# Comparative Study Between Conventional And White Tariff Modes In Customer Consumption In The Mining Forest Zone

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***Abstract :*** *This article seeks to define the new tariff mode implemented to ANEEL for limited hours charging estuary of consumers classified as Group B, was performed the analysis of the consumption profile of some customers with high consumption considering the limited hours range would they occurred, through an intelligent and programmable energy meter capable of exporting complete consumption reports. These data were tabulated and processed, and the monomial and white tariffs were applied for comparison. The objective of this study was to verify from what percentage of the concentration of consumption during off-peak hours the white tariff becomes economically viable to the consumer. A qualitative analysis was performed through the analysis of customer consumption, which enabled the production of graphical reports to expose the results found, and the comparison of tariff modalities.*

**Keywords —** *ANEEL; White Tariff; Consumer Unit; Post Office.*

## I. INTRODUCTION

Given the need for conscious use, with the possibility of differentiated charging according to consumption time, the Brazilian energy scenario has been changing with the implementation of the "white tariff" charging modality.

Consumers served at low voltage had their energy bills calculated based on a monomic supply tariff, called by the National Electric Energy Agency (ANEEL) as "constituted by a monetary value applicable only to the consumption of active electricity, obtained by the conjunction power demand and electricity consumption component that make up the binomial tariff "(ANEEL, 2012).

In order to improve the country's tariff structure, from 2016 ANEEL implemented the white hourly tariff, which encourages low-voltage residential and commercial customers to reduce their energy consumption during peak hours, or to redistribute them to their customers. Times where the fare is cheaper. This results in relief in the country's distribution system.

This work is justified in analysing the new tariff modality in force, and verifying if in the consumer units target of the simulations, the implantation would be a good option or not. By searching the World Wide Web, there is a possibility that all consumers can make quick simulations in order to make this decision more accurately. In this work the analysis was made with the real load of the consumer units, mapped the correct times, thus having a greater precision in the result obtained when compared to the available simulators.

The general objective of this scientific work is to analyse the economic viability of the application of the new tariff modality to the residential consumers served at low voltage analysed, in comparison to the conventional monomial tariffs. According to Reis (2018), this analysis refers to a study with the purpose of evaluating whether the investment is viable or not, comparing the demanded investment with the returns it can generate, and thus deciding whether it is valid or not. The investment.

## II. LITERATURE REVISION

### *A. National Electric Energy Agency*

The Brazilian Electricity Regulatory Agency, called ANEEL - National Electric Energy Agency, is a special regime autarchy linked to the Ministry of Mines and Energy, created from Law No. 9,427/1996 and Decree No. 2,335/1997 and which beginning its operations in 1997 with the main duties of regular, supervise, implement policies, establish tariffs, settle differences and promote power sector grant licenses. Linked to the Ministry of Mines and Energy, it was created from Law No. 9,427/1996 and Decree No. 2,335/1997.

### *B. Tariff Modalities*

According to ANEEL (2019), tariff modalities are "a set of tariffs applicable to components of active electricity consumption and power demand, considering the following modalities". There are 5 modalities in Brazil, they are:

**Blue Tariff:** applied to group A consumers units (UC), where different tariffs are applied for

electricity consumption and power demand, varying with the hours of the day;
**Green Tariff:** applied to group A UCs, where different tariffs are applied for electricity consumption, varying with the time of day, and applying a single tariff of power demand, regardless of time;
**Binomial Tariff:** applied to group A UCs, where tariffs for electricity consumption and single power demand are applied, not considering the hours of use of the day. Such tariff modality will go into disuse after tariff revision of the distributor;
**Monomial Tariff:** applied to Group B consumer units, characterized by electricity consumption tariffs, regardless of the hours of use of the day; and
**White Tariff:** Applied to group B UCs, except subgroup B4 and subclasses Low Income of subgroup B1, characterized by different rates of electricity consumption, according to the hours of use of the day.

### *C. Time Stations*

According to Santos (2014), hourly pricing predicts the existence of hourly stations, characterized by periods of different tariffs during the day. Through this pricing, customers can vary their energy use due to the different prices charged.

