Energy efficiency through analysis of the contracted demand, consumption and framework group “A” tariff: case study at IFPA Parauapebas campus

Eficiência energética através da análise do demanda contratada, consumo e estrutura tarifa do grupo "A": estudo de caso na IFPA campus de Parauapebas

DOI:10.34117/bjdv8n10-008

Recebimento dos originais: 30/09/2022
Aceitação para publicação: 03/10/2022

Francisco Silva e Serpa
MSc degree in Electrical Engineering at University of Minas Gerais (UFMG)
Institution: Federal Institute of Pará (IFPA) - Parauapebas
Address: IFPA - Rodovia PA 275, União, Parauapebas - PA, CEP: 68515-000
E-mail: francisco.serpa@ifpa.edu.br

Ricardo Alex Dantas da Cunha
DSc in Mechanical Engineering at University of Rio Grande of Norte (UFRN)
Institution: Federal Institute of Pará (IFPA) - Parauapebas
Address: IFPA - Rodovia PA 275, União, Parauapebas - PA, CEP: 68515-000
E-mail: ricardo.alex@ifpa.edu.br

Lucas Araújo Nascimento
MSc degree in Rural Development at Federal Institute of Pará (IFPA)
Institution: Federal Institute of Pará (IFPA) - Parauapebas
Address: IFPA - Rodovia PA 275, União, Parauapebas - PA, CEP: 68515-000
E-mail: lucasborg@gmail.com

ABSTRACT
Waste of electricity in public educational institutions is alarming. The agency Electric Energy National (ANEEL) published in October 2016 through the call 01/2016 to electricity distributors, which aims, among other objectives, to invest in efficiency energy and mini-generation in institutions, which evidences the absence of strategic energy management and the lack of a culture of optimizing energy resources. Thus, this work may help in the search for the minimization of electrical energy waste and public resources in the institutions, as it will propose an efficient framework methodology tariff system, able to assess and adjust demand contracted (kW). The methodology consists of achieving the energy efficiency, through demand analysis, tariff framework and energy consumption electricity, in the consumer unit, in particular to the study case study of the Federal Institute of Pará – Campus Parauapebas (IFPA), through the analysis of invoices monthly electricity bills and the basis of the resolutions and rules on the types of tariffs for electrical energy from groups A4. With that, it is expected to adjust the contracted load demand (kW). and crave cost reduction for the Public Administrationproviding a practical form of analysis and indication of the best tariff framework for the group studied, and thereby achieve sustainable consumption and efficient electricity contracts.

Keywords: demand, cost reduction, energy consumption electricity.

RESUMO
O desperdício de eletricidade em instituições públicas de ensino é alarmante. A Agência Nacional de Energia Elétrica (ANEEL) publicou em outubro de 2016 através da chamada 01/2016 às distribuidoras de eletricidade, que visa, entre outros objetivos, investir em energia eficiente e mini-geração em instituições, o que evidencia a ausência de gestão estratégica de energia e a falta de uma cultura de otimização dos recursos energéticos. Assim, este trabalho pode ajudar na busca da minimização do desperdício de energia elétrica e dos recursos públicos nas instituições, pois irá propor um sistema de tarifas de estrutura eficiente, capaz de avaliar e ajustar a demanda contratada (kW). A metodologia consiste em alcançar a eficiência energética, através da análise da demanda, da estrutura tarifária e do consumo de energia elétrica, na unidade consumidora, em particular o estudo de caso do Instituto Federal do Pará - Campus Parauapebas (IFPA), através da análise das faturas mensais de energia elétrica e a base das resoluções e regras sobre os tipos de tarifas de energia elétrica dos grupos A4. Com isso, espera-se ajustar a demanda de carga contratada (kW) e almejar a redução de custos para a Administração Pública, proporcionando uma forma prática de análise e indicação da melhor estrutura tarifária para o grupo estudado e, assim, conseguir um consumo sustentável e contratos de eletricidade eficientes.

Palavras-chave: demanda, redução de custos, consumo de energia eletricidade.

