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IMPACTS AND BENEFITS OF CENTRALIZED MEASUREMENT SYSTEM. CASE STUDY OF A BRAZILIAN ELECTRICITY UTILITY

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Abstract - This article discusses the conceptual basis and the criteria for the installation of a centralized measurement system in the Baixada Fluminense, sub area of concession of the electricity utility of Rio de Janeiro (Light Energia). The study estimates the energy consumption and the average revenue that results from the implementation of the proposed facility to replace the traditional measurement system in place. The sub area of concession selected was defined based on the following two characteristics: area associated with high rate of electricity losses and vulnerability of the power grid exposed to the community. The methodology used to develop the work included a literature review on systems of electricity metering and a study of the socioeconomic profile of the selected region. The impact of the proposed technological change on the energy consumption was statistically evaluated based on the nonparametric Wilcoxon Test. Based on real data from municipalities located in the region, an analysis of energy consumption behavior was carried out before and after the proposed alternative technology was implemented.

Keywords: Metrology, Energy measuring system, Centralized measurement system, ANEEL.

1. INTRODUCTION

The main concept that characterize centralized measurements refers to its capacity to maintain the identity of each measurement individually, therefore allowing assessment of energy consumption associated to the centralized global consumption and sharing of common components of the measurement system, metrology reliability and significant reduction of the physical space traditionally required by conventional technologies.

The Centralized Measurement System (CMS) incorporates dedicated electronic modules devoted to individual measurement of electric energy. It performs functions associated with the concentration, processing and cautioning about consumption related information in a centralized fashion [1] [2].

Implementation of a CMS requires high investment to upgrade the overall electric network system in place to shield the installation from unauthorized users, therefore mitigating fraud occurrences [3] [4] [5]. In addition, CMS allows the on-line attendance of customers through the Measurement Control Center (MCC) [6].

Among the benefits to the utility and to the Regulator that results from the use of a CMS are: (i) cost reduction associated with theft detection; (ii) replacement of the manual readings by a real time remote measurement system and (iii) reduction of cost transaction and processing of debts from bad payers that imposes costly procedures associated with energy cuts and renewing of customer services.

To customers, the advantages of using CMS are remarkable as it adds unquestionable quality to the energy supply while avoids power failures and oscillation in the network. Detects failures in the distribution, improves quality of client attendance, identifying customers that are eligible to bonus or discounts in their electricity bills.

Recently, the Electricity Utility is investing in smart meters (CMS types) that brings benefits to the utility. In 2011, two hundred and eight thousand smart meters was installed in this sub area of the city of Rio de Janeiro here studied (i.e.: Baixada Fluminense, West Zone and Barra da Tijuca and Jacarepaguá condominiums). In 2013, one hundred twenty nine thousand new meters were installed, out of which 60% in the Baixada Fluminense.

Energy meters: state of the art

Despite of the fact that low income domiciles are more vulnerable to energy theft, and that Baixada Fluminense exhibits higher rate of energy losses and less geographic complexity, the electricity utility decided to install CMS in this region.

Considering that CMS is usually installed in domiciles connected to the low voltage line, more vulnerable to fraude, it was suggested that new installations should be made in domiciles of subnormal conglomerates, so defined in conformity with the 2010 Census criteria.

The case study focuses on seven of the thirteen counties of Baixada Fluminense (Belford Roxo, Duque de Caxias, Guapimirim, Itaguaí, Japeri, Magé, Mesquita, Nilópolis, Nova Iguaçu, Paracambi, Queimados, São João de Meriti e Seropédica). Those counties consume 18% of the total energy distributed by the electricity utility Light Energia in the State, it represents 22% of all residence consumption. These data attribute statistical reliability to the chosen sample that gathers 25% of the whole State population..

Even though there are thirteen municipalities at "Baixada Fluminense", this study concentrates in seven of them, where the electricity is supplied by Light Energia. CMS were installed in these communities, technology maintained by the electricity utility. They are: Belford Roxo,

Duque de Caxias, Nilópolis, Nova Iguaçu, Mesquita, São João de Meriti and Queimados.

The data analysis refers to two periods of 12 months corresponding to the first round of CMS installed in October 2011: one before and one after the implantation of the new measurement system (see Table 1). They are: Belford Roxo, Duque de Caxias, Nilópolis e Nova Iguaçu.

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Table 1. Average consumption before and after the CMS installation (Oct. 2011).

County	KWh	
	Before	After
Belford Roxo	136	223
Duque de Caxias	155	191
Nilópolis	183	236
Nova Iguaçu	180	209

Out of the total residential installations, 236 falls into the tariff subclass entitled "low-income consummers" (baixa renda), as shown in Table 2.

Out of the total official data made available by the Electricity Utility, at "Baixada Fluminenese", 109.858 installations effectively adopted CMS measurement technology, remaining 901.010 installations without access to the Centralized Measurement System. Out of those, only 792.761 installations were eligible to receive the CMS as they are located within the seven communities pre-selected to join the program. Data of Table 3 show the 2013 Investment Plan for the 2013 period.

Table 2. Installations analysed under both residential tariff-class: "pure residencial" and "low income consumer".

