TARIFF ASSESSMENT: HELPING THE ENERGY CONSUMER TO GET THE BEST TARIFF

Carlos C. Barioni de OLIVEIRA
Daimon Engineering – Brazil
barioni@daimon.com.br

Cristiano da Silva SILVEIRA
Daimon Engineering – Brazil
cristiano@daimon.com.br

Mauro Manoel MACHADO
Daimon Engineering – Brazil
mmachado@daimon.com.br

Lorena C. Borges dos SANTOS
CPFL Energia – Brazil
lorena@cpfl.com.br

Manoel E. Miranda NEGRISOLI
Brazil
manoel.negrisoli@gmail.com

ABSTRACT

This paper describes models for assessing the potential entrance to the White Tariff, a Brazilian time-of-use tariff, which is differentiated by usage level and exclusively destined to low voltage consumers. For each of the various low voltage consumers segments, specific groups with similar electricity consumption habits are analyzed. The methodology was developed through a R&D project sponsored by CPFL Energia, which is responsible for distribution services to 7,5 million consumers in Brazil.

INTRODUCTION

In order to improve the National Interconnected System (SIN) loading, the Brazilian Electricity Regulatory Agency – ANEEL set a new tariff modality distribution services, denominated *White Tariff*, a time-of-use (ToU) tariff modality specific for retail consumers connected to low-voltage distribution grids (*Group B* consumers) [1] [2] [3]. They represent 64% of the electricity market [7]. Furthermore, only the residential segment has 60% of this segment, demonstrating its relevance to the distribution system loading.

This ToU tariff modality is associated new paradigms for the Brazilian electricity sector, such as:

- Technical – by regarding the electrical system loading profile;
- Strategic – by reckoning the liaison to consumers, as well as the expansion planning;
- Commercial – by quantifying forward consumer response to the established tariff modalities; and
- Financial – by establishing the impact of this new tariff on earned income by distribution utilities.

THE *WHITE TARIFF*

The *White Tariff* consists of a voluntary, opt-in ToU tariff modality. This will be an alternative to the existing *Conventional Tariff*, a flat tariff (i.e., with no differentiation over different periods within a day) that is currently applied to all Group B consumers.

The *White Tariff* was created with the objective of stimulating consumption during off-peak hours, seeking the postponement of the distribution network expansion, besides the allowance for consumers to control their electricity use and also the distribution network use optimization [4]. More specifically, it also aims to reduce the peak system loading.

In order to support the creation of time-varying economic signals, three different tariff tiers were instituted:

- Peak tariff tier: three consecutive hours within weekdays, defined by the distribution utility and approved by ANEEL for the entire concession area. It is the time at which the power consumption reaches its peak;
- Intermediary tariff tier: consists of two hours within weekdays – one immediately before and one immediately after the Peak tariff tier;
- Off-Peak tariff tier: consists of the hours complementary to those defined above during weekdays, and all hours of weekends and holidays.

The values for each of the three tiers of the *White Tariff* are calculated based on: (i) the ratio between the Peak and the Off-Peak Distribution Use-of-System Tariff-Transport for the *White Tariff* equals 5; (ii) the ratio between the Intermediary and the Off-Peak one equals 3; and least (iii) the Off-Peak period one will be defined as a parcel of the Distribution Use-of-System Tariff – TUSD for the *Conventional Tariff*. The proportionality constant used for this tariff modality is denominated *kz* parameter.

The method currently described to obtain *kz* is based on the calculation of the *indifference value* of this proportionality constant for a typical consumer [5]. Given pre-defined Peak/Off-Peak and Intermediary/Off-Peak ratios and a representative loading profile of this typical consumer, the value of *kz* is calculated for each distribution company considering the electricity bill of the consumer undermeath the *White Tariff* equals the one which was obtained underneath the *Conventional Tariff* modality, as shown in Figure 1.