1 INTRODUCTION

Energy efficiency in public buildings is a sustainable trend increasingly demanded of managers public, however, many have the understanding that in order to achieve this objective would require high investments, the that in some cases this may even be true, but there are actions aimed at energy efficiency that can provide good results, provided that internal policies are considered to be complied with and monitored constantly (OLIVEIRA et al., 2015). in relation to that Batista et al (2012) adds that the analysis of the history of monthly electricity tariffs can be indicated with one of these actions, and which is framed as a proposal efficiency that directly involves the role of management energy, with the main purpose of identifying and applying method that reduces the consumption and cost of electricity.

2 REGULATORY RESOLUTIONS

This section presents important standards for characterization of the consumer unit (CU) under study. A. Tariff modalities According to the National Electric Energy Agency (ANEEL), through Normative Resolution (REN) No. 414 and updated by REN 418, which establishes the conditions general electric power supply, classifies the group A consumers in the supplied voltage range according to table 1.

Table I - Voltage supply in group a

GROUP A - High Voltage	
A1	Supply voltage equal to or greater than 230 kV.
A2	Supply voltage from 88 kV to 138 kV.
A3	88 kV supply voltage
A4	Supply voltage from 30 kV to 44 kV
AS	Supply voltage lower than 2.3 kV, served from underground distribution system and billed in Group A exceptionally

So for the groups mentioned, ANEEL through of REN Nº 414 updated by REN Nº 479 defines in its Art.2, Item L, tariff modality as: “set of tariffs applicable to energy consumption components electricity and active power demand, considering the following modalities belonging to Group A:

a) Green hourly tariff modality: applied to consumer units of group A, characterized by tariffs differentiated consumption of electric energy, according to the hours of use of the day, as well as a single tariff of power demand;

b) Blue hourly tariff mode: applied to units group A consumers, characterized by tariffs differentiated electricity consumption and demand of power, according to the hours of use of the day.

It is important to point out that for the concession area of Centrais Elétricas do Pará S/A (CELPA), where it is intended to apply this study, the Conventional Tariff Modality Binomial, was extinguished for application in group A, by the ANEEL's Ratifying Resolution 1930/2015, in the 4th Periodic Tariff Review - RTP, a fact also foreseen by REN Nº 414, as of the 3rd Periodic Tariff Review – RTP. Differentiated tariffs for periods of the year and hours of the day are defined by REN Nº 414 updated by REN Nº 479 defines in its Art.2, Item LIV-A, the periods, as:

a) Dry: period of 7 (seven) period of 7 (seven) cycles of consecutive billings, referring to the months of May to November;

b) Wet: period of 5 (five) billing cycles consecutive months, referring to the months of December of one year to April of the following year; And about the tariff post: time period in hours for application of tariffs differently throughout the day, considering the following division:

Peak tariff post: period consisting of 3 (three) hours consecutive days defined by the distributor considering the electrical system load curve., approved by ANEEL for the entire concession or permission area, with the exception of Saturdays, Sundays and public holidays nationally. It should also be noted that for the concession area of Centrais Elétricas do Pará S/A (CELPA) the tariff post Ponta comprises the period between 18:30 and 21:29. Off-peak tariff station: period composed of the set of consecutive and complementary daily hours to those defined at the peak stations. Another point to be highlighted is the framing of the tariff modalities belonging to group A:

I – in the blue hourly tariff modality, those with supply voltage equal to or greater than 69 kV;

II – in the blue or green hourly tariff modality, according to the consumer's option, those with voltage of supply of less than 69 kV and contracted demand equal to or greater than 300 kW; and III - in the hourly tariff modality blue or green, according to the consumer's option, those with a supply voltage lower than 69 kV and contracted demand of less than 300 kW.

Overtaking demand (DU), contracted demand (DCT) and demand consumed (DCN). When the Consumed Demand (DCN) exceeds 10% the Contracted Demand (DCT), will be accounted for as Exceeded Demand (DU). So, it fits the price paid for the kW of the DU (P(R$)DU).

3 METHODOLOGY

The verification of costs with outdated demand, the forecast of the optimized demand to be contracted, and the comparative simulation of the different tariff modalities for the UC of the Federal Institute of Pará Campus Parauapebas was granted by the inductive analytical method presented in this section.

