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The economic factor in the implementation of solar panels in a domestic network in Campina Grande - PB

Anderson Ítalo Freire

Economist, PhD student in Natural Resources at UFCG

Email: anderson.italo@estudante.ufcg.edu.br

Isabel Lausanne Fontgalland

Federal University of Campina Grande, Brazil

Email: isabelfontgalland@gmail.com

Abstract--The aim of this research is to analyze how the implementation of photovoltaic solar panels in a Grid-Tie system affects the economic and financial axes in the domestic grid of the city of Campina Grande. As a starting point, it can be seen that discussions ranging from models of panels and converters to how this new alternative source can affect the production of energy from traditional sources and how self-production can affect the consumer's pocket are growing daily and are constant. It is based on these discussions that we find the justification and relevance of the subject, since new means of producing solar energy are appearing with some frequency in the most diverse aspects. Since this research is an exploratory study, its analytical framework is of a descriptive, quantitative and qualitative nature, it should be noted that in order to carry it out, we sought to answer how the use of photovoltaic solar panels economically impacts residential consumers, based on a sample of residential electricity consumption and in a time frame of 12 moving months, for this, the investigation used technical materials, past research, and the application of forms to obtain data.

Keywords---Economy, Energy, Technology, Renewable resources, Sun.

Introduction

Currently, in the energy scenario in which all countries find themselves, the most diverse forms of electricity production, which are characteristically different from traditional models such as oil and coal, are being widely adopted. With regard to alternative sources, solar energy stands out from the sources that have traditionally predominated in society. In the past, solar energy was used as a heat source for various purposes, such as drying food, heating homes and producing salt from seawater. Solar-powered ovens were also used to bake bread, heat cooked food and dry fabrics. Thus, the use of solar energy has grown substantially in many different ways, so much so that, according to the International Energy Agency, IEA(2021) , solar energy production is expected to reach 200 GW by 2026, surpassing the 161 GW of 2021.

In order of observance of electricity consumption in the world, it can be seen that means of producing electricity from renewable sources are gaining ground in the electricity matrices of various nations, and among renewable sources, photovoltaic solar electricity is becoming increasingly popular around the world, with the technology used to generate electricity from solar radiation becoming more efficient and economical. Solar energy is being used to power homes, businesses, schools and public buildings in many countries, including the USA, China, India, Germany, Japan and Australia. In the USA, solar energy is the fastest growing source of electricity and currently accounts for around 2% of total electricity generation (IEA I. E., 2023) . California leads the way with over 20,000 megawatts of installed solar capacity, while China is the world's largest producer of solar energy with an estimated capacity of 100 gigawatts, India is the second largest producer of solar energy and has an estimated installed capacity of 20 gigawatts, Germany is the world's third largest producer of solar energy with an estimated installed capacity of 38 gigawatts, and Japan has around 7 gigawatts of installed solar capacity, while Australia has around 4 gigawatts (IEA I. E., 2023) .

Solar panels, also known as photovoltaic panels, are devices that convert solar radiation into electrical energy. Within the context of solar energy generation, it can be seen that its applicability extends from industries to homes. The model that currently predominates is the *on-grid* or *grid-tie* model. In this model, it is possible to use the energy produced by the panels themselves and the surplus is sent to the electricity grid, which becomes energy credits that can be used by the same consumer (ANEEL, 2012). With this method, the user can consume this energy to power any household appliances in the home. Logically, the greater the electricity consumption of a given home, the greater the need to use panels or the greater the need for energy compensation from the distribution network. It's important to note that this model disconnects from the power supply in the event of a power failure (Gomes Neto, Massa, & Florian, 2019) , as well as compensating for any energy shortfalls that may occur.

Among the applications of photovoltaic panels in the origin of their generation, which ranges from solar farms to small consumer units and mini solar power plants that keep some streetlights functioning, the generation models for homes have stood out in recent years. According to the Brazilian Solar Energy Association, ABSOLAR(2021) in Brazil, more than 678,000 solar systems are

connected to the electricity grid, providing energy for around 850,000 consumer units across the country. It is important to note that solar energy generation for homes is divided into *on-grid* and *off-grid*, i.e.: *on-grid* refers to solar energy generated by the panels and connected to the domestic grid and also to the distributor's electricity grid, in contrast, *off-grid* energy refers to solar energy generated by the panels, stored in batteries and used in environments isolated from the electricity grid (GreenVolt, 2021) .

