Utilities Policy 53 (2018) 38–48

Contents lists available at ScienceDirect

Utilities Policy

journal homepage: www.elsevier.com/locate/jup

A multi-criteria decision analysis method for regulatory evaluation of electricity distribution service quality

Ailson de Souza Barbosa*, Rafael Amaral Shayani, Marco Aurélio Gonçalves de Oliveira

Department of Electrical Engineering of the University of Brasilia, Campus Universitário Darcy Ribeiro, Faculdade de Tecnologia, Departamento de Engenharia Elétrica, Caixa Postal 4386, CEP 70904-970, Brasília, DF, Brazil

ARTICLE INFO

Keywords:
Incentive regulation
Service quality
Electricity distribution

ABSTRACT

This study aims to evaluate the performance of electricity distribution utilities with the use of a single global index based on a Multi-Criteria Decision Analysis (MCDA) method. The proposed approach allows the ranking of service quality according to three dimensions: supply continuity, voltage conformity and customer satisfaction. The challenge of aggregating various indicators into a single global index was overcome with the Analytic Hierarchy Process (AHP) and Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) methods. This ranking facilitates regulatory assessment of the distributors' performance, and thus improves the quality of services offered by utilities.

1. Introduction

The electricity industry globally underwent substantial changes during the 1990s and, as part of reform initiatives, incentive-based models supplemented or supplanted the traditional rate-of-return (cost-of-service) regulation models for overseeing natural monopolies (Ajodhia et al., 2006; Ajodhia and Hakvoort, 2005; Giannakis et al., 2005; Ter-Martirosyan and Kwoka, 2010).

Incentive regulation has been used in many countries to reduce costs through efficiency gains in natural monopoly activities. More precisely, some form of the RPI-X scheme originally proposed by (Littlechild, 1983) has been implemented in Europe (Cossent et al., 2009) and Latin America (Rudnick et al., 2007). In this mechanism, the regulator sets an initial price that lasts for a period and it is adjusted for changes in inflation and a target productivity change factor “X”. Companies are encouraged to cut their costs in the period between reviews to increase their profit (Joskow, 2008). These models promote efficiency improvements in the absence of market mechanisms and have been popularly used in the regulation of electricity transmission and distribution networks (Jamasb and Pollitt, 2001), being initially introduced in Chile (1982), the UK (1990), and Norway (1991), and subsequently in many other jurisdictions including Australia and Texas in the US (Pollitt, 2008).

In this context, effective regulation of service quality in this sector is increasingly important because when utilities are mainly concerned with profits, they may attempt to reduce their costs, and this may reduce service quality. Furthermore, utilities may seek quality levels that can deviate from the socio-economic optimum (Giannakis et al., 2005).

Service quality is a central problem in the electricity distribution sector. Consumers are sensitive to various aspects of service quality, namely the reliability of the electricity supply, voltage quality, and speed with which their complaints are handled. Regulators must also be concerned with potential contractibility of service quality, perhaps especially when utility companies are privatized (Fumagalli et al., 2007a).

Both theoretical and empirical evidence clearly shows that when regulators impose a price cap that is not directly related to actual costs, this may lower the utilities’ incentives to deliver efficient levels of service quality (Sappington, 2005; Ter-Martirosyan, 2003). As a result, service quality regulation complements price cap or revenue cap regulations in several European countries (Fumagalli et al., 2007a).

Service quality evaluation requires indicators that represent all types of services provided by electricity distribution utilities. This issue gains greater importance given the limited capacity of human resources at the regulatory agency, and the need for regulators to act preventively based on a systematic evaluation of each distribution utility's performance.

The importance of this subject is highlighted by principle number 1 of the Organization for Economic Cooperation and Development (OECD): “Regulatory enforcement and inspections should be evidence-based and measurement-based: deciding what to inspect and how should be grounded in data and evidence, and results should be evaluated regularly” (OECD, 2014).

* Corresponding author.
E-mail addresses: ailsonsb10@gmail.com (A.d.S. Barbosa), shayani@ene.unb.br (R.A. Shayani), mago@ene.unb.br (M.A.G.d. Oliveira).

https://doi.org/10.1016/j.jup.2018.06.002
Received 21 February 2018; Received in revised form 2 June 2018; Accepted 2 June 2018

1.1. Problem formulation

No international standard specifies how a regulatory agency must measure service quality. In the United States, each state may adopt its own criteria, and these vary from state to state. Criteria used include: reliability (System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI), Customer Average Interruption Duration Index (CAIDI)) and security; response to broken cable situations; work accidents; worst circuits in terms of interruption duration and frequency; response to phone calls (average time of response); complaints to the regulatory agency; percentage of meters read by the company, monthly; connection times to new consumer units; consumer satisfaction (LLC and Consulting, 2012).

In Brazil, the Brazilian Electricity Regulatory Agency (ANEEL) establishes the service quality indicators based on the National Electric System's Electric Power Distribution Procedures (PRODIST) (ANEEL, 2017) and on Normative Resolution Nº 414/2010 (ANEEL, 2010), both respectively establishing the technical and customer satisfaction parameters for the service provided. In spite of this advance, not all indicators have quality limits established by the regulatory agency. These indicators are submitted periodically to ANEEL by the distributors. The data are broken down by municipality, by concession area, and are aggregated by region and for the entire country. They are also available to the general public at the ANEEL website.