According to Energisa Minas Gerais (2019), an energy distributor in the region of the Minas Gerais forest zone, the hours practiced in its concession area are:

- Mid-peak (Intermediário - I): 04:30 pm to 05:29 pm
- Peak (Ponta - P): 5:30 pm to 8:29 pm;
- Mid-peak (Intermediário - I): 8:30 pm to 9:30 pm;
- Off-peak (Fora Ponta - FP): 09:30 pm to 04:29 pm;

The Figure 1 illustrates how these zones are weekday, comparing the tariff mode on time period. It is important to highlight that on weekends and national holidays, as recommended by ANEEL normative resolution 414/2010, peak and mid-peak times are not applied.

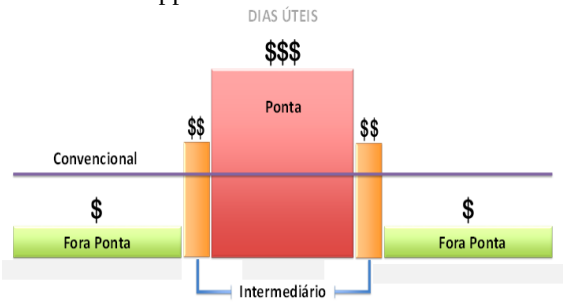



Fig. 1: Billing Time Stations

### *D. White Rate*

ANEEL made public through Normative Resolution No. 733/2016, on September 12, 2016, the conditions of the new hourly tariff modality of electricity called "White Tariff". This modality aims to enable consumers served by the energy distributors in BT (Low Voltage / Group B) to be able to reduce the amount paid on their electricity bill. (ABRAPCH, 2016)

According to ANEEL (2019), customers opting for this tariff mode have the possibility to pay seasonal hourly rates, differentiated according to the time and day of the week when there is the consumption of electricity. When consumption habits are prioritized at times with lower demand (eg morning), the new pricing offers the possibility of reducing the total amount paid. Prior to the creation of these modalities, consumer units (UC) served at BT (less than 2.3kV) were charged solely from the rate known as Conventional, with a single amount (R$) paid for energy (kWh) being applied, regardless of time or day of the week.

According to ABRAPCH (2016), although only in 2016 the white tariff was published, ANEEL Normative Resolution No. 479 of 2012 already mentioned it, defining it as the tariff modality applied to Group B consumers (except its exceptions). Characterized by differentiated charging of consumption according to the hours of use of the day. Consumers could not opt for such charging because there was no specific resolution defining procedures adopted in this charging, which was remedied in 2016.

From its approval, adherence to the new tariff followed a schedule according to customer consumption characteristics, as follows: 01/01/2018: new connections and for UCs with average monthly consumption of the last 12 cycles over 500 kWh/month; 01/01/2019: UCs with average monthly consumption of the last 12 cycles over 250 kWh/month; and, 01/01/2020: for the other UCs, regardless of the average monthly consumption of the last 12 cycles. (ANEEL, 2019).

According to Energisa (2019), for customers who choose the new tariff mode, the rate will vary according to three times called: peak - peak demand, intermediate - 1 hour before and after peak hours, and outside rush hour - lowest demand. In the first two hourly segments, the energy value is higher, since there is greater demand in the electrical system, whereas in the last hourly segment, the energy value is cheaper. The variation can be up to 5x higher during peak hours and 3x higher during intermediate hours compared to off peak.

The white tariff encourages consumers to shift their consumption from peak hours to times whose network of power distributors has idle capacity, but for this to be possible the consumer needs to know their consumption profile well, because if there is a large consumption at peak hours that cannot be

relocated, the new option is not recommended (ABRAPCH, 2016).

At the public hearing, there was a suggestion that the option for the white tariff be extended to consumers of the so-called Group A, defined by ANEEL as "grouping consisting of consumer units with supply at or above 2.3 kV, or served from underground distribution system in secondary voltage, characterized by the binomial tariff" (ANEEL, 2010). Such contribution was rejected, as the proposal would conflict with Decree 62.724 / 68, which establishes the binomial charging to consumers of this group.

## III. METHODOLOGY

For this work, a literature review was conducted on related issues , which according to Santos (2006) plays key role in the production of academic work, because it enables situated r academic production in the research area of which it is part, contextualizing - a . It is extremely important for both the author and the reader, because the writer will need to determine relevant authors to support the academic production , requiring vast, constant and repeated reading ; and for the reader , as it allows identifying the theoretical line in which academic production is inserted, based on the authors cited in the literature review process .

