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PUBLIC POLICIES AND SOLAR PLANTS: SOCIOECONOMIC INDICATORS AND POPULATION PERCEPTION IN MUNICIPALITIES OF MINAS GERAIS

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ABSTRACT

With the intensification of climate change, solar energy stands out as one of the fastest growing alternative energy sources in the world. In this article, the evolution of socioeconomic indicators related to the implementation of solar plants in 22 municipalities in Minas Gerais up to 2019 was researched. In addition, a field study was carried out in the city of Pirapora where, until the date of development of the research, the largest solar plant in Latin America was installed. In this municipality, qualitative interviews were conducted with relevant political and social actors, such as state deputy, federal deputy, councilor, local leaders, businessmen and civil society. We tried to show, through the analysis of the evolution of the indicators and field research, the limited potential for socioeconomic development provided by the mills in the municipalities where they were installed. Although there have been significant gains in the labor market of these municipalities in the short term, these were limited to the time of the installation of these plants, contrary to the idea that initiatives such as these have potential for local development. The research is believed to contribute to further studies on the development of local public policies, especially focused on the current challenges of climate change and local politics.

Keywords: Public policies, Local politics, Socioeconomic development, Local development, Climate change, Solar plants.

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Revista ARACÊ
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INTRODUCTION

Several countries have considerably reduced the use of fossil fuels as the main source of energy production. The search for new renewable sources has been gaining more importance with the intensification of the debate about climate change. These, in turn, have proven to be a source of great apprehension for governments, with non-trivial challenges that are imposed on the public agenda of countries. In the face of the problems that arise with the accelerated climate crisis, there has also been an increasing space on new forms of energy, including solar energy.

The production of energy through renewable sources is seen as one of the main current challenges, due to the continuous growth in global demand for electricity and the growing awareness of the relevance of promoting sustainable development on a global scale, aiming to reconcile social advancement with the protection of the environment.

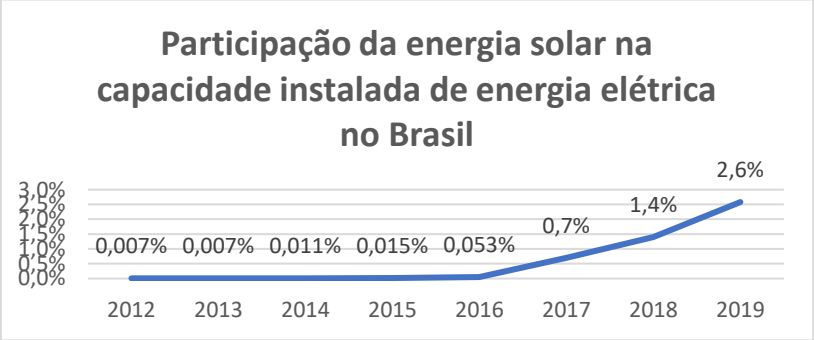
The benefits of alternative energy sources in relation to fossil fuels involve their renewable nature, the lower impact on greenhouse gas emissions, the contribution to the diversification and decentralization of countries' energy matrices, the increase in tax collection, their complementary role to existing energy systems, the opportunity to take advantage of land with low population density, in addition to the creation of jobs and income (Zolini and Franco, 2019; Tiba, Reis and Alves, 2014). In this scenario, the potential of photovoltaic solar energy stands out.

Since the early 2000s, the photovoltaic industry has been increasingly consolidated in the international market, mainly due to increases in demand for panels, production scale and technological advances, which have enabled a significant reduction in production costs. As Esposito and Fuchs (2013) point out, technological advances in the area began mainly in Germany, the United States of America and Japan, followed to a lesser extent by Italy, Spain and Norway. In Brazil, the share of this source in the installed capacity of national electricity is still small, but it is growing at a fast pace, from 0.01% in 2014 to 2.68% in January 2020. BloombergNEF (2019) even projects that solar energy will surpass hydro in 30 years, reflecting the high solar irradiation in the country. Even the areas with less insolation in Brazil have a higher potential for use than in any part of Germany.

Brazil also follows these transformations, both for the reasons mentioned above, and also because it is recognized as one of the countries whose solar irradiation indexes surpass the vast majority of other countries in the world. However, beyond the issues of the type of public policy itself, we believe that both the formulation and implementation of these

Revista ARACÊ
ISSN: 2358-2472

policies in societies like ours ends up being carried out in the midst of institutional mechanisms on which the interests of actors, executive, legislative and civil institutions are mediated. With regard to the local decision-making process, we believe the research contributes to the field of study draws attention to the development of policies in Brazil and its implications in democratic environments, in which there are mediations of different interests at work. The importance of political control over bureaucracy and the consequence on public policies is an interesting finding and corroborates studies on the subject.



Source: MME / Monthly Monitoring Bulletin of the Brazilian Electric System.

There are numerous justifications for the implementation of a photovoltaic plant project and we will explore from here different conditions for its feasibility and the incentives used.

The research aims to analyze possible socioeconomic impacts in Brazilian municipalities that had the installation of solar plants in Brazilian regions until the period of 2019. We understand that the work contributes not only by bringing analytical, theoretical and empirical elements about the construction of public energy policies and their relationship with decision-making processes that are established by relevant actors in the process, whether at the municipal, state or federal levels. Additionally, it is attempted to investigate under which institutional conditions the cooperation between different agents involved takes place, allowing to show the impacts of the implementation of this public policy in the benefited regions.

Finally, the work is divided into five sections, including this introduction. The second section exposes the methods applied. The third section demonstrates the analyses developed on the socioeconomic impact in municipalities of centralized generation. In the fourth section, the analyses made from the case study in Pirapora, Minas Gerais, are shown. Finally, the fifth section concludes the findings.

Revista ARACÊ
ISSN: 2358-2472

METHODS APPLIED

To develop this research, a combination of different methodologies was used, known as triangulation, which aims to cover the maximum breadth in the description, explanation and understanding of the object of study. For the quantitative analysis, the IBGE/Population Estimates, Atlas of Municipal Human Development databases were used. For the qualitative research, a field research was carried out in Belo Horizonte and Pirapora, both cities in the state of Minas Gerais.

The use of triangulation between quantitative and qualitative methods, such as in-depth interviews with political agents, technical specialists, businessmen, civil society and other stakeholders in the installation of the plants were important to understand the issues involved in this public policy. For this, quantitative and qualitative studies were carried out and the work covered three main activities: i) survey and analysis of the literature on the subject; ii) conducting interviews with key actors of the institutions involved; and iii) case analysis of the Pirapora Power Plant work. The interviews, conducted in June 2019, updated the understanding of the perception and vision of key actors about the role of their institutions and the other institutions involved in the realization of the work as such.

The interviews took place in order to answer research questions and were elaborated in a semi-structured format. This material sought to understand, from the oral report of the strategic actors, their perception of the impacts of the implementation of the plant in the city. In general, the investigation was oriented, therefore, to complement the analysis of the public data used in the research in order to understand, in the view of each one, whether the solar plant project implemented was able to promote socioeconomic development and in what way. Briefly, the research contemplated the following issues: increase in employment; increased income; improvement in local infrastructure; communication between those involved: civil society, public sector, private sector, etc.

SOCIOECONOMIC IMPACT IN MUNICIPALITIES OF CENTRALIZED GENERATION

There are numerous justifications for the implementation of public policies. When it comes to large-scale centralized generation, photovoltaic solar plants can generate a series of impacts in the places where they are installed, from the economic, social, and even environmental spheres. According to Hernandez et al. (2014), the effects of these plants vary throughout their useful life, covering the planning, installation, operation, and decommissioning phases. With regard to large-scale centralized generation, photovoltaic

Revista ARACÊ
ISSN: 2358-2472

solar plants can cause a series of impacts in the places where they are implemented, and these impacts are economic, social and environmental. As stated by Zolini and Franco (2019), Hernandez et al. (2014), the effects of photovoltaic plants vary throughout their useful life, covering the stages of planning, installation, operation, and decommissioning.

The objective of this section is to show the results of the analyses of the socioeconomic impact of Brazilian municipalities that had the implementation of photovoltaic plants in the light of the analysis of available public indicators and whether these are sufficient justifications for the development of solar plants in Brazilian regions. We selected 22 Brazilian municipalities where photovoltaic plants for centralized generation were installed and whose power would be among the largest in the country, according to *the* 2019 ranking of ABSOLAR (Brazilian Association of Photovoltaic Solar Energy). After the selection, the socioeconomic indicators (population, education, infrastructure, economy, income and poverty condition) of each location were observed in order to identify the profile of each one and correlate information between them. The data comprises the period from the first activities related to the sector, in the holding of auctions, as well as the period following the operation of solar plants.

The analysis includes a historical series for each of the indicators, from the moment the electricity auctions were held, until the implementation of the first plants, which took place between 2014 and 2019[2]. It should be noted that some indicators are not available for all municipalities in the most up-to-date national databases at the time of the survey, such as, for example, access to water and sewage treatment, for example. In these cases, it was decided to present the information from the Censuses carried out in the country, in order to try to visualize the most recent condition available for each location. Unfortunately, these do not allow us to measure possible socioeconomic impacts of the installation of these plants, because the last Census took place in 2010, that is, before the 1st auction for this type of source.

The municipalities selected for the analyses are Pirapora – MG, Tabocas do Brejo Velho – BA, Bom Jesus da Lapa – BA, Guaimbê – SP, Ribeira do Piauí – PI, Quixeré – CE, Paracatu – MG, Juazeiro – BA, Areia Branca – RN, Dracena – SP, Aquiraz – CE, Ouroeste – SP, Guimarânia – MG, Malta – PB, Coremas – PB, Itaguaçu da Bahia – BA, Açu – RN, João Costa – PI, São João do Piauí – PI, Agrestina – PE, Guanambi – BA and Miracema

[2] See timeline at the end of the text.

Revista ARACÊ
ISSN: 2358-2472

do Tocantins – TO. Their order seems according to what has the highest installed power in MW to the one with the lowest.

We chose to analyze all municipalities at first and then show the results of Pirapora separately. It is in this same municipality where the field study was carried out because it has the largest centralized plant in South America, in addition to having the largest installed power in MW so far. In this sense, we believe that the impact of the installation of the plant on the indicators would tend to be more evident to observe, which in turn would be a justification for the implementation of solar energy policies in certain regions of Brazil. The information below accounts for all the others, except for Pirapora, which is presented soon after.

EVOLUTION OF INDICATORS AFTER THE INSTALLATION OF PHOTOVOLTAIC PLANTS IN MUNICIPALITIES OF MINAS GERAIS

Population

The plants considered for this analysis are located in cities with a number of inhabitants ranging from approximately 3 thousand to 216 thousand inhabitants. In general, the average population of these municipalities is currently just under 41 thousand inhabitants.

