

Non-Technical Losses in Light's Concession Area

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Abstract— One of the critical problems that electricity distribution companies come across are non-technical losses, also known as commercial losses. These losses impact the economic and financial balances of the electricity distributors, limiting their ability to make further investments. In the state of Rio de Janeiro, the major non-technical losses take place in urban informal settlements (slums). They emerged in the city's hills as a response to hygiene policy in the early twentieth century. Throughout time, they expanded to peripheral zones and many are dominated by criminal groups, which are responsible for limiting the operation and supervision of electricity distribution companies, preventing adequate actions against non-technical losses. In this sense, the concession area of Light, a private utility located in Rio de Janeiro, has different geographic and socioeconomic characteristics. This paper aims to analyze the non-technical losses in Light's concession area, based on social aspects considered relevant by the international literature and Rio de Janeiro's social specificities.

Keywords— Non-technical losses; Theft of Electricity; Socioeconomic Aspects.

I. INTRODUCTION

The electricity sector can be divided into three different segments: generation, transmission and distribution. The generation units produce energy that the transmission companies carry from generation units to consumer centers. From there, distribution systems deliver electricity to their consumers. The main characteristic of the electric power sector is a substantial temporal and spatial interdependence among its components, since electricity is a non-storable product.

Considering its economic characteristics, power distribution constitutes a natural monopoly, operating in each concession area. To avoid the appropriation of extraordinary profits by a monopoly company, the prices charged for the service provided are duly regulated, in order to search for a balance between the interests of companies and consumers. In the case of the distribution segment, the payment received for the services provided is the electricity tariff.

The tariff aims to ensure that the service providers have enough revenue to cover efficient operating costs, compensate the investments made and assure the capital to expand their capacity and ensure quality services. The

electricity tariff in Brazil is divided into two parts: Parcel A and Parcel B. The Parcel A involves non manageable costs of the utility, like generation and transmission activities, as well the legal charges (ANEEL, 2007; PWH, 2005). Parcel B represents directly manageable costs of the utility, that are subject to their control or influence, according to management practices adopted by the company. Among the components that form Parcel B, the Operating Costs are those that stand out. These costs are associated to the operation, maintenance, commercial and administrative tasks, including activities such as meter reading and billing errors, inspection of consumer units, pruning of trees, substation operations and actions against energy losses (PWH, 2005).

The electricity losses are divided into two parts: technical losses and non-technical losses (NTL). The former is intrinsically caused by the operation of the power grid and the use of installed equipment; and the latter are largely the result of inaccurate reading, meter issues and energy theft¹ (Navani et al, 2012; Smith, 2004). However, these last two factors predominate in most cases. NTL in electricity distribution can reach 40% of the total energy

¹ Clandestine connections in the distribution network.

distributed in certain countries (Coma-Puig; Caromona, 2019; Glauner et al., 2017). The international literature states that these illicit practices are related to the lack of state governance, and that it as a much more urgent topic in developing countries, reaching losses of up to 30% in India, for instance (World Bank, 2009). The informal urban settlements (slums) reflect the state's failure, characterized by the absence of the law and precarious housing conditions for lower income individuals. Therefore, this social problem is not manageable by companies and they have difficulties in operating in these areas.

NTL affect the companies' economic and financial balance and the quality of their service, increase the tariff of regular consumers, hamper network security, encourage waste of energy resources, pressure the expansion of the national electricity sector and may create a vicious cycle if there is not a correct arrangement between electricity distribution companies and the regulator to manage this problem.

This paper will specifically address the issue of NTL in electricity distribution, focusing on a study case of Light, a private Brazilian utility company. Light is located and operates in the city of Rio de Janeiro and in a few areas of the state of Rio de Janeiro in Brazil, a state marked by great social inequalities. As a result of these facts, which are beyond the utility's responsibility, the distributor operates in a very heterogeneous concession area. Furthermore, NTL and socioeconomic complexity are positively correlated: the higher the complexity, the greater the NTL.

It should be noted that most places of high social complexity are attended by militias² and criminal factions, responsible for preventing the operations of the company. One relevant fact is that the public safety program put in place by the state government to fight against these groups has affected the utility, impacting how it deals with NTL (Castro et al., 2019).

