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IMPACT OF ECONOMIC CHANGES AFTER THE YEAR 2022 ON THE ECONOMIC VIABILITY OF PHOTOVOLTAIC MICROGENERATION IN HOMES IN THE CITY OF FORTALEZA, BRAZIL

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***Abstract.** The present study aims at the use of photovoltaic solar energy in the Northeast region, more precisely in the city of Fortaleza. The study includes the analysis of the insertion of photovoltaic plants in homes in Fortaleza and its economic viability due to the new conditions created after the year 2020. de 2023. Thus, three photovoltaic systems for the generation of electricity at residential level were studied, with different powers, but within the most used ranges in the residential sector of Fortaleza. Each plant took into account three types of analysis, with the acquired right, with the taxation of 100% of FIO B and for the current scenario, taking into account the escalation of the charge for FIO B, which starts at 15%, in 2023, increasing linearly until reaching 100% in 2029. The customer who obtained the system by cash payment or financing was considered. An economic feasibility study was carried out, in which an inflation of 5.79% p.a. was used, and a tariff readjustment of 11.35% p.a. in the three plants, in light of a sensitivity analysis of this variable.*

Keywords: photovoltaic energy, economic analysis, residential sector, law 14300/2022, FIO B.

1. INTRODUCTION

The electricity sector around the world is undergoing a transformation process driven by the growth of renewable energy resources, and the need for distributed generation (DG) systems, from solar or wind energy, storage systems has been increasingly more relevant to society (Ramos, et al., 2020).

What prevented the growth of transmission capacity and generation of electric power systems were the economic restrictions imposed by recessive policies, which occurred in the 90s. and proper control of the system. On the other hand, the advancement of new technologies allowed access to numerous electronic equipment that became part of the daily use of consumers, as well as public utility equipment, domestic and industrial production (Ferraz, 2016).

Energy systems are going through a period of rapid evolution. The former status of large centralized generators operating within a monopoly is being replaced by a paradigm within which sustainability and competition are key priorities (Pec, 2010; Schleicher-Tappeser, 2012).

Vertically integrated power utilities were dismantled and competitive market actions were established to encourage maximum effective use of generation and grid resources. The push for sustainability has resulted in the introduction of carbon caps and, most importantly, moving forward with ambitious renewable energy targets. Under current practical operation, large amounts of expensive systems and operating reserves are often required to ensure security of electrical power supply. This is a particular issue in systems and energy with high penetrations of uncertain and renewable generation (Kenneth, et al., 2012).

Solar energy has the potential to play the crucial role in energy production and cost-effectiveness of energy. Photovoltaic modules were analysed and developed, considering new concepts of performance characteristics, longer service life and high reliability for market launch (Kenneth, et al., 2012). The issue of self-consumption of electricity has

increased due to changes in the global energy market and government policies. The energy generated by local photovoltaic or hybrid photovoltaic and wind systems has sufficient power supply capacity for small to large powered systems and reduce electricity price and tariff rates (Benda, 2015).

Solar energy corresponds to 2.5% of the Brazilian electricity matrix (BEM, 2022), which shows that it has been growing over the years. Photovoltaic solar energy is used in this work, and this has been undergoing a new reformulation due to Law 14300/2022. Solar energy helps to reduce the energy bill, to reduce overload in the distribution networks of concessionaires, and also reduces environmental impacts.

It was in this aspect that the cases of insertion of photovoltaic solar energy in homes in Fortaleza were analysed and the economic analysis study was carried out for this investment, to obtain the photovoltaic solar energy system in cash or by bank financing, considering the acquired right, customers who adhere in 2023 (transition period of the law) and customers who adhere with 100% of the FIO B charge, thus showing that it is feasible to invest in a photovoltaic solar system for the residential sector.

2. METODOLOGY

2.1 Study site mapping

In Brazil, in general, the months of January and February are responsible for the highest consumption. Figure 1 shows the electricity consumption of the Northeastern residential sector from January to November of the years 2020 and 2021, according to EPE data (EPE, 2022), this analysis serves to verify how the public under study behaves.