ANEEL has introduced several indicators that depict various dimensions of the service quality provided by distributors (ANEEL, 2017, 2010). Defining which dimensions should be part of the performance evaluation of a utility company is not an easy task. Determining the most relevant dimensions of service quality, considering the various indicators available in the electricity distribution sector, will shape the results (Carregado, 2003; Santos, 2003). ANEEL currently has a ranking of the distributors, based on the Global Continuity Performance indicator (DGC). In spite of its utility, this index only considers the service continuity dimension, expressed by the following indicators: *Equivalent Duration of Interruption per Consumer Unit (DEC), and Equivalent Frequency of Interruption per Consumer Unit (FEC),* corresponding respectively to the SAID and the SAIF (ANEEL, 2017).

The service provided by electricity distribution utilities is characterized by the following dimensions: supply continuity, voltage quality, and customer satisfaction (Fumagalli et al., 2007b, 2007a). As mentioned, the indicators that represent the continuity of the power supply are the interruption duration and frequency indices. The voltage quality dimension is expressed by voltage imbalances, voltage fluctuation, short variations in voltage, wave distortion, and harmonics, among others. The customer satisfaction dimension is related to call-center performance issues, quality of information on the electric bill, time to establish new connections, and consumer complaints, among others.

Consequently, a need exists to develop a global index that expresses the quality of the service provided by the distributors, as well as to establish a ranking of the quality of the service provided by the distributors. This index may thus facilitate monitoring and supervision by regulatory agencies, given the agencies' limited capacity and resources.

This study proposes a method of global evaluation of the quality of the services provided by the electricity distributors in Brazil, considering the technical and customer satisfaction aspects, with the use of a metric based on multi-criteria decision analysis (MCDA), to determine a ranking of companies.

Electricity service quality involves multiple conflicting criteria. Each criterion has its own units, and certain criteria may be minimized or maximized. Any given distributor may rarely present the best performance simultaneously for all dimensions considered and some criteria may be in conflict. In essence, MCDA addresses the challenge of optimization when faced with different simultaneous objective functions (Gomes et al., 2004).

This paper is divided into eight sections. In Section 2, the two main methods of multi-criteria decision support are presented; Section 3 presents the service quality dimensions; Section 4 presents the methodology proposed in this paper; Section 5 presents the comparison of quality dimensions and defines the weights; Section 6 presents the case study; Section 7 presents the results and discussion; and Section 8 concludes the study.

2. Multi-criteria decision analysis methods

2.1. Applying MCDA to the energy sector

The use of MCDA has been growing fast in several areas such as Operational Research (OR) over the last decades. MCDA can be used to rank various alternatives, based on multiple conflicting criteria. MCDA is used in management, business, engineering, science, and other areas of human activity to address complex theory and methodology problems (Marttunen et al., 2017). The most common methods are given in the literature: the Analytic Hierarchy Process (AHP; Saaty, 1990), the Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE; Brans et al., 1986), ELimination Et Choix Traduisant la REalité (ELECTRE; Roy, 1996), and Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH; Bana e Costa and Vansnick, 1994).

These multi-criteria methods have been used in various areas (Diaz-Balteiro et al., 2017), from agriculture, forestry and fishing to transportation and utilities, including electricity, and water supply, sewerage, and waste management (Pinto et al., 2017).

In the energy sector, Barin et al. (2009) combined the AHP and Fuzzy Logic methods to manage energy using renewable sources and energy storage. Also in this area, Wei et al. (2016) used a combination of the AHP and Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) and Geometric Analysis for Interactive Aid (GAIA) with good results, to prioritize the best energy storage technologies. Soares et al. (2014) also used the combination of AHP and PROMETHEE and service quality indicators to prioritize investments in distribution networks. The ELECTRE method was used to a governance scorecard for regulatory agencies (Marques and Pinto, 2018).

PROMETHEE applications in energy management have focused on selecting and evaluating energy generation, or the exploitation of alternatives (Behzadian et al., 2010). PROMETHEE was employed in this same context to evaluate energy technology, environmental impacts, and social and economic factors, and then the authors proposed development of strategy for future energy systems in Taiwan (Tzeng et al., 1992).

2.2. Methods chosen

AHP and MACBETH are similar decision-making process that can incorporate tangible and intangible criteria to rank alternatives. According to Ishizaka and Siraj (2018), “MACBETH is at first glance very similar to AHP. However, the two main differences from the user perspective are the evaluation scale (interval instead of ratio) and the need to be consistent in providing judgments. In MACBETH the priorities cannot be calculated at all when the (decision maker) DM is inconsistent.” In this regard, the AHP method was chosen to determine the service quality assessment criteria because it may be implemented in a simple spreadsheet, while MACBETH cannot be implemented with spreadsheets alone since the priorities vector is calculated with linear programming model (Salomon, 2008).

PROMETHE and ELECTRE are methods of over-outranking, that can be applied for several sectors: comparisons are made between action potentials by means of binary relations given the option of one overcoming the other. According to (Campos, 2011), the PROMETHEE and ELECTRE methods presented similar results. Gomes et al. (2004) pointed out that “both methods are vulnerable to subjectivities,