The present paper is divided into the following sections: the first section is dedicated to the introduction; the second section describes the methodology that was used; the third addresses the losses of electrical energy with a focus on NTL and the treatment of NTL in the Brazilian regulation; the fourth section reviews the international literature to understand the socioeconomic factors related to NTL and develops a specific analysis of the determinants of the state of Rio de Janeiro; the fifth section explores the case of Light, explaining the

² Militia are clandestine paramilitary groups made up of current and former police officers which carry out both vigilante and organized crime activities.

peculiarities of its concession area, besides presenting the loss indexes and the methodologies adopted to combat this problem; and the conclusion will identify possible scenarios for the reduction of losses in Rio de Janeiro.

II. METHODOLOGY

NTL are a critical problem for companies in the Brazilian electricity distribution sector. This article aims to conduct a case study on Light, a utility that operates in the state of Rio de Janeiro, to analyze the impact of NTL for the company. The company was selected for this study because, at the national level, Light's problem has gained very serious outlines. In the utility's concession area, tariffs are one the most expensive in Brazil, which present a surplus of 17% due to the cross subsidy derived from NTL. Light has around 11 million consumers in 31 municipalities in the state of Rio de Janeiro, and its concession area holds the national record of NTL: 17% of total energy stolen in Brazil (Light, 2013; Light 2016; Castro et al., 2019).

In several areas of the state of Rio de Janeiro, the utility has difficulties in operating to provide, maintain and charge services, as a result of violence. For this purpose, the research question that guides this paper is to verify if part of the difficulty in combating NTL is associated with specific characteristics of the concession area, regardless of the observable variables related to the socioeconomic complexity of the Brazilian Electricity Regulatory Agency's (ANEEL)³ complexity model.

In other to achieve this objective, this study crosses data from three sets of information: (i) variables that capture the socioeconomic heterogeneity of the empirical context, obtained through the 2010 Census developed by the Brazilian Institute of Geography and Statistics (IBGE); (ii) variables that locate areas of serious operational restrictions and NTL within Light's concession area, obtained through technical reports and studies developed by the company; and (iii) official indicators of violence, developed by the Institute for Work and Society Studies (IETS) and experts in the field.

III. NON-TECHNICAL LOSSES: DEFINITION AND THE IMPORTANCE OF THIS CONCEPT

³ ANEEL is a government autarchy linked to the Ministry of Mines and Energy and has the mission of providing favorable conditions for the electricity market to be developed in a balanced environment for the benefit of the whole society

This section presents a definition of electrical power losses, subdividing them into technical losses and NTL. These concepts will be addressed throughout this section, highlighting its impact on electricity distribution companies and the population.

3.1 - Global energy losses, technical losses and Non-Technical Losses

The power losses in the distribution segment are defined as the difference between the energy injected into the grid and the amount that was effectively supplied and sold to the consumer. They can be divided into two categories: (i) technical losses and (ii) NTL. The technical losses are intrinsic to the operation of the distributor and are originated by physical factors. They are caused by the dissipation of energy in the components of transport, voltage transformation and measurement systems. On the other hand, NTL, also called commercial losses, arise from energy theft; fraud in supply or the measurement system; lack of meters in consumer units; failure or lack of gauging in the meters and errors in the reading or billing of the consumer units (Penin, 2008). Ahmad (2017) states that NTL may occur due to a series of factors, among which stand out the following aspects: unauthorized line diversion, that is, theft through meter fraud or illegal compliance; unauthorized line interception; lack of quality and inaccurate meter reading; or deficient techniques for poor revenue collection. Therefore, NTL may be caused not only by the inefficiency of the distributors but also by illicit consumer practices.

Technical losses may be minimized with company investment in modern market technologies. The solution for NTL, however, is not so simple, since the social factor is predominant in most cases. Hence, the problem becomes exogenous and unmanageable on many occasions, imposing a great challenge for the distributor's operations, who need to find different means to reduce NTL according to the reality of each concession area. The analysis of the socioeconomic factors involved will be done in more detail in the next section.

3.2 The relevance of the theme Non-Technical Losses

NTL causes negative impacts throughout society, entailing losses to the population, distribution companies and the government. The first agents directly impacted by this adversity are electricity distribution companies. It is estimated that, on average, commercial losses generate a reduction of 3% to 5% in revenues for these companies (USAID, 2004). This compromises their economic and financial balance sheets, harming their ability to make new investments and may lead to the bankruptcy of many utilities (Smith, 2004). It should be noted that the most

critical locations are precisely those where companies make a relatively larger investment because of the inadequate existing infrastructure to operate. These areas are still characterized by relatively low consumption, which induces many utilities to expect zero or negative returns for the investments made in these zones (UN Habitat, 2009).