The use of solar panels in domestic networks, with the aim of producing their own solar energy, is currently on the rise, and several analyses have already been carried out on this subject, with the aim of producing data on the potential economic and energy aspects of solar panels (Silva, Assunção, Rocha Sobrinho, Freitas, & Assunção, 2019) . Solar panels are devices that convert sunlight into electricity. They are made up of many photovoltaic cells, which are usually made of silicon (Sanhueza & Freitas, 2018) . When sunlight hits the cell, the photovoltaic cells absorb the light and create an electric current, which can be used to power electrical devices. Solar panels are becoming increasingly popular as an alternative energy source, as they provide clean, renewable energy and can be used to reduce electricity costs.

Solar panels are most commonly used in residential and commercial settings, as they are an efficient way to generate electricity; they are also often used in remote locations, such as on boats, trailers and in off-grid systems (Yadav, Davies, & Sardokie, 2019) . Solar panels can be used to power a variety of devices, including lights, appliances and even air conditioners. Solar panels are generally easy to install and require little maintenance, however, they do require regular cleaning as dirt and debris can reduce the efficiency of the panels (Silva, Assunção, Rocha Sobrinho, Freitas, & Assunção, 2019) . In addition, solar panels need direct sunlight to function, so they are most effective in sunny locations, such as the southwestern United States (Tabassum, et al., 2021)

Methodology

This research is characterized as an exploratory study, as it seeks to investigate a subject whose object is little known or unknown to the general public. As stated by Temporini and Piovesan (1995, p. 321) , "in other words, exploratory research, or an exploratory study, aims to get to know the study variable as it is presented, its meaning and the context in which it is inserted." Forms with pre-established questions will therefore be applied in the city's five zones. This choice is justified by the fact that forms are one of the most practical and efficient data collection techniques when compared to interviews, as they can be applied to different segments of the population and make it possible to obtain data that is easy to tabulate and quantify (GIL, 2002) .

From an analytical point of view, this research is quanti-qualitative in nature due to data collection, since the series of data collected from a residential sample will be the induction parameter for the research, i.e. this data will be used to guide the applicability of photovoltaic panels in homes. As far as research methods are concerned, this research is bibliographical in nature and, as a guiding aspect, this research will carry out a survey, which is a type of data collection tool used to

gather information on a particular aspect to be investigated. Surveys are composed of a set of questions that can be answered by participants, often using a multiple choice or rating scale format, they are generally used to study demographic data, behaviors and other characteristics of a population (GIL, 2002)

In this study, a sample of 617 households from all regions of the city was collected through an electronic form whose questions were: Average consumption over the last 12 months and the neighborhood where you live. There was no identification of the respondents, random numbers were used only to identify the form, not the individual who answered it; the data was tabulated systematically, i.e. the data collected was separated according to their common characteristic, being separated by consumption bands and corresponding classes, these bands being in groups of 25kWh counting from the smallest band (up to 63kWh) to the band beyond 313 kWh.

Results and Discussions

Initially, the first factor to consider is electricity production depending on the months of the year and the number of photovoltaic solar panels used, and based on this principle, comparative savings figures will be presented based on the number of solar panels used in the twelve months of the year. HDS is therefore adopted as *daily hours of sunshine*, and Δ HDS as the *variation in daily hours of sunshine* in relation to January and December, the months with the highest average hours of sunshine per day. This variation affects the capacity of the plates to generate electricity month by month, which directly contributes to the total amount that can be produced in a year.

Table 1 - Variation in photovoltaic generation according to month and number of panels

Month	HSD	Δ HSD	W	kWh/m ²	Panels - kWh generation			
					1	2	3	4
Jan	12,5	100,0%	550	5,25	69,3	138,6	207,9	277,2
Feb	12,3	98,4%			68,2	136,4	204,6	272,8
Sea	12,1	96,8%			67,1	134,2	201,2	268,3
Apr	11,9	95,2%			66,0	131,9	197,9	263,9
May	11,8	94,4%			65,4	130,8	196,3	261,7
Jun	11,7	93,6%			64,9	129,7	194,6	259,5
Jul	11,7	93,6%			64,9	129,7	194,6	259,5
Aug	11,9	95,2%			66,0	131,9	197,9	263,9
Set	12,1	96,8%			67,1	134,2	201,2	268,3
Out	12,3	98,4%			68,2	136,4	204,6	272,8
Nov	12,4	99,2%			68,7	137,5	206,2	275,0
Ten	12,5	100,0%			69,3	138,6	207,9	277,2
Total					804,99	1.609,98	2.414,97	3.219,96

