NON-TECHNICAL LOSSES IN LIGHT'S CONCESSION AREA

Overview
One of the critical problems that the electricity distributors face is non-technical losses, also known as commercial losses. These losses impact the economic and financial balance of the distributors, limiting their ability to make further investments. In the state of Rio de Janeiro, the major non-technical losses occur in urban informal settlements (slums), that are dominated by criminal groups. These groups are responsible for limiting the operation and supervision of the company, preventing adequate combat against non-technical losses. This paper aims to analyze the non-technical losses in Light concession area.

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

1. Introduction

The electricity sector can be divided into three productive segments: generation, transmission and distribution. The generating units, from different sources, produce energy that the transmitter units carry from the generation point to the consumer centers. From there, the distribution units lead the electric energy to their customers. The main characteristic of the sector is a strong temporal and spatial interdependence among its components, since electricity is not a storable product.

The electricity distribution stands out as a natural monopoly, operating in a given concession area. In order to avoid the appropriation of extraordinary profits by the monopoly company, the prices charged for the service are provided duly regulated, seeking a balance between the interests of companies and consumers. In the case of distribution, the payment received for the services provided is the electricity tariff.

The tariff aims to ensure that the service providers (public service concession companies) have sufficient revenue to: cover efficient operating costs, remunerate the investments made and have enough capital to expand their capacity and ensure quality service. The electricity tariff in Brazil is divided into two parts: Parcel A and Parcel B. The first parcel involves the costs not manageable by the distribution utility, like generation and transmission activities, as well the legal charges (ANEEL, 2007; PWH, 2005).

The second parcel represents the costs directly manageable by the distributor, subject to their control or influence, according to the management practices adopted by the company. Among the components that compose Parcel B, the Operating Costs are those that stand out for this work. These costs are associated to the operation, maintenance, commercial and administrative tasks, including activities such as, reading and delivery of invoices, inspection of consumer units, pruning of trees, substation operations and the combat against energy losses (PWH, 2005).

The non-technical losses affect the companies' economic and financial balance and quality of their service, increase the tariff of the regular consumers, hamper network security, encourage waste of energy resources, pressure the expansion of the national electricity sector and can creates a vicious cycle if there is not a correct treatment of the distributors and the regulator to contain the problem.

This paper will specifically address the issue of non-technical losses in the distribution of electricity, focusing on the study case of the Light concessionaire. Light is present in the state of Rio de Janeiro, a state marked by great social inequalities. As consequence of these problems, which are beyond the concessionaire's responsibility, the distributor operates in a very heterogeneous concession area. It should be noted that most places of high social complexity are attended by militias and criminal factions, responsible for preventing the operation of the company. One relevant fact is that the public safety program, put in place by the state government to combat these groups, has affected the concessionaire, impacting how it deals with non-technical losses.

The present paper is divided as follows: the first section is the introduction; the second section addresses the losses of electric energy with focus on non-technical losses and the treatment of non-technical losses in Brazilian regulation; the third section reviews the international literature to understand the socioeconomic factors related to non-technical losses and makes a specific analysis of the determinants of the state of Rio de Janeiro; the fourth section explores the case of Light, explaining the peculiarities of its concession area, besides presenting its loss indexes, the methodologies adopted

to combat this problem and the relation between Light and regulation; finally, the conclusion will approach Light's limitations in the operation in severely restrictive areas and the company's project with the research group GESEL to propose regulatory innovations to ANEEL for the treatment of non-technical losses in these locations.

2. Non Technical Losses: definition and importance.

This chapter presents a definition of electric power losses, subdividing them into technical losses and non-technical losses. These will be addressed in more detail in this section and throughout the article, highlighting their impact on distributors and the population as a whole. In addition, the evolution of Brazilian regulation for non-technical losses will be presented.

2.1 - Global energy losses, technical losses and non-technical losses

The losses of electricity 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) non-technical losses. 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, transformation of voltage and measurement of energy. On the other hand, non-technical losses, or commercial losses, arise from energy theft; fraud in supply or 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). Therefore, non-technical losses can be caused not only by the inefficiency of the distributors but also by the illicit practices of consumers.

It should be noted that the technical losses are calculated considering only the regular loads. In this way, technical losses arising from theft and fraud are attributed to non-technical losses. As these illicit practices often use non-standard connections and low quality materials, current leakage is greater, which amplifies the technical losses. In order to solve this measurement problem, the concept of "Wire losses" is used to calculate the amount of technical losses. This includes both losses from regular and irregular consumption (Penin, 2008).