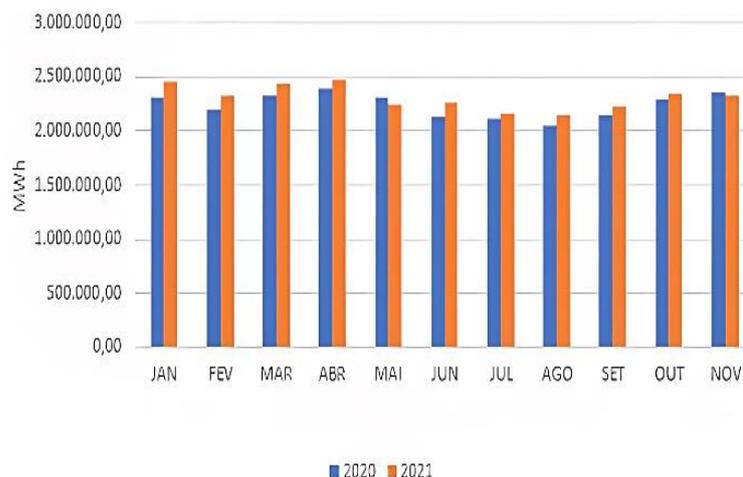


Figure 1. Monthly electricity consumption in the residential sector in the Northeast

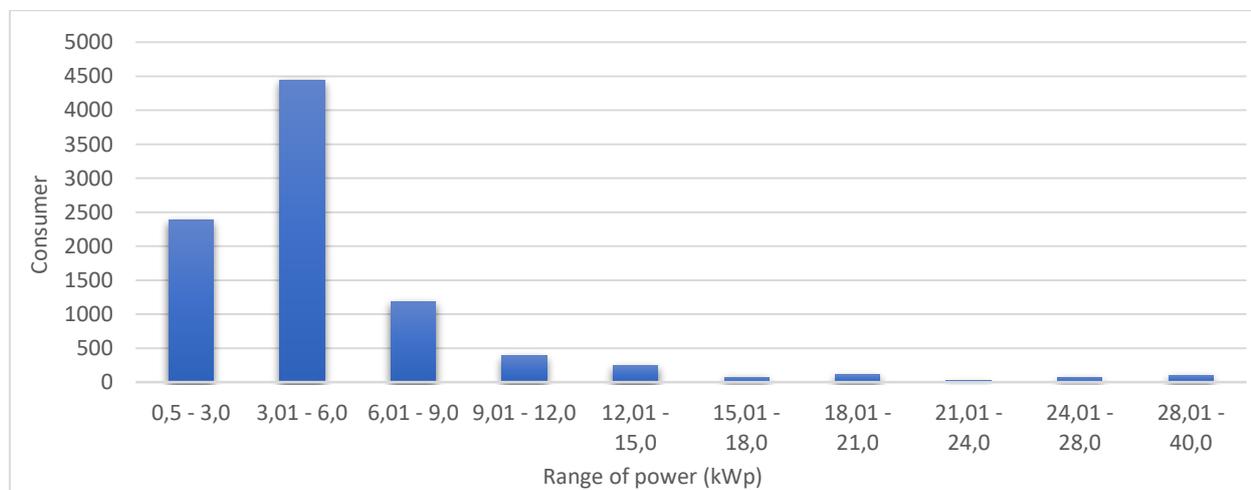


Figure 2. Residential Class Consumers in Fortaleza and System Power Range.

2.2 Generation of Photovoltaic Plants

Monitoring the power generation of a photovoltaic generation system is done through the monitoring portal, made available by the manufacturer of the inverter/microinverter present in the solar plant. Normative Resolution No. 482/2012 (ANEEL, 2012) determines that consumer units (UC'S) with generation along with the load, that is, the consumer unit located in the same environment where the photovoltaic system is installed, must be used to offset consumption of the generating CU, and in case there is surplus energy, stored in the form of credits, which can be used for up to 60 months.