The data collected from the mass memory of invoices for electrical energy that were analyzed can be obtained in any power distribution company. The invoices of electrical energy were examined through measurements in medium voltage for group A4 green tariff modality, in the form of a monthly report for 12 months, with the specified periods, presenting the measurements of active consumption (kWh), contracted demand, consumed and outdated.

The level of efficiency of the contract in relation to demand contracted will be based on the average of the maximum demands consumed during the period of data collected. then it will be multiplied by the consumption demand assessment factor - ft, as can be seen in equations (1) to (3) below, for forecasting and adjusting billing demand green time.

$$ft = \frac{((\sum_{P:2}^{M} DCmy)x100)}{(\sum_{P:1}^{M} DCmy)} \quad (1)$$

$$EDM = \frac{\sum_{Y:2017,2018}^{M} DCmy}{12} \quad (2)$$

$$DE = ft\ x\ EDM \quad (3)$$

Where: DCmy - Maximum Demand Consumed in Month M of year Y; M = 1 to 12 Months; Y = 2017 and 2018; EDM - Estimated Maximum Demand; DE - Estimated Demand for the efficiency of the contract; ft – Evaluation factor of demand consumed in period P; P - Are the periods or the time interval in months M that will be compared, the longer the period of significant and reliable data best and most reliable is factor ft, with P1 being the longest period old and P2 the most current period. Whereas for blue hourly-seasonal pricing it is necessary to define the demand to be contracted in peak hours (6:30 pm to 9:29 pm) and for off-hours peak (9:30 pm to 6:29 pm). And in view of the average estimated demand for efficiency (DE = DCN) as 100% of the demand consumed for the contract, as can be understood by equations (4) and (5) below:

$$DCPmy = ((ECP)/(ECP + ECF)) + DME \quad (4)$$

$$DCFmy = ((ECF)/(ECP + ECF)) + DME \quad (5)$$

Equations (6) and (7) are for the definitions of peak and off-peak demands.

$$DCEP = ((\sum_{M}^{-} DCPmy)/\beta) \quad (6)$$

$$DCEF = ((\sum_{M}^{-} DCFmy)/\beta) \quad 7)$$

Where: ECP – Energy consumed at peak hours in kWh, in month M of year Y; ECF - Energy consumed in off-peak hours in kWh, in month M of year Y; DME - Estimated demand for contract efficiency; DCPmy - Efficient peak contracted demand in kW, considering the consumption of month M of year Y; DCFmy- Efficient off-peak contracted demand in kW, considering the consumption of month M of year Y; DCEP - Efficient peak contracted demand in kW to be contractor, considering the average DCPCmy; DCEFDemand efficient off-peak contract in kW to be contracted, considering the average DCFCmy; β - Number of months of electricity consumption history analyzed;

Then equation (8) will calculate the cost (R$) of the electricity consumption for seasonal pricing green and equation (9) for the blue season, for each UC of the A4 group under study.

$$THVc = ((ECFc \; x \; VEF) + (ECPc \; x \; VEP) \; x \; (VD + DCc) \quad (8)$$

$$THAc = ((ECFc \; x \; VEF) + (ECPc \; x \; VEP) \; x \; (DCPc + VDP) + \\ + \quad (DCFc \; timeVDF) \quad (9)$$

Where: ECPC – Energy consumed during peak hours; ECF – Energy consumed during off-peak hours; DC - Contracted demand (peak and off-peak) of the contract; PDD – Efficient peak contracted demand; DCFdemand efficient contractor off-peak; DV - Value of single contracted demand for peak and off-peak in BRL per kW; VDF - Value of demand contracted outside of peak in R$ per kW; VDP - Value of contracted demand peak in R$ per kW; VEF - Value of energy consumed at off-peak hours in R$ per kWh; VEP - Value of energy consumed at peak hours in R$ per kWh; THV – Green hourly-seasonal pricing value in (R$); THA - Blue hourly-seasonal pricing value in (R$);

After defining the THVc and THAc values of the history of data, the comparison of the two modalities tariffs.