Population growth in the period 1991-2019 occurred in almost all municipalities, with the exception of Ribeira do Piauí-PI, Malta-PB and Miracema do Tocantins -TO, whose number of inhabitants decreased by 21%, 4% and 1% respectively between the selected years. Still over the same period, it can be highlighted the increase of 111% in the population of Ouroeste-SP, 73% in Aquiraz-CE and 68% in Juazeiro-BA. In absolute numbers, Juazeiro-BA had an increase of about 88 thousand inhabitants, followed by Aquiraz-CE, whose population increase was almost 34 thousand people and Paracatu-MG with just over 30 thousand new inhabitants.

Analyzing a more recent time interval, with an initial period in the year of ANEEL's first solar energy auction (2014), it is possible to note that possibly the most impacted municipalities in terms of population growth were Ouroeste-SP (10%), Aquiraz-CE (4%) and Guimarânia-MG (3.5%). This information can be seen in Table 1.

Revista ARACÊ
ISSN: 2358-2472

Table 1 - Evolution of the population by municipality

Municipality	2014	2015	2016	2017	2018	2019
Pirapora - MG	55.972	56.229	56.474	56.706	56.208	56.428
Tabocas do Brejo Velho - BA	13.008	13.025	13.043	13.057	12.517	12.518
Bom Jesus da Lapa - BA	68.922	69.526	70.090	70.618	68.609	69.148
Guaimbê - SP	5.676	5.696	5.717	5.737	5.743	5.765
Ribeira do Piauí - PI	4.368	4.381	4.393	4.403	4.464	4.477
Quixeré - CE	21.410	21.572	21.728	21.876	22.008	22.149
Paracatu - MG	90.294	91.027	91.724	92.386	92.430	93.158
Juazeiro - BA	216.588	218.324	220.253	221.773	215.183	216.707
Areia Branca - RN	27.115	27.356	27.176	27.401	27.162	27.774
Dracena - SP	45.600	45.847	46.088	46.324	46.536	46.793
Aquiraz - CE	76.967	77.717	78.438	79.128	79.563	80.271
Ouroeste - SP	9.392	9.564	9.733	9.897	10.177	10.361
Guimarânia - MG	7.764	7.831	7.895	7.956	7.971	8.039
Malta - PB	5.675	5.672	5.668	5.665	5.766	5.759
Coremas - PB	15.400	15.409	15.418	15.426	15.423	15.445
Itaguaçu da Bahia - BA	14.533	14.667	14.604	14.718	14.311	14.429
Açu - RN	56.829	57.292	57.743	58.183	57.644	58.017
João Costa - PI	2.968	2.965	2.963	2.961	3.010	3.008
São João do Piauí - PI	20.077	20.146	20.206	20.258	20.537	20.601
Agrestina - PE	24.052	24.256	24.454	24.644	24.702	24.885
Guanambi - BA	85.237	85.797	86.320	86.808	84.014	84.481
Miracema do Tocantins - TO	19.934	19.634	19.340	19.055	18.566	18.248

Source: Prepared by the authors based on IBGE data.

The data from the survey carried out for this study also show that, over the years, the share of urban pollution has increased in relation to the rural population in practically all locations. For the municipalities for which 2017 data were available, only Tabocas do Brejo Velho-BA showed a reduction in percentage terms of the urban population in relation to 1991, with the others showing growth and Pirapora-MG showing practically zero variation.

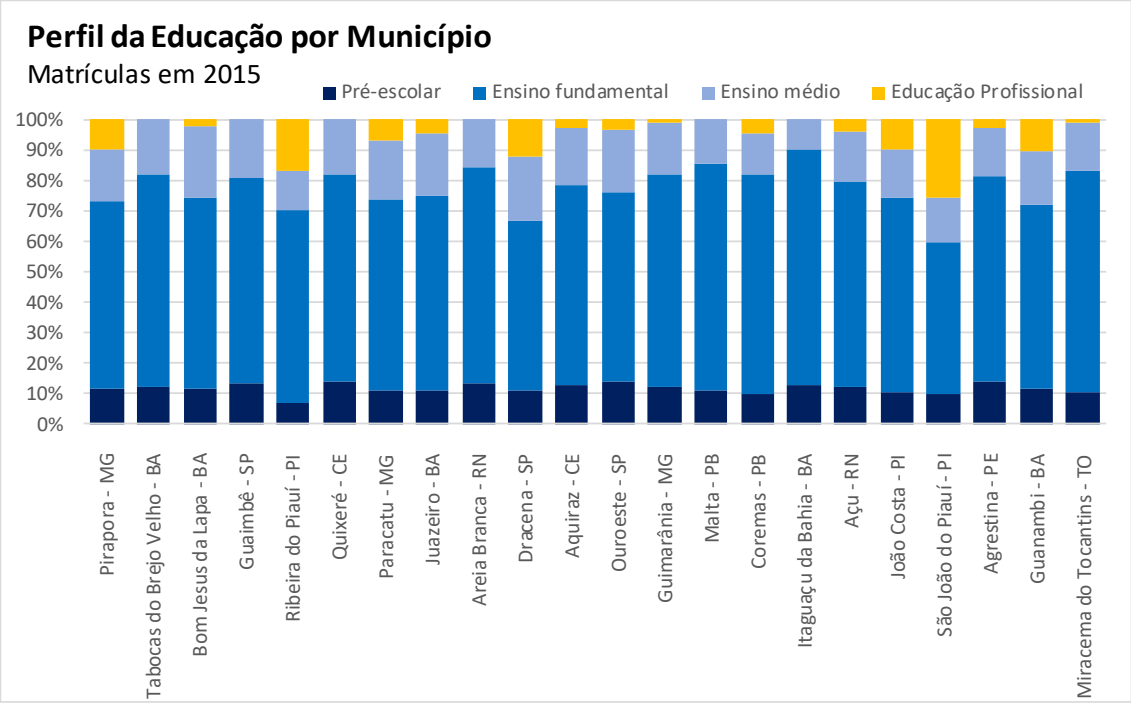
Education

Regarding the educational profile of the selected municipalities, using data between 2015 and 2018, it is observed that enrollment in elementary education predominates over the other levels of education.

Comparing the information from the database collected for this same period, it was possible to observe that there was no significant change in the number of enrollments in the selected municipalities. On the other hand, some cities that had vocational education no longer seem to make this level of qualification available to their inhabitants, as is the case of Ribeira do Piauí-PI, which in 2015 had around 17% of the total enrollments in vocational education and in 2018 this share was zero. Figure 1 shows the distribution of enrollments in 2015.

Revista ARACÊ
ISSN: 2358-2472

Figure 1 - Distribution of Enrollments by Municipality in 2015

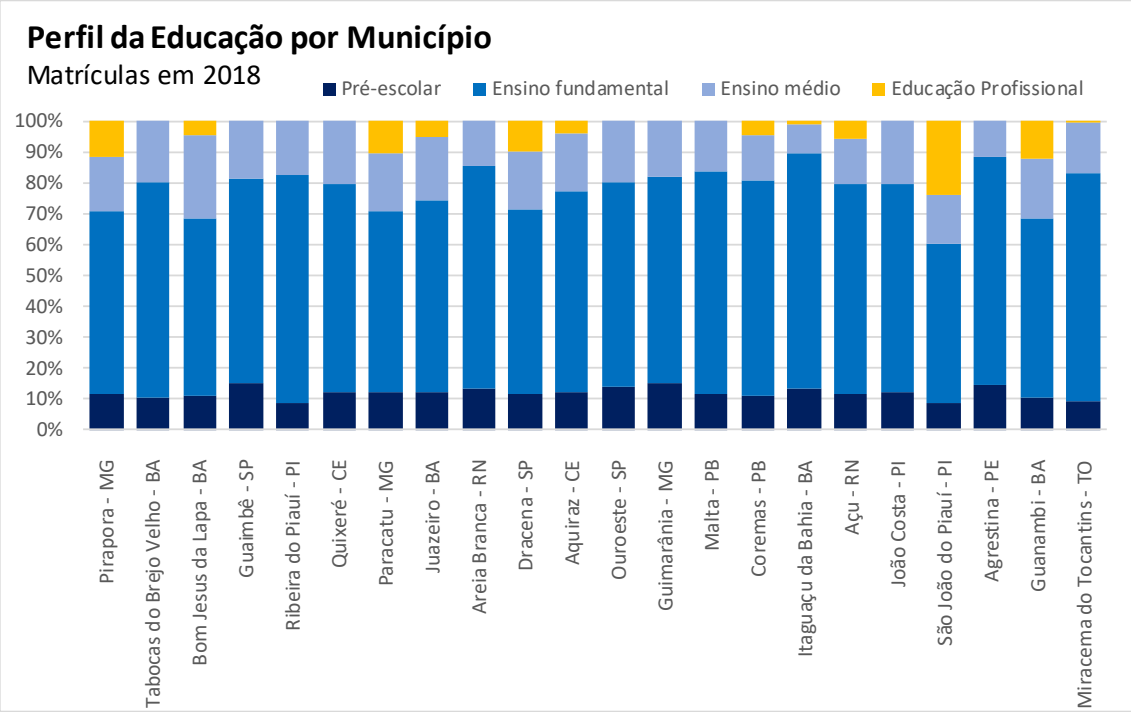


Source: Prepared by the authors based on data from INEP – Statistical Synopses of Basic Education.

In 2018, the municipalities with the highest share of students enrolled in vocational education were São João do Piauí with 24% of total enrollments, Pirapora-MG with 11% and Paracatu-MG with 10%. Still on professional education in that year, among the 22 municipalities selected, only 12 had students enrolled in this level of schooling. In 2015, this number was 16. This result may be influenced by two factors: the first concerns the Brazilian demographic transition, in which there is a decrease in the number of young people in Brazil (Tafner, Botelho, Erbisti, 2014) and the second may be associated with the serious economic crisis that Brazilian society has been going through since 2014. The impact of economic crises on school dropout has already been amply demonstrated in the literature on the subject (Barros, Mendonça and Velazco, 1994; Barros and Mendonça, 1990). Figure 2 shows the profile of education by municipalities in 2018.

Revista ARACÊ
ISSN: 2358-2472

Figure 2 - Distribution of Enrollments by Municipality in 2018



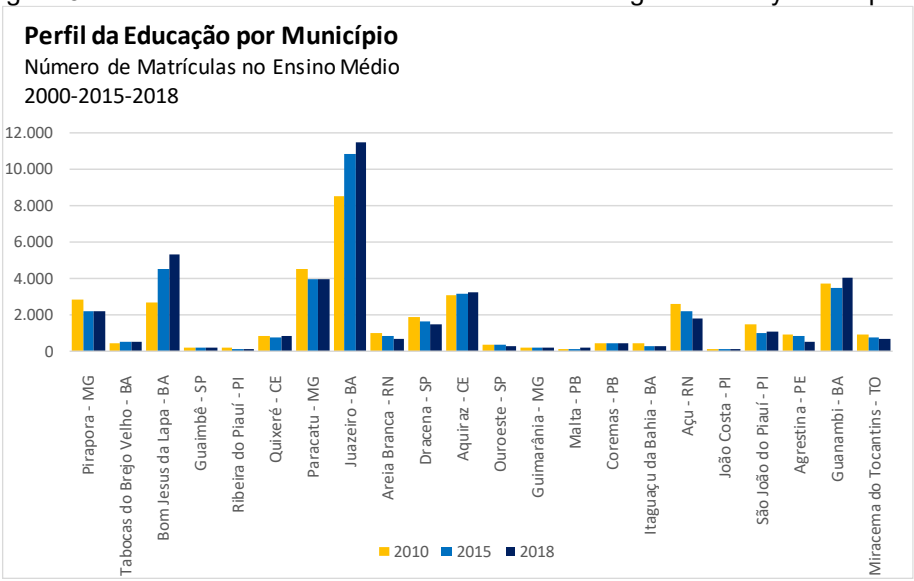
Source: Prepared by the authors based on data from INEP – Statistical Synopses of Basic Education.

