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USE OF SOLAR FARMS AS ISOLATED SYSTEMS TO SUPPLY ENERGY SUPPLY IN SOME REGIONS OF NORTHERN BRAZIL

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ABSTRACT

For a solar farm to adequately meet the energy needs of electrically isolated Brazilian systems in the North Region, at prices compatible with local income, subsidies are necessary, whose establishment must correspond to a consensus of Brazilian society through its representative bodies. from the concrete bibliographic study of the electric supply of the northern region, it illustrates these previous observations and points out the need for the current efforts of sectorial restructuring to consider this issue and seek a new institutional design, capable of satisfactorily meeting the needs of those systems. This topic, until the date this article was written, does not seem to be receiving due attention from local government officials, for reasons until then unknown to the population suffering from a lack of energy supply.

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INTRODUCTION

The electrically separated Brazilian systems, centralized in the Northern Region of the country, can hardly, in the coming decades, have their electrical supply carried out within exclusively commercial principles. So that a company with profitable purposes can operate in this region and adequately meet the energy needs of the population, at prices compatible with local income.Many obstacles exist when talking about alternative energy source in the country. Solar farms are a great alternative to these isolated locations where conventional energy does not arrive. Solar farms are different from solar energy applications mounted on buildings and other decentralized solar energy applications because they provide solar power to utilities rather than to local grids. The size of solar plants available on large-scale solar farms ranges from 10 MW to more than 200 MW. Reports claim that approximately 25 acres of land is needed for each 5 MW facility that can supply 1,515 homes. Currently, there are only two types of solar technology that are capable of converting solar energy into an energy source: solar thermal and photovoltaic. Solar thermal collectors absorb solar radiation to heat a house or water. Photovoltaic devices use sunlight to replace or supplement the electricity supplied in the electricity grid. Currently, there are 235 separate locations in Brazil. Most of them are in the Northern region, in the states of Rondônia, Acre, Amazonas, Roraima, Amapá and Pará. The island of Fernando de Noronha, in Pernambuco, and some localities of Mato Grosso complete the list. Among the capitals, Boa Vista (RR) is the only one that is still served by an isolated system. Use in these locations is low and represents less than 1% of the total load of the country. The demand for energy from these regions is mainly met by thermal diesel oil.
Thus, the fulfillment of the new prerogatives of the Operator, related to the issuance of the Annual Plan of the Energy Operation of isolated systems for the year 2018, ANEEL authorized the ONS, through Order No. 4,343/2017, effective December 26, 2017,the "Operational Procedures for estimating the load and scheduling of the operation of isolated systems" proposed in Public Hearing No. 19/2017. This project aims at the development of solar farms in regions where the conventional system is not sufficient for supply, being one of

the alternatives of energy support as the thermal diesel oil already existing in the region. We will also show all the infrastructure needed to create a solar farm from the structure to the policies for the construction.

Teorico Reference: A broader definition of solar farms could include a huge number of solar panels mounted on the ground large enough to provide power to many homes. This general concept of a solar farm can be associated with both residential community solar energy and large-scale solar energy (1). Customers can buy a portion of the solar farm boards and own that part of the general set, or they can rent power from the solar system and, in a way, replace their monthly payments for utilities with monthly community solar payments that typically have a lower price.

Solar Farm in the northern region: The largest solar farm in the Northern region of Brazil. This is how the new investment of the Flat Group in the Amazon is presented. Located in Manaus, the power generation system is one of the company's bets for the coming years and invests in a concept that gains more and more strength and is a trend around the world: a sustainable future. With more than 5,000 square meters of solar panels and generating four megawatts per hour on average per day, The Solar Energy Farm of Flat is located in Manaus and will generate clean renewable energy for the company's employees and customers who compare quotas. With this, the electricity bills at the end of the month become cheaper for those who participate in the program. The Solar Energy Farm of Flat has the capacity to produce energy to supply the equivalent of 570 homes. In addition, it also avoids the emission of three tons of carbon per day. Initially the benefit will be shared with Flat employees and will soon be available to customers," explains the institutional video posted on Twitter by The CEO of Flat, Denis Minev.

Source: Agro Amazon Forest

Figure 1. Solar Farm of Flat

Shared Generation: According to Denis Minev, while it does not reach consumers, Bemol will set up a cooperative to make the generation shared with employees. The shared generation of solar energy is characterized by the union of consumers through consortium or cooperative (6). These consumers, who may be individuals or legal entities, will share the costs and benefits of the generating unit, which will be installed in a different location from the consumer units. The energy generated by the plant is injected into the concessionaire's network in the form of energy credits. As in the consumer unit in which the plant will be connected there should be no power consumption, (5) all generation must be converted into credits.

