71	0.45	-0.3	-0.17
ASAI	0.46	-0.97	-0.68	1	0.27	-0.45	-0.34	0.23	-0.26	0.07	-0.41	-0.54
Energy Sales/km	0.09	-0.32	-0.61	0.27	1	0.73	-0.85	0.5	-0.76	-0.82	0.48	-0.02
Losses	-0.2	0.34	-0.18	-0.45	0.73	1	-0.61	0.29	-0.58	-0.82	0.81	0.5
O.H.L. M.V. /100Cust.	-0.01	0.49	0.84	-0.34	-0.85	-0.61	1	-0.21	0.96	0.86	-0.47	-0.27
U.C. M.V. /100Cust.	0.83	-0.23	-0.37	0.23	0.5	0.29	-0.21	1	0.07	0.02	0.55	-0.02
# of transf./100 Customers	0.28	0.4	0.71	-0.26	-0.76	-0.58	0.96	0.07	1	0.92	-0.31	-0.24
O.H.L. L.V./100 Customers	0.41	0.05	0.45	0.07	-0.82	-0.82	0.86	0.02	0.92	1	-0.46	-0.28
U.G L.V./100 Customers	0.27	0.24	-0.3	-0.41	0.48	0.81	-0.47	0.55	-0.31	-0.46	1	0.76
Labor Productivity	-0.03	0.32	-0.17	-0.54	-0.02	0.5	-0.27	-0.02	-0.24	-0.28	0.76	1