Source: Own elaboration based on (ABSOLAR, 2023) (CRESESB, 2021)) (GSA, 2023

Based on the projected figures in Table 1, the annual generation data can then be compared with the annual consumption of households, highlighting the evolution depending on the number of photovoltaic solar panels installed. In this respect, the first point to note when comparing *production versus consumption* is the simultaneity factor, which corresponds to all the electricity that is generated and consumed without the need for it to be injected into the distribution network. If a household is producing 270 watt-hours and consuming 200 watt-hours, the simultaneity factor is 74%, i.e. 74% of the electricity produced is being consumed and does not need to be supplemented by the external grid, while 26% of the electricity produced is being injected into the external grid, generating credits. This aspect will be analyzed economically later, but the idea of bringing it up now is timely.

Once we have looked at electricity generation according to the months of the year and the number of photovoltaic solar panels, we can see a comparison of electricity consumption and production based on the average total production. It should be noted that positive values in the table represent a surplus of electricity injected into the external grid, while negative values indicate a deficit of electricity and the need to supplement it through the external grid.

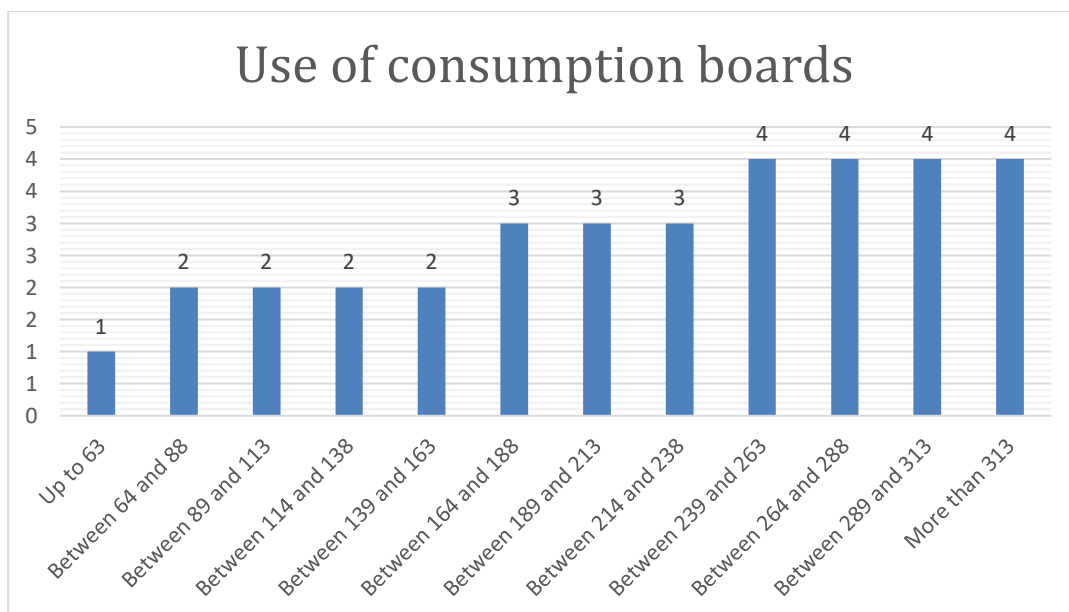
Table 2 - Electricity consumption *versus* production by number of solar panels