Electricity distribution companies need to determine the amount of energy that should be supplied to regular and irregular consumers. Through this information, distributors will design the network that will be installed in a certain location. However, the energy needed to meet irregular consumers is not easily predicted, since its illegal consumption is often wasteful. Therefore, if planning is not correct, there is a possibility of overloading the network during peak periods, causing blackouts that cut off power supply, damage company's equipment and harm customers. The loss of safety can also jeopardize the lives of those who operate the network illicitly, in addition to the residents themselves, since the wires may release sparks. Thus, NTL directly affect the quality of the services, damaging the relationship between a company and their customers (Depuru, Wang and Devabhaktuni, 2011).

NTL are also responsible for increasing tariffs for regular consumers in order to help with the recovery of distributors revenues. This creates a kind of cross subsidy, as some customers may end up paying for energy consumed by others (Depuru, Wang and Devabhaktuni, 2011). In Brazil, in 2018, in terms of the percentage of the total energy injected into the grid, losses corresponded to 14%, with technical losses corresponding to 7.5% and NTL representing 6.5% of the total amount (ANEEL, 2019). ANEEL recognizes and authorizes the transfer of part of the NTL to energy tariffs to guarantee the financial operability of the distributors. In addition, NTL pressures costs of the national electricity system, since they increase the need to generate energy to compensate wasted resources and investments to fight against this problem.

The concern about NTL is even more relevant if we consider the possibility of introducing a vicious cycle in the system. Regarding tariffs, the recognition of higher levels of losses, maintenance costs and/or efficient investments required to fight this problem may affect the payment capacity of low-income consumers and may lead them to incur into irregular practices. This may lead to a new tariff increase, triggering a new cycle (Araújo, 2007; Tasdoven, Fiedler and Garayev, 2012). In this sense, the regulator needs to be aware of these aspects to avoid cyclical effect. NTL also generates loss of revenue for the government, due to the taxes that are not collected through electricity consumption.

3.3 The treatment of Non-Technical Losses in the Brazilian regulation context

Power losses were always present in the electricity tariff in Brazil. The first tariff review cycle (2003-2006) defined the reduction targets based on the historical averages of each company (ANEEL, 2010). The second cycle (2007-2010), in turn, brought regulatory innovations that radically changed the calculation of limits, such as starting to consider the recent history of each company and the most efficient levels of losses attained by distributors in places of great or equal social complexity. They were considered as a benchmark by the regulator; that is, the reference for achieved losses. ANEEL compared the social complexity of the concession areas through an index, formulated with an econometric data panel model with random effects. There is a relation between this rule and the traditional "Yardstick Competition" principle, widely used to stimulate efficiency in natural monopoly activities (ANEEL, 2006; ANEEL, 2008).

The third tariff review cycle (2011-2014) maintained the main guidelines of the second cycle, but improved some aspects, among which two will be highlighted. The variables used in the econometric model were violence, inequality, precariousness (an expansion of the concept of informality) and infrastructure. The other main change was in relation to the speed of loss reduction. In the previous cycle, the agency stipulated that companies should achieve their benchmark in a single cycle, but this disregarded differences between the concession areas and consequently their different capabilities. Thus, ANEEL began to consider different reduction rates between companies (ANEEL, 2010).

The fourth tariff review cycle, initiated in 2015, improves the methodology built in the previous two cycles, implementing two significant changes. The first concerns the construction of three econometric models to calculate three different indexes of socioeconomic complexity. The second is related to the fact that the agency relaxed the starting point limits for three cases: a) companies that have already been practicing low levels of NTL; b) companies with low comparison probability; and c) utilities whose established targets are higher than the starting point of the previous cycle and do not fit under item b (ANEEL, 2015).

IV. SOCIOECONOMIC FACTORS RELATED TO COMMERCIAL LOSSES

This section presents the socioeconomic factors related to NTL, according to the international literature. In addition, it analyzes the specificities of the state of Rio de Janeiro.

4.1 Socioeconomic factors highlighted by the international literature

According to Smith (2004), NTL are related to governance, since this concept is used to explain patterns of social, economic and political development. Based on six governance indicators provided by the World Bank, the author evaluated this relation. The results of the research concluded that NTL are positively associated with the following indicators: lack of civil and political rights, overlapping of violence against government, hostile regulatory policies, corruption, disrespect for the legal rules of society and lack of quality in bureaucracy and in the public service.