ANEEL's Generation Information System (SIGA) provides all data on Brazil's generation capacity, enabling access to matrix information by source. For the present study, it is necessary to extract data from the distributed generation of photovoltaic systems. In Figure 2, it is possible to observe the adherence of consumers from the residential class of Fortaleza who chose to adhere to the insertion of photovoltaic systems in their homes, this data refers to nine thousand consumers. The chart also shows the power range (kWp) that these consumers adhered to.

In Figure 2, the separation of this number of consumers by the power range of the chosen system was adopted, with this, it can be seen that most of the public under study opted for the power range between 3.01kWp to 6.0kWp. With this, it is clear that this range is the most common for the residential class public in Fortaleza. Based on this, the study carried out was of 3 scenarios of residential consumers with power in the range of the two with the most consumer adherence. The first photovoltaic plant has characteristics described in Table 1. Plant 1 is a residence that needs a monthly generation of 518kWh, consisting of 12 modules of 330Wp and used 3 micro inverters from the manufacturer Hoymiles, the system has a power peak of 3.96kWp, which produces an average monthly generation of 518kWh, in which the system price is R\$20,000.00 in cash. Table 1 will show the characteristics of this second plant under study, in which the average consumption of the residence is 566kWh, has 8 modules of 545Wp, and 1 Livoltek inverter, with a peak power of 4.36kWp and the price of obtaining of the system is R\$20,617.00 in cash.

Table 1. Technical characteristics of the photovoltaic plants.

	Plant 1	Plant 2	Plant 3
Price	R\$ 20.000,00	R\$ 20.617,00	R\$ 26.000,00
Local	Fortaleza-Ce	Fortaleza-Ce	Fortaleza-Ce
Number of modules	12	8	10
Module power (Wp)	330	545	550
Qty. of inverters	3	1	3
Brand of inverters	Hoymiles	Livoltek	Deye
Rated power (kW)	3,6	3	4,8
Peak power (kWp)	3,96	4,36	5,5
Estimated monthly generation (kWh)	518	566	722

The data in Table 1 is about Plant 3 under study, which has an average monthly consumption of 722kWh, with 10 modules of 550Wp and 3 micro inverters from the manufacturer DEYE, with a peak power of 5.5kWp, and a price acquisition of this system of R\$26,000.00 in cash. The prices of the TUSD and TE components for the residential sector, for the conventional B1 group, in which the TE is equivalent to R\$0.38576/kWh and the TUSD to R\$0.53994/kWh.

An economic feasibility study was carried out in the three plants under analysis, observing the behavior of these plants according to each scenario, with acquired rights (without charging the FIO B), with the taxation of FIO B (100% of this rate) and for the transition period (staggered payment of the FIO B fee until reaching 100% in 2029), and these comparisons were also made considering the payment method (cash or financing).

2.3 Economic Viability

The first step in analysing the feasibility of an investment is to consider its economic aspects. Understand whether the investment is profitable, and, if there are several possibilities, which is the most profitable. This step determines the economic parameters of the decision. Two criteria to be considered are the financial and the imponderables, the financial one referring to the availability of resources to carry out the investment, and the imponderable one referring to the repercussions that cannot easily be converted into monetary terms (Casarotto Filho, Kopittke, 2020).

Investment analysis refers to an assessment of the economic viability of investments, built in a context that encompasses a series of parameters, criteria and objectives. The biggest challenge concerns the interpretation of future occurrences. Cash flow represents the main financial statement tool, whose objective is to project for future periods all inputs (inputs) and outputs (outputs) of financial resources and point out how the cash balance will be for the projected period (Brom and Balian, 2007).

Gross revenue covers the total revenue arising from the core activities of the company, this gross revenue can be defined as all the input of resources that matches the activities for which the company was created. To understand the gross revenue formula, simply multiply the price of products and services that a company offers and multiply by the quantity of goods sold. It is also necessary to discount the investment and amortization on equity for a period of 25 years, which represents the average useful life of the solar energy system. To analyse these financial statements, the following methods will be applied: payback and net present value (NPV).