Technical losses can be minimized if companies invest in the most modern technologies on the market. The solution for non-technical losses, however, is not so simple, since the social factor is predominant in most cases. In this way, the problem becomes exogenous and unmanageable on many occasions, imposing a great challenge for the operation of the distributors, who need to find different means to reduce non-technical losses according to the reality of each concession. The analysis of the socioeconomic factors involved will be done in more detail in the next chapter.

2.2 - The relevance of the theme "non-technical losses"

The non-technical losses cause negative impacts throughout society, bringing losses to the population, distribution companies and the government. These impacts will be explained briefly below.

The first agents directly impacted by this adversity are the distributors. It is estimated that, on average, commercial losses generate a reduction of 3% to 5% in the revenues of these companies (USAID, 2004). This compromises their economic and financial balance, harming their ability to make new investments and may lead to the bankruptcy of many concessionaires (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 a low relative consumption, which induces many distributors to expect zero or negative returns for the investments that were made (Smyser, 2009).

The distributors need to determine the amount of energy to be supplied to regular and irregular consumers. From this information, they will design the network to be installed in a certain location. However, the energy needed to meet irregular consumers is not easily predicted, since it is an illegal consumption that is often irresponsable, generating a waste of resources. Therefore, if the planning is not correct, there is a possibility of overloading the network during peak periods, causing blackouts that cut off the power supply and can damage the equipment of companies and customers as a whole. 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 can begin to release sparks. Thus, we observe that non-technical losses directly affect the quality of service offered, damaging the relationship between company and customers (Depuru, 2011).
The non-technical losses are also responsible for increasing the tariff of regular consumers, in order to recover the revenue of the distributors. This creates a kind of cross subsidy, as some pay for energy consumed by others (Depuru, 2011). In addition, commercial losses pressure the costs of the national electricity system, since they increase the need to generate energy to compensate wasted resources and investments to combat this problem.
The concern with non-technical losses is even more relevant if we consider the possibility of introducing a vicious cycle in the system. The recognition in the tariff of a higher level of losses, maintenance costs and/or efficient investments required to combat this problem may affect the payment capacity of low-income consumers and lead many to incur irregular practices. This can lead to a new tariff increase, causing a new cycle (Tasdoven, Fiedler and Garayev, 2012; Araújo, 2007). In this way, the regulator needs to be aware to avoid this cyclical behavior. The non-technical losses also generate loss of revenue for the government, due to the taxes that are not collected with the consumption of electricity.

2.3 The treatment of non-technical losses in Brazilian regulation

The electric losses were always present in the Brazilian electricity tariff. In the period of cost regulation, which lasted until the beginning of the first tariff review cycle in 2003, non-technical losses were incorporated in the energy purchase costs of Parcel A. Thus, they were fully recognized in the tariff. In the 2000s, however, National Electric Energy Agency (Agência Nacional de Energia Elétrica – ANEEL) began to limit this transfer through incentive regulation, which set fixed or decreasing reduction targets during the tariff review period. This scheme offered strong incentives for companies to be more efficient in combating losses insofar as it guaranteed them the difference between the level of losses defined and the level of losses fulfilled. On the other hand, there is a burden on revenues if companies do not achieve regulatory goals. About this incentive regulation, it is worth noting two points: i) targets need to consider the non-manageable aspects and must prevent the transfer of inefficiency factors to the tariff; and ii) subsequently, they need to be redefined in order that society absorb the efficiency gains and the system has a greater tariff modality (ANEEL, 2010). The methodology that calculates these limits has changed over time and this evolution will be briefly explained below.
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. It began to consider the recent history of each company and the most efficient levels of losses achieved by distributors in places of greater or equal social complexity. They were treated as a benchmark by the regulator, that is, the reference of losses to be achieved. We can see the relationship between this rule and the traditional "Yardstick Competition" principle, widely used to stimulate efficiency in natural monopoly activities (ANEEL, 2006; ANEEL, 2008).
ANEEL compared the social complexity of the concession areas through an index, constructed from an econometric panel data model with random effects. It has been hypothesized that non-technical losses can be subdivided as follows: $NTLi = Ci + Xij*\beta + MIi$. Where: NTLi = Level of non-technical losses of the firm “i”; $Xij*\beta$ = Socioeconomic characteristics "j" of the concession area "i"; MIi = Portion of the non-technical losses of distributor "i" due to managerial inefficiency in the combat against thefts e Ci = Specific variables of company "i" that influence its level of non-technical losses and that were not considered in the other terms (ANEEL, 2008).
The elaborated model sought to capture the β effect of socioeconomic variables of interest Xij on non-technical losses. These variables addressed the following concepts: violence, income inequality, informality and infrastructure. The index for a given company was then formulated by the sum of the product of the variables with their estimated coefficients.
This index allowed ANEEL to rank the distributors according to the degree of social complexity of their concession areas and, therefore, to compare them. As a rule, the starting point was not allowed to exceed the lowest level of losses observed in the recent history. The regulation of this cycle also