The evolution of the number of enrollments in secondary education by municipality is shown in Figure 3. Growth in the number of students enrolled in this stage of education can be observed between 2015 and 2018 in 11 municipalities, with the most significant variations in percentage terms being recorded in Bom Jesus da Lapa-BA, Malta-PB and Guanambi-BA.

Still on the number of enrollments in high school, Juazeiro-BA was the municipality with the highest number of students, reaching a total of 11,491 enrolled in 2018. Another case to be highlighted is that of Bom Jesus da Lapa-BA, which reached a total of 5,321 enrolled. Both municipalities showed a strong increase between 2010 and 2018 (34.7% and 99.5%, respectively). In the same period, there was a drop of 7.8% in this same indicator at the national level.

Revista ARACÊ
ISSN: 2358-2472

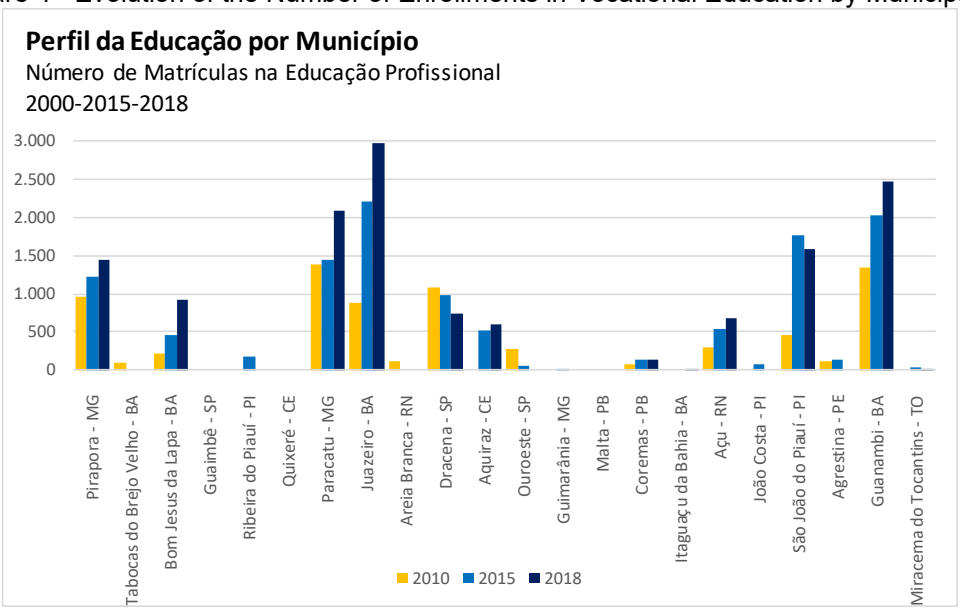
Figure 3 - Evolution of the Number of Enrollments in High School by Municipality



Source: Prepared by the authors based on data from INEP – Statistical Synopses of Basic Education.

In terms of professional education (Figure 4), the increase in enrollments in the municipality of Juazeiro-BA is once again highlighted, from 878 in 2010 to 2,977 in 2018. Other municipalities to show good evolution of these indicators recently were Guanambi-BA, Paracatu-MG, Pirapora-MG, Bom Jesus da Lapa-BA, Aquiraz-CE, Açu-RN and São João do Piauí-PI.

Figure 4 - Evolution of the Number of Enrollments in Vocational Education by Municipality



Source: Prepared by the authors based on data from INEP – Statistical Synopses of Basic Education.

Another indicator analyzed for education was the number of classes per municipality (Figure 5). The survey considers the same levels of education presented for the number of

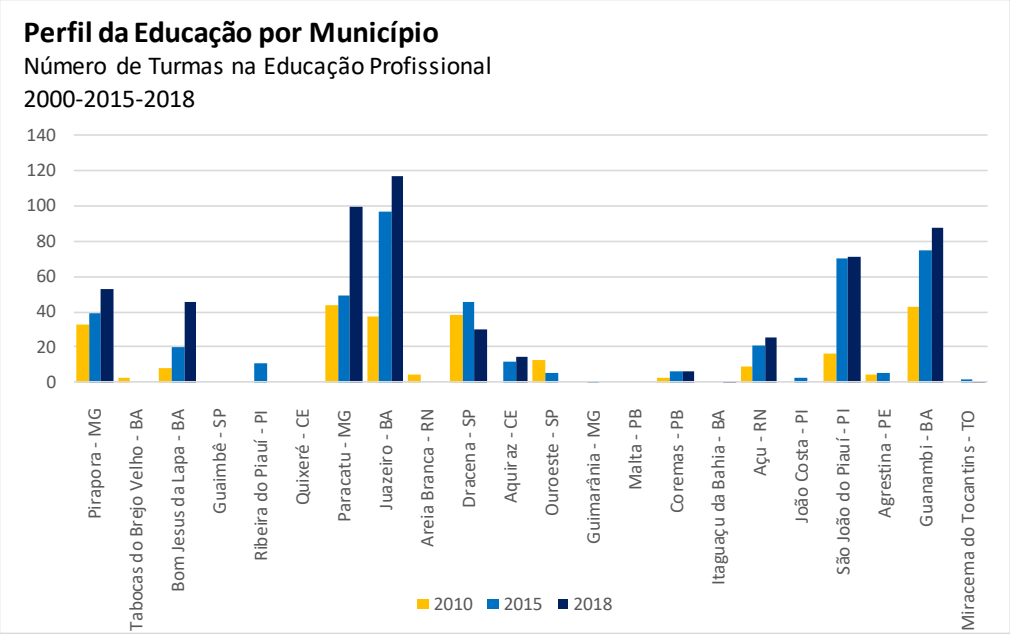
Revista ARACÊ
ISSN: 2358-2472

enrollments, but in this section only the graph prepared for professional education is presented.

Between the years 2015 and 2018, the municipality of Paracatu-MG appears to be the one that was possibly the most positively impacted in terms of investment in professional education, going from 49 to 100 classes in the period. Other municipalities to be highlighted for the growth in the number of classes over the years are Juazeiro-BA, Guanambi-BA, São João do Piauí-PI, Pirapora-MG, Bom Jesus da Lapa-BA, Açu-RN, Aquiraz-CE and Coremas-PB.

On the other hand, some municipalities do not seem to have been impacted in terms of investments in professional education, since they had classes in the past and currently do not have them, such as Tabocas do Brejo Velho-BA, Ribeira do Piauí-PI, Areia Branca-RN, Ouroeste-SP, Guimarânia-MG, João Costa-PI and Agrestina-PE. The municipalities of Guaimbê-SP, Quixeré-CE and Malta-PB did not have professional classes in any of the selected years.

Figure 5 - Variation in the Number of Classes in Vocational Education by Municipality



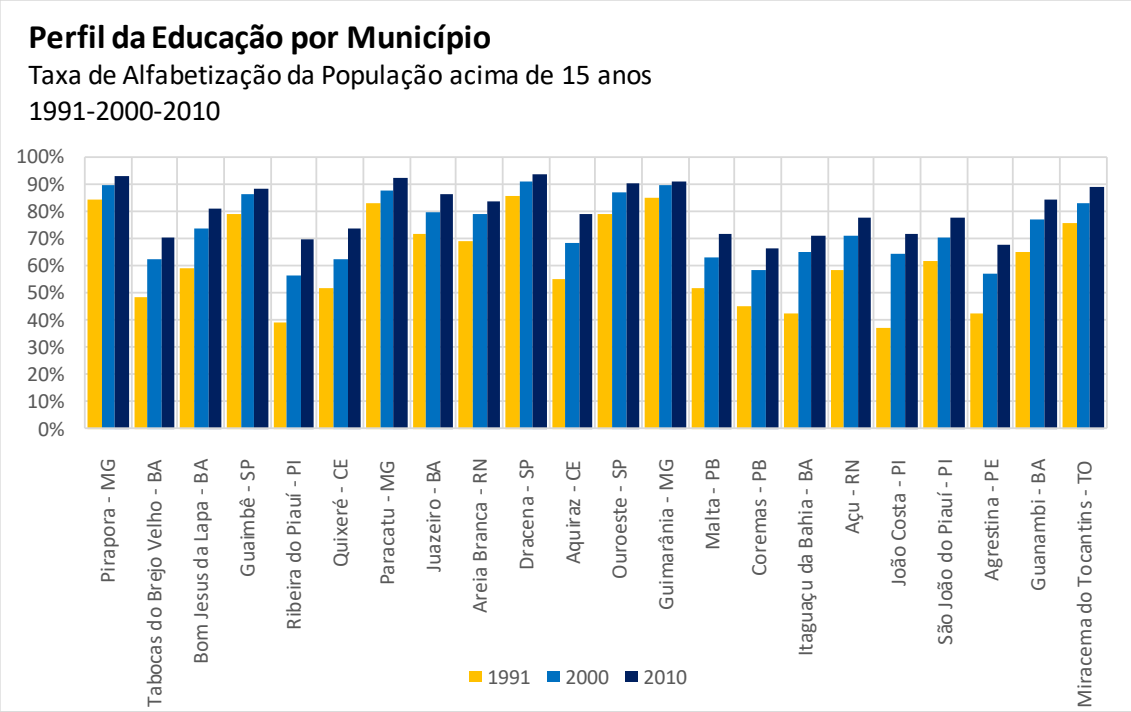
Source: Prepared by the authors based on data from INEP – Statistical Synopses of Basic Education.

The data referring to the literacy of the population over 15 years of age show the evolution of this indicator in all municipalities over the years 1991, 2000 and 2010 (Figure 6). Of the 22 municipalities analyzed, in 2010, only three had literacy rates below 70% (Coremas-PB, Agrestina-PE and Ribeira do Piauí-PI). On the other hand, only 5 had literacy

Revista ARACÊ
ISSN: 2358-2472

rates above 90% (Dracena-SP, Pirapora-MG, Paracatu-MG, Guimarânia-MG and Ouroeste-SP). The average rate of the 22 municipalities was 80.6% in 2010, 73.9% in 2000 and 62.4% in 1991, also following the increase in national rates, as indicated in reports on the subject (UN, 2015).