Ranges - kWh	Consumption	Production - kWh (deficit/surplus)			
	Average	1	2	3	4
Up to 63	54,5	12,6	79,6	146,7	213,8
Between 64 and 88	76,8	-9,7	57,4	124,5	191,6
Between 89 and 113	102,6	-35,5	31,6	98,7	165,8
Between 114 and 138	127,8	-60,7	6,4	73,5	140,6
Between 139 and 163	152,1	-85,0	-17,9	49,1	116,2
Between 164 and 188	175,1	-108,0	-40,9	26,2	93,3
Between 189 and 213	199,0	-131,9	-64,8	2,3	69,4
Between 214 and 238	224,4	-157,3	-90,3	-23,2	43,9
Between 239 and 263	253,2	-186,1	-119,1	-52,0	15,1
Between 264 and 288	280,1	-213,0	-145,9	-78,8	-11,7
Between 289 and 313	296,8	-229,7	-162,6	-95,6	-28,5
More than 313	349,6	-282,5	-215,5	-148,4	-81,3

Source: Own elaboration, 12/2023

As can be seen in Table 2, the use of just one solar photovoltaic module can only meet the needs of homes that consume up to 63 kWh, whose average measured was around 54.5 kWh, resulting in a monthly injection of just over 12 kWh into the external grid, figures that do not take into account the simultaneity factor, while the other ranges would be operating at a deficit and requiring electricity injection from the external grid. When the comparison is made with the installation of two photovoltaic modules, the ranges up to 138 kWh would also produce a surplus of electricity, with the other ranges at a lower level of electricity deficit, but still requiring electricity from the external grid

The projections remain for the adoption of three and four panels, the latter being the one that would generate the most surplus electricity for the external network, and only the bands with consumption of more than 264 kWh would need to be supplemented by the external network. Based on this perspective, some adjustments will be made so that the projections are as close to reality as possible. The first point is to understand that the simultaneity factor essentially needs to be close to 100%, since the greater the injection of electricity into the external network, the greater the charge for the Tariff for the use of the distribution system - TUSD Fio b - will be on this amount, so the way in which the use of the boards would eventually be arranged is as follows:



Graph 1 - Projected use of license plates by consumption range
Source: Own elaboration, 12/2023.

This distribution aims to reconcile the average consumption by band with the production of enough electricity to meet the needs of the homes and avoid the highest level of injection of electricity into the external network, or that, if there is any, it is as small as possible. Another possibility within the panel arrangement is for homes to synchronize the use of household appliances so that the simultaneity rate is as close to 100% as possible, or to have batteries so that

electricity can be accumulated for later use at a time when the photovoltaic panels are not generating electricity.

Below is a projection based on a household in the city of Campina Grande using solar panels, distributed according to the size of the subsets of the consumption bands. In this projection, two consumption bands are considered to be used: FP - the productive band, which runs from 8:00 am to 5:30 pm and FD - the deficit band, which runs from 5:31 pm to 7:59 am, hypothetically considering around 60% of electricity consumption in the FD band and 40% in the FP band.

Table 3 - Consumption and generation projections considering simultaneity

Consumption - Generation kWh				
kWh bands	FD	FP	Generation	Export
Up to 63	398,0	265,4	816,2	550,8
Between 64 and 88	560,3	373,5	1.632,3	1.258,8
Between 89 and 113	748,8	499,2	1.632,3	1.133,1
Between 114 and 138	932,7	621,8	1.632,3	1.010,5
Between 139 and 163	1.110,4	740,2	2.448,5	1.708,3
Between 164 and 188	1.278,0	852,0	2.448,5	1.596,5
Between 189 and 213	1.452,4	968,2	2.448,5	1.480,3
Between 214 and 238	1.638,3	1.092,2	3.264,7	2.172,5
Between 239 and 263	1.848,5	1.232,3	3.264,7	2.032,4
Between 264 and 288	2.044,5	1.363,0	3.264,7	1.901,7
Between 289 and 313	2.166,6	1.444,4	3.264,7	1.820,3
More than 313	2.552,3	1.701,5	3.264,7	1.563,2

Source: Own elaboration, 12/2023

Notably, there is a surplus of electricity in all the projections adopted, from the projection with one photovoltaic panel for the first range to the last consumption range with the adoption of four photovoltaic panels. This is because the simultaneity factor in consumption is relatively low, which favors the export of electricity even at times when production is at its lowest. According to the information in the table, the electricity deficit range has the highest electricity consumption because it is in this range that the appliances that consume the most electricity are activated, from electric showers to fans and air-conditioners, as well as appliances that generate heat such as irons, microwaves and other smaller appliances, as well as appliances that are on stand-by during the night and light bulbs to illuminate the room.