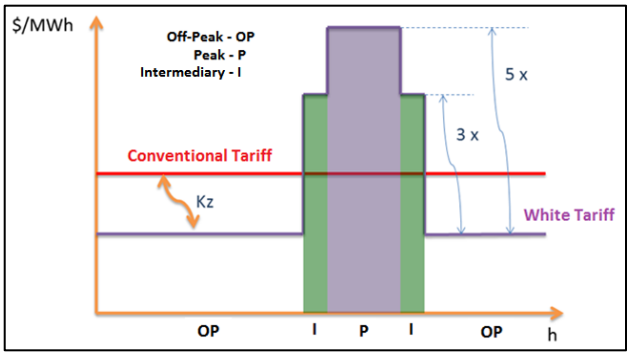

Figure 1. White Tariff versus Conventional Tariff**.**

THE MAIN PROJECT

The study presented in this paper is part of an R&D project sponsored by CPFL Energia, respecting the following primary objectives:

- To develop models for assessing the impact of new tariff modality for Group B in the behavior of retail consumers connected to low-voltage distribution grids and their technical and business implications;
- To develop models for assessing the most relevant aspects related to the characterization of the *White Tariff* in our concession area, such as the determination of the *kz* proportionality constant; the duration of each tier (peak, off-peak and intermediary) and their ratios;
- To conduct field survey, with representative samples of consumers in each tariff Group B subclass to assess: (i) the qualitative form of electrical energy consumption by final energy usage; and (ii) their intention to modify consumption habits caused by the possible consumers savings cost;
- To start a second round of field survey after a *White Tariff* implementation period to assess the actual behavior of consumers;
- To conduct studies to assess consumer responses fronting the adoption of the *White Tariff* combined with price demand elasticity concepts and, the field surveys results with a representative sample of Group B consumers.

RESULTS AND DISCUSSION

Given this new tariff arrangement set in Brazil, this work aims to develop models for assessing consumer responses to the adoption of the *White Tariff* modality.

As specific studies, we can highlight some issues:

- Potential entrance to the *White Tariff* for each of the low-voltage consumers subclasses, and for each of them it is summarize those with similar characteristics over the energy usage;
- To analyze adoption of customer scenarios of the *White Tariff*, granting an comprehension enhancement of the risks and tariff modification impacts; and
- To prepare and perform a field survey to assimilate the most relevant consumers' decisions features facing a new tariff modality, regarding the possible benefits and risks associated with this decision.

In order to comprehend performed analyzes in this study on the evaluation of the potential entrance to the *White Tariff* and to create loading modulation scenarios (either by modulating consumption to other periods or by decreasing its amount during the day), it is necessary to identify the rates which are applied to consumers and to establish the amount of energy consumed in each tariff tier. To identify these values, it is necessary to define loading curves for each consumer.

Studies conducted by ANEEL use representative loading profiles for consumer classes obtained by the loading characterization process [6] [9]. Therefrom, it is possible to allocate the energy at each tariff tier and to calculate their costs. These results represent the total market amount of which this type of loading profile represents (i.e., the loading profiles which are considered to be representative as a grid users subset).

Therefore, loading modulation scenarios can be evaluated from the measurements of each of the representative loading profiles, which was constructed from individual consumers usage.

Triage Curves (defining the potential entrance to the *White Tariff*)

To identify different potentials entrance sets to the *White Tariff* for each consumer subclasses, triage curves were created.

An important result in these analyzes was the identification that the consumers which have higher energy consumption underneath *White Tariff* would be best adherents to *White Tariff* than to *Conventional Tariff*, as shown in Figures 2 and 3. These consumers represent a market portion, which will have immediate financial benefits, without the necessity to perform any change in their consume electricity behavior.

To assess the different consumer responses exposed to this new tariff modality with low subjectivity, consumers were segregated into classes (residential, rural, industrial and commercial) and energy consumption ranges.

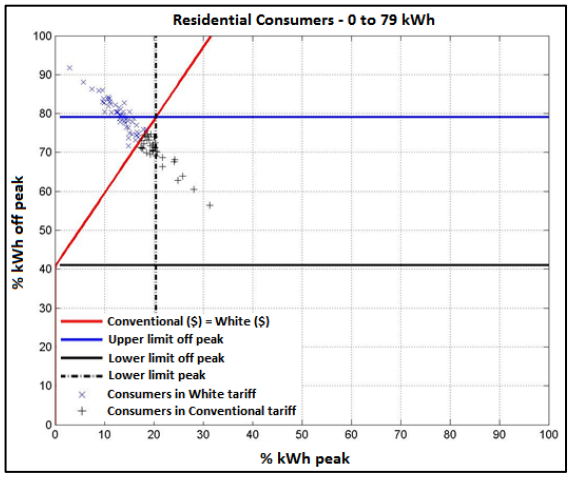

Figure 2. Informative triage curve for the cheapest alternative for each residential consumer (0 to 79 kWh).