2.3.1 Payback Method

In order to analyse the economic impact of Law 14,300/2022 (BRASIL, 2022), in comparison with the current scenario, the payback of investments in both scenarios was analysed. This indicator shows the time in which the accumulated economy exceeds the value of the initial investment. For the study, the compound payback was used, considering an annual adjustment rate of 11.35%, since this was the average value for the tariff adjustment in 2022.

Despite Law 14,300/2022 (BRASIL, 2022), having a transitional period of 6 years after its approval, in the analysis, the transition scenario was considered and also after the transition period, that is, where 100% of FIO B, should be charged. With this, the extremes between the economic impacts and the current pricing model were analysed.

Payback is defined as the period in which the return on the initial investment occurs (Brito, 2012). This methodology weighs the estimated time for the recovery of the capital initially invested, helping in the evaluation of large projects.

The Payback, in addition to indicating the time for linking resources to a given project, also presents an auxiliary indicator for liquidity and risk: the shorter the payback, the lower the risk and the greater the liquidity of the project and vice versa.

To calculate simple Payback, just use Eq. (1):

$$Payback = \frac{Initial\ investment}{Cash\ flow\ with\ investment\ gain} \quad (1)$$

The payback decision rule is given as follows:

- a) If the investment is paid within the period of time established by the investor, the investment project is accepted;
- b) If the investment is not paid within the period of time established by the investor, the investment project is rejected.

The Cash Flow considers the annual tariff adjustment, to find out when the customer would continue paying the energy bill without using photovoltaic solar energy each year and is also used to analyse the savings of this same customer during the same period with the use of the acquisition of the photovoltaic solar system, the flow being the difference between these two situations.

2.3.2 Net Present Value (NPV)

The Net Present Value (NPV) is based on the algebraic sum of all cash flows discounted to the present instant, that is, the initial investment. Also known as the method of evaluating discounted cash flows, the NPV provides a comparison between the value of the investment and the value of expected returns, with all values considered at the current moment (Brom and Balian, 2007). The NPV objective is to estimate, in present value, all cash flows relevant to a project, for this purpose an estimate of the present value is made for the future cash flows generated and the investment made initially is deducted. Mathematically, the NPV can be calculated according to Eq. (2):

$$VPL = -Investment + \left(\sum_{n=1}^x \frac{ATn}{(1+i)^n} \right) \quad (2)$$

where:

NPV = net present value

ATn = after-tax cash flow in year n

i = discount or attractiveness rate

n = project life in years

There is a basic decision precept by the NPV method, as follows:

- a) If $NPV > 0$: viable (the investment project is accepted), since the offered returns will cover the invested capital;

- b) If $NPV = 0$: indifferent, as the investment return will only cover the capital invested and the minimum return charged by the investor (it does not offer any advantage or gain);
c) If $NPV < 0$: rejected, as the offered returns will not cover the invested capital plus the minimum return required by the investor.

For the discount or attractiveness rate, the 2022 inflation value of 5.79% p.a. was used, according to the Extended National Consumer Price Index (IPCA, in Portuguese).

2.3.3 Internal Rate of Return (IRR)

The Internal Rate of Return, is an analysis that indicates the profitability of the investment, indicates the rate of attractiveness that causes the net present value to be zero. That is, if the profitability is lower than the attractiveness rate, the investment will be disadvantageous for the customer. The IRR can be calculated by equating the net present value equation to zero:

$$NPV = -I_0 + \sum_{t=1}^n \frac{F_t}{(1+IRR)^t} = 0 \quad (3)$$

NPV = Net present value (R\$)

I_0 = Investment (R\$)

F_t = Cash flow in the period (R\$)

n = Generator lifetime (years)

IRR = Internal rate of return (% per year)

2.4 Sensitivity analysis

A sensitivity analysis was carried out, in which there was a variation in the monthly interest rate of the financing by $\pm 0.5\%$, as well as a reduction in the financing period to 36 months and a variation of $\pm 7\%$ in the annual tariff adjustment. On the other hand, for the customer who purchased the system by paying in cash, the analysis was carried out only in the variation of the annual tariff adjustment.