provided an additional for operational costs and investments directed to combat losses (ANEEL, 2008).
The third tariff review cycle (2011-2014) maintained the main guidelines of the second cycle, but improved some aspects, among which we will highlight two. The variables of interest used in the econometric model became: violence, inequality, precariousness (an expansion of the concept of informality), infrastructure and default. The other change referred to the speed of losses reduction. In the previous cycle, the agency stipulated that companies should achieve their benchmark in a single cycle, but this disregarded the differences between the concession areas and consequently the different combat capabilities. Thus, ANEEL began to consider differentiated reduction rates between companies (ANEEL, 2010).
The fourth tariff review cycle, initiated in 2015, improves the methodology built in the previous two cycles. Once again, we will highlight two changes. The first is the construction of three econometric models to calculate three different indexes of socioeconomic complexity. It should be noted that these models used the same concepts of previous cycles. The target of a certain company is then calculated by the average of the three goals obtained with its recent history and the efficient levels of losses of the three different benchmarks. The second is that the agency flexibilized the starting point of the limits for three cases: a) companies that have already been practicing low levels of non-technical losses; b) companies with low probability of comparison; and c) concessionaires whose established targets are higher than the starting point of the previous cycle and do not fall under item b (ANEEL, 2015).

3. Socioeconomic factors related to commercial losses

This chapter presents the socioeconomic factors related to non-technical losses, according to the international literature. In addition, it analyzes the specificities of the State of Rio de Janeiro, where the Light concessionaire operates, the object of this article's analysis.

3.1 - Socioeconomic factors highlighted by the international literature

According to Smith (2004), non-technical losses 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 relationship. The results of the research concluded that non-technical losses 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 is the informal urban settlements, popularly known as "slums". They arise in places where there are economic opportunities, but there are no houses for everyone to live legally. Thus, low-income citizens occupy irregular places, that is, not authorized by the public agent, characterized by insecurity and absence of law. Government planning generally does not follow the development of these areas, leading them to have a precarious infrastructure of mobility (streets and transport networks), energy (electricity and natural gas), communication (fiber optic lines to access the Internet), water and sanitation (sewage). The need to access these resources induces the residents of these localities to acquire them illegally (Smyser, 2009 and; Ruffin, 2015).
The negative governmental and social aspects impose many challenges for the distributors to act successfully in the slums. Among them, we point out four: non-payment culture, limited payment capacity of residents, "technological race" with illegal service suppliers and conflict between incentives and requirements of the regulator.
The culture of nonpayment comes from the perception that a private company is profiting enormously at the expense of a poor population while providing it with poor quality service. In addition, in many places the energy supply was provided at government subsidized rates, which contributed to the creation of a patronage heritage. The limited ability to pay comes directly from the weight that the bill has on the family budget. The "technology race" with illegal service providers forces distributors to invest in more advanced and expensive technologies in the network to hinder or even prevent energy theft. The conflict between incentives and requirements of the regulator appears, for example, when

the company is obliged to comply with the principle of universality, but the public agent does not recognize in the tariff the problems and extra costs to be able to attend slums (Lawaetz and Smyser, 2011).

3.2 - The socioeconomic factors 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 problem of development, measured in the work by the conditions of the households, per capita income and education of the population. Census data indicate that the population has a relatively high per capita income, a low illiteracy rate, and households with good water and sewage conditions. What explains the high rates of non-technical losses in the state are informality, violence and the cost of electricity in the family budget (IETS, 2008).

One of the measures of informality is "*favelização*". In the 2010 Census, made by Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística - IBGE), it is measured by the percentage of private house occupied in subnormal clusters. A subnormal cluster is a set of 51 or more housing units occupied without title to property and which have irregularities in the roadways, in the size and shape of lots and/or in the 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%. Evaluating by municipalities, we find the following percentages for some cities that belong to Light's concession area: Rio de Janeiro (19,9%), Duque de Caxias (6,8%), Belford Roxo (7,1%) e São João de Meriti (9,8%).