On the other hand, the productive range has lower consumption, since it is considered to be the time when residents are generally not at home, and only the consumption of household appliances that are naturally in constant use, such as the refrigerator, whose cooling cycle always occurs when there is an increase in the internal temperature of the appliance. In addition to this, the use of TVs in standby mode and other smaller appliances can also be observed

The next scenario relates to what would be paid in electricity each month with the use of the panels and without the use of solar photovoltaic panels, highlighting

what is paid with the availability charge - a tariff paid even if there is no electricity consumption, just because the electricity is available for consumption at any time - and with the tariff TUSD Fio B, a tariff paid for using the electricity system to inject electricity into the electricity system outside the consumer unit.

Table 4 - Electricity bill with the use of photovoltaic panels

	30%	45%	60%	75%	90%
Ranges - kWh	2024	2025	2026	2027	2028
Up to 63	R\$ 3,43	R\$ 5,15	R\$ 6,86	R\$ 8,58	R\$ 10,29
Between 64 and 88	R\$ 7,84	R\$ 11,76	R\$ 15,68	R\$ 19,60	R\$ 23,52
Between 89 and 113	R\$ 7,06	R\$ 10,59	R\$ 14,11	R\$ 17,64	R\$ 21,17
Between 114 and 138	R\$ 6,29	R\$ 9,44	R\$ 12,59	R\$ 15,73	R\$ 18,88
Between 139 and 163	R\$ 10,64	R\$ 15,96	R\$ 21,28	R\$ 26,60	R\$ 31,92
Between 164 and 188	R\$ 9,94	R\$ 14,91	R\$ 19,89	R\$ 24,86	R\$ 29,83
Between 189 and 213	R\$ 9,22	R\$ 13,83	R\$ 18,44	R\$ 23,05	R\$ 27,66
Between 214 and 238	R\$ 13,53	R\$ 20,29	R\$ 27,06	R\$ 33,82	R\$ 40,59
Between 239 and 263	R\$ 12,66	R\$ 18,99	R\$ 25,31	R\$ 31,64	R\$ 37,97
Between 264 and 288	R\$ 11,84	R\$ 17,76	R\$ 23,69	R\$ 29,61	R\$ 35,53
Between 289 and 313	R\$ 11,34	R\$ 17,00	R\$ 22,67	R\$ 28,34	R\$ 34,01
More than 313	R\$ 9,74	R\$ 14,60	R\$ 19,47	R\$ 24,34	R\$ 29,21

Source: Own elaboration, 12/2023.

In the illustration in Table 4, the values observed refer only to the fact that the surplus electricity generated has been injected into the external network. This does not reflect the final value of the electricity bill, as the household's consumption must still be taken into account by offsetting what was consumed against the amount produced by the solar panels. It should be noted that there is no fixed value in each consumption band, and some values are reduced even in bands with higher electricity consumption than the immediately preceding band, such as the 164-188 and 189-213 bands, which have lower TUSD Fio B values than the immediately preceding band. Another point that needs to be made is about the percentage of TUSD Fio B that is paid year after year, since after law 14.300, there will be a gradual charge of 15% in 2023, doubling in percentage (30%, 45%, 60%...) until 2028, and from 2029 onwards, new rules will be defined by ANEEL.

It is important to note that the amounts are substantially low, because what is charged for this injection into the external electricity grid corresponds to a very small portion of the TUSD. Even if this charge does exist, it does not make the option of using photovoltaic solar panels unfeasible, since it does not correspond to 100% of what consumers will pay in the end. The next scenario we look at is the effective surplus between what would be produced and consumed if 10% of the city's consumer units opted to use solar photovoltaic panels, with the percentage distributed according to the proportional number of homes by consumption band.