Solar Panels and Solar Cells: Before we begin to explain the comprehensive process of the solar farm, let's first define the nuances of solar panels, also known as photovoltaic panels (and the solar cells from which they are made) - since they are the most important and necessary component in capturing and harnessing the power of the sun.

As with any electrical circuit, solar cells create electricity generating a stream of electrons, but how does that start?

Simply put, a solar cell is composed of four layers, with the two outermost layers being conductive plates from which electrons will flow to the energy source (7).

However, it is from the two innerlayers where most of the solar-electric magic happens.

The two innermost layers of a solar panel are two different types of silicon - one that has been positively charged (with fewer electrons than standard silicon) (7) and the other that has been negatively charged (with extra electrons than standard silicon).

It is with these two layers of silicon that light particles (known as photons) react.

When the sun shines on a solar cell (a solar panel is composed of several solar cells), it beats an electron from the negatively charged silicon layer.

Then, due to the charges inherent to the two layers of silicon, the newly removed electron is forced into the outer conductive plate.

From the outer conductive plate, the electron flows into the connecting wires and then to its destination (be it a battery, a light, etc.) in the form of direct current.

Although a cell can generate only up to 0.5 V, if you chain multiple cells into a panel, the power output increases accordingly.

For example, 12 solar cells together will be enough to charge your phone directly.

If you connect some cells with a battery (similar to a solar power bank), the cells can be used to charge the battery, which will store the power charge and output with enough amperage to charge your phone.

How Energy is Converted

It can be noted that solar panels produce direct current (DC) energy, while our modern electri03/093/9al system is in alternating current (AC).

So how is solar panel energy converted into the form of electricity that is used in our electricity grid?

Typically, (2) you'll find that attached to each solar panel is a solar inverter (an energy inverter explicitly designed for use with photovoltaic cells) - with static solar inverters being the most common these days due to the lack of moving parts, which as we explained before means less maintenance.

Now, solar inverters also have to deal with many continuously different environmental conditions, such as temperature and solar irradiation, which causes spikes and depressions at the DC outlet of a solar panel (12).

Therefore, to maximize the amount of energy at any given time, the solar inverter needs to employ Maximum Power Point Tracking (MPPT) so that the resistance can be adjusted to an optimal level, which will later optimize the power output.

This technology has now reached a point where solar inverters, known as 'solar micro inverters', can be coupled to each solar panel to maximize the production of each solar panel and, as such, better maximize the production of the entire plant as a whole.

How solar farms maximize the energy of the sun

In the past, it was quite reasonable for solar panels to be installed at a fixed angle, which would be the ideal angle for the entry of photon cells throughout the year.

But in some seasons, ingestion would be less than ideal due to changing the angle of the sun as it passes through the sky throughout the year (12).

In recent years, there have been significant developments to maximize photon cell intake for each solar panel, and that's what we'd love to discuss here.

The first development was the tracking of a single axis, which would follow the sun as it passed through the sky.

Although single-axis tracking did not take into account the change in the trajectory of the sun in the sky as the seasons changed, it helped capture more photons, as the solar panel would follow the sun from sunrise to sunset (12).

Then there was dual-axis tracking, which does exactly what single-axis tracking does, but also accommodates changes in the sun's trajectory throughout the seasons.

Therefore, about normal flat solar cells, the entry of photons was fully optimized.

However, the future of solar energy may be even more sci-fi than you can imagine.

A recent development in solar agriculture is the introduction of potential floating solar arrays (or more colloquially known as 'photovoltaics').

While capturing direct sunlight may be ideal, the new introduction of these floating solar arrays can also choose any photons that ricochet on the surface of the water, potentially capturing photons that didn't even hit the solar panel in the first place.

In addition, it has been shown that this new development in 'photovoltaics' increases the efficiency of solar panels due to the natural cooling properties of water.

What size of solar panels on a solar farm?

While a single/double cell panel may be small enough to fit into an energy bank, commercial/industrial sized solar panels unite a much larger number of solar cells.

The panels you'll find on solar farms consist of at least 72 interconnected solar cells, and perhaps more, depending on the size and age of the solar farm.

A panel of 72 solar cells is on average 78 inches long and 39 inches wide with a depth of 1.5-2 inches.

A panel of this size will generate about 400W depending on the efficiency of the solar cells used.

This is, of course, much more than the previous examples we are discussing, but where a solar farm stands out is not in the size of a single solar panel, but in the absolute number of solar panels that may be present on a single farm (11).

Largest solar farms in the World ?

The first 1 megawatt-peak solar farm (MWp) was built in 1982, with MWp referring to the maximum theoretical direct current production of the farm - in this case, 1 megawatt. However, since then, the capacity and efficiency of solar parks has only increased with the improvement of photovoltaic technology (19).