Figure 6 - Evolution of the Literacy Rate by Municipality



Source: Prepared by the authors based on data from the IBGE - 1991, 2000 and 2010 Censuses.

Access Condition: Electricity

Access to electricity in the country is very close to reaching 100% of the population, according to 2018 data from the IBGE's National Household Sample Survey – PNAD. In the country, the survey points out that 99% of people have access to electricity. In some states such as Rio de Janeiro, São Paulo and Amapá, access has already reached the entire population.

As for the data by municipality, they were not made available for the last few years, being found only in the last Censuses. Of the 22 municipalities selected in 2010, all had a share of the population above 85%, and only 2 were below 90%, as can be seen in the data reported in Table 2.

PNAD's national data for the year 2018 show that access to electrification in the country reached 99% of the population, and the state with the lowest percentage of access (Acre) has 97% of people being served. With this indicator showing rates very close to the ceiling in practically the entire country, it will be difficult to measure the impacts of the

Revista ARACÊ
ISSN: 2358-2472

installation of photovoltaic plants in the municipalities when the data from the next Census are available.

Table 2 - Access to electricity by municipality

Municipality	1991	2000	2010
Pirapora - MG	96,6%	97,1%	99,6%
Tabocas do Brejo Velho - BA	35,6%	56,9%	94,8%
Bom Jesus da Lapa - BA	65,0%	72,7%	94,1%
Guaimbê - SP	97,7%	98,9%	99,5%
Ribeira do Piauí - PI	4,7%	40,7%	86,2%
Quixeré - CE	56,4%	93,2%	99,4%
Paracatu - MG	83,7%	94,7%	99,6%
Juazeiro - BA	85,5%	92,4%	99,5%
Areia Branca - RN	90,3%	97,3%	99,5%
Dracena - SP	99,3%	99,7%	99,8%
Aquiraz - CE	59,8%	92,7%	98,9%
Ouroeste - SP	98,1%	99,2%	100,0%
Guimarânia - MG	87,2%	97,6%	100,0%
Malta - PB	76,0%	92,3%	98,2%
Coremas - PB	60,1%	86,1%	99,8%
Itaguaçu da Bahia - BA	25,7%	60,9%	87,0%
Açu - RN	83,3%	93,5%	98,7%
João Costa - PI	15,3%	55,1%	90,9%
São João do Piauí - PI	57,3%	77,7%	96,0%
Agrestina - PE	60,6%	98,2%	99,7%
Guanambi - BA	76,9%	86,4%	97,4%
Miracema do Tocantins - TO	69,5%	84,9%	99,0%

Source: Prepared by the authors based on data from the IBGE - 1991, 2000 and 2010 Censuses.

Access Condition: Water and Sewage

Regarding access to the water and sewage treatment network in the country, data from the latest Censuses show that these indicators have shown progress in recent years in most of the selected municipalities, but access is still short of reaching the entire population.

Table 3 shows that in 2010, 15 of the 22 municipalities already had more than 90% of the people served with adequate water and sewage treatment, while in only 3, this percentage was less than 80%. As in the case of access to electricity, it may be difficult to measure the impact of the installation of photovoltaic plants on this indicator, since many municipalities were already close to the 100% ceiling in 2010.

Table 3 - Access to water and sewage treatment by municipality

Municipality	1991	2000	2010
Pirapora - MG	98,1%	92,2%	98,7%
Tabocas do Brejo Velho - BA	73,8%	74,6%	84,1%
Bom Jesus da Lapa - BA	76,9%	91,1%	89,4%
Guaimbê - SP	100,0%	98,9%	98,9%

Revista ARACÊ
ISSN: 2358-2472

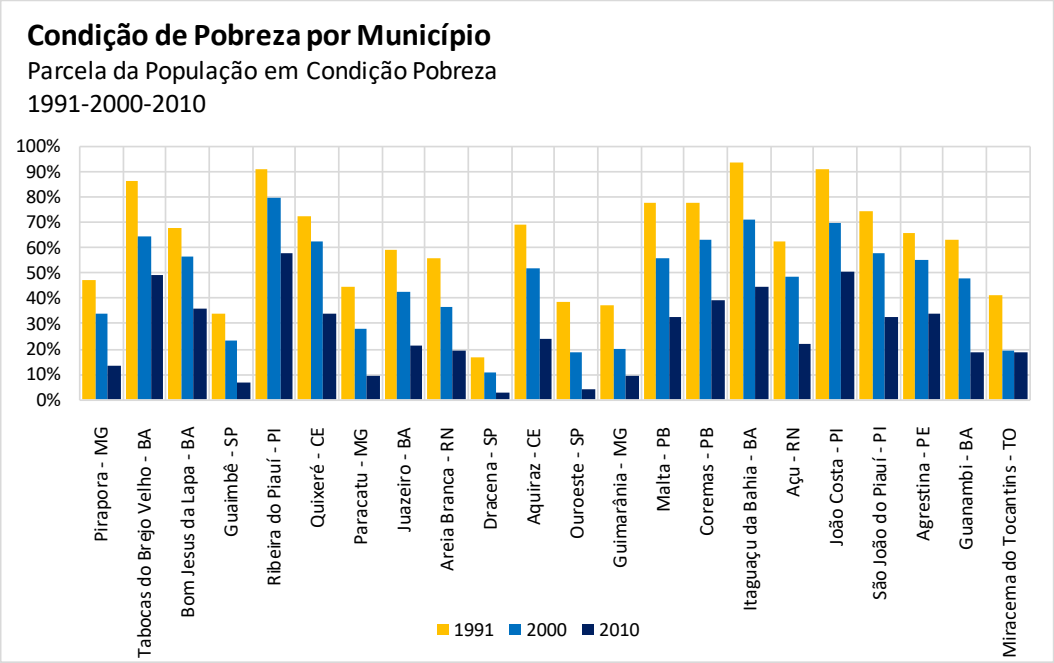
- Piauí River - PI	17,2%	87,0%	93,4%
Quixeré - CE	48,5%	72,4%	91,0%
Paracatu - Y	96,3%	93,4%	97,6%
Juazeiro - BA	87,0%	93,0%	94,7%
Areia Branca - RN	83,1%	77,6%	92,3%
Dracena - SP	99,6%	99,3%	99,7%
Aquiraz - CE	70,8%	72,4%	73,6%
Ouroeste - SP	99,9%	98,5%	99,9%
Guimarânia - MG	100,0%	97,9%	99,1%
Malta - PB	63,3%	94,7%	93,7%
Coremas - PB	39,8%	93,7%	95,9%
Itaguaçu to Bahia-BA	54,5%	79,5%	78,8%
Açu - RN	64,7%	73,9%	89,5%
João Costa - PI	19,2%	98,1%	79,9%
São João do Piauí - PI	72,6%	96,3%	92,0%
Agrestina - PE	58,7%	82,2%	89,6%
Guanambi - BA	83,8%	89,2%	94,2%
Miracema do Tocantins - TO	96,6%	85,1%	95,6%

Source: Prepared by the authors based on data from the IBGE - 1991, 2000 and 2010 Censuses.

Poverty

The indicators of poverty and extreme poverty by municipality show a reduction in the share of the population in these conditions over the years. In all the municipalities analyzed, there was a systematic reduction in the percentage of inhabitants living in poverty over the years (Figure 7). A similar movement was observed in the indicators of extreme poverty Figure 8, with the exception of the municipality of Guimarânia-MG, which showed a residual increase between 2000 and 2010, according to data from the last Censuses.

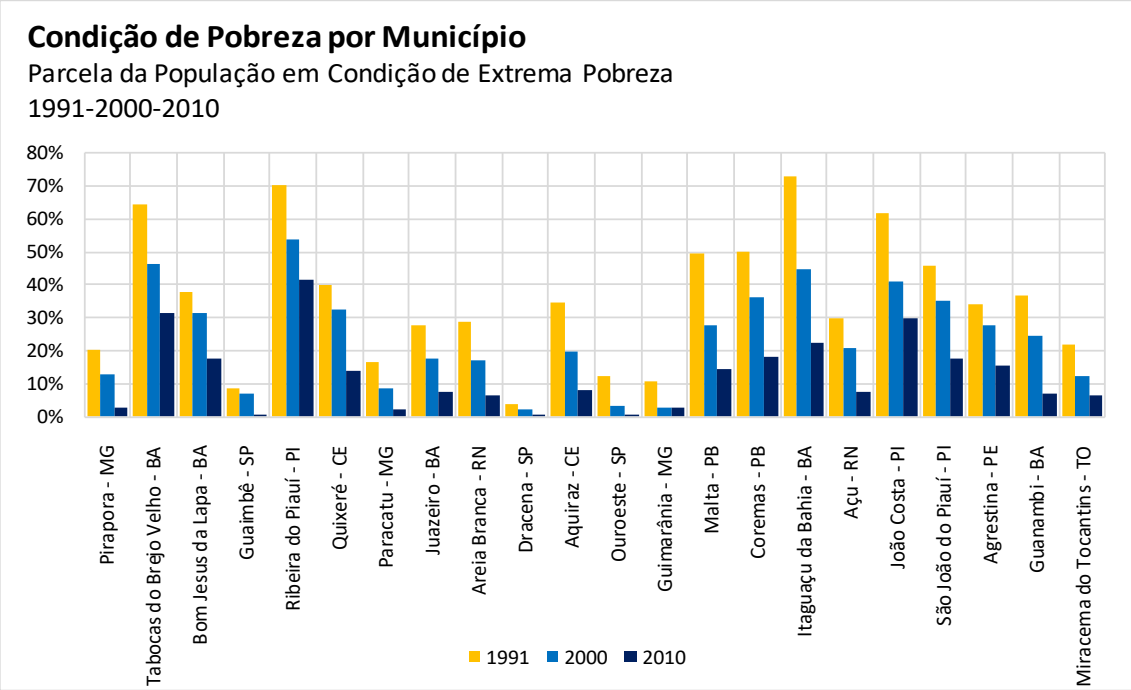
Figure 7 - Share of the Population in Poverty



Source: Prepared by the authors based on data from the IBGE - 1991, 2000 and 2010 Censuses.

Revista ARACÊ
ISSN: 2358-2472

Figure 8 - Share of the Population in Conditions of Extreme Poverty



Source: Prepared by the authors based on data from the IBGE - 1991, 2000 and 2010 Censuses.

In recent years, practically all municipalities have shown a reduction in the share of the population in the Unified Registry, which is the instrument that the government uses to register and identify low-income Brazilian families (Table 4). The survey shows that after 2014, the year in which photovoltaic solar energy projects began to be tendered, there was a sharp drop in the number of registered in almost all municipalities, with few cases of increase in the following years. In general, we can note that the municipalities located in the southeast region have a lower percentage of registered populations, while those located in the northeast region have a larger portion of their population registered, although there are exceptions in both cases.