However, IETS (2008) argues that there are many criticisms regarding the methodology adopted by the IBGE and there are indications that these numbers are underestimated.

It is noteworthy that the occupation of the hills of Rio de Janeiro began in the second half of the nineteenth century, as an alternative to the lack of housing near the large urban and commercial center. However, there was still no connotation of slum, due to the absence of marked characteristics such as illegality, insalubrity and disorder. The slums emerge as a response to hygiene policies in the early twentieth century, which strongly attacked the tenements of the city (Gonçalves, 2013). Over time, they expanded through the most varied hills and reached municipalities in the metropolitan region, such as Niterói, São Gonçalo, Nova Iguaçu and Duque de Caxias.

The slums in the state are mostly controlled by armed criminal groups, known as "commands" and "militias". They are responsible for preventing the entry of the company in certain areas, harming the operation, the grid maintenance and the combat of non-technical losses.

The commands were born in the military period with the coexistence between regime opponents and bank robbers in the prisons of Rio de Janeiro. These learned to coordinate with those and created an organization called "Red Command (RC)". The fall in the price of cocaine, due to the beginning of the production in Colombia, made the members of this faction take the marijuana points of sales in the slums of Rio to sell it. From the 80's, there was the consolidation of a networked model and the emergence of rival commandos, who began to dispute territories with the CV in a very aggressive way. This has significantly worsened state violence rates (Misse, 2011).

The militias, in turn, originated in so-called "extermination groups", a group of police officers, former police officers, firefighters and penitentiary agents who, during the 1960s, 1970s, and 1980s, were hired by merchants to protect certain areas against the occurrence of crimes. In the 1990s, it also began to protect residents, in order to prevent the entry of drug traffickers. Over time, people with political interests joined this organization, which became to be known as militia. It should be noted that the militia is located mainly in the western part of the municipality of Rio de Janeiro and in the "Baixada", where it controls the distribution of bottled gas, cable and internet services and illegal public transportation, not paying the distributors of these services the amount consumed (Cano, 2012). However, the regulation of these services is different from electricity, making it difficult to compare the different cases. 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.

Figure 1 - Presence of Militia and Commands in the concession area of Light 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 in 2008 the so-called "Pacifying Police Units" (Unidades de Polícia Pacificadora - UPPs). These units seek to reduce the incidence of "lost bullets", the presence of rifles in the hands of armed groups, disputes over drug sales, the influence of drug dealers on people's routines and homicides practiced by police officers. In addition, they valorize the price of real estate and enable the entrance of municipal organs and social projects in the region (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)1, it was possible to verify that, in fact, there was an improvement of important indicators related to violence in the areas of action of the UPPs. Between 2007 (year before the start of the pacification program) and 2013 (when there were 36 UPPs already installed and the economic scenario was still relatively positive) there was a 71% drop in homicides, a drop of 63% in the vehicle robbery and 65% on cargo thefts and a 342% increase in drug seizures.

However, this public safety program has had bad consequences for the cities around the capital, especially Niterói and São Gonçalo, which belong to other utility. Data from the ISP show that, between 2011 and 2012, robbery in commercial establishments grew by 33%, car robbery increased by 43% and drug seizures rose by 37% in those places. This reflects a migration movement of criminals from the areas with UPPs to outlying locations. This fact was corroborated by the Secretary of Public Security of Rio de Janeiro, José Mariano Beltrame, in a statement made in April 2012[2]. In the statement, the secretary affirms that there is migration of bandits from the slums of Rio de Janeiro to areas of Niterói and São Gonçalo, but there is no exact number of how many thieves carried out this migration. That is, the boundaries of organized crime were only widened and gained new locations in the Rio metropolitan region.

Recently, the UPPs have been weakening due to the lack of resources to maintain, improve and expand the program. The state crisis promoted a cut of 30% in the budget of the security summit in early 2016[3]. In addition, violence has also grown with the worsening of economic indicators, which makes the future of UPPs even more uncertain.

Finally, on the cost of electricity, IETS (2008) argues that two factors contribute to the fact that the electricity bill in Rio de Janeiro is higher than in other states: a) Rio has the highest state tax rate in

[1] Available at: http://www.isp.rj.gov.br. Acessed in 23/02/2017.
[2] Available at http://g1.globo.com/bom-dia-brasil/noticia/2012/04/bandidos-migram-de-comunidades-pacificadas-e-assalto-violento-explode-em-regiao-metropolitana-do-rio.html. Acessed in 23/02/2017.
[3] Available at: http://www.bbc.com/portuguese/brasil-37685003. Acessed in 23/02/2017.