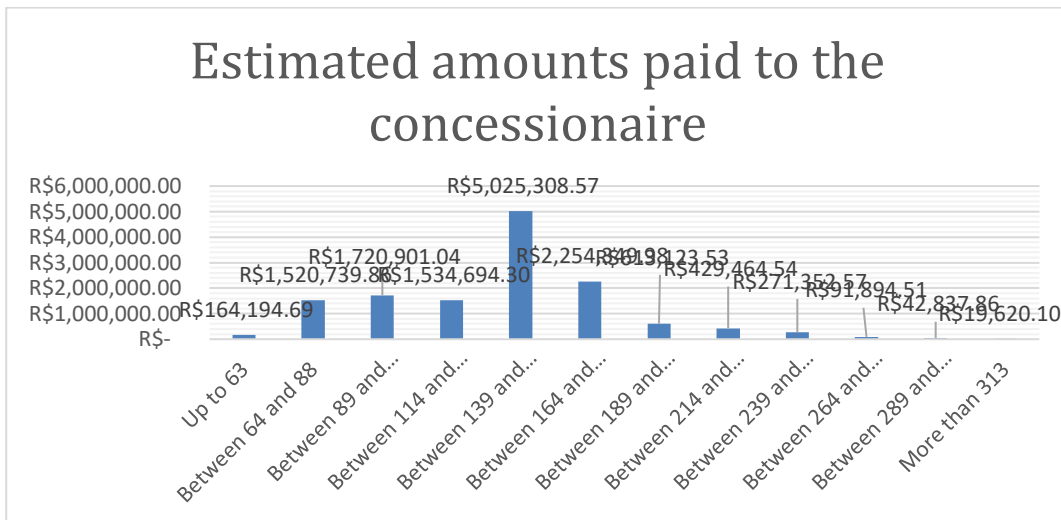
Table 5 - Effective annual surplus in the event of 10% of HUs having solar panels

Surplus - MWh						
Consumption ranges kWh	UC	2024	2025	2026	2027	2028
Up to 63	452	249,2	236,7	224,9	213,6	203,0
Between 64 and 88	1.833	2.307,9	2.192,5	2.082,9	1.978,7	1.879,8
Between 89 and 113	2.305	2.611,7	2.481,1	2.357,0	2.239,2	2.127,2
Between 114 and 138	2.305	2.329,1	2.212,6	2.102,0	1.996,9	1.897,1
Between 139 and 163	4.464	7.626,5	7.245,2	6.882,9	6.538,8	6.211,8
Between 164 and 188	2.143	3.421,2	3.250,2	3.087,7	2.933,3	2.786,6
Between 189 and 213	629	930,5	884,0	839,8	797,8	757,9
Between 214 and 238	300	651,8	619,2	588,2	558,8	530,9
Between 239 and 263	203	411,8	391,2	371,7	353,1	335,4
Between 264 and 288	73	139,5	132,5	125,9	119,6	113,6
Between 289 and 313	36	65,0	61,8	58,7	55,7	53,0
More than 313	19	29,8	28,3	26,9	25,5	24,3
Total	14.762	20.774	19.735	18.748	17.811	16.920

Source: Own elaboration, 12/2023

For the projection of the years following 2024, the consumption of consumer units was projected to vary by +5% in relation to the immediately preceding year, circumstances which assume the replacement of household appliances for more intensive use, the purchase of other household appliances which did not previously exist in the home, extensions to homes which ultimately result in higher electricity consumption and other smaller but also important factors, such as the occurrence of climatic events which require the use of cold or heat generating equipment, whose electricity consumption is higher than that of other household appliances. If at least 10% of homes in the city of Campina Grande were to adopt solar panels, ignoring the fact that other homes already have them, the injection of surplus electricity into the external grid could reach almost 94,000 MWh over the five years projected, representing approximately 7% of the city's projected consumption over the same five-year period.