The data in the following table show the existence of a great disparity between the portions of inhabitants of each municipality that make up the base of the Unified Registry in the country. In 2019, we have at both extremes: Dracena-SP with less than 20% and Tabocas do Brejo Velho-BA with almost 75% of its population registered. The simple average (unweighted) of the percentages of people registered among the selected municipalities fell from 65% to 55% between 2013 and 2019.

Table 4 - Share of the population in the Unified Registry

Municipality	2013	2014	2015	2016	2017	2018	2019
Pirapora - MG	60,9%	62,5%	59,8%	56,2%	51,7%	48,3%	47,5%
Tabocas do Brejo Velho - BA	87,1%	88,0%	80,8%	75,3%	73,1%	73,4%	74,0%

Revista ARACÊ
ISSN: 2358-2472

Bom Jesus da Lapa - BA	71,9%	72,0%	64,4%	62,9%	61,2%	57,9%	58,2%
Guaimbê - SP	59,6%	62,4%	53,1%	51,3%	47,0%	42,6%	39,9%
- Piauí River - PI	83,0%	84,2%	80,1%	76,0%	71,5%	73,5%	73,6%
Quixeré - CE	83,1%	82,8%	78,4%	73,4%	68,7%	68,1%	68,7%
Paracatu - Y	43,1%	40,7%	33,2%	31,6%	31,2%	29,7%	29,2%
Juazeiro - BA	62,2%	64,8%	60,9%	59,3%	57,8%	58,2%	59,1%
Areia Branca - RN	59,7%	60,1%	55,5%	53,2%	50,2%	45,6%	44,1%
Dracena - SP	32,2%	33,2%	23,7%	19,5%	19,2%	18,2%	18,3%
Aquiraz - CE	70,6%	72,6%	62,8%	62,4%	61,4%	58,3%	57,6%
Ouroeste - SP	54,4%	54,1%	48,8%	40,9%	38,2%	35,0%	34,4%
Guimarânia - MG	63,3%	62,2%	59,7%	65,1%	69,6%	65,4%	68,0%
Malta - PB	71,4%	74,8%	68,9%	70,5%	72,1%	69,7%	71,0%
Coremas - PB	25,6%	27,0%	24,3%	23,8%	23,8%	25,1%	26,3%
Itaguaçu to Bahia-BA	88,8%	89,0%	78,1%	74,5%	68,4%	65,6%	67,4%
Açu - RN	66,7%	67,2%	58,8%	54,3%	55,4%	57,0%	58,5%
João Costa - PI	94,2%	90,8%	89,7%	85,8%	79,0%	73,5%	73,2%
São João do Piauí - PI	68,9%	70,4%	64,9%	61,5%	59,0%	56,2%	56,5%
Agrestina - PE	68,6%	69,7%	71,6%	71,0%	69,0%	68,4%	68,2%
Guanambi - BA	63,6%	65,7%	65,6%	62,6%	61,0%	61,4%	61,5%
Miracema do Tocantins - TO	61,7%	65,0%	59,5%	57,4%	59,3%	60,4%	61,4%

Note: Data from December of each year, except 2019, whose data refers to the month of September.
Source: Prepared by the authors based on data from the MDS.

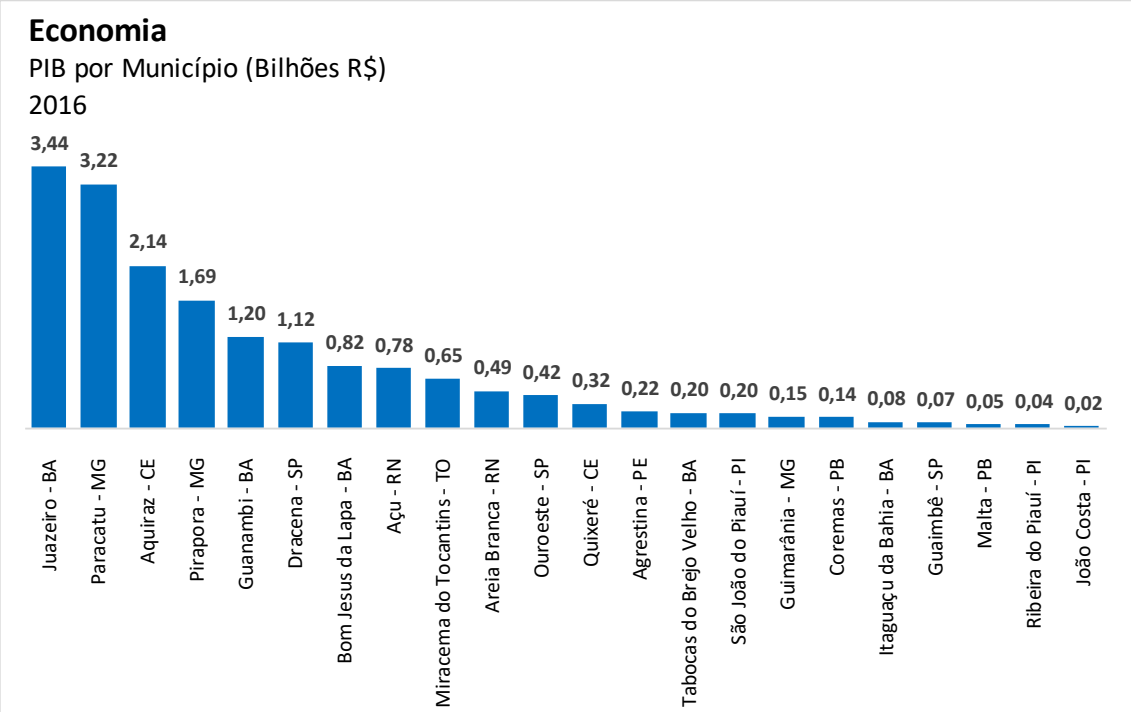
Economy

According to the IBGE definition, the Gross Domestic Product (GDP) is the sum of all final goods and services produced by a country, state or city, usually in a year. For the selected municipalities, their values for the year 2016 were presented in descending order by municipality in Figure 9.

It is possible to see that the two most populous municipalities and with the highest GDP's, Juazeiro-BA and Paracatu-MG, are the only ones above R$ 3 billion. At the other end, we have two municipalities located in Piauí, Ribeira do Piauí and João Costa with the lowest values recorded (less than R$ 50 million) in 2016 respectively. It should be noted that João Costa is the smallest municipality in terms of population among those considered.

Revista ARACÊ
ISSN: 2358-2472

Figure 9 - GDP by Municipality in 2016



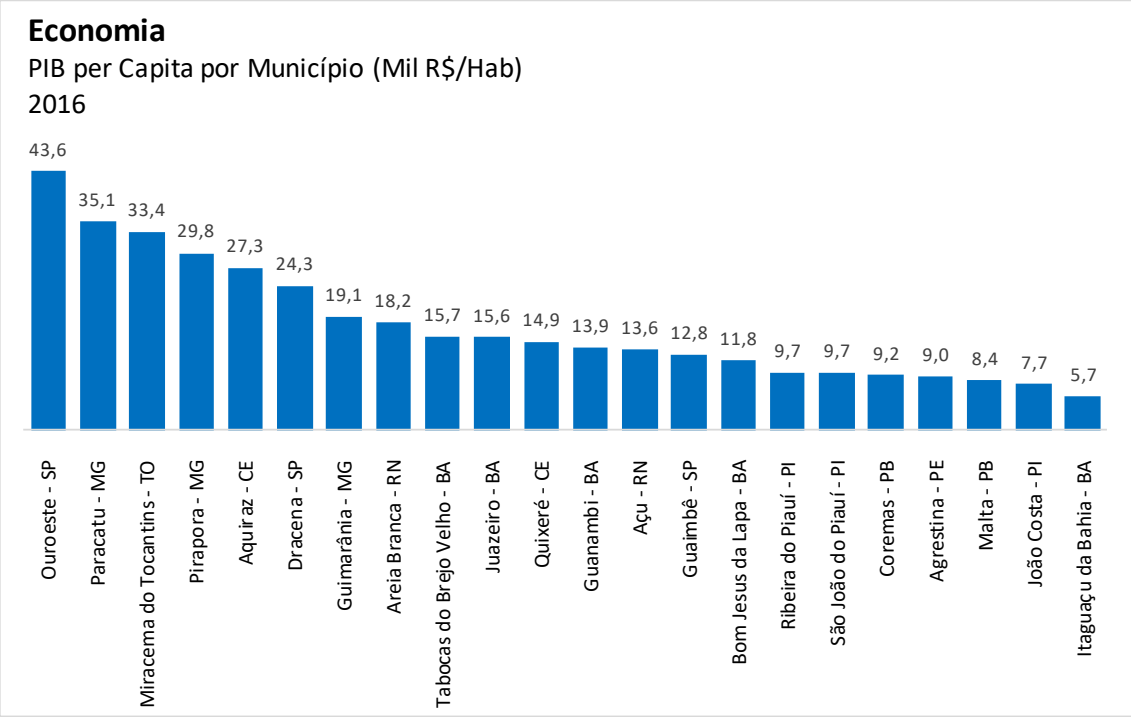
Source: Prepared by the authors based on IBGE data.

In the analysis of the GDP per capita of these municipalities for the year 2016, some results are different from the previous case, as in the example of Juazeiro-BA, which had the highest GDP and in terms of GDP per capita, is in an intermediate position.

For comparison purposes, the Brazilian GDP per capita in the respective year was R$ 30.6 thousand/inhabitant, and among the selected municipalities, only 3 presented values above the national level (Ouroeste-SP, Paracatu-MG and Miracema do Tocantins-TO) (Figure 10).

Revista ARACÊ
ISSN: 2358-2472

Figure 10 - GDP Per Capita by Municipality in 2016



Source: Prepared by the authors based on IBGE data.

The real GDP growth for each year was calculated by applying the implicit GDP deflators made available by the IBGE in order to bring the GDP of previous years to 2016 values. In the two most recent years of the time series (2015 and 2016), we have that some municipalities managed to present positive results in terms of GDP growth, despite the economic crisis and the recession faced by the country in recent years. It would be appropriate to explore more deeply the impact of the installation of the plants in these regions after the beginning of the ANEEL auctions in 2014, as can be seen in ANNEX III of this research.

