EVALUATION OF THE EFFECTIVENESS OF THE TARIFF FLAGS POLICY IN THE SOUTHEASTERN OF BRAZIL (2015-2018)

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Abstract: In 2015, the National Electric Energy Agency (ANEEL) implemented the Tariff Flags Policy on the energy bill, as a way of giving the consumer a short-term economic impact signal and, thus, inducing a consumption reduction behavior in critical periods. This paper aims to evaluate the effectiveness of this policy, from 2015 to 2018, by testing the hypothesis that there is significant reduction in energy consumption when different tariff flags are applied. In this sense, data of residential consumers in the Southeast region of Brazil were analyzed using two statistical approaches: the multiple linear regression from variables with explanatory potential on the consumption profile and the comparison of averages of consumption variation. The results indicate that the application of the Tariff Flags Policy did not significantly alter the consumption of electricity, which suggests a possible failure in the effectiveness of this policy.

Keywords: Public Policy; Electrical Energy Consumption; Tariff Flags; Comparison of Averages; Multiple Linear Regression.

1 Introduction

The supply of electricity is an essential service for the well-being of society, and is therefore considered public utility. The importance and essentiality of this service requires it to be supplied with quality, efficiency and, at the same time, with tariff modicity[1]. Such premises

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[1] The principle of tariff modicity is expressly provided for in Paragraph 1 of art. 6 of Law No. 8,987 of 1995 – General

represent major challenges for the electricity sector that, in recent years, have sought new management models amid scenarios of water crisis, fiscal adjustment, environmental requirements, diversification of the energy matrix and readjustment economic and financial process of generating, transmitting and distributing electricity.

In 2015, the National Electric Energy Agency (acronym in Portuguese: ANEEL) (2016) instituted the Tariff Flags Policy on the energy bill, as a way to give short-term economic signal to consumers and thus induce a behavior of consumption reduction in critical periods. The process consists of charging the amounts of the additional tariffs of the yellow and red flags (levels 1 and 2), activated whenever consumption reaches certain ranges, which are defined from the forecast of costs related to the generation of energy by thermoelectric source and exposure to the short-term market affecting distribution agents. From this context, the following research question arises: the application of the Tariff Flags Policy in the Southeast region of Brazil, between 2015 and 2018, brought a significant reduction in residential electricity consumption? In other words, it is desired to know whether the yellow and red flags actually produce a change in the pattern of consumption.

Within this perspective, the present study aims to evaluate the age of this policy between 2015 and 2018, based on the data on residential consumption in the Southeast Region, through two approaches. The first uses multiple linear regression and evaluates variables with explanatory potential for consumption. The second uses the comparison between mediums for test the hypothesis that there is significant variation in energy consumption when different tariff flags are applied, that is, that there is a reduction in consumption when flags with additional tariff are applied.

With this, it is hoped to contribute to public policy evaluation efforts and the process of adopting evidence-based policies, according to Gertler *et al.* (2011, p. 3). According to Batista and Domingos (2017, p. 1), in a context in which the budgetary, informational and decision-making restrictions faced by the State are increasingly clear, the use of evaluation results for the formulation and review of public policies is highlighted.

The article is organized into sections, in addition to this introduction. The second section discusses the role of the State in regulating electricity tariffs and presents the Management by the Demand Side method, in which tariff flags are inserted. The third section presents the Brazilian Electrical System and the main aspects of infrastructure and tariff composition. The fourth section details the Tariff Flags System. The fifth section describes the consumer market for electricity in Brazil. The sixth section presents the methods used for analysis. The seventh section presents and discusses the results. Finally, the last section brings the main conclusions.

Law of Concessions – and establishes, as one of the conditions for the public service provided to be considered appropriate, the collection of a mobile tariff, which allows access of all users to the service. At the same time, the value of the tariff should make investments possible, ensuring a sustainable and quality provision (BRASIL, 1995).

2 Demand-side management (DSM)

The electricity sector comprises three segments: generation, transmission and distribution. In each segment, there are specific risks that should be the focus of concern of regulators. One of the characteristics that brings complexity to the sector is the fact that the transmission and distribution segments constitute services of natural monopoly, so that companies operate with great costs for the implementation of the infrastructure and, at the same time, with costs that decrease with the increase in the customer base. Investments in the electricity sector are extremely specific and the return usually takes long periods to materialized, something like 20 or 30 years (INSTITUTO ACENDE BRASIL, 2007, p. 2).

Another factor that makes the sector complex is its composition in terms of power generation infrastructure. Different types of infrastructure impose different costs, operational needs, levels of availability and reliability in generation, and a wide variety of actors and agents to manage and operate the entire system. This whole panorama ends up imposing, also, complexity in the tariff composition of the electricity sector.

This context makes the regulatory action of the State extremely important, to lead the sector to the objectives of providing the service with quality and tariff modicity. In Brazil, the National Electric Energy Agency (ANEEL), created through Law No. 9,427/1996, regulated by Decree No. 2,335/1997 (BRASIL, 1996, 1997), conducts this regulation. Among the main tasks of ANEEL is to establish electricity tariffs, an issue that is of great complexity and produces considerable impacts on society.

Among the different methodologies used for tariff regulation are those inserted in Demand-Side Management (DSM). The DSM refers to "planning, implementation and monitoring of activities or strategies that aim to modify the consumer load curve" (BRASIL, 2018, p. 6). For a better understanding of matter, it is also worth considering the definition employed by Campos (2004):

> Demand-side management programs are deliberate interventions [...] in the consumer market (demand) to promote changes in the profile and magnitude of the load curve. The desired changes can be the reduction of power at peak hours, the filling of vouchers, changes in cargo, strategic conservation, strategic growth and the construction of flexible load curves. (CAMPOS, 2004, p. 1).

This strategy can be applied by changing the total consumption value or shifting it over time, and can involve the deployment of equipment, technologies, processes or techniques of management and planning of resources. By modifying the load curve, DSM strategies have the potential to increase system efficiency by reducing costs along the supply chain and, consequently, the tariff charged to the consumer. Thus, the DSM seeks to change the demand, that is, the modification of the patterns of electricity consumption due to changes in service prices over time or due to the payment of incentives.

One of the recent DSM measures implemented by ANEEL is the Tariff Flags System (acronym in Portuguese: SBT). In force since January 2015, this system uses price changes in the tariff to provoke demand reactions. More specifically, the system consists of setting an additional value to the electricity tariff, as soon as there is a prospect of an increase in operating and generation costs to signal to the consumer the price variation in the short term. Commercial procedures for the application of SBT are established in Normative Resolution ANEEL No. 547 of April 16, 2013, and the values of flags are published by the Regulatory Agency, each calendar year, in a specific act.