Brazil; and b) the hot weather and the easier access to durable goods, especially air-conditioning, led to increased consumption.

The reduction of the Industrialized Products Tax (Imposto sobre Produtos Industrializados - IPI) between 2012 and 2015 provided an incentive for the purchase of intensive electrical appliances. In addition, the economic growth of recent years has improved the financial conditions of much of Brazilian society, but this increase in income has not resulted in an exit of the informal market to the formal energy market (Light, 2013). According to the Goods Asset Survey, conducted in 2013 by an institute called "Data Popular", most of the houses in the communities (slums) in the concession area of Light rely on electro-intensive products, as shown in Figure 2, below.

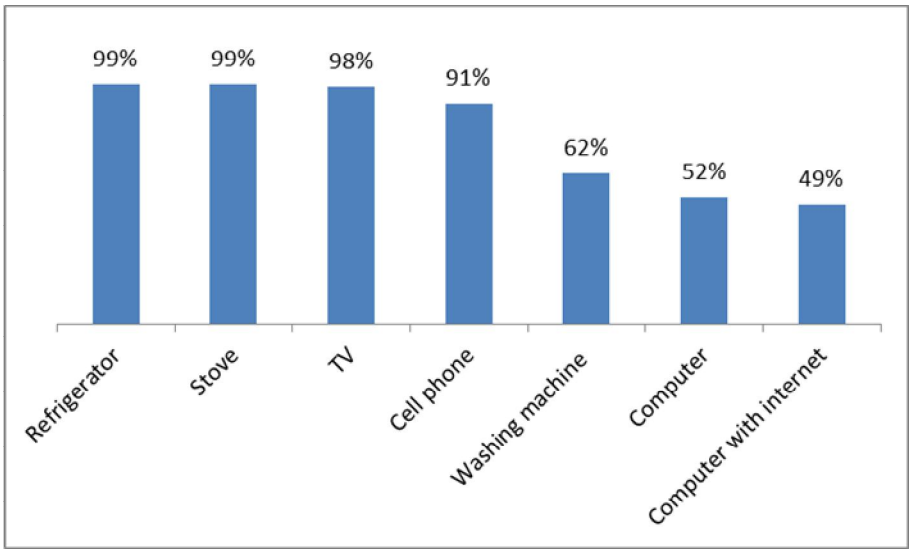

Figure 2 - Ownership of goods in the communities of Rio de Janeiro 2013. Source: Light (2013)

This survey did not include air conditioners. However, there is evidence of the increasing spread of this good in homes as a whole and especially in the informal areas, contributing to further aggravate Light's problems of losses. Given that in these areas population density is higher and residence ventilation is much lower than in formal areas, temperatures reach higher than normal levels, causing residents to use these appliances excessively. However, it is important to note that the theft and adulteration of meters contribute to the wasteful use of this device in warmer periods, as the consumption of the residents is not affected by the price of energy. Studies by Light (2013) show the strong correlation between temperature and losses.

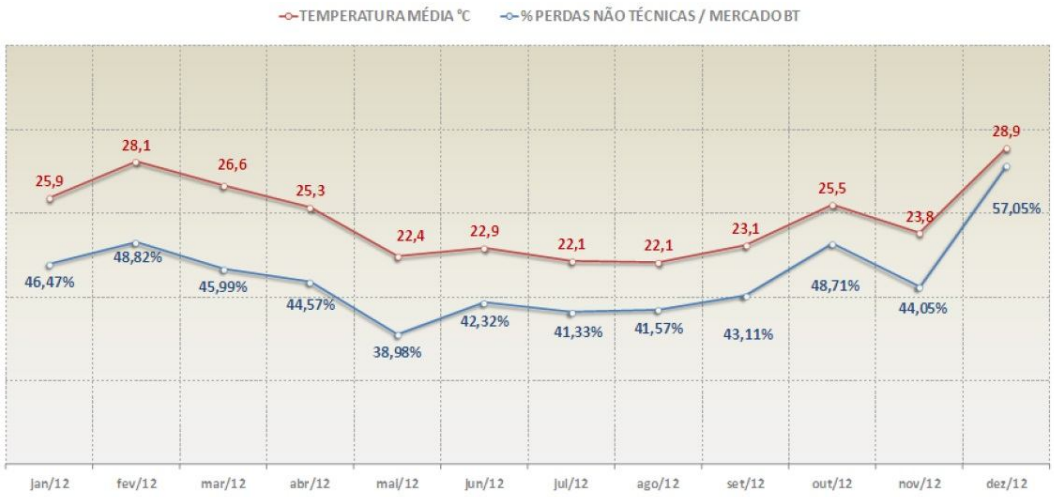

Figure 3 - Mean Temperature X Non-Technical Losses/ ***Low Voltage Market****. Source: Light (2013)*