Table 5 - Real GDP growth by municipality

Municipality	2011	2012	2013	2014	2015	2016
Pirapora - MG	10,7%	-7,9%	-6,5%	7,8%	-25,9%	21,9%
Tabocas do Brejo Velho - BA	7,7%	5,3%	-2,9%	-0,6%	2,6%	143,1%
Bom Jesus da Lapa - BA	6,3%	2,2%	5,3%	6,8%	13,3%	-1,4%
Guaimbê - SP	-6,4%	-24,7%	25,8%	-0,3%	-0,8%	-3,3%
Ribeira do Piauí - PI	13,0%	-8,7%	9,6%	7,6%	1,0%	65,2%
Quixeré - CE	36,4%	38,1%	60,4%	-6,1%	-27,5%	-22,6%
Paracatu - MG	15,4%	16,7%	1,2%	-9,2%	-7,1%	4,5%
Juazeiro - BA	-3,1%	5,4%	13,6%	6,4%	-3,2%	1,4%
Areia Branca - RN	0,6%	4,5%	-3,4%	-13,5%	-24,2%	-31,6%
Dracena - SP	4,3%	1,3%	10,1%	-7,3%	-2,6%	-3,3%
Aquiraz - CE	5,5%	14,8%	32,5%	-1,1%	2,9%	8,5%
Ouroeste - SP	1,6%	15,1%	26,9%	0,7%	-1,5%	4,1%
Guimarânia - MG	14,5%	-2,9%	4,9%	5,1%	4,1%	14,0%

Revista ARACÊ
ISSN: 2358-2472

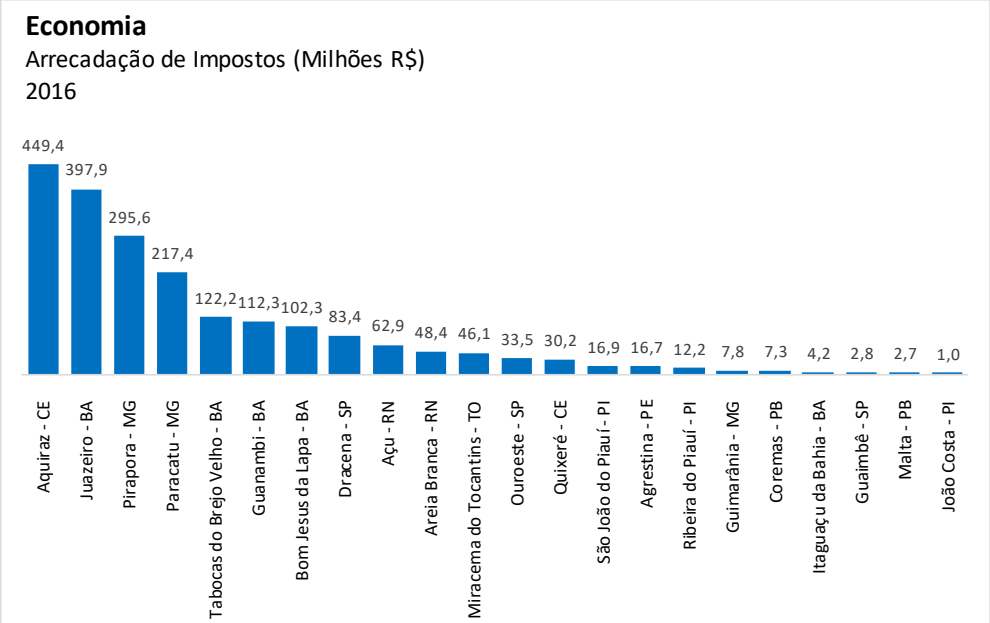
Malta - PB	3,0%	1,6%	6,3%	2,9%	2,9%	0,4%
Coremas - PB	-0,4%	4,5%	5,7%	12,3%	-1,7%	0,7%
Itaguaçu da Bahia - BA	-5,5%	-2,0%	2,8%	8,8%	2,1%	0,9%
Açu - RN	26,2%	7,0%	8,9%	-5,9%	-4,5%	-15,0%
João Costa - PI	3,8%	-6,3%	-9,6%	16,4%	-1,0%	6,5%
São João do Piauí - PI	5,1%	9,6%	10,3%	3,0%	-2,2%	7,2%
Agrestina - PE	3,8%	6,5%	4,6%	7,7%	-4,7%	1,8%
Guanambi - BA	8,8%	4,9%	10,2%	12,1%	1,9%	-2,9%
Miracema do Tocantins - TO	-4,2%	6,1%	-20,7%	-12,3%	18,6%	18,7%

Source: Prepared by the authors based on IBGE data.

Tax collection is one of the items that are part of the composition of the GDP, along with the Value Added (Industry, Services, etc.). Its relevance in the formation of GDP is quite variable between municipalities, such as the cases of Tabocas do Brejo Velho-BA, whose taxes represented 60% of GDP, and Juazeiro-BA, where its representativeness was only 12%, both in 2016.

The amounts collected by municipality in 2016 are shown in a decreasing manner in Figure 11. The largest amounts collected came from the municipalities of Aquiraz-CE, Juazeiro-BA and Pirapora-MG. On the other hand, the municipalities of João Costa-PI and Malta-PB had the lowest amounts.

Figure 11 - Tax Collection by Municipality in 2016



Source: Prepared by the authors based on IBGE data.

In terms of growth, in 20 of the 22 municipalities, there was an increase in the amounts collected, as seen below (growth calculated from current prices), in 2016, as can be seen in the table below. It is possible that the installation of photovoltaic plants in these

Revista ARACÊ
ISSN: 2358-2472

regions has meant some impact in this regard. It is worth highlighting the significant increases in 2016 in Tabocas do Brejo Velho-BA and Ribeira do Piauí-PI.

Table 6 - Growth in Tax Collection

Municipality	2015	2016
Pirapora - MG	-15%	54%
Tabocas do Brejo Velho - BA	21%	3340%
Bom Jesus da Lapa - BA	19%	70%
Guaimbê - SP	10%	6%
Ribeira do Piauí - PI	67%	768%
Quixeré - CE	-27%	-15%
Paracatu - MG	15%	26%
Juazeiro - BA	14%	10%
Areia Branca - RN	-9%	-19%
Dracena - SP	5%	1%
Aquiraz - CE	13%	31%
Ouroeste - SP	3%	2%
Guimarânia - MG	28%	28%
Malta - PB	55%	7%
Coremas - PB	4%	17%
Itaguaçu da Bahia - BA	-2%	30%
Açu - RN	22%	8%
João Costa - PI	22%	45%
São João do Piauí - PI	8%	24%
Agrestina - PE	11%	24%
Guanambi - BA	13%	7%
Miracema do Tocantins - TO	25%	20%

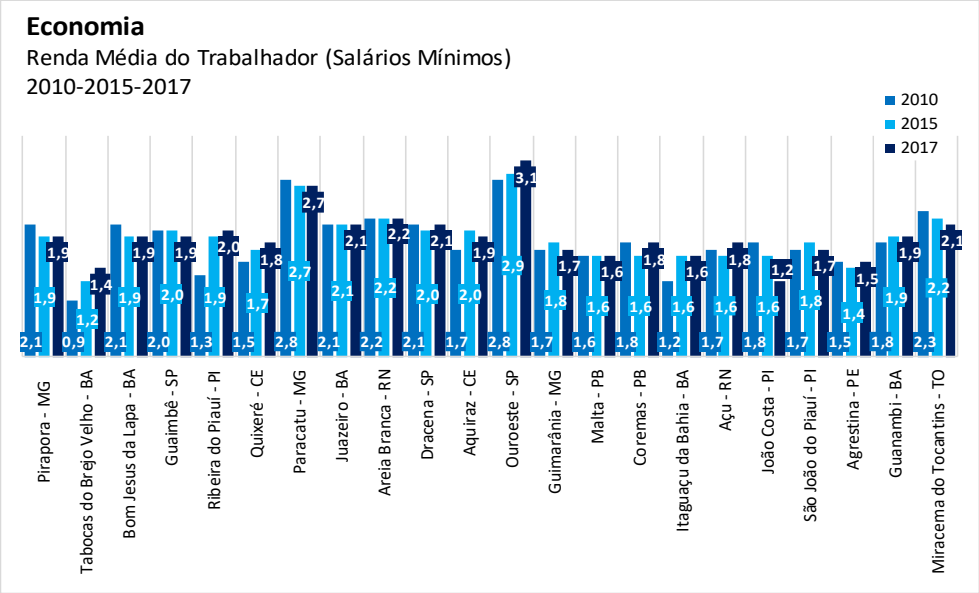
Source: Prepared by the authors based on IBGE data.

The average income of the worker is presented in terms of minimum wages for the years 2010, 2015 and 2017 in Figure 1. With the strong increase in the minimum wage in recent years (according to data from IPEADATA, from 2008 to 2017 the minimum wage increased by 126% in nominal values, from R$ 415 to R$ 937) the results presented in the graph were directly impacted, so that the increase in the worker's income in monetary terms may not have been reflected in relation to the income per minimum wage.

However, it is possible to note that in some cases, the worker's income in terms of minimum wages remained constant or even increased over the years, as in Ouroeste-SP, which went from 2.8 to 3.1 minimum wages between 2010 and 2017, which in monetary terms represented a much more significant increase.

Revista ARACÊ
ISSN: 2358-2472

Figure 1 - Average worker income

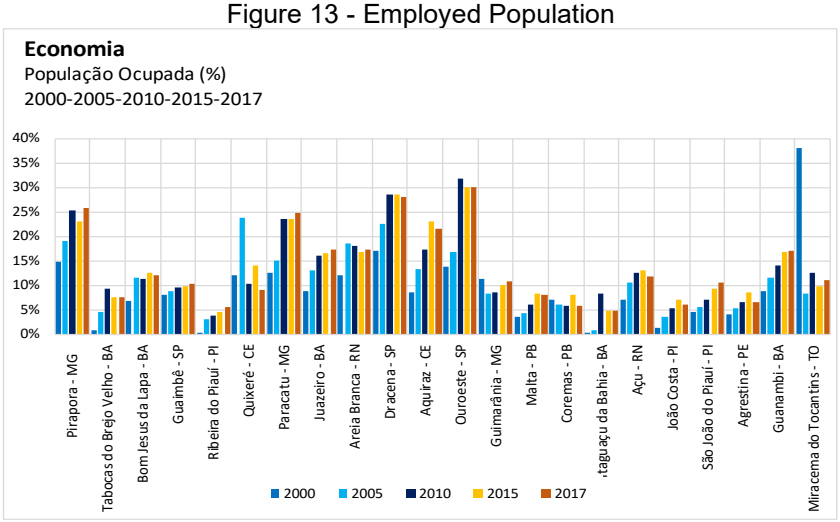


Source: Prepared by the authors based on IBGE data.

The population employment rate in different periods for each of the selected municipalities is shown in Figure 13. It is observed that in 12 of the 22 locations, there was an increase in this rate between the years 2015 and 2017, possibly with the photovoltaic plant projects having a positive impact in this regard.

In 2017, the three municipalities with the highest population employment rates were Ouroeste-SP, Dracena-SP and Pirapora-MG, all above 25%. On the other hand, in the same year, the lowest rates were found in Coremas-PB, Ribeira do Piauí-PI and Itaguaçu da Bahia-BA, all close to 5%.

Figure 13 - Employed Population



Source: Prepared by the authors based on IBGE data.