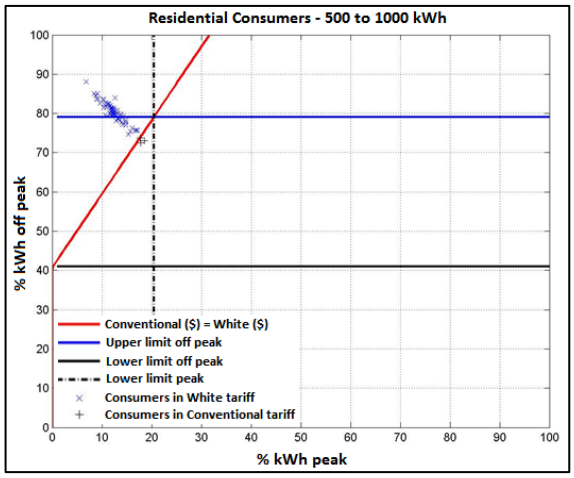

Figure 3. Informative triage curve for the cheapest alternative for each residential consumer (500 to 1000 kWh).

Consumers who are close to the red line, the one that indicates the breakeven line between the *Conventional Tariff* and *White Tariff,* and has a lower energy cost underneath *Conventional Tariff* (Consumers in *Conventional Tariff* at Figure 2 and Figure 3), once identified, can receive specific information from the company over how could they modify their consumption behavior if they are willing to migrate to the *White Tariff* and make it worth. Likewise, consumers who are remote from that red line can be informed of the required effort to ensure that the *White Tariff* is a good alternative. This effort measurement is calculated for each consumer. To clarify the consumers' comprehension, these information is associated with some of their electrical equipment and its typical ToU use.

Effort Measurement with Structural Changes of the Loading Profile (Loading Modulation Effort)

The use of triage curves allowed the identification of loading modulation effort possibilities. These results, when analyzed as probability distributions, can establish which loading modulation will be more likely depending on how far is each consumer from the breakeven line. These demonstrate how great would be its effort to lower its electricity bills cost by making the *White Tariff* option worthy.

Studies using Monte Carlo simulations, despite the absence of all consumers' measurements, were performed with the original sample of consumers, as illustrated at Figure 4.

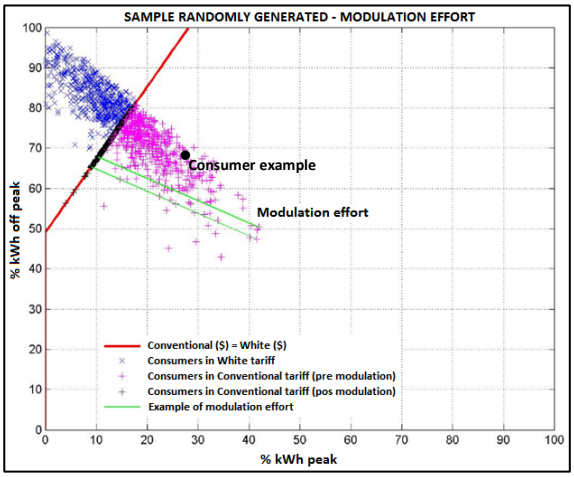

Figure 4. Energy consumer responses universe (energy consumption modulations and/or reductions).

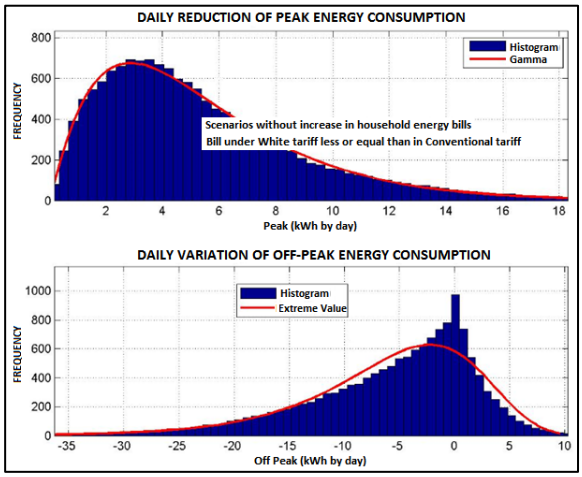

Figure 5. Energy consumer responses in kWh/day (peak and off-peak variations).