We can also point out that very few consumers benefit from the discount on the account provided by the Social Tariff. This occurs because, to receive the benefit, the family must have a monthly income per capita less than or equal to half a national minimum salary, equivalent to R$440.00, which is not feasible for survival in Rio de Janeiro, where the cost life is very high. In the state of Maranhão, for example, where per capita income is lower, the utility distribution, CEMAR, has been able to register many low-income consumers in the Social Tariff, bringing to the legality many citizens who steal energy because they did not have the capacity to pay the electricity bill.

4. Non- technical losses in Light's concession area

This chapter addresses the issue of non-technical losses for Light. Based on information collected in meetings with company employees and reports, the aim is to characterize the concession area in relation to socioeconomic indicators and losses. In addition, it will present the methods of combat adopted by Light and the situation of the company in relation to the regulation.

4.1 Light's concession area

There are 31 municipalities in the concession area of Light Distributor in the state of Rio de Janeiro, and serves approximately 4.5 million customers (LIGHT, 2016). The company divides its concession area into 5 regions: South Center, East, West, “Baixada” and Valley.

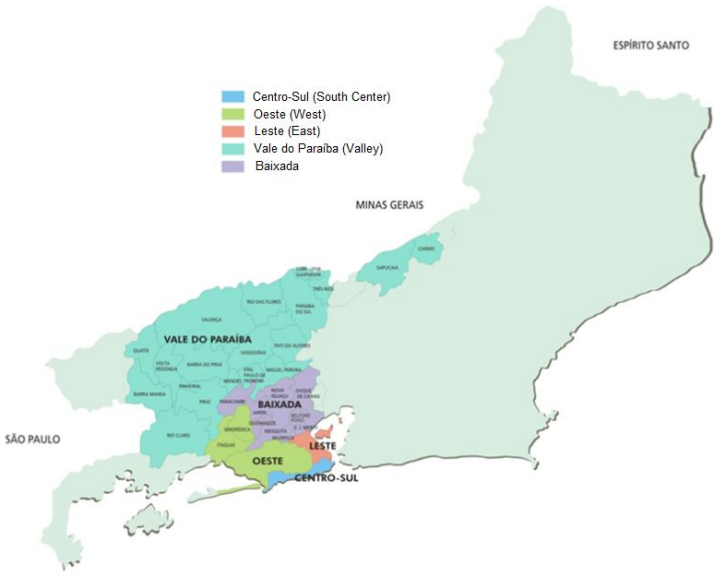

Figure 4 - Light's concession area. Source: Light (2013)

The South Center region is mainly composed of the districts of South Zone, Center, Barra da Tijuca and a small portion of North Zone, all of them belonging to the municipality of Rio de Janeiro. The principal characteristics are the predominance of large vertical and horizontal condominiums, good urban organization, strong presence of underground network, high density of load and substandard or precarious households in slums. The Eastern region covers almost the entire Northern Zone of the same municipality. There is in this region the highest density of the concession area, horizontal residences, villages, medium-sized trade, predominant air network and high number of communities, among which the Complexo do Alemão and Maré are the most famous.

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 characterize 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 air network are the main elements of this area of the state. Finally, a part of the municipalities of the regions (Médio Paraíba, Centro Sul Fluminense and Serrana) compose the Valley region. The principal characteristics are the presence of an air distribution network, few subnormal or precarious households and large industrial loads (Light, 2013).

We can conclude by the descriptions that the regions are quite heterogeneous with each other. This is reflected in the percentages of non-technical losses verified. The regions of Baixada, East and West were those that, between October 2014 and September 2015, presented the highest percentage of the indicator "Non-Technical Losses/Low Voltage Market", registering 72.5%; 68.8% and 67.8%, respectively. The Valley and South Center regions recorded, respectively, 1.1% and 1.53% in this indicator (Light, 2013).

In 2012, non-technical losses in the company's concession area reached 6TWh. This is equivalent to 20% of all energy stolen in the country, and to the annual consumption of the state of Espírito Santo (Light, 2013). Nowadays, this amount is slightly higher, recording 6,029TWh. As will be noted below, the company has difficulties to meet the regulatory targets of non-technical losses. In 2015, the losses caused an impact of R$ 400 million in the company EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortization) (Gomes, 2016).