3. RESULTS

3.1 Sensitivity analysis

Some variations were made in important variables in the analysis of the economic viability of the plants under study, and the parameters that were changed were the variation in $\pm 0.5\%$ of the interest rate per month of the financing, the period of time of the financing was reduced to 36 months, that is, 3 years and a variation of $\pm 7\%$ in the annual tariff readjustment for both types of obtaining the system.

3.1.1 Variation of $\pm 0.5\%$ of the interest rate per month of the financing

All 3 plants were analysed, only for consumers who subscribed to the system through financing, making this variation of $\pm 0.5\%$ in the monthly interest rate to verify the impact that this has on the investment payback period, or that is, if it is still a viable and attractive investment.

The value of the instalment for plant 1, which is from the R\$20,000.00 system, is R\$655.33 per month, through the Santander bank platform, for an interest of 1.61% per month, with a variation of 0.5% both for more and for less, one can observe the certain results that can be seen in Table 4. The instalment with interest of 2.11% p.m., results in an instalment of R\$755.33/month, already for the rate of interest referring to 1.11% p.m., results in an instalment of 555.33/month.

It can be observed, as already expected, that in the analysis of 100% of the payment of FIO B by the consumer, it would be in the case that the payback period would have a greater increase. It is possible to notice that there was an average increase of one year for more or less. At Plant 1, with the usual interest rate of 1.61% p.m., a payback time of 7 years and 5 months was obtained for the acquired right, with the variation in interest at $\pm 0.5\%$ resulting in a payback of 8 years and 4 months and 6 years and 6 months, an average of 1 year of difference both for plus and minus.

The value of the instalment for plant 2, which is from the R\$20,617.00 system, is R\$675.55 per month, for an interest of 1.61% per month, with the variation of 0.5% both for more and for less, one can observe the certain results that can be seen in Table 2. The instalment with interest of 2.11% a.m., results in an instalment of R\$778.64/month, already for the interest rate referring to 1.11% a.m., results in an instalment of 572.47/month.

Plant 2 presented results similar to those of Plant 1, since for the initial analysis of the work for an interest of 1.61% per month, an average difference was obtained in relation to the variations carried out in the interest referring to an average time of 1 year for more with the variation to 2.11% a.m., and on average one year less referring to the use of the interest

rate of 1.11% a.m., had a more significant increase in the analysis of 100% of the taxation of FIO B, where in the variation of interest to 2.11% p.m., it was obtained in an increase in the payback period of 1 year and 7 months.

The value of the instalment for plant 3, which is from the R\$26,000.00 system, is R\$851.93 per month, for an interest of 1.61% per month, with the variation of 0.5% both for more and for less, one can observe the certain results that can be seen in Table 2. The instalment with interest of 2.11% per month, results in an instalment of R\$981.93/month, already for the interest rate referring to 1,11% a.m., results in an instalment of 721.93/month.

Table 2 presents the results for these variations made in the monthly interest rate, in plant 3, which has a peak power of 5.5kWp, this presented in all analyses, whether acquired right, 100% of Wire B, or even the transition period, an average increase of 1 year more or less. It is the plant with the fastest payback time, in all analyses carried out, since the higher the energy bill, the faster it will be possible to obtain a return on investment.

Table 2. Interest rate changes.

	Plant 1		Plant 2		Plant 3	
Interest rate variation	+0,5%	-0,5%	+0,5%	-0,5%	+0,5%	-0,5%
Vested Right						
Payback	8 years and 4 months	6 years and 6 months	8 years and 8 months	6 years and 9 months	7 years and 6 months	5 years and 10 months
IRR	28,59%	41,86%	27,23%	39,12%	32,95%	51,93%
NPV from the project	149538,97	159706,66	145314,06	155795,42	227504,28	240722,28
100% FIO B						
Payback	11 years and 9 months	9 years and 3 months	11 years and 11 months	9 years and 5 months	9 years and 5 months	7 years and 4 months
IRR	18,88%	25,08%	18,54%	24,58%	24,55%	34,15%
NPV from the project	83065,77	93233,46	83058,53	93539,90	160206,62	173424,62
Transition period						
Payback	9 years and 4 months	7 years and 3 months	9 years and 6 months	7 years and 5 months	8 years and 4 months	6 years and 5 months
IRR	25,11%	34,95%	24,34%	33,58%	28,92%	42,34%
NPV from the project	130640,98	140808,68	129363,32	139844,68	202349,11	215567,10

According to the analyses carried out, it is possible to conclude that the change in the interest rate entails direct changes in the return time of the investment, so if there were no exclusive financing for this purpose of solar energy and the interest rates were high, it could make the investment unfeasible, but it can be seen that through the analyses carried out the investment remained attractive.