Revista ARACÊ
ISSN: 2358-2472

RESULTS OF THE QUANTITATIVE ANALYSIS – MUNICIPALITIES OF CENTRALIZED GENERATION

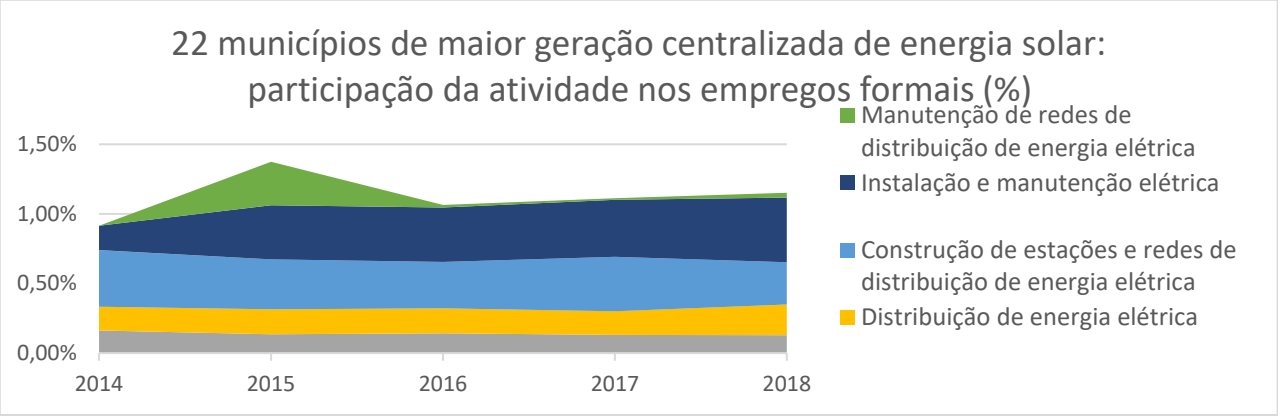
Despite the initial high expectations of public managers and the population of Pirapora, the socioeconomic benefits were limited after the installation of the plant. According to managers of Pirapora, the transfer of ICMS linked to the activity did not seem to significantly impact the municipality's coffers, to the point that businessmen and local residents, as well as politicians, did not know exactly if it was already entering tax revenues. At the time the case study was carried out, an opposition councilor requested a formal response from the city hall about the entry of this revenue, but there was still no response. In the set of 22 municipalities analyzed, formal jobs related to electricity were 1,682 in 2018, less than 1.2% of the total, with percentages that varied little between 2014 and 2018. The most consistent and sustained expansion occurred in the activity of electrical installation and maintenance, whose share went from 0.18% to 0.46% of local formal jobs.

Sociodemographic indicators of the municipalities with the highest centralized generation

	Brazil	Pirapora (MG)	22 munics. With higher centralized generation
Population (2014)	203.609.306	55.972	887.781
Population (2015)	205.265.741	56.229	893.933
Population (2016)	206.871.181	56.474	899.468
Population (2017)	208.077.915	56.706	904.980
Population (2018)	209.321.013	56.208	892.544
% without electricity (2010)	1,42	0,39	1,64
IDHM (2010)	0,727	0,731	0,676
Renda per capita (2010)	793,87	596,44	478,20
Life expectancy at birth (2010)	73,94	74,65	73,06
Total fertility rate (2010)	1,89	2,42	2,14
Infant mortality (2010)	16,70	15,90	19,45
Mortality up to 5 years of age (2010)	18,83	18,46	19,95
Dependency ratio (2010)	45,92	46,40	49,30
Freq. Rate net to high school (2010)	43,38	53,08	42,78

Source: IBGE/Population estimates and IPEA-PNUD-FJP/Atlas of Municipal Human Development.

Revista ARACÊ
ISSN: 2358-2472



Source: Prepared by the authors based on microdata from RAIS / Ministry of Economy.

We summarize below the main information taken from the analyses:

- In 2016, of the 22 municipalities listed, 17 presented better economic results than the national one, which had a real drop in GDP of -3.3%. Of these 17 municipalities, 15 showed growth and 2 a reduction.
- The GDP per capita (calculated from current prices) of 22 municipalities increased in the period 2010-2016. In the 2015-2016 period, there were 19, with the municipality of Areia Branca – RN showing the highest growth, 162%. It is important to note that this growth occurred when a serious fiscal crisis affected the country's economy.
- Tax collection (at current prices), in general, increased in almost all municipalities in 2016. Only Quixeré – CE and Areia Branca – RN had a drop in values. It should be noted that both municipalities had a significant increase in 2014 and a decrease in the following two years. The positive highlights of 2016, which possibly had the installation of solar plants as one or perhaps the main catalyst, were Tabocas do Brejo Velho – BA and Ribeira do Piauí – PI.
- There was a balance in the number of municipalities with an increase and reduction in the population employment rates between 2015-2017, although in most locations it increased.
- The value added of industry (at current prices) grew in 15 of the 22 municipalities in 2016, with emphasis on the significant increase of 800% in the municipality of Ribeira do Piauí – PI. In the case of the services sector, an increase was recorded in 19 of the 22 municipalities, with emphasis again on Ribeira do Piauí – PI, with a growth of 31%. Combined with the strong growth in tax collection, the municipality was one of the most economically impacted in recent years.

Revista ARACÊ
ISSN: 2358-2472

- In the 12 municipalities that showed growth in the number of enrollments in vocational education between 2010 and 2018, in 10 of them the growth was quite significant. In the total of the 22 municipalities, the balance was an increase of 89% in the number of students enrolled. However, this result follows the national results of improvement in basic education due to public policies aimed at the area.
- Among the indicators of poverty conditions, the survey for the selected municipalities shows that between 2014, the year of ANEEL's first solar energy auction, and 2019 there was a reduction in the number of inhabitants registered in the single registry in 21 of the 22 locations. Guimarânia – MG, was the only one to show an increase. In the same way as policies aimed at education, there were several policies in Brazil during the period of analysis to increase income and reduce poverty and extreme poverty. In this sense, the activity linked to photovoltaic production should not be considered the main motivator.

In general, the results indicate that there has been an improvement in socioeconomic indicators in recent years during the beginning and end of the activities of installation of the plants in the municipalities, which demonstrates a limitation in the capacity for regional development from the implementation of this public policy.

FIELD RESEARCH – PIRAPORA MG

As a way to complement the quantitative analyses on the impact of the installation of solar plants in municipalities, it was decided to carry out a field study in Belo Horizonte and Pirapora. There are reasons why Pirapora was chosen to carry out the field research. Among them, there is the one that we consider especially important: the municipality, which is located in the north of the state of Minas Gerais, has the largest centralized plant in South America and with the highest installed power in MW so far.

In addition, it is known that Minas Gerais was the pioneer state in solar energy regulation models in Brazil, which gives us reasonable justifications for the choice and to explore issues related to the decision-making process in the political mapping section. Brazil is the country that receives the most solar irradiation in the world. The fact that it is located close to the equator means that the country has a high incidence of sunshine throughout the day, with little variation throughout the year. According to ABSOLAR data, Minas Gerais, São Paulo and Rio Grande do Sul have a privileged location. Nascimento's

Revista ARACÊ
ISSN: 2358-2472

(2017) research also highlights that Brazil has one of the largest reserves of silicon, the main source of raw material for photovoltaic panels sold today.

The original leadership of the state of Minas Gerais in the photovoltaic sector is due to a combination of incentive instruments, which can be categorized into three groups: regulatory policies, tax incentives and the political dynamics that occurred between the local, state and national levels. There are also important geographical factors. The main one, certainly, concerns the incidence of sunlight, which offers comparative advantages to the state of Minas Gerais. However, other states are also in similar solarimetry positions, but the regulatory model of Minas Gerais has a series of standards, policies and programs created from the state for the production of electricity through the solar matrix.

Zolini (2019) showed the conditions of MG to differentiate itself from other regions: "In addition to the nationally agreed provisions, State Law No. 20,849 (2013) stands out, which instituted the state policy to encourage the use of solar energy. Another relevant legislative mechanism in the scope of solar energy is State Decree No. 46.296 (2013), which provides for the Minas Gerais Renewable Energy Program and measures to encourage the production and use of renewable energy, including tax incentives and differentiated tax treatment for companies in the sector." Also noteworthy is the pioneering ICMS exemption on solar energy and the high local energy tariff, which, under high levels of insolation, make photovoltaic systems an attractive option.

We understand that part of the explanations would be a contribution offered to studies on the relations between bureaucracy, strategic actors in society and the implementation of public policies in Brazil, taking its place in the comparative political literature on this topic. The field trip was also justified because this is an important resource to overcome the impasses in the observation of the political relations between local and national power, which are not resolved through conceptual discussions, requiring field research (Carvalho, 1997). The political science literature has also provided important information about the dynamics and political role of municipalities. According to Brambor and Ceneviva (2012), "in an unusual constitutional arrangement, municipalities are considered autonomous federated entities: they are not politically subordinate even to the states in which they are located, which implies that a mayor is a sovereign authority in his constituency. (p. 21)". In addition, mayors also care about the electoral results of a possible reelection, "municipal elections are politically relevant and their importance is recognized by Brazilian voters".

Revista ARACÊ
ISSN: 2358-2472

As a way of pointing out information about the process by which the plant was built, we will highlight here some information about the report found during the field research carried out in Pirapora, in 2019. On the occasion, different strategic actors were interviewed: a federal deputy, a state deputy from Minas Gerais, a parliamentary advisor, a councilor, a municipal secretary, a director and teacher of a municipal school in the region, two businessmen living in the region, three residents, a researcher who had carried out field research on the social impacts of the implementation of the photovoltaic plant and a social responsibility manager of an energy company, as can be seen in Table 36.

Table 36 - Strategic actors

Strategic actors	Quantity.
Federal deputy	1
State Representative	1
Parliamentary advisor	1
Alderman	1
Municipal secretary	1
Principal and teacher of a municipal school	1
Entrepreneurs	2
Researcher	1
Social Responsibility Manager of Energy Company	1
City dwellers	3

Prepared by the authors.

As in the other municipalities, the implementation of the plant provided the residents of Pirapora both in terms of job generation and income was limited and occurred more prominently during the installation phase of the project.

Despite the numerous advantages associated with the use of solar energy, its role in improving local social indicators in less developed areas seemed concentrated in the period, which would justify a further investigation of the reasons that led Pirapora to be the place where the largest photovoltaic power plant in Brazil was installed. We also saw that the geography and the solar factor are not special to a few regions in Brazil, since a large part of the country's territory has this asset. In this sense, we believe that a case study carried out in the city in which it was implemented would help to understand these issues.