The increase in operating and generation costs is usually due to the need to drive thermal power plants and due to hydrological risks. Brazil, in recent years, has undergone long periods of drought, which caused excessive decreases in reservoir levels of its hydroelectric plants. Water scarcity made it necessary for the most frequent activation of thermoelectric plants, considerably burdening the electricity sector.

Prior to the validity of SBT, these additional costs were added to the tariff paid by consumers only in times of tariff adjustment, bringing problems to the cash flow of concessionaires and energy distribution holders, and causing sudden increases in the consumer account. SBT aims to fix these problems. When detecting increases or risks of cost increases, the energy bill now has additional values. These additional values should cause, in thesis, reduction of energy consumption, improvement in the cash flow of companies and less fluctuation in prices in the revisions and tariff adjustments of electricity distributors.

However, the mechanism's ability to achieve these ends, especially the first, has been widely questioned. In March 2018, the Federal Court of Auditors (acronym in Portuguese: TCU) disclosed, through Judgment No. 582/2018, audit findings on the subject, in which it concludes by the ineffectiveness of this measure as a sign of consumer prices and efficiency-inducing mechanism in energy tariff adjustments. The Court even issued a determination to prohibit ANEEL from transmitting and making available information on its website or in any other media that consumer signaling would be the main objective of the Tariff Flags System (BRASIL, 2018). Subsequently, the determination was reviewed and replaced by the recommendation that the Ministry of Mines and Energy and the Regulatory Agency adopt measures to ensure the effectiveness of the mechanism, with the definition of qualitative or quantitative goals and periodic monitoring of results, if no response is obtained in terms of consumption reduction (BRASIL, 2019).

As a repercussion of the TCU's performance, the Draft Legislative Decree – PDL No. 907/2018 was presented in the House of Representatives, which aims to suggest the instituting decree of the SBT, despite the criticism of the ANEEL to the conclusions of the TCU audit. In addition to this, until August 2019, PDL No. 338/2019 had been presented in the same Legislative

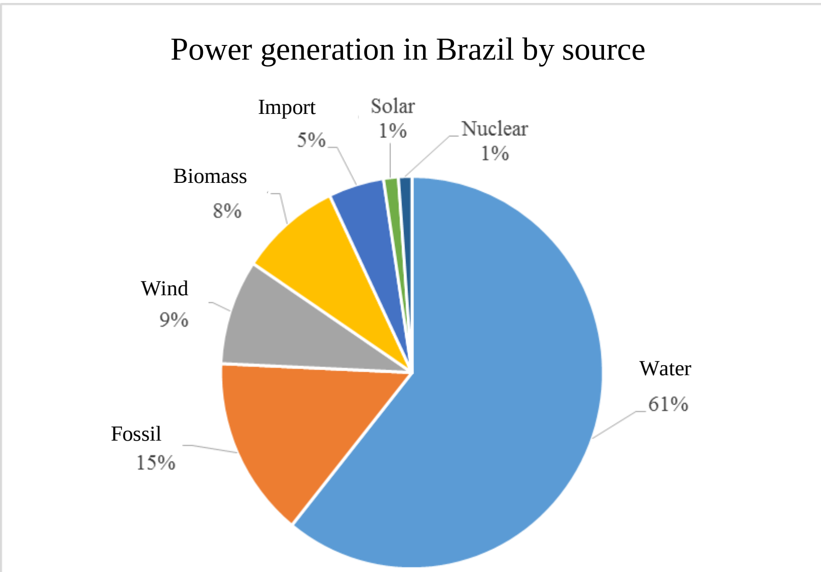
House and the Draft Bills No. 10,439/2018 and No. 2,473/2019, with similar objectives. It is observed, therefore, that there are discussions and uncertainties around the results of the SBT, a context that reinforces the need for a more rigorous evaluation of this policy.

3 The Brazilian electrical system: main aspects of infrastructure and tariff composition

The Brazilian Electric System (acronym in Portuguese: SEB) has a full interconnection between the regions, generating what was convinced to call itself the National Interconnected System (acronym in Portuguese: SIN). The SIN consists of four subsystems, which is, the subsystems South, Southeast/Midwest, Northeast and most of the Northern Region. Systems that serve non-SIN-related locations – 237, in 2019 – are called isolated systems (OPERADOR NACIONAL DO SISTEMA ELÉTRICO, 2019).

The SEB has a predominance of hydroelectric generation, which, in proportional terms, represents approximately 61% of the installed capacity. Despite its undeniable advantages, such as the fact that it is a renewable and non-polluting source, the seasonality of hydroelectric plants makes it essential to use complementary sources that can be triggered at any time, with reliably. In the Brazilian scenario, this role has been fulfilled mainly by thermoelectric. Thermoelectric plants represent the second largest source of generation, with 15% of the installed capacity, according to data from ANEEL (2019a). Figure 1 illustrates the composition of power generation in Brazil.

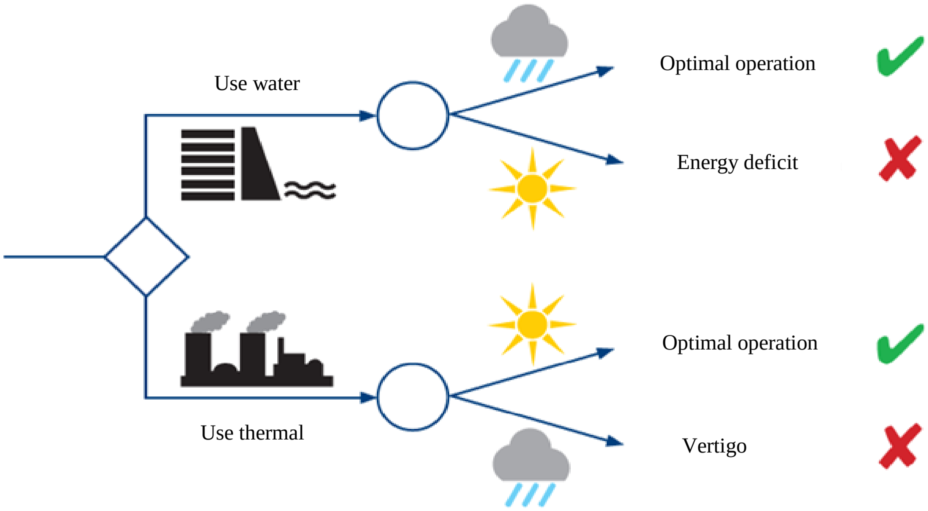
Figure 1 – Composition of power generation in Brazil in 2019.



Source: Own elaboration. ANEEL data.