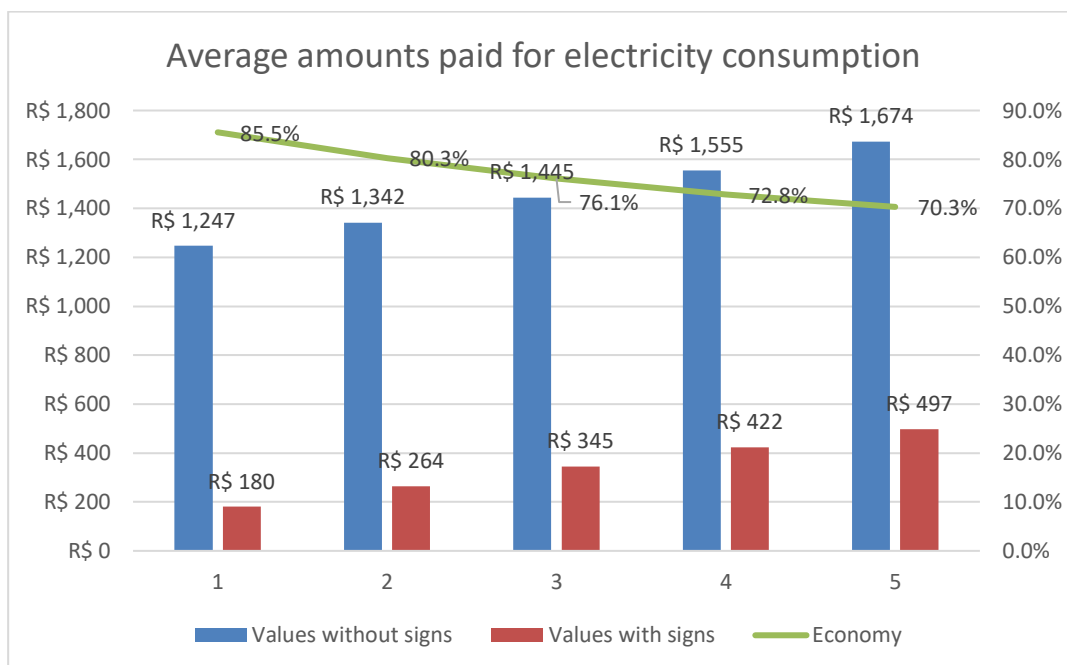
In the same timeframe, the amounts paid by consumer units to the electricity concessionaire also reach significant amounts, although there is a decrease in the surplus injected into the electricity grid, the amounts paid would always be higher than the year immediately before due to current legislation, the last year of which transition is scheduled for 2029. Below is a projection of what would eventually be paid over the projected five years, highlighting the classification made according to consumption bands.



Graph 2 - Estimated amounts paid to the electricity company
 Source: Own elaboration, 12/2023.

As you can see, the figures above represent the amount paid only in TUSD Fio B values, the portion paid only on electricity exports. Of the consumption bands, the one that would pay the most on use of the network is the 139-163 kWh band, which also has the largest number of homes, both based on the sample and the 10% projection. In the overall context, approximately 13.6 million reais would be paid on the surplus electricity generated over the five-year period. These figures represent very little of what would actually be paid by the consumer units if they did not use photovoltaic solar panels; this scenario is simulated below, where there is a comparison between what would be paid with solar panels and without solar panels.

The generalization made takes into account only the portion of households that choose to use solar panels, as opposed to the same portion that uses only electricity from the external grid. In the comparison, the observation period is the same - five years from 2024 - the hypothesis takes into account an average increase in consumption of 1.75%, an average increase in electricity production of around 3% year on year, and a variation in self-consumption of around 5% in the same model as the previous sectors; finally, the variation in the tariff charged on the TUSD Fio B portion is applied in accordance with ANEEL standards, assuming that there would be an annual 4.5% adjustment in the electricity tariff, and that all the consumer units in this hypothesis do not have an acquired right - boards installed before law 14.300 - and considering that all the homes in this hypothesis do not have an acquired right - boards installed before law 14.300 - and considering that all the homes in this hypothesis do not have an acquired right - boards installed before law 14.300 - and considering that all the homes in this hypothesis do not have an acquired right.300 - and considering that all households opt to install the panels in 2024.



Graph 3 - Economic comparison with 10% of HUs with solar panels.
Source: Own elaboration, 12/2023.

In Graph 3, the model adopted and simulated used 14. The values reflect what would be paid on the electricity bill with the assumption that taxes and fees are close to 23.65% - 20% ICMS, 3% COFINS and 0.65% PIS, in average values - noting that these values are variable over consumption and that in order to arrive at an exact value, they should be measured one by one to arrive at values close to accuracy. The hypothetical example considers that the tariff with plates is made up of the charge on the TUSD Fio B + compensation fee, which corresponds to the difference between what would be charged by the company for supplying energy in the period of deficit and the amounts that would be compensated for what was injected into the external network.

Table 6 - Overall aspects of the use of solar panels in 10% of the CUs.