One of the obvious consequences of this unfavorable government environment are the informal urban settlements, popularly known as "slums". They arise in places where there are economic opportunities, but not enough houses for everyone to live legally. Thus, low-income citizens occupy irregular places that are not authorized by public agents and characterized by insecurity and absence of law. Government planning generally does not prioritize the development of these areas, leading them to have precarious mobility, energy, communication, water and sanitation infrastructure. The need to access these services induces the residents of these locations to acquire them illegally (UN Habitat, 2009; Rufin, 2015). These negative governmental and social aspects impose many challenges for electricity distribution companies to act successfully in slums. Among them, four factors stand out: the non-payment culture, limited payment capacity of residents, "technological race" with illegal service suppliers and conflict between incentives and regulatory requirements (Lawaetz and Smyser, 2011).

4.2 - The socioeconomic factors of the state of Rio de Janeiro

According to the Institute for Work and Society Studies (*Instituto de Estudos de Trabalho e Sociedade - IETS*), the problem of the state of Rio de Janeiro is not a development problem, as measured by the work conditions of the households, per capita income and education of the population. Census data indicates that the population has a relatively high income per capita, a low illiteracy rate, and households with good water and sewage conditions. What explains the high rates of NTL in the state are informality, violence and the share of the cost of electricity in the family budget (IETS, 2008).

One of the measures of informality is "favelização". In the 2010 Census, this aspect was measured by the percentage of private occupied households in subnormal clusters. A subnormal cluster is a set of 51 or

more housing units occupied without property title and with irregularities in roadways, in the size and shape of lots and/or with a lack of essential public services such as garbage collection, sewage and water, electricity and street lighting (IBGE, 2011). If we calculate this index for the whole state, the number reaches 11.8%. When evaluating municipalities, the following percentages may be verified: Rio de Janeiro (19,9%), Duque de Caxias (6,8%), Belford Roxo (7,1%) e São João de Meriti (9,8%); all these municipalities are in Light's concession area. However, IETS (2008) argues that several criticisms may be made

regarding the methodology adopted by the Brazilian Institute of Geography and Statistics (IBGE), such as the fact that these metrics are underestimated.

The slums in the state are mostly controlled by armed criminal groups, known as "commands" and "militia". They are responsible for preventing the entry of a company in certain areas, preventing their operations, grid maintenance and the combat of NTL. Figure 1 shows that militia (identified by blue "balloons") and commands (identified by "balloons" in other colors) are spread over much of Light's concession area.



Fig.1: Presence of Militia and Commands in Light's concession area in 2013. Source: *Jornal o Dia*, apud Light (2013).

In order to regain control of the state over areas dominated by armed criminal groups, the government created the so-called Pacifying Police Units in 2008 (*Unidades de Polícia Pacificadora - UPPs*) (Leite, 2012). Currently, there are 38 UPPs, only one outside the capital, in the municipality of Duque de Caxias, but all within the concession area of Light. Evaluating the data provided by the Institute of Public Security (*Instituto de Segurança Pública - ISP*)⁴, it is possible to verify that, in fact, there was an improvement of important indicators related to violence in with installed and operating UPPs.

Recently, the UPPs have been weakening due to the lack of resources to maintain them, as well as improve and expand the program. The state crisis promoted a 30% cut in the budget of the security summit in early 2016. In addition, violence has also grown with the worsening of economic indicators, which makes the future of UPPs even more uncertain.

Finally, regarding the cost of electricity, IETS (2008) argues that two factors contribute to a higher electricity bill in Rio de Janeiro than in other states: a) the state has the highest state tax rate in Brazil; and b) the hot weather and easier access to durable goods, especially air-conditioning, lead to increased consumption.

The reduction of the Industrialized Products Tax (*Imposto de Produtos Industrializados - IPI*) between 2012 and 2015 provided an incentive for the purchase of intensive electrical applications. In addition, the economic growth of recent years improved the financial conditions of Brazilian society, but this increase in income has not resulted in a transition from informal markets to the formal energy market (Light, 2013).

According to the Goods Asset Survey conducted in 2013, most of the households in communities (slums) in the concession area of Light rely on electro-intensive products. This survey did not include air conditioners. However, there is evidence of the increasing spread of this good in homes and especially in the informal areas,

contributing to further aggravate Light's losses problems. Since the population density of these areas is higher and residence ventilation is much lower than in formal areas, temperatures reach higher than normal levels, causing

residents to use air conditioning and other electricity related equipment excessively. Studies conducted by Light (2013) show there is a strong correlation between temperature and losses.