All possibilities known from probability distributions can be associated with some electrical equipment and its corresponding ToU. Figure 5 shows only those consumers randomly generated whose electricity bills underneath *White Tariff* were lower than or equal to the ones underneath the *Conventional Tariff*.

Example

Taking in consideration the proprietorship of certain electrical equipment and a 10% peak consumption reduction scenario for a typical Brazilian household (four residents whose average monthly consumption of electricity is equal to 200 kWh, 45 kWh-Peak – 22.5% kWh and 67.5 kWh-Off Peak), it can be inferred the following actions aiming that this reduction is reached:

- To reduce electric shower daily usage (4,500 Watts) in 2 minutes (considering average daily usage of 32 min);
- To reduce a TV daily usage in 1.5 hour;
- To turn off 1 incandescent lamp (100 Watts) for 1.5 hour/day or 1 fluorescent tube (110 Watts) for 1.2 hour/day or 3 compact fluorescent lamps (3x15 Watt) for 3 hours/day.

However, considering the possibilities shown at Figure 4, this 10% reduction scenario for this typical customer example (or 4.5 kWh), would not be enough to bring the *White Tariff* energy bill alternative in a higher financial benefit than the *Conventional* one. To make it worth, the reduction at tier Peak should be equivalent on scenarios where energy percentage at tier Peak is immediately to the left of the breakeven line.

As can be seen in Figure 5, to *White Tariff* be worthy than *Conventional* one, in this example, different daily efforts are required to reduce the Peak energy, which is represented by the right side of the probability distribution curve (reductions greater than 9 kWh/day).

From the use of triage curves, analytic frameworks can be achieved by the distribution utility, which can help it to better inform its customers to choose the best tariff (greater energy bill reductions). Not only will the distribution utility have more accurate information of those consumers who will have immediate benefit without any effort, but also will it figure out those who can get the same benefits if they modulate consumption habits. These changes, when linked to proprietorship information and each consumer's electrical equipment use, will overcome a powerful instruction tool analysis, and also the communication enhancement with electricity consumers.

Field survey on energy consumption

The analyses of energy consumption survey results are still ongoing. However, some observations can be incorporated into this work.

A reaction model of consumers will be designed to the new ToU tariff using information collected in the consumers responses surveyed (the same consumers who will have their energy consumption monitored by the distribution utility monthly from March 2015 on the next six months) such as: energy usage; electrical equipment proprietorship and behavioral tendencies of the *White Tariff*; associated with the results of potential entrance to the *White Tariff* and the identification of several scenarios of loading modulation efforts (illustrated by Figure 4 and Figure 5). Therefore, the main concepts for the model are: *a) entrance probability of consumers to the White Tariff + b) facility/difficulty of consumer reaction front the possible efforts of behavior changes + c) degree of intentionality to habits changing captured in field survey.*

CONCLUSIONS

Obtained results indicate great advances in studies assessing of the new ToU tariff impact in the low-voltage consumers behavior served by distribution utilities.

Triage curves proved to be fundamental in obtaining more objective analysis to the portion of the electricity market low-voltage liability to change after the introducing of *White Tariff*. It is believed that any ToU tariff can be subjected to similar analysis. Therefore, targeted communication actions and adequately arrangements for different consumer groups may reflect higher success in ToU tariffs, permitting studies to create other rules where the previous tariffs have not been effective for a part of the electricity market.

It is important to highlight the realization of a pilot study initiated in March 2015 with approximately 1,000 low-voltage consumers. In this study, consumers will have access to a website where they can monitor their energy bills values in the two tariffs, *White* and *Conventional* ones. In addition, each energy consumer will have access to customized information on how to proceed in order to have his energy bill underneath the *White Tariff* to become cheaper than the *Conventional*.

From the results pointed in this paper, there will be a data crossing between the identified need to change the energy consumption and its reproduction converted into change of use on the each consumer electrical equipment, which has been pointed out at the survey (the company will ensure the confidentiality of information).

It is intended to consolidate knowledge in identifying the consumers groups that could enable a more synergistic gain of tariff reductions and electrical system optimization. Other inductive actions of the distribution utility, such as the implementation of a strategic action set, which include advertising, tariff benefits clarification of for consumers, and better management of distribution utility electrical system in terms of the loading profile, are also provided.

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