3.1.2 Reduction of the financing period to 3 years

All 3 plants were analysed, only for consumers who joined the system through financing, reducing the financing to 3 years, in order to analyse the impact that this provides on the return on investment period, that is, if it still remains a viable and attractive investment.

The value of the instalment for plant 1, which is from the system of R\$20,000.00 is R\$877.55 per month, for an interest of 1.61% per month, making a decrease to 36 months in the financing period, it can be observed in the results on Table 3, and conclude that the results of the reduction of the financing period resulted in a decrease in the average time of return of the plant 1 in 1 year.

The value of the instalment for plant 2, which is from the system of R\$20,617.00 is R\$904.63 per month, for an interest of 1.61% per month, making a decrease to 36 months in the financing period, it can be observed the results in Table 3, and it is concluded that the results of the reduction of the financing period resulted in a reduction of the average time of return of the plant 2 in 1 year and 2 months when compared with the financing in the period of 5 years.

Figure 3 shows, in a more didactic way, the turnaround time for plant 2 for the analysis of 100% of FIO B, that is, the assessment of the full value referring to this cost that makes up the TUSD. Through the figure, it is clear that there is a peak in expenses with the payment of energy plus the financing portion in the third year, and that after the third year ends, costs already reduce and after that it is already possible to verify the return on the investment made.

The value of the instalment for plant 3, which is from the system of R\$26,000.00 is R\$1140.82 per month, for an interest of 1.61% per month, making a decrease to 36 months in the financing period, it can be if we observe the certain results that can be seen in Table 3, and it is concluded that the results of the reduction of the financing period resulted in a decrease in the average time of return of the plant 1 in 1 year.

Through the analyses carried out in the reduction of the financing time, it was noticed that there was an average reduction of 1 year referring to the period of time of return of the study carried out for the period of 5 years. With this, it can be concluded that the financing time is also a very important variable and that it has a direct impact on the return on the investment made.

Table 3. Time reduction

	Plant 1	Plant 2	Plant 3
Vested Right			
Payback	6 years and 6 months	6 years and 7 months	5 years and 10 months
IRR	33,01%	32,46%	37,72%
NPV from the project	159680,63	161349,32	240688,34
100% FIO B			
Payback	9 years and 3 months	9 years and 1 month	7 years and 4 months
IRR	22,34%	22,79%	28,59%
NPV from the project	93207,44	99093,80	173390,67
Transition period			
Payback	7 years and 3 months	7 years and 5 months	6 years and 5 months
IRR	29,14%	28,29%	33,32%
NPV from the project	140782,65	139818,02	215533,16