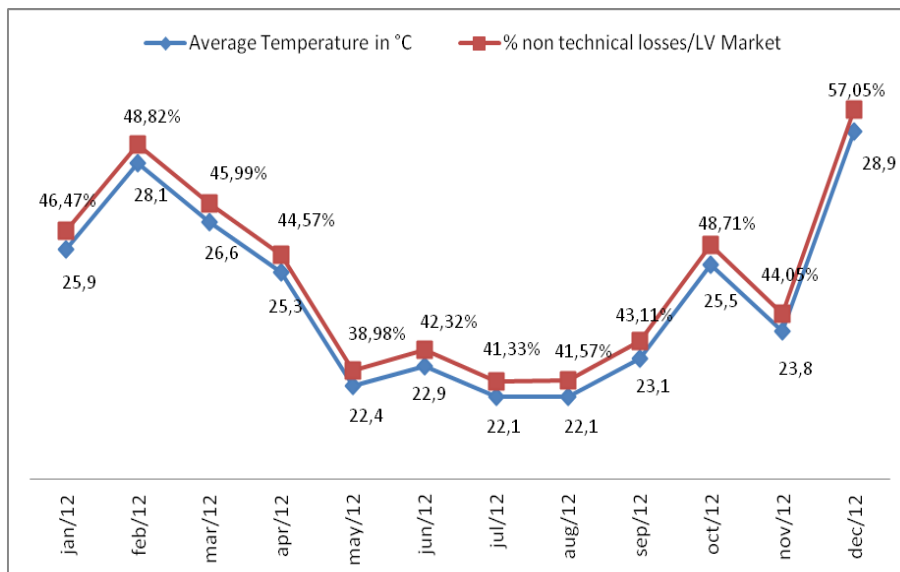


Fig.2: Average temperature X NTL. Source: Light (2013)

We can also point out that very few consumers benefit from discounts on their account provided by the Social Tariff⁵. This happens because to receive the benefit the family must have a monthly income per capita less than or equal to half a national minimum salary; in Rio de Janeiro the cost of living is very high, which makes it very difficult for a family to survive with that value.

concession area into 5 regions: South Center, East, West, Baixada and Valley.

V. RESULTS: NON- TECHNICAL LOSSES IN LIGHT'S CONCESSION AREA

Based on information collected with the company employees and in specialized reports, the objective of this section is to characterize Light's concession area in relation to socioeconomic indicators and losses. In addition, it will present the actions and initiatives adopted by Light in relation to regulation.

5.1 - Light's concession area

There are 31 municipalities in Light's Concession area in the state of Rio de Janeiro, with approximately 4.5 million customers (Light, 2016). The company divides its

⁵ The Electricity Social Tariff - TSEE was created by Law No. 10,438, of April 26, 2002. Due to the tariff discounts are granted to consumers in the Low Income Residential Subclass.

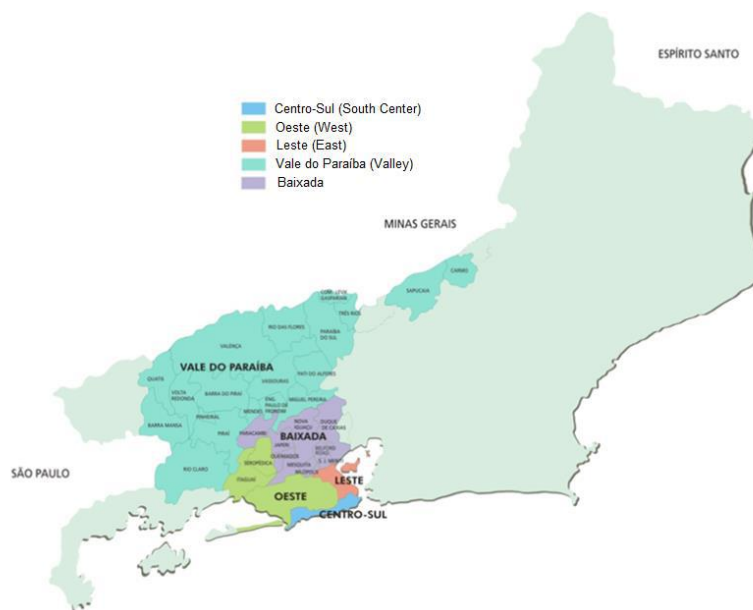


Fig.3: Light's concession area. Source: Light (2013)