While solar parks of 1 MWp and 10 MWp were quite popular in the late 20th century, the most recent solar power stations that were completed this decade or are still under construction have MWps of at least 200.

However, some of the world's largest solar parks have mind-blowing capacities of more than 1 GWp (which equates to 1,000 MWp), such as the Tengger Desert Solar Park, which was completed in (17) and had a capacity of 1,547 MWp.

The limit does not stop there, however, as some solar parks that are still under construction, such as the Pavagada Solar Park in India, have a planned capacity of more than 2 GWp - with this example expecting a whopping 2,050 MWp (17)

To see a list of some of the largest modern solar parks and their potential, you can look at some of the biggest ones at this link here.

This incredible energy supply should require an incredible amount of space that you might think requires an incredible amount of space, but it's just not the case.

You can imagine that solar farms require an impossible amount of space to provide an adequate amount of energy to a city, but that would be wrong.

The largest solar farm listed in the aforementioned list occupies a space of 20.46 square miles.

To put this in the world's perspective, it is estimated that between tens and hundreds of thousands of square miles would be needed to provide enough energy to the entire world, while the Sahara Desert alone has more than three million square miles.

So, relatively speaking, the space needed for solar panels to provide energy to the world is minimal.

What is most crucial and necessary for better distribution of solar energy in the poorest parts of the world is a more reliable electricity grid for these solar parks.

METHODOLOGY

This article, aims to present a methodology for the study of the implementation of a solar farm in the northern region of Brazil, will first make a theoretical approach regarding the exploitation of concentrated solar energy (10), existing technologies and the current world scenario of solar energy generation. After the theoretical basis, the feasibility study will be developed emphasizing the analysis of costs, performance and financing of electrical systems connected to the network in a simple way and with a user-friendly platform. The feasibility study will consist of assessing the potential of the northern region for the exploitation of concentrated solar energy. The literature clearly shows that environmental criteria, including solar radiation and appearance, have a very large impact on the selection of areas for the location of a solar farm (12). In addition, in many analysis criteria such as proximity to built areas, proximity to power lines or proximity to roads are taken into account (14). These criteria have an impact on minimizing the costs of solar farm construction generated by the provision of technical infrastructure. The criteria that determine the location of solar parks can be classified into three groups: technical and socioeconomic environmental.

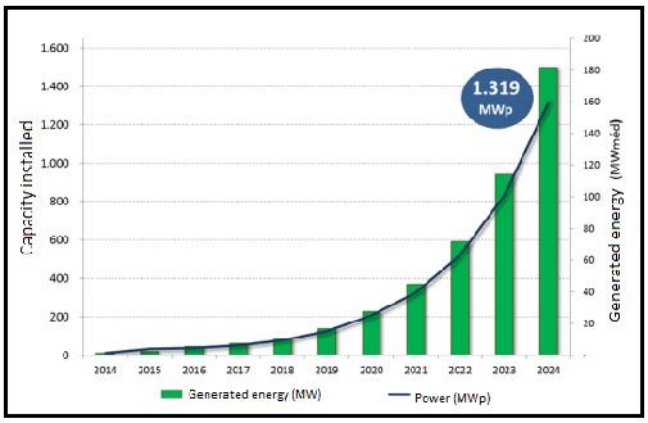
Table 1. Division of Criteria

Environment	Technical	Socioeconomic development
• Solar radiation. • Aspect.	• Proximity to power lines. • Proximity to built areas. • Proximity to roads	• Lot size. • Form factor. • Property structure.

Source: Own authorship, 2020

RESULTS

In 2012, the National Electric Energy Agency (ANEEL) published Normative Resolution No. 482, later updated by Normative Resolution No. 687/2016, in which the general conditions for micro and minigene ration distributed in the country are established, as well as the electricity compensation system. This resolution allows customers of energy distributors to have their own generation systems and to inject their surplus into the grid in exchange for energy credits and can be used to reduce the value of future electricity bills for a period of 60 months.