The diversified composition of the system makes the good performance of the National Electric System Operator (acronym in Portuguese: ONS) extremely important. According to Facto Energy (2018), "operating the system is to define, at each moment, which plants will be activated (dispatched) to meet the demand for electricity". The dispatch of different generation structures causes different costs, with reflections on energy tariffs. Thus, the great challenge of the operation is to meet the demand at the lowest possible cost, while ensuring energy security. According to Tolmasquim (2015), the optimal operation of a hydrothermal system involves a compromise between depleting reservoirs (using water) or not depleting reservoirs (using fuels). Figure 2 illustrates this dynamic.

Figure 2 – Electrical Power Operator Decision Diagram.



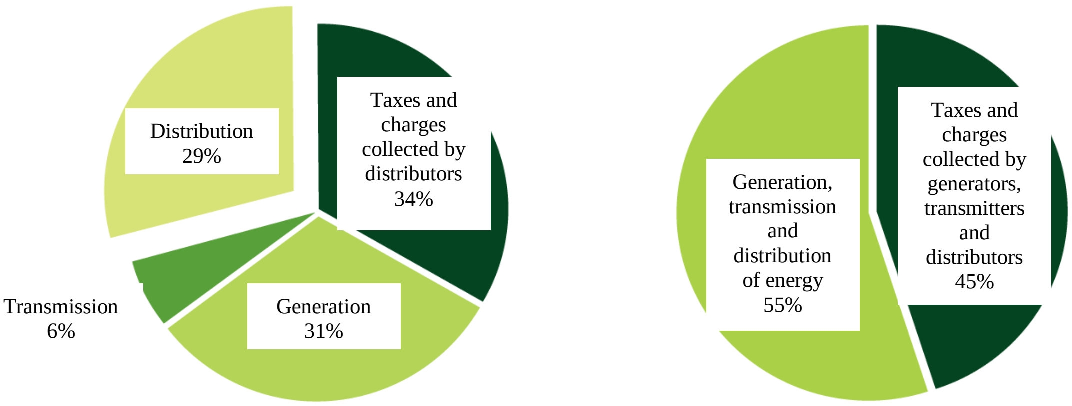
Source: FGV Energia (2017).

Thus, in the occurrence of a negative hydrological scenario, because the thermals present a higher Marginal Operating Cost (acronym in Portuguese: CMO) than Hydroelectric Power Plants (acronym in Portuguese: UHE), their drive increases the overall cost of generating the system. If generation costs increase with the activation of thermals, and, given that they, unlike the UHE, are pollutants and consume non-renewable resources, it is appropriate that there is a mechanism to induce the reduction of consumption in these scenarios. This is one of the justifications for the application of tariff flags.

With regard to the tariff composition, it is important that the electricity tariff has several components, each with specific methodology of determination, which has the theme of significant complexity. Given the objective of this article, only the main concepts and characteristics of tariff components will be presented, in an attempt to bring clarity and objectivity to the subject.

The first important feature of the energy tariff, as explained by the Instituto Acende Brasil (2011, p. 2), is that most of it "is not intended for the energy distribution concessionaire, but it is passed on to the Government, through charges and taxes or to upstream companies of the production chain (transmitters and generators)”. Less than a third of the tariff is effectively intended for the distributor. Figure 3 illustrates the composition of the energy tariff and shows that, in fact, there is little room for direct action of ANEEL (29%, related to distribution) in the regulation of the value of the tariff.

Figure 3 – Composition of the energy tariff.



Source: Instituto Acende Brasil (2011).

Another factor that considerably limits ANEEL's performance in tariff regulation is the composition of the tariff in terms of cost management capacity by distributors. From this point of view, it was agreed that the energy tariff consists of two installments, the so-called Parcel A and Parcel B. The Parcel A makes up most of the tariff and refers to costs from other segments of the sector, which are only passed on by distributors to final consumers. Distributors call these costs “unmanageable”. As explained by the Instituto Acende Brasil (2011, p. 4): "ANEEL has little influence on Portion A and on taxes on the tariff, since they are mostly activities whose prices are not directly regulated by the Agency".

The Parcel B of the tariff is the slice of the price of energy, which may have greater influence of ANEEL, to the extent that it represents the costs under the control of the distributor. These costs are essentially derived from two types of expenditure: operating expenses and capital expenditure. The first represent the expenses with the effective operation and maintenance of the electricity distribution service. Capital expenditures represent investments in assets, such as substations, networks and distribution lines, real estate, vehicles, among others.

Throughout the contract for the provision of electricity distribution services, the tariff regulation by ANEEL will therefore focus on part of Portion B of the tariff. And, although it seems limited, such an action has great importance, because it will allow, among other aspects:

a) avoid abuse of market power, essential action in markets of natural monopolies, such as the electricity distribution market;
b) simulate economic efficiency conditions in a competitive market;
c) ensure remuneration of investments consistent with the risks of the sector; and
d) promoting policies that seek efficiency and cause cost and price reductions.

In short, the regulation, as already mentioned, should seek to ensure the provision of economically viable service, with the best quality and at the lowest possible cost. In addition to specific regulatory policies and systems, the electricity sector has systematic tariff regulation processes that constitute tariff review and tariff adjustment.

The tariff adjustment takes place annually and seeks to correct inflation, adjusted with productivity gains or losses. In addition, the costs more or less are recognized, in relation to those provided for in the previous tariff adjustment, of Parcel A. In tariff reviews, which occur every four years, consumer productivity gains are passed on and deviations that jeopardize the investment capacity of companies.

At this point, it is easy to understand the problem once generated by water scarcity with consequent greater use of thermoelectric generation: the dispatch of thermal scans increased the cost of operation of the system, which was only considered annually, in the events of adjustment. Until the adjustment, the distributors assumed all this cost, with losses to their cash flow. Only after the adjustment, this cost was passed on, with significant increases in the consumer's energy bill. This was, therefore, the motivating context of the creation of SBT.

4 The tariff flags system (SBT)

As explained by the TCU, the SBT works based on an additional tariff, which has the function of anticipating a future and uncertain cost for the consumer, and has as reference the generation scenario. With the flags, the transfer of costs with the thermoelectric generation, which would be carried out accounting for the entire period between adjustments or revisions of the tariff, happens to occur with monthly frequency. The operation of the system consists of the definition of colors (green, yellow and red) that indicate whether the energy tariff will be added value, with the aim of signaling the higher cost of generating electricity in the SIN (BRASIL, 2018, p. 4).

The following are the different levels of this system, according to what is determined by ANEEL (2019b):

- **Green flag:** favorable conditions of power generation. The tariff does not suffer any surcharges;
- **Yellow flag**: less favorable generation conditions. The tariff is increased by R $ 0.015 for each kilowatt-hour (kWh) consumed;

- **Red flag - Level 1**: more costly generation conditions. The tariff is increased by R $ 0.040 for each kWh consumed.
- **Red flag - Level 2**: even more costly generation conditions. The tariff is increased by R $ 0.060 for each kWh consumed.