	2024	2025	2026	2027	2028
Consumption MWh	24.723	25.465	26.229	27.016	27.826
MWh generation	20.774	20.982	21.191	21.403	21.617
Self-consumption MWh	9.889	10.384	10.903	11.448	12.020
Export MWh	20.774	19.735	18.748	17.811	16.920
Registered consumption MWh	14.834	15.081	15.326	15.568	15.806
Normal tariff consumption	R\$ 8.932.830	R\$ 9.490.388	R\$ 10.078.410	R\$ 10.698.048	R\$ 11.350.421
Discounted fare	R\$ 7.824.234	R\$ 7.799.778	R\$ 7.787.681	R\$ 7.789.474	R\$ 7.806.758

	2024	2025	2026	2027	2028
FioB installment	R\$ 1.552.518	R\$ 2.212.338	R\$ 2.802.295	R\$ 3.327.725	R\$ 3.793.606
Annual values without license plates	R\$ 1.247	R\$ 1.342	R\$ 1.445	R\$ 1.555	R\$ 1.674
Annual license plate values	R\$ 180	R\$ 264	R\$ 345	R\$ 422	R\$ 497
Economy	85,5%	80,3%	76,1%	72,8%	70,3%

Source: Own elaboration, 12/2023.

The above projection shows a positive result for the use of photovoltaic solar panels in the domestic network, although the comparative values tend to reduce over time, as it is not possible to assess each case and make a single projection that includes all households. Table 6 gives an overview of how some basic aspects would evolve, such as consumption, production, injection of electricity into the external network, tariffs paid and deducted, and the TUSD Fio B charged for injecting electricity into the external network.

As can be seen in table 6 above, the variations in the projection presented over the five years analyzed are small, but represent substantial savings on consumers' electricity bills. It can be seen that the higher the ratio between the energy exported and the consumption recorded on the meter, the greater the savings for consumers; on the other hand, if there is a great need to inject electricity into consumer units, the higher the bill to be paid at the end of the monthly consumption period measured by the utility company. It is therefore important to note that by generating their own electricity, residents of consumer units can significantly reduce or even eliminate their energy bills, depending on the size of the system and the energy consumption practiced from month to month, and allows for greater electrical independence for households, as can be seen in the year-on-year evolution in the hypothesis above.

Conclusion

When looking at the production and consumption data on a range-by-range basis, it can be seen that there are advantages and disadvantages for certain ranges. Essentially, the adoption of solar panels for homes that consume up to 63 kWh per month can be potentially beneficial, since with just one solar panel you can get enough electricity for all your daily domestic demands, even if you need to inject electricity from the external grid, at the end of the month of consumption there will be a small credit that will reduce consumption. In the other ranges, specifically in the 100-168 kWh per month range, the adoption of solar panels shows good results, although adjustments to electricity consumption during the day are necessary, as synchronization of simultaneity is essential to reduce the injection of electricity into the grid and reduce electricity consumption at times of deficit, i.e. having the lowest electricity consumption at night. To do this, some activities must be carried out during the day, such as washing and ironing clothes, storing food at room temperature in the fridge or using any other appliances that need to generate heat or require more electricity to operate.

In general terms for consumer units, Campina Grande's consumption is very close, with most of it concentrated in the 100 kWh to 189 kWh monthly range. When looking at the city's data as a group, the average monthly consumption is very close to the average consumption in the Northeast according to ANEEL, and this corroborates the fact that the profile of these homes shows few or almost no differences in the composition of household appliances. These factors lead to the inference that the research followed the correct path and that the data does in fact represent reality, reducing the risk of bias in the data and in the conclusions about the results found. It is therefore considered that the adoption of photovoltaic solar panels in homes in Campina Grande is economically viable, as well as helping to reduce electricity consumption from other sources that could possibly be polluting.

In general terms for the utility company, the use of solar panels could mean an alternative to buying electricity from other sources further away from the consumer units, saving money in some sectors and especially in terms of paying tariffs for the use of transmission networks. In addition to this, this implementation could mean a reduction in problems with power cuts at certain times, helping to change the electrical aspect of the city and making it fit the "smart cities" model in terms of electricity. On the other hand, the adoption of a photovoltaic system in the city's homes would jeopardize several of the electricity utility's economic mechanisms, since the company would not be specifically aware of the need to contract electricity to balance the city's electricity system, and would therefore have problems with voltage differences in the electricity grid, the risk of large volumes of electricity being injected into the external grid and possibly the risk of power cuts due to preventive disconnection of the system.

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