The South Center region is mainly composed of the districts of South Zone, Center, Barra da Tijuca and a small portion of the North Zone, all of them belonging to the city of Rio de Janeiro. The main characteristics of this area include the predominance of large vertical apartment complexes, good urban organization, strong presence of an underground power network, high population concentration and substandard or precarious households in favelas. The Eastern region covers almost the entire Northern Zone of the same municipality. This region has the highest density of the concession area, horizontal residences, villages, medium-sized trade, a predominant air power network and a high number of communities.

The Western region encompasses the West Zone of Rio de Janeiro and the municipalities of Itaguaí and Seropédica. The presence of horizontal residences and subnormal or precarious households characterizes this area. The Baixada region includes the municipalities of São João de Meriti, Nilópolis, Belford Roxo, Mesquita, Nova

Iguaçu, Japeri, Queimados, Paracambi and a portion of Duque de Caxias. High urban disorganization and a air power network are the main elements of this part of the state. Finally, a part of the municipalities of the regions Middle Paraíba, South Center Fluminense and Serrana compose the Valley region. The main aspects include the existence of an air distribution network, few subnormal or precarious households and large industrial loads (Light, 2013).

In 2016, according to Light (2017), NTL of the utility's concession area were 15.33%. The NTL index of the Paraíba Valley and the South-Centre were of 2% and 3%, respectively, in the same year. These percentages were well below Light's NTL and justified by the socioeconomic characteristics of these regions. In contrast to this reality, other regions had NTL higher than 30%, with socioeconomic conditions of those less-favored areas being a determinant aspect to explain high NTL (Castro et al., 2019), as we can see in the figure 4 below.

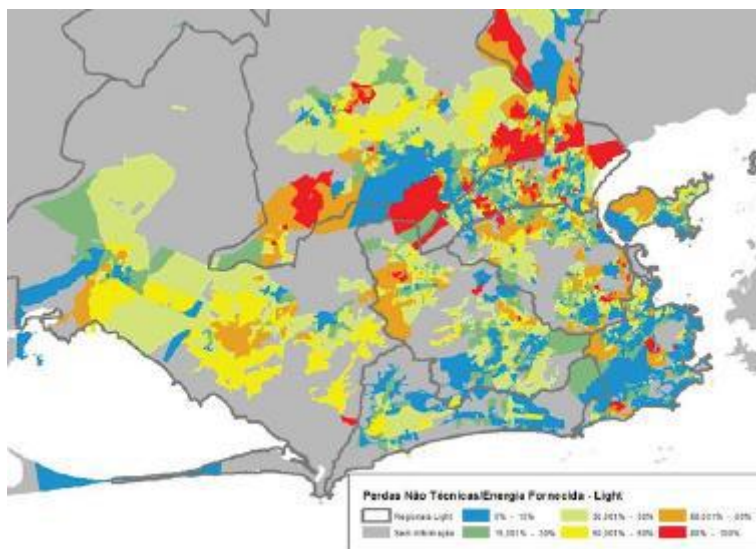


Fig.4: Distribution of NTL/Supplied Energy. Source: Castro et al (2019)

In 2016, NTL in the company's concession area reached 5,7 TWh. This is equivalent to 20% of all energy stolen in the country, and to the annual consumption of the state of Espírito Santo (Castro et al, 2019; Light, 2013). A large portion of this loss is associated to energy fraud, with an estimated 2.8 million fraudulent consumers in Light's concession area. As will be noted below, the company has difficulties to achieve the regulatory targets because of the NTL. In 2015, these losses caused an impact of R\$ 400 million in the company EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortization) (Gomes, 2016).

Currently, almost half of the company's NTL are present in areas known as "Areas with Severe Operation Restrictions" (*Áreas com Severas Restrições Operacionais* - ASROs) while the other half located in areas considered possible to operate (although with some restrictions). High levels of NTL and regions dominated by criminal groups characterize the ASROs. These groups are responsible for making it impossible for the company to enter and, consequently, operate in these places. However, not all poor communities have this classification for the company. Around 642 of the 1340 communities in the Light concession area present severe restrictions on operation.