It should be noted that, currently, almost half of the company's non-technical losses are present in areas known as "Areas with Severe Restrictions on Operation" (*Áreas com Severas Restrições*

Operacionais - ASRO) while the other half are in areas considered possible to operate (although with some restrictions). High levels of non-technical losses and the presence of criminal groups characterize the ASROs. These groups are responsible for making impossible for the company to enter and, consequently, operate in these places. However, not all poor communities have this classification for the company. About 642 of the 1340 communities in the Light concession present severe restrictions on operation.

The company estimates that about 1.95 million of its customers are fraudsters, with 1.1 million in possible areas and 850 thousands in ASROs. However, fraud is not, generally, of 100% of the energy bill, as people are concerned about continuing to receive the bill, which serves as a proof of citizenship to gain access to benefits such as bank credit. Thus, they often stole electricity from those appliances 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, equivalent to an account of approximately R$250,00[4]. This is a bill similar to that paid by regular customers and represents a relatively high burden on the budget of a low-income family. Meanwhile, Light only receive the payment of 60 KWh on average, resulting in a loss of 280 KWh (R$180,00[5]) per fraudster customer. It is important to say that the wasteful use of devices such as air-conditioning explains, in part, the high consumption (Gomes, 2016).

4.2 - Methods implemented by Light to combat non-technical losses

In recent years, Light has sought to combat non-technical losses by optimizing conventional inspection and regularization actions and by installing centralized metering and shielding systems in a great number of areas. In locations with UPPs, the company applied these technical improvements in the network and also invested in education of their clients to consume less energy, in the exchange of inefficient equipment of the residents, in the offering of credits in the account if there was trash recycling and it offered tiered discounts on the tariff over time for consumers to become accustomed to paying the bill.

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 electricians and commercial service agents to improve the indicators of losses and delinquency. The remuneration of the same has a variable aggressive component, which is greater when the success in the improvement of these indicators is higher. In areas with ZLA's, non-technical losses declined by an average of 20 percentual points, falling from 45.8% to 24.7%.

In December of 2012, there were 28 communities with UPPs, which Light completed the reform of the network (shielding and meter exchange) in 8 of them. In these areas, on average, losses fell from 64.1% to 14.6%, as can be seen in the table below.

Area	Conclusion Year	Losses	
		Before	2012
Santa Marta	2009	95%	8,22%
Cidade de Deus	2010	52,10%	14,45%
Chapéu Mangueira	2010	62,70%	14,75%
Babilônia			
Cabritos	2011	62,30%	12,47%
Tabajaras			
Formiga	2011	73,30%	9,37%
Batan	2012	61,80%	10,66%

Figure 5 - Losses in the UPPs with Light's performance. Source: Light (2013)

[4] Calculation based on the simulator present on the company's website with reference to the month of March 2017. Available at: http://www.light.com.br/para-residencias/Simuladores/conta.aspx

[5] Idem

It is possible to note that, depending on the locality, the technological advance alone was not enough to solve the problem. In the Complexo do Alemão community, the company implemented a Smart Grid system, for example, but there was no significant reduction of non-technical losses.
In recent years, as outlined above, the UPPs program is weakening. In this way, the company was not able to keep its ZLA programs in some areas, classified as possible because of the UPPs, due to an increase in violence levels. Those areas now present severe restriction again, resulting in an increase in losses, as can be seen in figure 6 below, which presents the case of Cidade de Deus. Now, the company is rethinking the strategy of following the steps of the UPPs. This fact together with inflation and unemployment makes the future of non-technical losses worrying in Light's concession area.