Table 2

Year. Month	D. Cons. (kW)	DUDC (kW)	DF (kW)	TDF (R$)	TDFSC (R$)	TFDU (R$)
2017.June	96.01	24.01	96.01	3,999.97	0.00	1,333.68
2017.July	77.11	5.11	77.11	2,238.92	0.00	0.00
2017.Aug	74.35	2.34	74.34	2,207.59	0.00	0.00
2017.Sept	97.02	25.02	97.02	5,157.90	0.00	1,755.07
2017.Oct	105.58	33.58	105.58	6,146.93	0.00	2,390.12
2017.Nov	89.96	17.96	89.96	4,460.44	0.00	1,272.95
2017.Dec	96.76	24.76	96.76	4,975.79	0.00	1,684.72
2018.Jan	77.36	5.36	77.36	2,963.18	0.00	360.87
2018.Feb	67.3	0	72	2,418.77	157.89	0.00
2018.Mar	91.72	19.72	91.72	4,370.89	0.00	1,314.63
2018.Apr	85.17	13.17	85,17	3,813,20	0.00	901.00
2018.May	88.68	14.68	86,68	4.164,80	0.00	1,054.11
Total Annual	1045.01	185.71	1049,71	46.918,37	157.89	12,067.15

Where: D. Cons.: Contracted Demand in kW; DUDC: Demand Exceeded Contracted Demand; DF: Billed Demand; TDF: Total Billed Demand; TDFSC: Total Demand Billed without being Consumed; TFDU: Total Billed for Exceeded Demand.

4 RESULTS AND DISCUSSIONS

4.1 FRAMEWORK OF THE TARIFF MODALITY

The first analysis of the results obtained was the simulation comparison of the tariff framework for the two modalities, as shown in figures 1 and 2. The tariff modality green, currently at the UC under study, remained throughout the 12 months always with the cost below in relation to the modality blue tariff. Regarding the annual cost of moving would lead to a 12.26% increase in the annual cost of the account power.

Figure 1. Comparison between the two tariff modalities over the months.

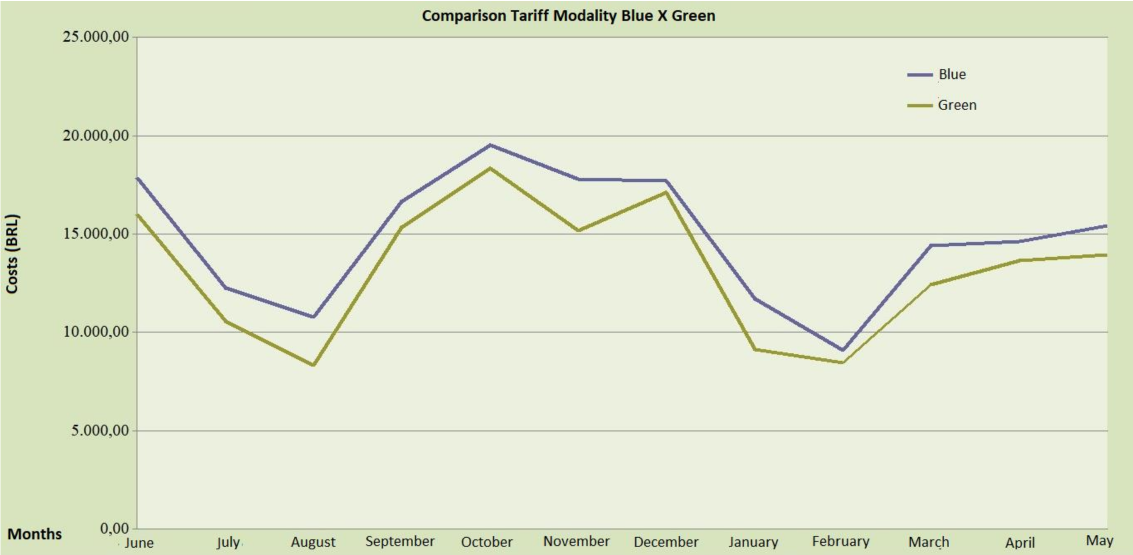
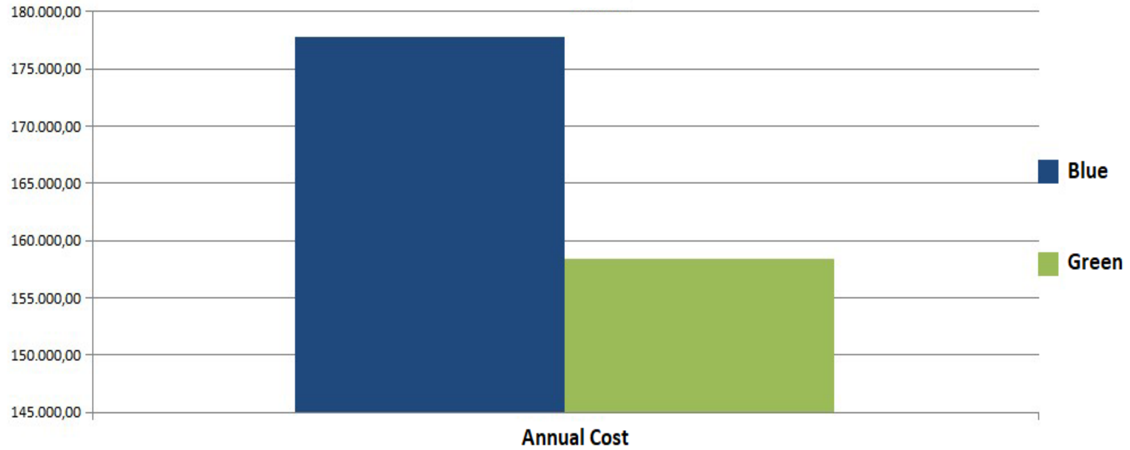