The company estimates that about 1.95 million of its customers are fraudsters, with 1.1 million located in possible areas and 850 thousand in ASROs. However, fraud does not, generally, correspond to 100% of the energy consumption, because consumers are usually concerned in continuing to receive the bill, which serves as a citizenship proof to gain access to benefits such as bank credit. Therefore, consumers often stole electricity from

applications that consume more electricity, such as air conditioning (Gomes, 2016).

The average monthly consumption estimated by the company in an ASRO is approximately 340 kWh. This bill is similar to the bill usually paid by regular customers and represents a relatively high burden on the budget of low-income families. Meanwhile, Light can only earn 60 kWh on average, resulting in a loss of 280 kWh (Gomes, 2016).

5.2 - Methods implemented by Light to combat Non-Technical Losses

In recent years, Light has sought to fight against NTL by optimizing conventional inspection, regularization actions and installing centralized metering and shielding systems in a great number of areas. In areas with UPPs, the company applied technical improvements in the network. Light also invested in education for their clients to consume less energy, as well as in the exchange of inefficient equipment, in credit offers in the case of trash recycling and progressive discounts on the tariff for consumers with a good paying history. In addition, the company applied the "Light Legal" program in small areas (called "Zero Loss Areas - ZLA"), which provides the installation of an independent microenterprise with electrical and commercial service agents to improve the losses and delinquency indicators. The remuneration of this project has a variable aggressive component, which is greater when the success in the improvement of these indicators is higher. In areas with ZLA's, NTL declined by an average of 20 percentual points.

In recent years, the UPPs program lost relevance. In this sense, Light abandoned some areas that resulted in

non-returns for invested capital and an increase in losses. This fact makes the future of NTL worrying in Light's concession area.

5.3 - Light and the regulation

In recent years, Light has found trouble to meet the regulatory targets for losses established by ANEEL. According to the utility, the estimation of the non-technical regulatory loss by the Brazilian regulator underestimates the social complexity faced by the company. As mentioned, there are areas in its concession area that the company cannot act due to criminality and, in theory, the model would capture this.

An important fact is that these areas often do not have high rates of violence and, therefore, indicators of deaths may not adequately reflect the correlation between crime and NTL. In addition, indicators of human development and subnormal clusters are not always good for identifying these areas, which leads to an underestimation of the losses by the ANEEL's model due to the specificities of Rio de Janeiro. Currently, losses are already 2% below the regulatory target.

VI. CONCLUSIONS

The long period of economic crisis that negatively impacts Brazil is exacerbating an economic and financial imbalance for electricity distribution companies, specifically NTL, commonly entitled as electricity theft. This trend tends to expand due to the ongoing economic and social crisis characterized by reduced spending capacity on security, health and education, that are pillars of a reasonable level of well-being.

In view of the factors presented in this paper, it is possible to conclude that socioeconomic aspects and violence affect NTL. Due to these factors, the role of the State as a key agent for the improvement of these indicators is particularly important, thus helping distribution companies to offer their services to all residents with quality, as well as overcoming and fighting NTL.

In Rio de Janeiro, the problem of violence is very pronounced due to the presence of drug dealers and militiamen. They interdict the entry of Light's operational teams, which cannot act to reduce losses. In locations where it is possible to manage the provided service, Light is managing to reduce its level of NTL with higher indexes than those established by ANEEL.

The socioeconomic complexity of the state of Rio de Janeiro is related not only to NTL, as recognized by ANEEL in the regulatory treatment, but also to severe

operating restrictions within Light's concession area. Although socioeconomic characteristics are relevant, there is still an unobserved heterogeneity that should be explained. The complexity in Rio de Janeiro's context is, to a large extent, associated with the fact that specific locations are controlled by criminal factions, regardless of socioeconomic characteristics or the provision of public services. This characterizes an extremely adverse and peculiar unobservable dimension in Rio de Janeiro, simultaneously correlated with the existence of areas with severe operation restrictions and difficulties in combating NTL.

In recent years, ANEEL developed regulatory incentives in order to induce a downward trend in NTL. For this, the agency started to carry out different regulatory treatments, according to the complexity of utilities in their respective contexts. However, almost half of Brazil's utilities have failed to reduce their NTL rates in recent years. This article sought to present that the complexity of the empirical context on which utilities operate are more restrictive than expected, due to relevant variables not considered in the complexity model. Therefore, it is important to differentiate regulatory treatments from one area in comparison to another within the concession space.

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