For monetary comparison purposes, the value of kWh was used as per Table 1 applied by the local energy concessionaire to Group B consumers.

**TABLE I**
**ELECTRICITY TARIFF VALUES**

| Tariff | R$/kWh | % |
|---|---|---|
| Monomial Tariff | 0,90239 | - |
| Peak Tariff | 1,72621 | 91,0% |
| Mid-peak Tariff | 1,09555 | 21,0% |
| Off-peak Tariff | 0,73969 | 0,82% |

These values are already added to the taxes and disregard additional costs of street lighting. Note in the column "%" that: R$/kWh in peak hours is 91% more expensive than in conventional tariffs, and in off-peak hours energy is 18% cheaper.

To enable data extraction, smart meters from the ARES 8023 200 model were used. This model is a bi-directional multi-function electronic meter, suitable for making seasonal hourly rate (THS) consumption measurements, such as residential, commercial and industrial customers (ELETRA, 2019).

The extraction of mass memory data from the meters was performed using the Elim Multifunctional Electricity Meter Software from the supplier Eletra, in its version 2.7.001. Equatorial Energia (2019) states that "mass memory consists of the set of paid-in readings every 15 (fifteen) minutes and that make up the total consumption calculated in the billing cycle. Information obtained from the mass memory file can be used to verify unit load and consumption profiles". In Figure 2 the data extraction screen is presented.

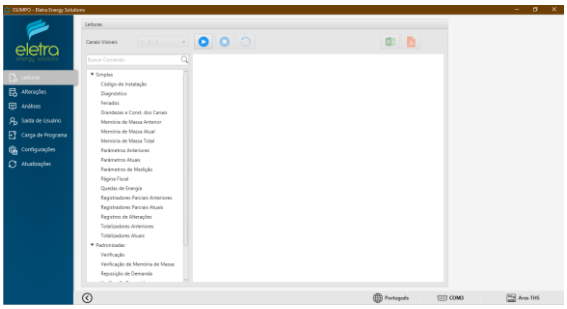


Fig. 2: Olimpo Software, vs 2.7.001

These data were exported from the software in .xlsx format, to be worked in Excel, where it was possible to identify consumption times at 15-minute intervals. Different formulas were applied to enable the identification of the reference day of consumption and the time station where it occurred.

After applying the above definitions, with the data worked, pivot tables were generated in order to group the data and enable the generation of dynamic graphs quickly, in order to expose the results found. Microsoft (2019) says the PivotTable "is a powerful tool for calculating, summarizing, and analysing data that allows you to see comparisons, patterns, and trends in data."

Subsequently, with the concentrated consumption by time segment, the aforementioned tariffs were applied and the total energy cost was compared, comparing the monomial and white tariffs. Through this comparison, ie, the amount to be paid if applied to the monomial tariff versus the amount to be paid if applied to the white tariff, it was possible to find the economic viability analysed customers.

## IV. RESULTS AND DISCUSSIONS

After extraction of data mentioned above, the information taken from the software Olympus were exported to Excel as spreadsheet model that can be viewed through the Figure 3.

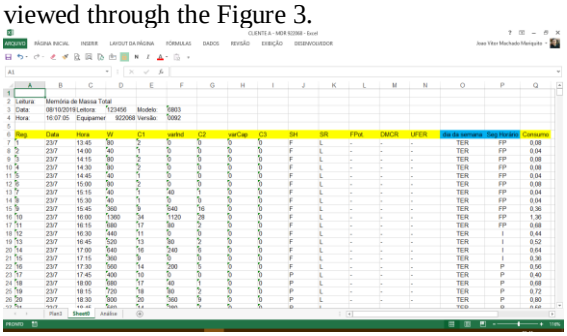


Fig. 3: Meter mass memory data being worked

The important information used is arranged as follows:

- Column B: date of registration of consumption;
- Column C: time of total consumption;
- Column D: consumption in Wh.

In column "O" a formula was used to define which day of the week corresponds to the date of the consumption record, being its syntax "=PROCV (DAY.EMANDAY(B7);$V$4:$W$10;2;FALSE)".
In column "P" a formula responsible for defining which time station corresponds the time of the consumption record, being its syntax "=SE(O7=" DOM";"FP";SE(O7="SAB";"FP";PROCV(C7;$V $13:$W$108;2;FALSE)))". In column "Q", the share of consumption presented in column "D" in unit "Wh " was converted to unit "kW" by a division by 1000, whose formula has syntax "= D7/1000". From these duly worked data, two pivot tables were created, as shown in Figure 4.