With the exception of the green flag, which does not imply tariff increase, it is expected that the application of the additional tariff of any of the other flags will induce consumption reduction by consumers. As detailed at the end of the next section, this expectation is based on the negative correlation between price and demand (MANKIW, 2011, p. 90). Regarding the collection of the additional costs of flags, it is important to highlight that, through Decree No. 8.401/2015, the Centralizing Account of Tariff Flags Resources (acronym in Portuguese: CCRBT) was created, with the objective of managing the additional resources originated by the system. The system applies to all captive consumers served by companies connected to the SIN. Therefore, the sites served by isolated systems and consumers who choose the free market are not subject to the flags (ANEEL, 2019c).

Normative Resolution ANEEL No. 547 of April 16, 2013 established the commercial procedures for the application of SBT, whose values are published by ANEEL, each calendar year, in a specific act. The first step of its implementation took place from July 2013 to December 2014, with the dissemination of tariff flags only on a didactic basis.

Effective collection was initiated only in January 2015 and, as of March of the same year; the submarket division gave way to a single flag for the entire SIN. The incidence of the red flag during 2015 occurred due to the water crisis that strongly affected the reservoirs of hydroelectric plants and led to the activation of thermoelectric plants to supply the system (ANEEL, 2016).

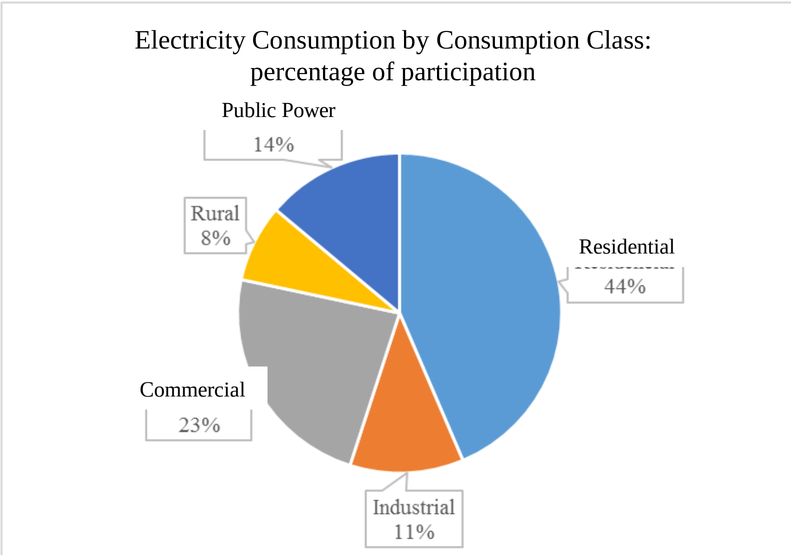
Until February 2015, tariff flags considered only the variable costs of thermal plants that were used in power generation. For every 100 kWh consumed (or its fractions), the red flag corresponded to R $ 3.00 and yellow, at R $ 1.50. As of March 2015, with the improvement of the system, other generation costs, which vary according to the hydrological scenario, began to compose the calculation of flags (ANEEL, 2016).

More recently, the flags have undergone further revisions by ANEEL. It was approved on April 24, 2018 the revision of the definition of additional, the drive rule and the treatment of tariff coverage related to tariff flags that had already been applied in a precautionary manner since November 2017. As stated, in June 2019, the values of the flags are defined as follows: yellow flag in the amount of R $ 1.50 per 100 kWh consumed and fractions; red flag level 1 in the amount of R $ 4.00 per 100 kWh and red flag level 2 in the amount of R $ 6.00 per 100 kWh (ANEEL, 2019c).

5 The consumer market of electricity

As already highlighted, the SBT aims to act specifically on a variable of energy consumption, namely the value of the tariff. However, it is important to understand that the tariff is only one of the conditioning factors of electricity consumption. In addition, one can mention the consumption class, which can be Residential, Industrial, Commercial, Rural, or Public Power. Figure 4 illustrates the representativeness of each class in global energy consumption in 2017. It is verified that the residential consumption class accounts for almost half of the total consumption of electricity in Brazil.

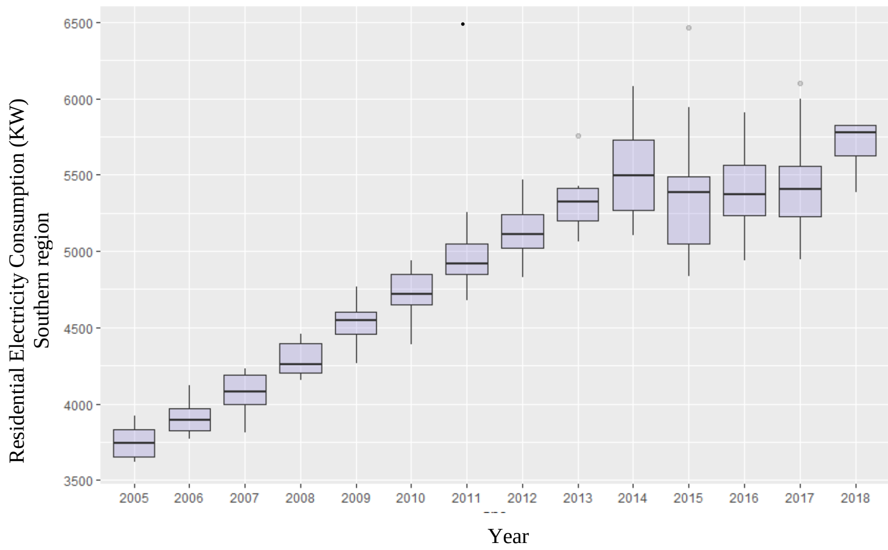
Figure 4 – Electricity Consumption by Consumption Class.



Source: Own elaboration. ANEEL data.

In addition, in the Southeast, positive consumption growth rates in residential class over the past decade are observed, as shown in Figure 5. Issues such as urbanization and economic warming in the country are factors that can explain the positive rates found.

Figure 5 – Residential Electricity Consumption in the Southeast Region between 2005 and 2018.



Source: Own elaboration. ANEEL data.

In addition to the natural variations between the consumption patterns of these classes, they are also differentiated by the margin of flexibility to reduce or increase the consumption of electricity, by the possibility of adopting more efficient technologies, and by specificities of the regulatory model. In this regard, it should be made clear that, under Decree No. 5,163/2004, the energy market in Brazil is divided into Regulated Contracting Environment (acronym in Portuguese: ACR), where captive consumers are, and Free Contracting Environment (acronym in Portuguese: ACL), formed by free consumers[2]. Captive consumers are those who buy the energy from distribution concessionaires to which they are connected, while free consumers can buy energy from distribution concessionaires or directly from generators or traders through bilateral contracts with freely negotiated conditions such as price, term and volume.

