***​MEASURING THE BENEFIT-COST OF A CENTRALIZED MEASUREMENT SYSTEM FOR REDUCING NON-TECHNICAL LOSSES***

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**Overview**

Non-technical losses (NTLs) are one of the main problems that electricity distribution utilities face in developing regions such as Latin America, the Caribbean, sub-Saharan Africa, and South Asia (Correia et al., 2023). In Brazil, NTL reached a level of 14.37 % in relation to the low voltage consumers, equivalent to 33.45 TWh destined for energy theft/misappropriation (ANEEL, 2022). This level is similar to all energy sold to low-voltage consumers in the states of Santa Catarina, Paraná, Mato Grosso do Sul, and Espírito Santo (Reis and Calili, 2023), comprising a populace numbering just over 25 million individuals (IBGE, 2022).

Centralized measurement systems (CMS) have been used in Brazil to reduce non-technical losses, especially in low-income communities. Recently, these systems have encompassed solutions commonly used in smart meters, enabling new functionalities. These features can benefit consumers, distribution utilities, and the government.

Important works in the literature measure the relationship between the benefits and costs of smart metering, such as BEIS (2019), EPRI 2012, Europenan Commission (2012), and Lamin (2013). These works make methodological proposals for calculating the benefit-costs of smart metering.

This article proposes a cost-benefit analysis to evaluate the effectiveness of a centralized measurement system for reducing non-technical losses in low-income communities.

**Methods**

To build a model for evaluating the effectiveness of measurement systems based on a benefit-cost (B/C) analysis, the following steps are proposed:

**Phase I - Documentation and project overview**

* State the basic information of the project and describe the functionalities of the technology used in the project.

**Phase II - Description of cost and benefit parameters**

* In addition to the economic aspect, the social and environmental dimensions must be considered.
* This phase must be conducted through a documentary and bibliographic analysis. For this work, we collected 37 benefit indicators and 22 cost indicators. Many of them have calculation methodologies, but others do not.

**Phase III – Assessment of conflicting parameters**

* Double counting of cost and benefit parameters should be avoided.

**Phase IV – Estimation and monetization of benefits and costs**

* Define the methods for estimating benefit and cost variables.
* Establish the baseline for comparing the parameters considered.
* Define the parameters for monetization (discount rate, inflation index, project time, etc.).

**Phase V – Conducting benefit-cost analysis (B/C)**

* Define comparison scenarios – benefits and costs considered.
* “Stress the analysis” by defining the scenarios.
* Calculate the benefit-cost index in the proposed scenarios.

**Phase VI – Carrying out sensitivity tests**

* Sensitivity tests on the most relevant variables must be carried out (e.g.: average cost of meters per UC and revenue recovered by the distributor).

**Results**

To demonstrate the applicability of the proposed B/C analysis model, a project was defined to reduce non-technical losses in the region of the Chapéu Mangueira and Babilônia communities in the Light electricity distribution concession area.

It was proposed to use a centralized measurement system—a Landis Gyr solution—with a remote cut-off/reconnection feature and intelligent measurement (every 4 hours).

A survey carried out by RevoluSolar in 2022 with 310 respondents from the Babilônia and Chapéu Mangueira communities was used to estimate benefit and cost indicators. The results of this research were extrapolated to the population of these communities, consisting of 1 579 households and 5,027 residents. This research was able to determine consumer consumption under the following conditions: theft, partial theft, and regular.

In the most general case, 15 benefits and 11 costs were considered. Some of the costs were built into the average price of CMS meters. The following figure shows the results. Scenario C1 has a B/C ratio of 1.32, demonstrating the benefit of CMS. Scenario C5 has a B/C ratio of 0.87, but this is a stress scenario, as will be presented below.



We explain the premises of each scenario: (i) Scenario C1: consider all benefits and costs; (ii) Scenario C2: consider all and costs, but not consider indicators of energy efficiency and environmental impacts; (iii) Scenario C3: consider all and costs, but not consider indicators of energy efficiency, environmental impacts and system reliability; (iv) Scenario C4: consider all and costs, but not consider indicators of energy efficiency, environmental impacts, system reliability and technical management; (v) Scenario C5: consider all and costs, but not consider indicators of energy efficiency, environmental impacts, system reliability, technical management and commercial management; (vi) Scenario C6: equals to C1, but consider a 20% reduction of IT and telecommunication infrastructure costs; (vii) Scenario C7: equals to C2, but consider a 20% reduction of IT and telecommunication infrastructure costs; (viii) Scenario C8: equals to C3, but consider a 20% reduction of IT and telecommunication infrastructure costs; (ix) Scenario C9: equals to C4, but consider a 20% reduction of IT and telecommunication infrastructure costs; and (x) (vii) Scenario C10: equals to C5, but consider a 20% reduction of IT and telecommunication infrastructure costs.

**Conclusions**

Through a cost-benefit analysis, it was possible to evaluate the effectiveness of a centralized measurement system for reducing non-technical losses in a low-income community in Rio de Janeiro. Furthermore, the benefit-cost analysis showed that CMS brings more benefits than costs in most simulated scenarios. However, this centralized measurement system must come with solutions used in smart meters, as proposed in this project.

As future work new indicators of benefits and costs should be used. Therefore, some studies to determine better ways of measuring them should be carried out.

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