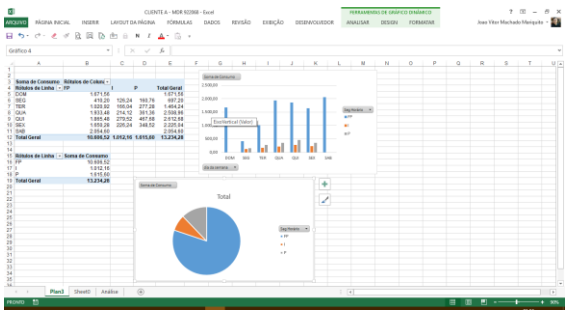


Fig. 4: PivotTables

The upper pivot table grouped the consumption data considering the time stations (FP, I and P) and the days of the week (SEG, TER, QUA, QUI, SEX, SAB, DOM), allowing the creation of a dynamic graph. This was important to validate which days of the week were being consumed. The lower pivot table, on the other hand, only grouped the consumption data considering the hourly stations (FP, I and P).

The total values of the upper pivot table were listed in the table "POSTOS HORÁRIOS", and applying the different energy tariffs in Table 1 we obtained the total values according to the table "CALCULO TARIFÁRIO". Both tables can be seen in Figure 5.

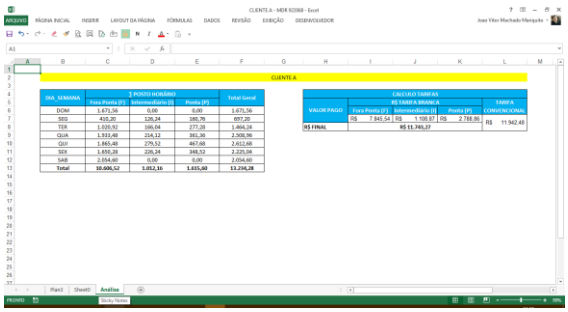


Fig. 5: Client an Analysis

Based on this, below will be presented the consumption records of some consumers used in data collection, with consumption pattern compatible with the white tariff, but not yet opting.

### *A. CUSTOMER A*

Class 03 Commercial Sub Class 01 Commercial
Group 02 Conventional Low Voltage Sub group B3 Other Classes
Consumption Analysis Period: 07/23/2018 to 12/5/2018.

**TABLE II**
**CONSUMER EXTRACT - CUSTOMER A**

| Day | Σ Time Station | | | Total |
|---|---|---|---|---|
| | F | I | P | |
| DOM | 1.671,56 | 0,00 | 0,00 | 1.671,56 |
| SEG | 410,20 | 126,24 | 160,76 | 697,20 |
| TER | 1.020,92 | 166,04 | 277,28 | 1.464,24 |
| QUA | 1.933,48 | 214,12 | 361,36 | 2.508,96 |
| QUI | 1.865,48 | 279,52 | 467,68 | 2.612,68 |
| SEX | 1.650,28 | 226,24 | 348,52 | 2.225,04 |
| SAB | 2.054,60 | 0,00 | 0,00 | 2.054,60 |
| **Total** | **10.606,52** | **1.012,16** | **1.615,60** | **13.234,28** |

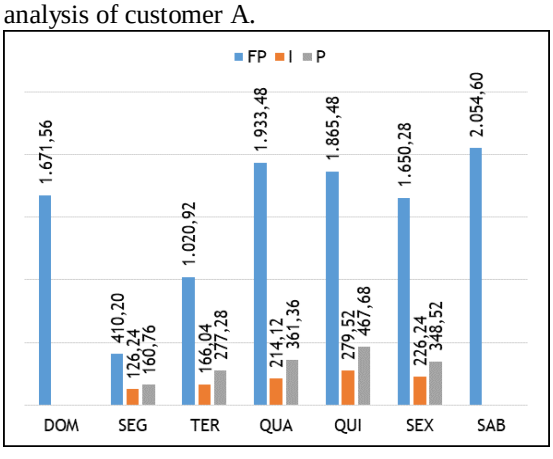
### *B. CUSTOMER B*

Industrial Class 02 Sub Industrial Class 01
Group 02 Conventional Low Voltage Sub Group B3 Other Classes
Consumption Analysis Period: 10/12/2019 to 10/23/2019.