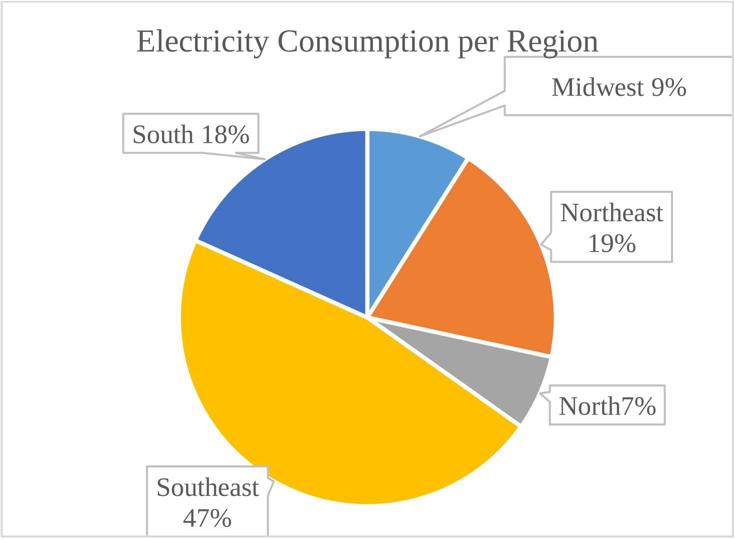
Consumers who have contracted demand greater than or equal to 500 kW can exercise the option of migrating to the energy-free market, a rule that does not cover residential units. The captive consumer, in turn, does not have purchasing management mechanisms, since the distributor performs this operation and assumes the associated risks. In this model, tariff composition is essential for the correct allocation of costs, as well as for the induction of conscious consumption.

In addition to the consumer class, they may have an influence on energy consumption issues such as household income and household size (for residential consumers), Gross Domestic Product (GDP) of the region, and temperature of the consumer region, which varies significantly throughout the year (VIANA; HOFMANN, 2017). Figure 6 illustrates the

[2] These concepts are explained in a didactic way in ABRACEEL (2019). The migration criteria for the free market are established in Law No 9,648/1998.

percentage share of consumption per region in 2017, in which there can be a significant domain in the Southeast Region, with 47% of national consumption.

Figure 6 – Electricity consumption per region in 2017: percentage participation.



Source: Own elaboration. ANEEL data.

This set of factors suggests that, even from a theoretical point of view, the effectiveness of the economic signal of tariff flags is expected to be limited, since it acts only on the tariff. Consider, furthermore, that its impact depends on price-demand elasticity, that is, how much consumption responds to the price change (MANKIW, 2011, p. 90). According to Viana and Hofmann (2017), ANEEL estimated, at the time of the implementation of the flags, a price-demand elasticity of 0.25 (25%). This estimate is aligned with the values found by Dantas, Costa and Silva (2016, p. 16): in the Southeast Region, for the residential market, these authors estimated a price-demand elasticity of 0.236. Thus, in view of the average residential tariff practiced in the Southeast Region, in 2018, of R $ 0.566/kWh (ANEEL, 2019d), the percentage increase to the rate resulting from the application of the red flag level 2, approximately 10% (R $ 0.060 ÷ R $ 0.566), and the price-demand elasticity estimated by the Agency, 25%, it is concluded that the potential reduction in consumption is limited to something around 2.5% (10% × 25%).

The expectation of consumption reduction due to the application of SBT also makes sense, from the perspective of mechanistic theory applied to sociological studies, or social mechanisms. According to Hedströmand Swedberg (1996, p. 7), a satisfactory explanation of the covariation between variables requires us to be able to understand the social gears that support the systematic relationship between these variables. Here, social gear lies in the financial impact generated on the consumer, that is, on the premise that the individual tends to modify his consumption pattern when he feels "hurt in his pocket". In other words, the causal mechanism of this work lies in the fact that the adoption of the additional tariff, through the SBT, has the potential to embarrass the behavior of affected individuals, reducing the consumption of electricity.

6 Method

The present work consists of a case study with quantitative approach, which investigates whether the application of SBT, or, more specifically, the additional tariff of yellow and red flags, complies with the purpose of inducing the reduction of electricity consumption.

The scope of the study focuses on the evaluation of the consumption of electricity of the residential class (segment that represents the highest consumption, according to Figure 4), delimited to the Southeast Region (region with higher consumption, according to Figure 6). In addition to representativeness, the restriction of the scope of the case study to these strata is also justified by two other reasons. First, as explained, residential consumers are captive consumers, not having the option to migrate to the free market to avoid the additional tariff resulting from SBT. Second, regional differences, such as the existence of significant consumption in isolated systems, could contaminate the analysis. Thus, the restriction of analysis to residential consumers in the Southeast Region, besides being representative, avoids these two problems.

In this study, two statistical approaches are used. The first evaluates variables with explanatory potential of consumption, through multiple linear regression. The second tests the hypothesis that there is significant variation in energy consumption when different tariff flags are applied.

Multiple linear regression aims at the construction of a statistical model capable of explaining the variation in residential consumption of electricity in the Southeast region of the country. The dependent variable and potential (independent) explanatory variables, measured in the Southeast Region, as described in Chart 1, are considered in the study:

Chart 1 – Description of model variables

Variable	Description
Electricity consumption (**Consumption**)	Variable dependent, quantitative, referring to monthly residential consumption of electricity, measured in kilowatt hours (kWh).
Application of the Tariff Flags System (**SBT**):	Independent, categorical variable (*dummy*) with 5 (five) categories, 4 (four) corresponding to the flags of the SBT ("green", "yellow", "red" and "red 2") and 1 (one) referring to the period prior to the institution of flags ("without flag"); expresses public policy in action, for which it seeks to find indicators of effectiveness regarding influence on the pattern of consumption of Brazilian residences (ANEEL, 2019c).
Number of residential	Independent, quantitative variable, expresses the monthly quantity of electric

units(**Q_{units}**)	power units; higher consumption is expected for greater quantities of claiming units (EMPRESA DE PESQUISA ENERGÉTICA, 2019).
Gross Domestic Product **(GDP)**	Independent, quantitative variable, expresses the value of Gross Domestic Product - GDP month by month, with seasonal adjustments; energy consumption is expected to be directly influenced by increases or reductions in GDP, that is, that economic warming scenarios will imply higher consumption (SERASA EXPERIAN, 2019).
Monthly average temperature (**Temp**)	Independent, quantitative variable, expresses the average monthly temperature in degrees Celsius (ºC); the temperature tends to influence the more or less intense use, as needed, of air conditioners, heaters, electric showers, etc. (INSTITUTO NACIONAL DE METEOROLOGIA, 2019).
Month of the year (**Month**)	Independent, categorical variable with twelve categories, one for each month of the year; with potential influence on consumption patterns due to seasonal migratory movements (for example, vacations) or cyclical temperature variations (seasons).