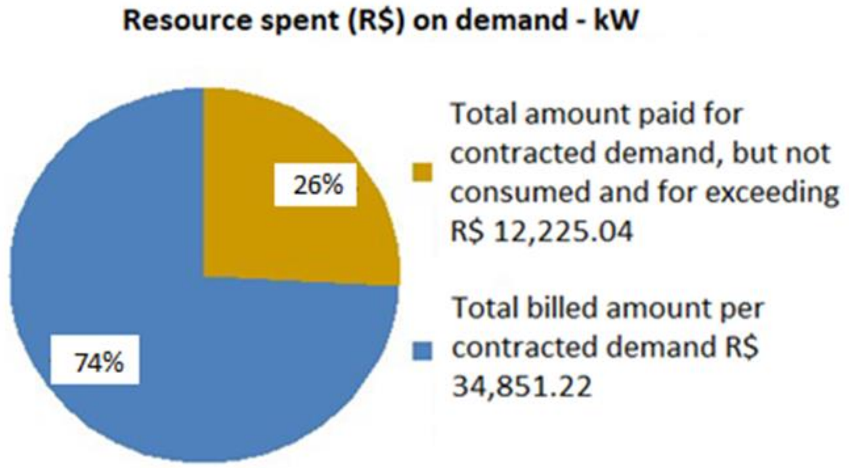
Figure 2. Comparative annual cost of the simulation of the two tariff modalities.



4.2 OPTIMIZATION OF CONTRACTUAL DEMAND

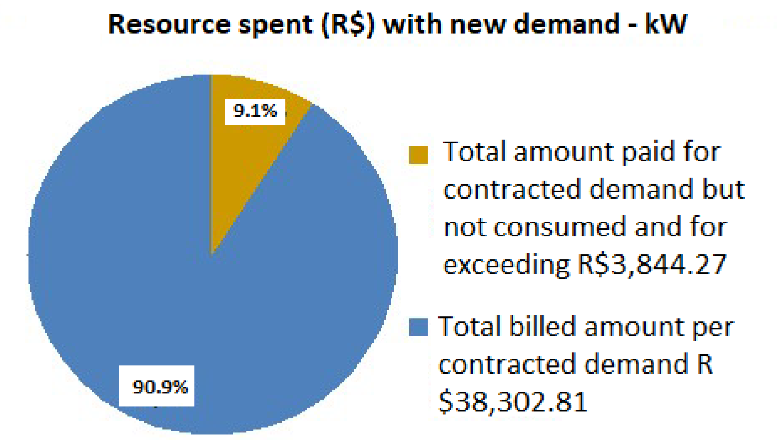
The current contractual demand for energy supply power of the IFPA Campus Parauapebas is 72.0 kW, and according to table 2 only in three months during the 12 months the overtaking demand was not charged, showing the inefficiency in reducing energy costs electricity and one of the bottlenecks to reach efficiency UC energy.