**TABLE III**
**CONSUMER EXTRACT - CUSTOMER B**

| Day | Σ Time Station | | | Total |
|---|---|---|---|---|
| | F | I | P | |
| DOM | 1.671,56 | 0,00 | 0,00 | 1.671,56 |
| SEG | 410,20 | 126,24 | 160,76 | 697,20 |
| TER | 1.020,92 | 166,04 | 277,28 | 1.464,24 |
| QUA | 1.933,48 | 214,12 | 361,36 | 2.508,96 |
| QUI | 1.865,48 | 279,52 | 467,68 | 2.612,68 |
| SEX | 1.650,28 | 226,24 | 348,52 | 2.225,04 |
| SAB | 2.054,60 | 0,00 | 0,00 | 2.054,60 |
| **Total** | **10.606,52** | **1.012,16** | **1.615,60** | **13.234,28** |

In the graphs below we can see the hourly stratification of the analysed customers' consumption. The Figure 6 shows the results obtained from the analysis of customer A.



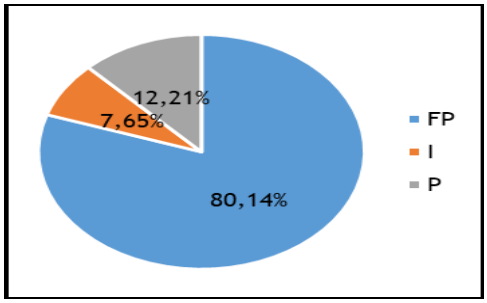


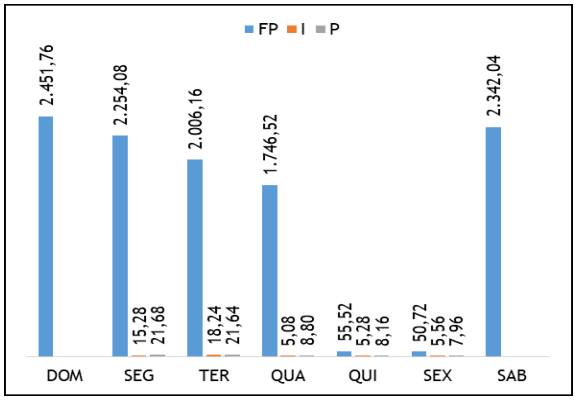

Fig. 6: Power Consumption by Time Station - Client A

Applying the current rates for the profile of costumer A concentrated to 80.14% of the period of consumption analysed in the time FP as shown in Figure 3, the white rate showed ben Efica, bringing savings 1.67% electricity bill (R$199.21 reais), according to the calculations shown in Table 4 .

**TABLE IV**
**CURRENCY CONVERSION - CUSTOMER A**

| White Tariff | | | Monomial Tariff |
|---|---|---|---|
| F | I | P | |
| R$7.845,54 | R$1.108,87 | R$2.788,86 | R$11.942,48 |
| R$11.743,27 | | | |

The Figure 7 shows the results obtained from the analysis of customer B.



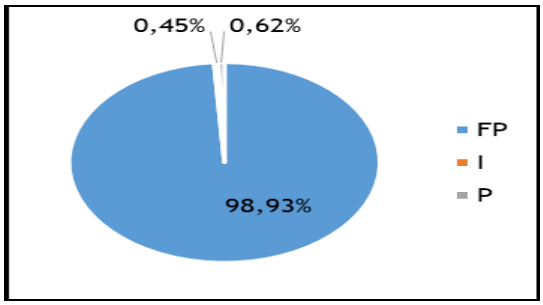




Fig. 7: Energy Consumption by Time Desk - Customer B

Applying the current rates for the profile of customer B, concentrated 98.93% of the period of consumption analysed in the time FP as shown in Figure 7, the white rate proved beneficial, bringing savings in 17.18% electricity bill (R$1,708.77), according to the calculations shown in Table 5 .

**TABLE V**
**CURRENCY CONVERSION - CUSTOMER B**

| White Tariff | | | Monomial Tariff |
|---|---|---|---|
| F | I | P | |
| R$8.067,65 | R$54,16 | R$117,80 | R$9.948,38 |
| R$8.239,61 | | | |

For this customer it is important to note that this savings found is based on a consumption of 11 days recorded. If the proportion is maintained, the economy can reach R$55,923.36 per year.