Source: Own elaboration.

The analysis therefore starts from the following model:

$$\textbf{Consumption} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1 Q_{units}} + \boldsymbol{\beta_2 GDP} + \boldsymbol{\beta_3 Temp} + \boldsymbol{\beta_4 Month} + \boldsymbol{\beta_5 SBT} + \in \text{, where:}$$

- β_0 – is the regression intercept, which corresponds to the expected value for consumption when all other variables assume the zero value;
- β_1, β_2 … β_n – are the regression coefficients associated with the respective explanatory variables, or independent;
- ϵ – is the residue associated with the model.

The data used to evaluate the multiple linear regression model refer to the period between January 2005 and May 2018, because only in this interval it was possible to collect data for all independent variables and for the dependent of the model. This period corresponds to 161 observations. The periods prior to 2015 (the year in which the SBT began) were included in a way that better evaluates the effects of the other independent variables on the variation in consumption.

Graphic analyses of adherence to the theoretical premises of the linear regression model (independence, normality and homoscedasticity of residues) were performed by averages of histogram of residues and residual plots versus values adjusted to the model. The *Kolmogorov-Smirnov* test was also adopted for the measurement of residue normality, with a confidence level of 95%.

The comparison of averages per hypothesis test aims to verify whether the average consumption in the months in which there was no application of the SBT ("without flag") or in which the flag "green" was signaled differs from the average consumption in the months in which the flags "yellow" , "red" or "red 2" were signaled. For this, two tests were conducted, from January 2005 to May 2018 (161 observations), and from January 2015 to May 2018 (41 observations), the latter comprising only the data collected during the duration of the SBT. In each period, the data were divided into two groups: months without flag (no additional cost) and months with flag (with additional cost). In the comparison of averages, we chose not to consider the influence of the type of flag on the variation of consumption, since this analysis already occurs in the linear regression model and that, conceptually, the SBT policy should induce the reduction whenever a sign of alerted to be carried out, regardless of the type of flag.

In preliminary analysis of the data, it was observed that it was not possible to directly use the variable "Consumption" for comparison between averages. This is because energy consumption in the Southeast region was increasing in the analyzed period (as illustrated in Figure 5), due to factors such as urbanization, population growth and expansion of the electricity access system. Therefore, it was found that the average of the percentage variations in consumption, calculated month by month, tends to be the most appropriate estimate, because the calculation of the change in consumption provides values free of the annual growth rate, revealing only the trend of variation energy consumption within a given year.

Based on these findings, the method used consisted of comparing the average percentage variations in electricity consumption of the two samples, namely, a sample in which there was no application of the SBT and a sample in which the system was actuated. In this sense, the hypothesis was formulated that there is a significant difference between the average percentage variation of residential electricity consumption in the Southeast Region in the months "without flag" and "with flag" (with the expectation of less variation in the months "with flag").

The hypothesis was evaluated using the *Student* (or *t-Student*) test, with a 95% confidence level for independent samples with different variances, which corresponds to the most rigorous mode of the test. It is noteworthy that the choice of *Student* test occurred due to the attendance of the normality premise of the samples, verified according to the *Shapiro-Wilk* test. For both approaches, the data was processed using programming scripts written in R language (version 3.5.1), in the *RStudio* environment (version 1.1.463), and the use of statistical functions and packages available in R, which estimate the coefficients of the linear regression model, as well as the parameters of the *t-Student* test.

Following practices of research reproducibility, which have been gaining mandatory character before the world scientific community (MCNUTT, 2014), the step-by-step construction of the statistical model and hypothesis tests, the set of data used and the programming codes written for obtaining results are available in public repository[3].

[3] https://github.com/Cefor/bandeirastarifarias

7 Results and discussion

The coefficients and other parameters estimated for the proposed linear regression model are shown in Table 1.

Table1: Coefficients and respective significance levels of the model.

Linear Regression		
Variable	**Estimate (Standard Error)**	**p-value**
$\beta_{0-intercept}$	-1.900,148 (354,855)	*
$\beta_{1-Qunits}$	0,00014 (0,00003)	*
β_{2-GDP}	18,867 (3,551)	*
β_{3-Temp}	11,079 (7,815)	0,159
$\beta_{4-February}$	-202,052 (59,244)	*
$\beta_{4-March}$	-137,228 (60,528)	*
$\beta_{4-April}$	-217,101 (60,986)	*
β_{4-May}	-409,403 (65,215)	*
β_{4-June}	-555,861 (68,350)	*
β_{4-July}	-606,395 (67,191)	*
$\beta_{4-August}$	-537,783 (64,609)	*
$\beta_{4-September}$	-471,649 (62,109)	*
$\beta_{4-October}$	-405,463 (61,083)	*
$\beta_{4-November}$	-337,388 (61,429)	*
$\beta_{4-December}$	-349,396 (60,809)	*
$\beta_{5-green}$	-10,137 (114,670)	0,930
$\beta_{5-yellow}$	-46,643 (127,368)	0,715
β_{5-red}	-78,680 (85,500)	0,359
$\beta_{5-red\ 2}$	-113,856 (159,181)	0,476

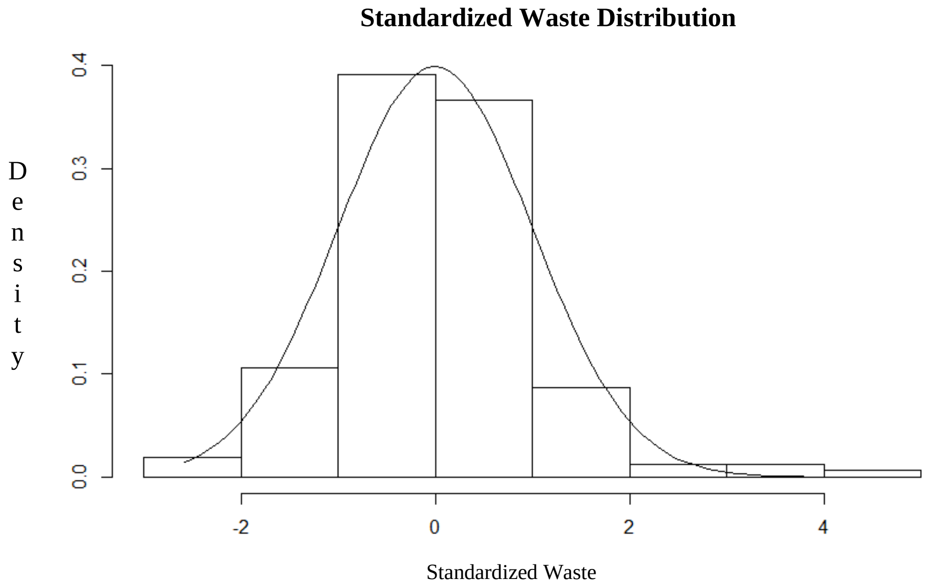
* significance level of 5% ($p < 0.05$) R^2-adjusted: 0,944

Source: Own elaboration.