The results of the analysis of the interviews showed important information that will be described in detail below. As part of the interviewees did not allow the recording of the interviews, it was decided to describe the results in the form of items as follows:

Revista ARACÊ
ISSN: 2358-2472

a) The political alignment between the federal and state legislatures with local businessmen and political leaders were decisive in the implementation of the public solar energy agenda in Pirapora.
b) The mayor and councilors who were at the time of the 1st energy auction that took place (2014) were influential in the Working Group that preceded the creation of Resolution 482, one of the most important documents for the development of photovoltaic energy production in Brazil (see Timeline in ANNEX I).
c) The mayor at the time also played an important role in granting the exemption "informally" to companies subcontracted by the company that implemented the plant and that provided a series of services in the region
d) Two state deputies were the biggest influencers in the three spheres, helping in the articulation between the company, the municipality of Pirapora and the federal government.
e) The mayor at the time played an important role by granting the exemption "informally" to companies subcontracted by Solatio Energy and that provided a series of services in the region;
f) Solatio Energy managers maintained liaison and communication with the MME and deputies from energy committees of the Chamber of Deputies;
g) There was no influence on the civil society process, it was only informed about the installation of the plant.
h) In addition, communication with society was done in very limited forums, creating immense expectations of improved employment, income and well-being that were not confirmed in the subsequent period. Residents, some politicians and school principals said that communication was deficient, generating demands from the population and different versions to account for the smaller amount of jobs generated in proportion to what was expected. One of the versions stated that there was not so much employment because of the corruption involving the city hall.
i) A local merchant, who provided food to the construction site and services related to the works, reported that he sold around a thousand meals a day during the installation period;
j) Reports from residents showed that there was no significant improvement in local indicators of social welfare, partly due to the installation phase having had limited

Revista ARACÊ
ISSN: 2358-2472

effects on employment and income, and partly due to allegations of corruption involving public managers;

k) Society showed broad social acceptance to the extent that there was a great expectation of a significant increase in tax collection, which has not yet been confirmed;

l) What was observed in practice is that the possible increases in revenue occurred in the installation phase of the generating complex, with the levy of ISS on services performed by companies subcontracted by the concessionaires.

If, on the one hand, few benefits were perceived locally, on the other hand, the plants contributed to the diversification and security of the Brazilian energy matrix. Finally, with regard to the local decision-making process, we know that a project such as stimulating the emergence of a new electricity matrix in Brazil brings many challenges to public management. We tried to highlight, through the mapping of the decision-making process, political resources used by the local bureaucracy to allow the implementation of this public policy. Thus, it is believed that this research highlights aspects of the Brazilian bureaucracy, especially that focused on photovoltaic energy, which help to explain successes and failures in the implementation of public policies in different Brazilian regions. Both employment and income generation were limited and occurred more prominently during the installation phase of the project, confirming the findings of quantitative analyses and part of the literature on the subject (Hochstetler, 2021; Zolini and Franco, 2019, Hernandez et al, 2014).[3]

The reports reported a significant increase in the number of jobs around the installation of the plant and services that were mobilized through it, thus there was a

[3] During the interviews, it was possible to identify some problems that deserve to be described. Political disputes that hindered the process of building the plant were mentioned. Conflicts in the region between opposition politicians and the situation disrupted part of the process of implementing the plant, triggering a crisis that made the company threaten to leave the city. The company's position was supported by opposition councilors, businessmen and trade associations in Pirapora. This is in line with the findings of Hochstetler (2021) on the installation of wind farms in northeastern Brazil, according to which, in Brazil, with a high incidence of conflicts, compared to experiences in South Africa, for example. The survey also identified that half of the interviewees and residents of the city consulted were not aware of whether there was an increase in the municipal GDP. Many of whom did not even know about the installation of the plant in the city. Communication noises also occurred between society/companies/politicians, there was a lack of transparency about the process of implementing the plant. Some of the interviewees stated that communication actions could have occurred in a broader and more systematic way, including more meetings with the community/public authorities and using mechanisms to formalize these meetings (official records of public access, public minutes, etc.).

Revista ARACÊ
ISSN: 2358-2472

significant movement in the local economy. The city's restaurants, for example, served a thousand meals a day to workers who worked at the plant. A part of the restaurant's operation was placed, which is located in the center of the city, operating in the construction site itself.

FINAL CONSIDERATIONS

Brazil is the country that receives the most solar irradiation in the world. The fact that it is located close to the equator means that the country has a high incidence of sunshine throughout the day, with little variation throughout the year. This in itself would already be justification for the construction of solar parks and for our energy source to be increased on a large scale from solar energy.

There would be numerous justifications for the implementation of a photovoltaic plant project and we explore in this work different conditions for its feasibility. Some states, however, seem to have better solarimetric conditions than others. According to data from ABSOLAR (2019), in addition to Minas Gerais, part of the Northeast and the states of São Paulo and Rio Grande do Sul also have similar characteristics, but the state of Minas Gerais is the one with the best position in the production of solar energy in Brazil. We can say that the Minas Gerais region was the pioneer, so much so that it is in this region that the largest photovoltaic plant in South America was built until then, with the one in Pirapora.

The analyses of the indicators developed also did not prove to be sufficiently capable of justifying the investment in the mills, not even on the choice of regions. Everything indicates that the success of Minas Gerais was due to a combination of factors. The first of them, certainly, concerns the location of this state and the incidence of sunlight. The location, therefore, offers comparative advantages to the state of Minas Gerais. However, other states are also in similar positions of solarimetry.

However, the research shows that in addition to the privileged geographical location of Pirapora, the installation of the plant was only possible due to political strategies and tax exemption. Zolini (2019) showed the conditions of MG to differentiate itself from other regions:

"The differentiation in Minas Gerais occurs, therefore, when analyzing the particularities of the state control models (including legislation, legislative projects and the state licensing model for this type of enterprise). The State was a pioneer in the exemption of ICMS on solar energy and the expensive local energy tariff, associated with the high

Revista ARACÊ
ISSN: 2358-2472

levels of radiation in Minas Gerais, make photovoltaic systems connected to the grid a great solution".[4]

In addition, we try to show that both the formulation and implementation of large-scale public policies in societies such as the Brazilian one depend on the articulation and decision of different dimensions of the public bureaucracy, the executive, the legislative and civil society. The field research allowed us to understand important questions about the process of implementing the plant. The testimonies indicate that there was political and decision-making alignment between councilors, mayors of the municipality, state deputies, representatives of the Ministry of Mines and Energy (MME) in the Dilma and Temer governments and the Chamber of Deputies, lobbyists who worked in Congress, owner of the solar plant and businessmen from subcontracted companies in Pirapora. Therefore, the importance of political control over bureaucracy and the consequence on public policies is an interesting finding and corroborates studies on the subject (Arretche, 2023). Project implementation of local public policies, such as solar plants here, tend to be challenging for public management. The findings of the research seem to demonstrate that political alignment was decisive and the main enabler of this public agenda among councilors, mayors of the municipality, state deputies of the legislative assembly of Minas Gerais, representatives of the federal government and the federal legislature (Ministry of Mines and Energy and Chamber of Deputies), lobbyists who worked in Congress, owner of the solar plant, entrepreneurs of subcontracted companies in Pirapora. In addition, and in addition to the privileged geographical location of Pirapora, the installation of the plant was only possible due to political strategies and tax exemption.

The benefits of adopting more sustainable energy policies are unquestionable, especially considering that solar energy has several advantages, such as being proven to be less polluting and causing minimal impacts on natural resources. In the face of the current global climate crisis, there has been a significant increase in interest in transitioning from fossil fuel-based economies to renewable sources of energy. However, the findings of the research demonstrate that the socioeconomic impacts of photovoltaic plants are mostly concentrated in the installation phase, with the creation of jobs, heating of the local economy, greater social interaction and the possibility of tax collection, although these benefits are often exaggerated in political discourse (Zolini and Franco, 2019; Hernandez et al. 2014). During the operation stage, these effects decrease significantly, with the drastic

[4] Local development from the centralized generation of photovoltaic solar energy (2019).

Revista ARACÊ
ISSN: 2358-2472

reduction of jobs, the stagnation of the local economy and the drop in taxes collected by the municipalities.

Even though solar energy offers several advantages, public policies aimed at the construction of solar plants can fulfill very specific functions for the energy demands of some groups, however, with regard to regional development, its role in improving social indicators in less developed regions seemed limited, with few propagation effects in the local production chain due to the expected benefits being diffuse and not concentrated in any specific group (Hochstetler, 2021). Most of the benefits—whether economic or environmental—tend to be more diffuse, thus generating an extremely localized political economy.

The analysis of the indicators shows that there was a real increase in the municipal GDP from 2015 onwards, even considering the scenario of national economic crisis, however, this increase cannot be attributed to the implementation of the plant. Thus, socioeconomic benefits expected by both public managers and the population, although large at the beginning, had limited capacity after the installation of the plant and were greatly reduced at the end of the project. So far, the transfer of ICMS linked to the activity did not seem to significantly impact the municipality's coffers, to the point that businessmen and local residents, as well as politicians, did not know exactly if it was already entering tax revenues. This motivated an opposition councilor to request a formal response from the city hall about the entry of this revenue, but still no response.

Finally, the quantitative and qualitative analyses of public policies for the implementation of solar plants in municipalities in Minas Gerais municipalities chosen for this research show that the impact of this policy is quite limited and localized, in addition to being strongly dependent on and anchored in institutional and political incentives present since the implementation process. Thus, the limitations intrinsic to this type of project in relation to its capacity to foster local development are highlighted.

Revista ARACÊ
ISSN: 2358-2472

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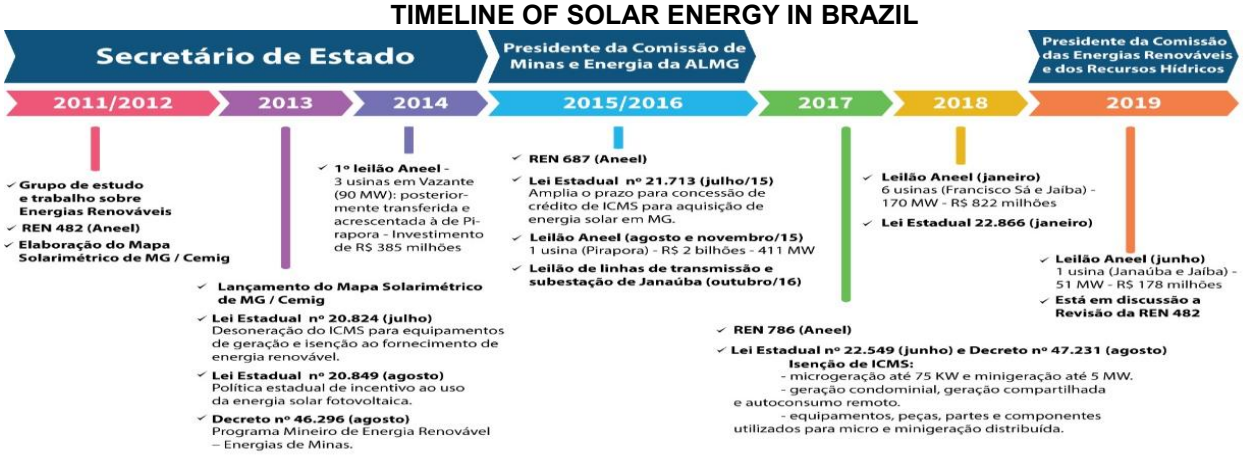
ANNEX I

TIMELINE OF SOLAR ENERGY IN BRAZIL



Source: Legislative Assembly of Minas Gerais.