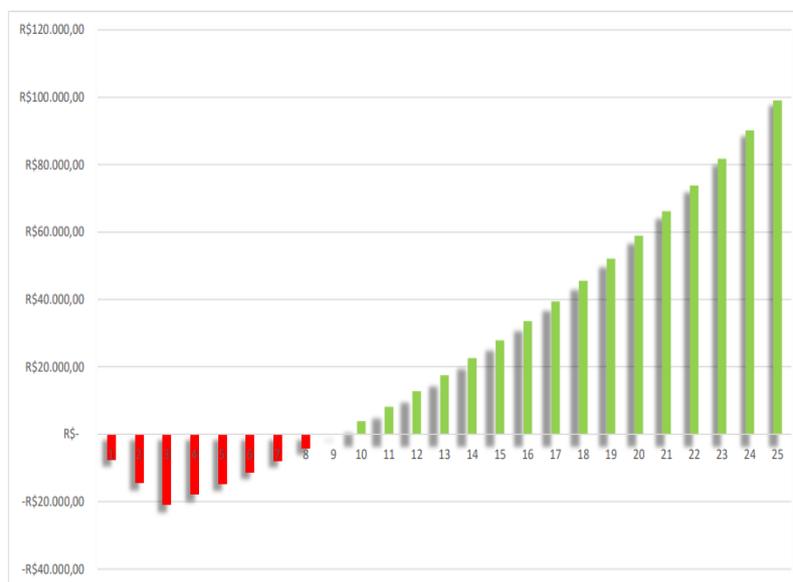


Figure 3. Plant 2 with 100% of FIO B and 3 years of financing

3.1.3 Variation of $\pm 7\%$ in the annual tariff adjustment

All 3 plants were analysed, for consumers who joined the system through the two payment methods that would be cash and financing, making this variation of $\pm 7\%$ in the annual tariff readjustment to verify the impact that this provides in the period return on investment, that is, if it is still a viable and attractive investment.

This variation was carried out in all analyses, in each plant, which would be for Vested Right, 100% of FIO B and transition period, and from these analyses we were able to verify what this variable represents for changes in the return time of the system. It is known that it is a fundamental variable with regard to payback, since cash flow is based on the

value of savings, which would be the difference between what the customer would pay without solar energy for the amount that the customer would pay with solar energy, considering this annual data, so the tariff adjustment is necessary in this calculation.

Table 4 shows the results of all the analyses of plant 1, for Vested Right, 100% of FIO B and the transition period of Federal Law 14300/2022. These analyses are based on the variation of $\pm 7\%$ in the annual tariff readjustment, since the average readjustment of the electricity tariff for residential consumers in 2022 was 11.35%, according to ANEEL, the annual tariff readjustment was analysed being 4.35% p.a., and 18.35% p.a.. Table 4 presents the data based on the initial analysis of this work, it has an acquisition value of R\$20,000.00, a discount rate (inflation) of 5.79% p.a., with a peak power of 3.96kWp and for the analysis of the financing a monthly installment of R\$655.33 over a period of 5 years.

Table 4. Annual tariff adjustment variation.

	In Cash		Financing	
	+7%	-7%	+7%	-7%
Vested Right				
Payback	4 years and 4 months	5 years and 6 months	6 years and 5 months	9 years and 4 months
IRR	38,03%	24,20%	45,82%	21,72%
NPV from the project	476971,06	61008,59	463655,10	47692,62
100% Fio B				
Payback	6 years and 1 mês	8 years and 7 months	8 years and 7 months	14 years and 11 months
IRR	30,13%	16,52%	31,16%	11,90%
NPV from the project	301194,37	32356,17	287878,41	19040,21
Transition period				
Payback	4 years and 10 months	6 years and 3 months	7 years	10 years and 9 months
IRR	35,47%	21,56%	40,18%	18,02%
NPV from the project	438861,72	51341,62	425545,76	38025,65

Table 5 presents the results of all analyzes for plant 2, for Vested Right, 100% of FIO B and the transition period of Federal Law 14300/2022. These analyzes are based on the variation of $\pm 7\%$ in the annual tariff readjustment, since the average readjustment of the electricity tariff for residential consumers in 2022 was 11.35%, according to Aneel, the annual tariff readjustment was analyzed being 4.35% p.a., and 18.35% p.a.. Table 5 presents the data based on the initial analysis of this work, it has the acquisition value of R\$20,617.00, a discount rate (inflation) of 5.79% p.a., with a peak power of 4.36kWp and for the analysis of the financing a monthly instalment of R\$675.33 over a period of 5 years.