The adherence of the model to the theoretical premises was confirmed by the *Kolmogorov-Smirnov* test regarding the normality of the residues (p-value = 0.38) and by the graphic analyses of figures 6 and 7. Figure 7 presents the histogram of standardized residues with normal distribution. Figure 8 presents the graph of residues versus adjusted values and allows us to verify that there is no pattern observed in residual variation, which characterizes the homoscedasticity of the model, that is, constant residual variance.

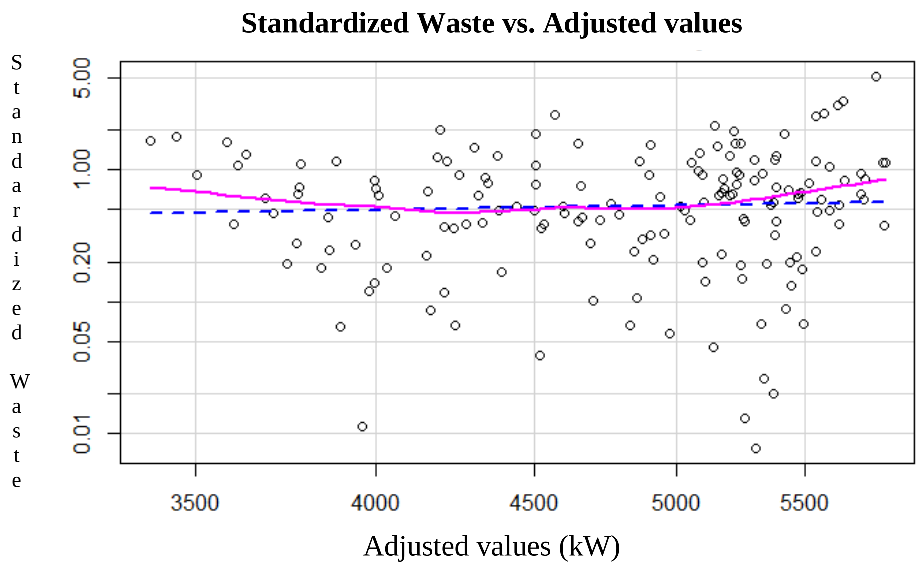
The linear model revealed (Table 1) that the number of consumer units, GDP and months of the year exert a statistically significant influence on the variation in residential electricity consumption. The average monthly temperature does not explain the variation in consumption at the significance level (α) of 5%. However, the fact that there is a significant difference in consumption when observed month-by-month can, at least in part, be attributed to climatic variations resulting from the seasons. Regarding the effectiveness of the application of SBT, the object of the question of this research, no statistically significant regression coefficient was detected (α = 5%) for any of the tariff flags.

Figure 7: Linear model waste histogram



Source: Own elaboration. Data from the Energy Research Company (2019).

Figure 8: Residual plot versus adjusted values



Source: Own elaboration. Data from the Energy Research Company (2019).

Moving to the approach of comparison of the averages, it was initially verified the fulfillment of the premise of normality of the samples, confirmed by the *Shapiro-Wilk* test (Table 2). By performing the *Student* test (Table 2) for the periods considered, it was not possible to reject the null hypothesis in either case. It is concluded, therefore, that there is no significant difference between the averages of the percentage variation of residential electricity consumption in the Southeast Region in the months "without flag" and "with flag".

Table 2: Comparison of the averages of the percentage change of consumption.

Period	**Sample**	**Shapiro-Wilk**	***t*-Student**	
		p-value	***p-value***	***IC* (95%)**
Jan/2005 to May/2018	without flag (n = 135)	0,64	0,75	-2,18 to 2,98
	with flag (n = 26)	0,20		
Jan/2015 to May/2018	without flag (n = 15)	0,88	0,84	-3,27 to 4,02
	with flag (n = 26)	0,20		

Source: Own elaboration.

The results found through the two statistical approaches represent an indication that SBT is not fulfilling its goal of provoking reaction in demand. Although the methods adopted are not adequate to confirm causal relationships[4], the results obtained indicate that there is no impact of the policy of tariff flags on residential consumption of electricity, since the first assumption of causality was not even identified, according to Pearl (2000): the correlation.

There are several reasons that can contribute to possible regulatory failures. The Instituto Acende Brasil (2007) explains that, for regulation to be effective, some basic principles must be met, among which stand out the quality of the rules and the quality of the regulatory process. The quality of the rules involves the adoption of procedures and methodologies consistent with each other and the other aspects of the sector, the development of clear and understandable rules and methodologies, respect for the rights and obligations established by law, and stability of the rules. The quality of the regulatory process involves transparency in the adoption of criteria and in communication and public participation.

In Judgment No 582/2018, the TCU explains that since its implementation, the methodology used to trigger flags had already been amended three times and that such changes had not been communicated in a timely manner. Only in October 2017, ANEEL reported that a new methodology would take effect as early as the following month, along with new values for each type of flag. These values, in turn, have changed more than five times. The Red Flag Level 2 is also a modification that occurred already during the duration of the SBT (BRASIL, 2018).