County	Residential	Low income residencial	Total
Belford Roxo	1.598	38	1.636
Duque de Caxias	43		43
Nilópolis	2.541	69	2.610
Nova Iguaçu	1.199	129	1.328
Total	5.381	236	5.617

Table 3. Installations with and without CMS in "Baixada Fluminense".

	Installations		
County	Total	With SMC	Without SMC
Queimados	45.869	1.582	44.287
Mesquita	59.649	3.352	56.297
Nilópolis	58.195	9.475	48.720
Belford Roxo	145.752	13.830	131.922
São João de Meriti	150.436	15.137	135.299
Duque de Caxias	171.254	27.163	144.091
Nova Iguaçu	271.464	39.319	232.997
Itaguai	42.948		42.948
Japeri	23.997		23.997
Paracambi	16.371		16.371
Seropédica	24.933		24.933
Total	1.010.868	109.858	901.010

Table 4 shows the amount of new CMS installations implemented in 2013, whose details for analysis is not yet available.

Data on Table 5 confirms that installation of CMS indeed led to a differentiated increase of consumption (kWh) and of the revenue generated (R$). Moneywise speaking, increase in revenues is higher than the correspondent increase energy consumption (kWh), explained by the increase in state taxation (ICMS) affecting the final tariff of energy made effective at the end of 2010.

2. POINTS FOR IMPROOVEMENTS

According to the Wilcoxon Test [7] for paired samples, there is an evidence that the average consumption (kWh) measured at the analysed municipalities was influenced by the installation of CMS (measurements performed before and after insertion of centralized measurement confirms such hypotesis.

Table 4. Installations to receive the CMS in 2013.

County	2013
Duque de Caxias	25.790
São João de Meriti	18.247
Belford Roxo	14.084
Nova Iguaçu	12.626
Queimados	2.135
Nilópolis	3.371
Mesquita	1.148
Total	77.401

Table 5. Increase in R$ (Reais) and in kWh after the installation of the CMS in the selected municipalities.

County	Reais R$			KWh		
	Before CMS	After CMS	Increase (%)	Before CMS	After CMS	Increase (%)
Duque de Caxias	78	119	52.56	163	223	36.81
Belford Roxo	71	97	36.62	155	191	23.23
Nova Iguaçu	85	121	42.25	183	236	28.96
Nilópolis	89	111	24.72	180	209	16.11

Taking into account CMS installed in 2013, (whose data are quite available) it will be possible to expand the analysis. Preliminary view, however, suggests an average monthly earnings of 38% (expressed in reais, R$) and 26% (when expressed in MWh).

Based on the constant actualization of the CMS technology and more efficient procedures to combat and prevent against non-technicallosses, supported by efficient campaigns, it is the authors' belief that correlative studies always contributed to advance the knowledge in such energy-related topics. Among the alternatives for future unfolding of this topic, studies should consider:

- Definition of a regulatory pathway, in order to improve investments in new technologies that aims to reduce the tariff impacts and to inhibit fraud;
- Combat losses associated with new technologies;
- Energy tariff differentiation applicable to specific regions, therefore aiming to reduce deficit in payment;
- Characterization of types of energy consumption in subnormal and conventional domiciles;
- Energy projections showing differences in energy consumption associated with either, low income and conventional domiciles;
- Use of tailor made solutions for specific areas (e.g.: pacified communities);
- Characterize commercial losses and consumption increase induced by the use of CMS at "Baixada Fluminense" communities and neighborhoods;
- Prevision of losses by region, to explain the increase in consumption with the adoption of intelligent CMS technology and its capacity of reducing non-technical losses;
- Georeferencing techniques of defrauders domiciles to be studied.

3. CONCLUSIONS

Combat to technical energy losses and lack of payment of the energy bill impose a complex agenda to be overcome and requires substantialinvestments by the electricity utility. The introduction of the Centralized Measurement System (CMS) —demanding an interactive communication between all involved parts of the energy distribution chain— constitutes a trustable approach for combating against losses and for implementing a sustainable development strategy to be adopted to ensure a reliable measurement of individual and overall energy consumption. The introduction of CMS benefits all interested parts. Reliability in measurement results generates comfort to the consumer and to the regulator, the latter responsible for controlling quality of the of supplied service. Knowledge of the consumption in real time benefits the concessionaire, providing strategic information to base decision-making and management control of non-technical losses and combat lack of payments. Other further generator agents also benefit from this modernization: suppliers, importers and exporters of energy assures more rationality improve their management control of energy systems.

Not less important, it has an educative action as adoption of new technology inhibits fraud temptation (before easily achieved), recovering the dignity of citizenship. Additionally to these advantages, the introduction of CMS helps planning the expansion of the energy system and simplify the calculation of the tariffs that, unavoidably, impacts on consumption. Centralized measurement system (CMS) also has a positive impact to reduce commercial losses.

This work discusses the benefits of using more sophisticated measurement system of energy in light with the applicable legislation. It accomplishes a diagnostic of the measurement park of the electricity utility Light Energia based on socio-economic indicators and in the perspective of using modern smart grid technology capable to assess and grade frauds, losses, and lack of payment in the Baixada Fluminense area of concession.

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