Table 5. Plant 2 annual tariff adjustment variation

	In cash		Financing	
	+7%	-7%	+7%	-7%
Vested Right				
Payback	4 years and 5 months	5 years and 7 months	6 years and 6 months	9 years and 6 months
IRR	37,67%	23,84%	44,98%	21,19%
NPV from the project	483072,49	61486,72	469345,57	47759,80
100% FIO B				
Payback	6 years	8 years and 5 months	8 years and 5 months	14 years and 7 months

IRR	30,50%	16,87%	31,71%	12,30%
NPV from the project	318448,70	34652,28	304721,78	20925,36
Transition period				
Payback	5 years	6 years and 6 months	7 years and 2 months	11 years and 2 months
IRR	34,86%	20,96%	39%	17,23%
NPV from the project	438897,34	50569,60	425170,42	36842,68

Table 6 shows the results of all analyzes for Plant 3, for Vested Right, 100% of Yarn B and the transition period of Federal Law 14300/2022. These analyzes are based on the variation of $\pm 7\%$ in the annual tariff readjustment, since the average readjustment of the electricity tariff for residential consumers in 2022 was 11.35%, according to Aneel, the annual tariff readjustment was analyzed being 4.35% p.a., and 18.35% p.a.. It has the acquisition value of R\$26,000.00, a discount rate (inflation) of 5.79% p.a., with a peak power of 5.5kWp and for the analysis of the financing a monthly instalment of R\$851.93 over a period of 5 years.

It is observed through the analysis of the variation of the annual tariff readjustment, that the bigger the readjustment, the more viable the acquisition of the photovoltaic solar energy system, since the time of return of the investment reduces, with that the consumer obtains a return faster in regions where this readjustment is higher, on the other hand, an annual tariff readjustment of around 4.35%, as the analysis was carried out, shows that the project does not become unfeasible, and that even if the readjustment is not so high, the investment is still attractive.

Table 6. Plant 3 annual tariff adjustment variation

	In cash		Financing	
	+7%	-7%	+7%	-7%
Vested Right				
Payback	3 years and 11 months	4 years and 10 months	5 years and 10 months	8 years and 2 months
IRR	40,89%	27,01%	53,48%	26,36%
NPV from the project	707599,23	93580,08	690288,42	76269,27
100% FIO B				
Payback	4 years and 11 months	6 years and 5 months	7 years and 1 month	10 years and 11 months
IRR	35%	21,23%	39,37%	17,57%
NPV from the project	529645,39	64572,29	512331,58	47261,48
Transition period				
Payback	4 years and 4 months	5 years and 5 months	6 years and 4 months	9 years and 3 months
IRR	38,29%	24,36%	46,3%	21,98%
NPV from the project	656759,02	80726,79	639448,21	63415,99

4. CONCLUSION

The residential class leads the installed power of photovoltaic generation in Brazil, solar energy has been advancing more and more in relation to energy generation; as a result, the need to include alternative sources of energy in the energy matrix becomes increasingly noticeable. This is because the system remains with generation options and is not based on

just one. The focus is the diversification of the energy matrix through renewable sources, thus reducing the emission of CO₂.

With regard to the application of distributed generation, the importance of this study is clear, especially at a time when the world is turning to the debate on the depletion of energy sources, climate change caused by the emission of polluting gases and other issues related to the sustainability and environmental impact. In this scenario, it is emphasized that the current energy situation in Brazil is on alert, the need for studies that encourage the implementation of alternative energy sources becomes increasingly pressing.

This work aims to show the benefits of inserting distributed generation in homes, since quantitatively, this is the largest class in the country, and to carry out this technical, economic analysis and in terms of reducing net GHG emissions. Awareness and benefits for those opting for these actions should be more publicized to become increasingly effective, as well as the use of equipment and its replacement through the analysis of the impact on demand arising from this action.

The present study simulated three residential scenarios, with different consumptions, within the fixed of greater adequacy of the population under study in the city of Fortaleza. With this, we can verify that all scenarios are viable since it has an attractive payback time, both for the consumer who purchases the system in cash or through financing. The study, therefore, proved to be feasible in the State of Ceará, in the Northeast region of Brazil, but precisely in the city of Fortaleza.

Therefore, photovoltaic solar energy is a viable and profitable option for the residential sector in Fortaleza-CE, which can bring savings in the electricity bill, reduce environmental impacts and value the property.

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7. RESPONSIBILITY NOTICE

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