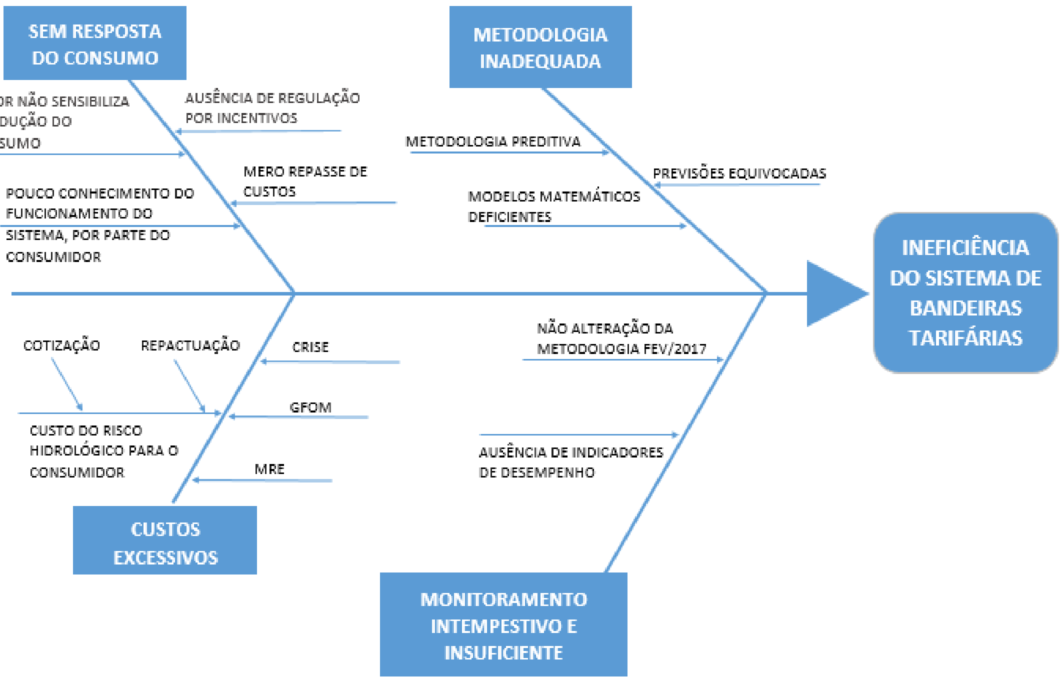
[4] Some quantitative methods appropriate to the impact evaluation of public policies (sufficient to confirm causal relationships) are addressed in Batista and Domingos (2017).

This context shows that, with regard to SBT, the principles of stability and clarity of the rules have not been fulfilled. These may be some of the causes by which there is no effectiveness in regulatory action. Weiss and Pereira (2018, p. 7) corroborate this thesis, highlighting that the SBT "continues to make sudden changes between flags". The authors also point out as the problem of the SBT the dismarriage of the activation of flags with the evolution of the level of the reservoirs, and affirm that:

> These precariousities of the flag system added to the elastic profile of electricity demand in the face of price variations can further hinder the potential for consumer response to system generation conditions (WEISS; PEREIRA, 2018, p. 7).

In addition, the TCU found in audit the lack of publicity and transparency of information that subsidize the operation of SBT. Other causes that may compete for the ineffectiveness of SBT are illustrated in Figure 9 (BRASIL, 2018).

Figure 9: Possible causes for ineffectiveness of the Tariff Flags System.



Source: Judgment No 582/2018 of the TCU (BRASIL, 2018).

Translation of figure 9 content:

Left side, from top to bottom: blue box - NO RESPONSE TO CONSUMPTION, Value does not sensitize consumption reduction, beside - Absence of regulation by incidents, Little knowledge of the operation of the system by the consumer, beside - Mere transfer of costs, Quotation, Renegotiation, next - Crisis, Cost of hydrological risk to the consumer, next - GFOM, MRE, blue box - EXCESSIVE COSTS.

Right side, from top to bottom: blue box - IMPROPER MRTODOLOGY, Predictive methodology, beside - Mistaken forecasts, Deficient mathematical models, blue box to the right in the middle of the image - INEFFICIENCY OF THE TARIFF FLAG SYSTEM, No change in methodology Feb / 2017 , Absence of performance indicators, blue box - INTEMPESTIVE AND INSUFFICIENT MONITORING.

What is observed, therefore, is that the results found here seem to be consistent with the regulatory context of the SBT, marked by lack of transparency, lack of publicity, lack of clarity and excessive instability of the rules. Apparently, the SBT was architected considering only the elements of classical economic theory, which considers only economic incentives as a way to influence people's decisions. Castro *et al.* (2018) emphasizes the importance of considering elements of behavioral economics for incentive planning. Thus, when dealing specifically with SBT, the authors also conclude that there is a need to improve the system to reduce its complexities, instability and, from there, communicate its operation to the consumer clearly and easily. The problems in the SBT, because they hinder their understanding on the part of the consumer, influence consumer decisions, which can impair the effects desired by public policy.

Despite the indications of ineffectiveness in reducing consumption, it should be emphasized that the SBT has contributed to the sustainability of the cash flow of distributors. In other words, according to Weiss and Pereira (2018,p. 7),there is evidence of the "commitment of the system of tariff flags with the anticipation of revenue to distributors, leaving the signaling to the consumer about the conditions of generation as a secondary objective". The very values defined for flags – low in relation to tariffs and with small potential for reduction in consumption, as discussed in section 5 – are evidence that consumer signaling is not the main objective of this policy.

On the one hand, this characteristic can be seen as a deviation of purpose, according to the interpretation of the TCU itself (BRASIL, 2018). On the other side, however, it can be affirmed that such a function is useful for the economic and financial balance of the system and should not be ignored in discussions about the future of this public policy, at least until the current model of the sector is modified, which pushes the risk hydrological to the consumer, to the detriment of other agents more able to manage it.[5]

8 Conclusion

The electricity supply service is considered public and essential to the well-being of society. The characteristic of a natural monopoly present in the electricity sector, as well as the complexity of its operation, makes the performance of the State extremely important through regulation, to ensure that the service is provided with quality and at the lowest cost possible. One of the axes of operation of the regulation on the electricity sector focuses on the tariff values of collection by the service. I is worth highlighting, the value of the tariffs also has a great impact on the lives of service users.

To bring greater efficiency to the system and provoke demand reaction to the point of

[5] With the implementation of the physical guarantee quota regime, through MP 579/2012, part of the hydrological risk was transferred from generation agents to consumers (through distributors). The relationship of this regime with the adoption of SBT is described by Weiss and Pereira (2018).

reducing energy consumption in periods of higher generation cost, it began to take effect in Brazil, in January 2015, SBT. Depending on this system, whenever increased or risk of increased generation costs is detected, energy bills must be increased in the value of the tariff.

This article aimed to evaluate the effectiveness of BTS in modulating electricity consumption, in the period from 2015 to 2018, through the application of two statistical approaches: multiple linear regression and the comparison between averages. The analysis took place on data from residential consumers in the Southeast region of Brazil. In both cases, there was no statistically significant influence on the activation of tariff flags on electricity consumption.

The results obtained are an indication of the ineffectiveness of SBT in provoking reaction in the demand for energy, which can be explained by the non-compliance with basic regulatory principles such as transparency and stability in the rules, in addition to the inelastic profile of the demand for this essential service in the face of price variations. Nevertheless, the SBT has fulfilled other relevant functions, which need to be considered in discussions on the future of this public policy.

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