It can be seen from the examples above that for customers whose off-peak consumption concentration is between 80 ~ 85% of the unit's total consumption, this tariff mode is becoming interesting.

Elsewhere in the world this tariff mode is called time-of-use (TOU). According to Santos (2014 apud LAMIN, 2009), for example, there is the province of Ontario, Canada, which faced an energy crisis during peak summer hours in 2003. The high demand in this province occurred only at a few hours of the day, but due to system overload required huge investments in the distribution network. Given this, if there was a reduction in demand in this time slot would generate a significant reduction in costs, also bringing savings to consumers. The government then set the goal of reducing 5% of this consumption by 2007. A pilot project was implemented, applying TOU between 2006 and 2007, and this project showed that 90% of consumers changed part of their consumption to different times from peak hours, bringing savings of between 3 and 6% on energy bills and a relief in Canada's distribution system. Given the positive results, TOU was regularized in this province, being an example of the applied structure exposed in the province. The Figure 8 shows the distribution of hours put in this province, as days of the week in the seasons.

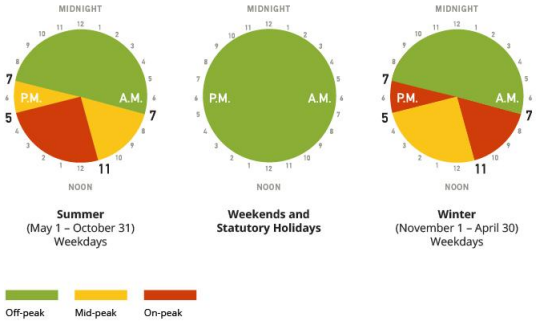



Fig. 8: TOU in Ontario (Canada)

In green are the hours of off-peak consumption, or off-peak according to the terminology used in Brazil. In yellow the hours of consumption of "medium peak", or intermediate, and in red the consumption in "peak", or tip. Between May and October, the on-peak time station is comprised of 6 consecutive hours

between 11 am and 5 pm, and the mid-peak time station for 6 hours between 7 am and 11 pm and 5 pm at 7 pm. Already between November and April, the time stations are reversed, being the mid-peak time between 11 am and 05 pm, and the on-peak time between 07 am to 11 am and 05 pm at 07 pm. On weekends and holidays, only off-peak hours apply.

It is noted that there are differences between the methodologies applied for the charging of energy for time stations between Ontario and Brazil, especially regarding peak, off peak and intermediate times. In Brazil there are no changes in these times with the changing seasons of the year as in Ontario, but to compensate for the difficulties in the generation of energy is applied since 2015 the "tariff flag system", which according to ANEEL (2015) aims to indicate whether or not there is a need to pass on an additional kWh tariff to end consumers over the conditions of the country's generation system. There are four flags (green, yellow, red 1 and red 2), which similar to a traffic light, show the severity of the generation system (favourable, less favourable, more expensive 1, more expensive 2) adding values to kWh (from R$0,00, R$0.015, R$0.040 and R$0.060) paid by captive clients from all states of the federation linked to the National Interconnected System (SIN). Roraima, not being connected to the SIN, does not suffer the application of the flag system.

## V. CONCLUSIONS

Through this article, it was possible to understand about the new tariff modality implemented by ANEEL, which allows consumers to be charged according to the time of use of electricity. The literature was reviewed on the main themes related to the subject, and the consumption profile of some high consumption customers was analyzed, considering the time and day of the week in which they occurred. The data were then worked and applied to them the monomial and white tariffs, being possible to compare the amount to be paid in both modalities.

The objective of verifying the minimum percentage at which the white tariff becomes viable was reached. Although it is not possible an exact%, because this varies according to the share of consumption of other hours, we note that with a percentage of consumption close to 80/85 in off-peak hours the new tariff mode becomes attractive.

It was also possible to compare this result with the province of Ontario, Canada, which has been applying a similar tariff mode since 2007, obtaining satisfactory results. It was also possible, through the example of Ontario, to see how Brazil bypasses the difficulties in power generation through the tariff flag system, which add a certain value to kWh to cover the use of more costly power generation means.

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