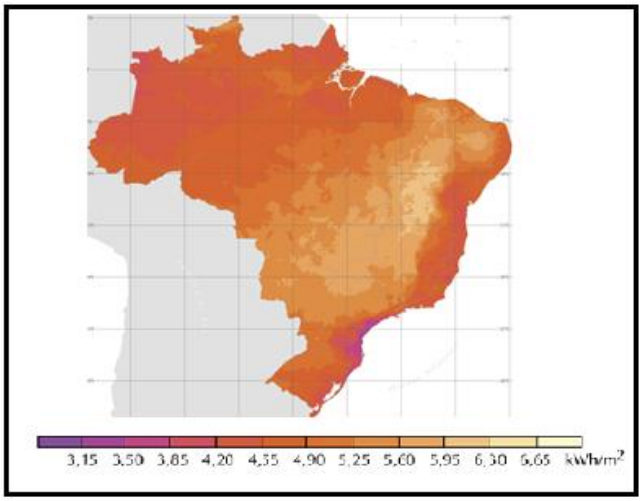


Source: Energy Research Company 2014

Graphic 1. Forecast for growth by 2024 is exponential

In this context, it is seen that the photovoltaic power generation sector is one of the fastest growing Brazilian sectors, even during the country's recent economic crisis, with a growth projection of 300% in 2016 (4). In the period from 2013 to 2015, the number of photovoltaic solar installations in Brazil grew more than 70 times. Even though the number of installations is numerically low compared to consolidated countries in the sector, such as Germany, China and the United States, the Energy Research Company (17).

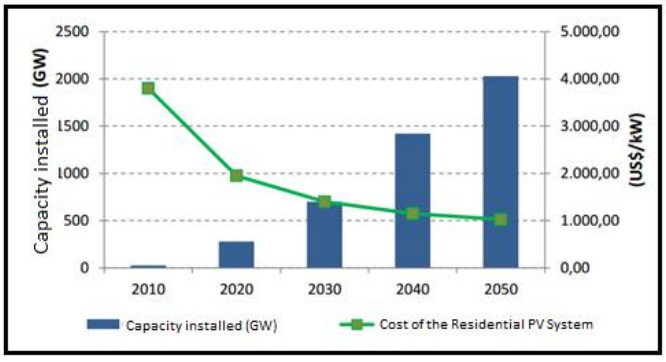
Brazilian Potential: Brazil is a country that has high levels of insolation and, thanks to this, is seen with great potential to become a consolidated generator of photovoltaic solar energy. German heat stroke levels, one of the largest photovoltaic producers in the world, are lower than in Brazil. So much so that the best place in German territory in relation to insolation has only two thirds of the insolation of the worst Brazilian place. In Brazil, the North. Northeast and Midwest regions receive the highest solar insolation. The Brazilian National Institute of Space Research (INPE) produced the Brazilian Solar Atlas (14), below illustrated with global solar radiation in the inclined plane, annual average.



Source: National Institute of Space Research, 2019

Figure 2. Horizontal annual average solar irradiation map

Global Perspective: The prospects of the International Energy Agency (IEA) are exponential growth in installed photovoltaic capacity. It is estimated that by 2050 there will be about 2000 GW installed, more than 100 times the total installed capacity in Germany in 2010.



Source: Preparation of the EPE from IEA

Graphic 2. Projected growth of installed capacity and costs by 2050

Table 2. Types of photovoltaic systems

Type of System	Equipment used	Purpose	Cost
Connected to the network	Photovoltaic Panels Frequency inverters	Reduced light bill Reducing environmental impact Shielding against fare increase	Less
Isolated	Photovoltaic Panels Batteries Frequency Inverter Load Controller	Generate power in isolated locations of the power grid Independence of the Electricity Network	Greater

Source: *Solstice Energy, 2017*

According to IEA data, by 2020, residential and commercial systems are expected to account for approximately 60% of photovoltaic generation, while photovoltaic plants will account for 30% and isolated systems 10%. This growth is the result of increased demand for small systems due to a drop of approximately 50% in costs between 2010 and 2020 (5).

Analysis of the Types of Photovoltaic Systems: Photovoltaic systems connected to the network differ from isolated network systems (off-grid) in three main aspects: in the types of equipment used, in the purpose of use and in the associated cost. This system offers advantages, such as greater guarantee of energy availability at times without heatstroke, lower installation cost, regularized market and reductions in the electricity bill and environmental impact of those who install such a system, besides having lower maintenance cost *than off-grid systems* because they do not have batteries.

Conclusion

The northern region of Brazil is one of the most deprived in the country and does not offer cheap energy to all regions. According to a report by the International Energy Agency (IEA), at least 1 billion people still do not have access to electricity in the world, with 1 million living in Brazil, mainly in the legal Amazon. Photovoltaic power generation has also contributed to the monitoring of some turtle species in the Amazon and to the fight against illegal deforestation. As the riparian's have managed to remain in the area for sustainable extraction of biodiversity products, they contribute to the protection of forests and thus to the increase of the carbon absorption capacity of the atmosphere. S climate changes related to deforestation and biome degradation greatly enhance the effects for a population that relies on natural resources to survive. And the Amazon is fundamental to the rain's regime of the Midwest, for example. So, it's important to know that everything is connected. By conserving the forest and promoting sustainable development, we are also contributing to the well-being of people throughout the country.

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