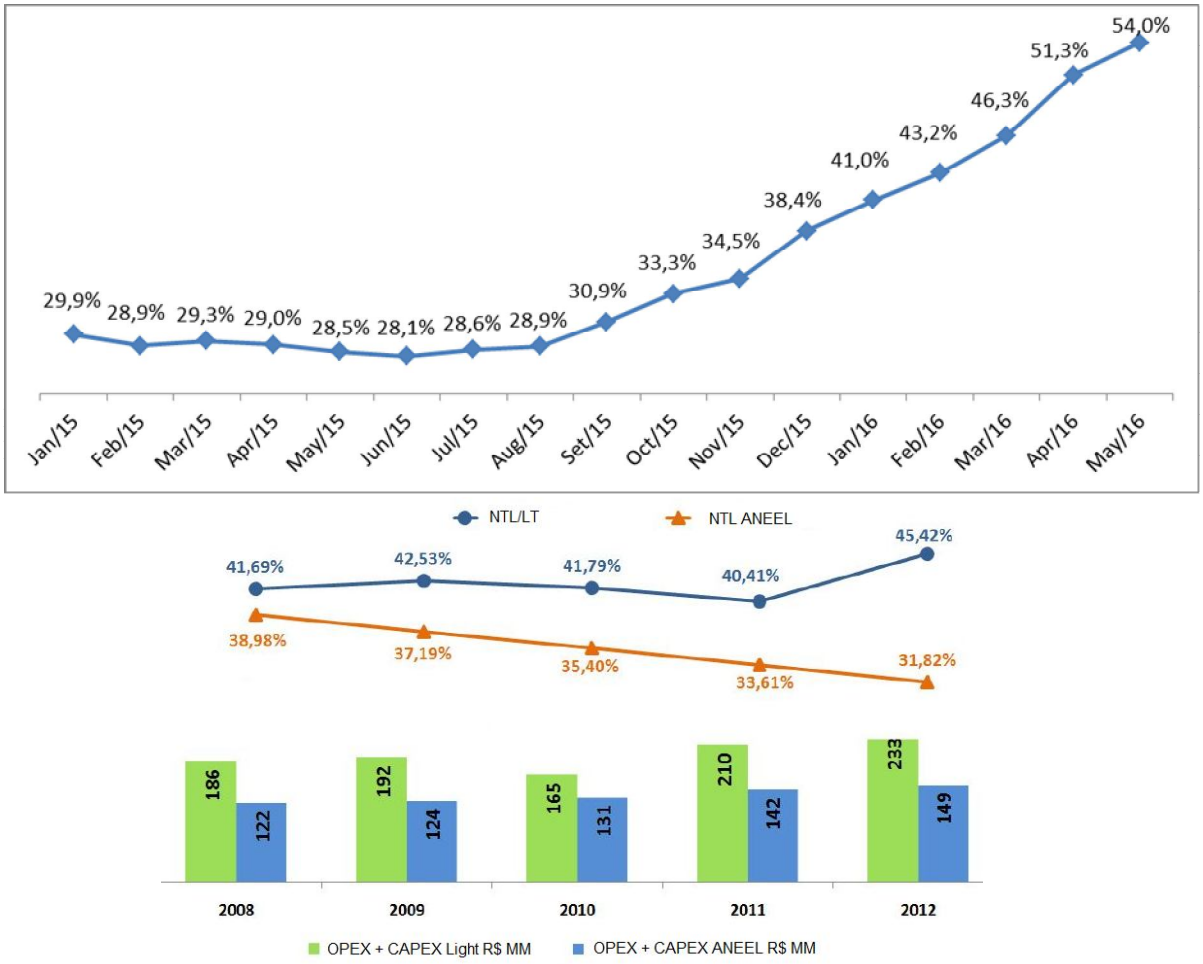

Figure 7 - Non-technical losses of Light Regulation. Source: Light (2013)

According to Light, 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 that the company cannot act due to criminality and, in theory, the model would need 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 non-technical losses. In addition, indicators of human development and subnormal clusters are not always good for identifying these areas, which leads the ANEEL model to underestimate the losses due to the specificities of Rio de Janeiro.

The company reduced losses in the areas considered possible. Currently, losses in these areas are already 2% below the regulatory target.

5. Conclusions

In view of the factors presented, it is possible to conclude that socioeconomic aspects and violence affect non-technical losses. Because of this, the role of the State as a key agent for the improvement of these indicators is very important, thus helping distributors to offer their service to all residents with the same quality and to combat non-technical losses.

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 service provided, Light is managing to reduce its level of non-technical losses with indices higher than those established by the electric system regulator.

The regulator qualifies the concession areas as being homogeneous throughout its length. However, this is not verified in Light's area of activity. In this context, it is timely that ANEEL reanalyzes the regulatory treatment of non-technical losses in order to better characterize concessions with severe operational restrictions areas (ASROs).

Light is working on a research and development (R & D) project with the Electric Energy Research Group (GESEL) of the Federal University of Rio de Janeiro (UFRJ), in order to propose regulatory innovations to ANEEL in the case of ASROs. The objective of this study is to define new parameters of complexity that better identify the difficulty of acting in these areas and the proposition of flexibility in the regulatory target of these localities, since the company has a high level of losses in ASROs.

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