Figure 3. Resource spent on contracted demand x Resource demand expense cont. but not consumed and for overtaking - year 06/2017 to 05/2018.



As per annual spend with current demand shown in figure 3, 26% represents contracted demand but not consumed and by overtaking, on a total billing demand of R$ 47,076.26 (forty-five seven thousand, seventy-six reais and twenty-six cents). From this need, the analytical method described in section 3 to arrive at demand optimization was hired. After processing the data, the result for contractual demand optimization was 96 kW. Figure 4, presents the same history of consumed demand of figure 3, but processed with the new contractual demand for comparative purposes. From a comparative perspective, we can see that despite the increase in contracted billed demand and the contracted demand but not consumed, the demand was eliminated overtaking (higher pricing). Then, we obtained a percentage reduction of the resource spent on demand cont. but not consumed and for exceeding 65% and the reduction percentage of the final cost of the demand of 10.47%.

Figure 4. Resource spent with new demand x Resource spent with exceeded demand - year 06/2017 to 05/2018



5 CONCLUSIONS

The results pointed to a clear and critical analysis about the change in contractual demand that interferes potentially in the cost of electricity, if there is need for change. The case study with the scenario presented, showed that the framework of the tariff modality for blue is not feasible and that the point critical to achieving energy efficiency over costs is on demand. It is worth mentioning that the data collected for the case study were 12 months, but for units consumers with high average annual variation is due to a wider range of data collected and future projections.

REFERENCES

[1] BATISTA, O.E.; FLAUZINO, R. A. Management Measures Low Cost Energy as a Strategy for Reducing Electricity Costs. GEPROS Magazine. Management of Production, Operation and Systems, Vol. 7, No. 4, p.117-134, 2012.

[2] NATIONAL ELECTRIC ENERGY AGENCY – ANEEL. Normative Resolution (REN) No. 414. Establishes the Conditions General Electricity Supply in an updated form and consolidated, 2010.

[3] NATIONAL ELECTRIC ENERGY AGENCY – ANEEL. Normative Resolution (REN) No. 418. Amends the Resolution ANEEL Regulation No. 414, of November 23, 2010.

[4] NATIONAL ELECTRIC ENERGY AGENCY – ANEEL. Normative Resolution (REN) No. 449. Amends the Normative Resolution No. 414, of September 9, 2010, 2011.

[5] NATIONAL ELECTRIC ENERGY AGENCY – ANEEL. Normative Resolution (REN) No. 479. Amends Normative Resolution No. 414, of September 9, 2010, which establishes the General Conditions for the Supply of Electricity in an updated and consolidated form, 2012.

[6] NATIONAL ELECTRIC ENERGY AGENCY – ANEEL. Ratifying Resolution No. 1,930. Approves the result of fourth periodic tariff review - RTP of Centrais Elétricas do Pará S/A., CELPA, energy tariffs - TE and usage tariffs of the distribution system – TUSD, and other provisions, 2015.

[7] NATIONAL ELECTRIC ENERGY AGENCY – ANEEL. Call No. 01/2016. Priority Project for Energy Efficiency and Strategic R&D:" Energy Efficiency and Minigeneration in Federal Education Institutions, 2016.

[8] OLIVEIRA C.S.; MARQUES J.J.A.; JUNIOR B.F.S.; LINARD F. M.A.; ALMEIDA A. R. University Tariff Analysis Federal University of Piauí – Petronio Portela Campus. Technical Congress Engineering and Agronomy Scientist – CONTECC. Strength - EC 2015.