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PHOTOVOLTAIC ENERGY AS A SOLUTION FOR ENERGETIC CRISIS: ANALYSIS OF TECHNICAL FEASIBILITY OF ITS IMPLEMENTATION IN BUILDING AN INSTITUTION OF HIGHER EDUCATION IN ITAPERUNA- RJ CITY

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ABSTRACT

This paper has two aims, first to review existing literature on solar energy, addressing topics such as their origin, development, possible uses, projects involving solar energy, institutions already employ and utilize this energy and how solar power came to help the fight of future energy demands that are to come. The second objective is to study the technical feasibility for the implementation of a photovoltaic system at Redeemer University Society in Itaperuna City, RJ. Checked the technical feasibility of installing a system at the institution, which had an average high annual solar radiation between 4,5 and 5,10 kWh / m².day and a large area available for installation of photovoltaic modules.

Keywords: solar energy, photovoltaic, renewable energy.

INTRODUCTION

The world on alert. The world population is growing at an alarming rate, is there framework for such growth? With the passage of time and the population growth exists need of advance and creation of new technologies to somehow meet the needs as well as improve the way of life of the population. In contrast with this technological advancement, it resulted in an increase of energy consumption worldwide. This consumption is growing in leaps and bounds. It is estimated that world energy consumption will grow one-third over the next 25 years. As the largest consumer China followed the United States. China consumes 70% more energy than the US. Much of the increase in energy consumption is China and India responsibility. (IEA, 2011)

The Brazil, is not far behind, energy consumption grows remarkably and with their events to be held in Brazil, which will result in an even greater leap in the Brazilian energy consumption due to infrastructure requiring such events. It is estimated that Brazil will be the second country in the world with the fastest growth in primary energy consumption in the next 25 years, second only to India which will hold the first place. It is estimated that in the next two decades the energy consumption in Brazil will increase about 80% of current consumption. This will lead Brazil to a jump in the ranking of countries with the highest energy consumption. The Brazil which occupies the eleventh position, with that growth, is expected to jump to seventh, leaving behind great powers such as South Korea and the United Kingdom. (IEA, 2011).

These data, presented by the International Energy Agency, are alarming to Brazil. Despite the creation of another nuclear power plant in Angra dos Reis and other projects for a few more nuclear power plants, incentives for the use of PCH's and the much-discussed Belo Monte Dam, such measures are still insufficient to meet this future energy demand. There is a lot of pessimistic theories on energy demand in Brazil, citing that within five (5) years if Brazil not structure himself effectively, it will suffer from continuous blackouts, resurrecting the ghost haunting as energetic rationing, lived in time of the FHC government, which could lead the country to a total chaos. Despite being just a theory, it connects the warning sign and should generate new energy initiatives, so that in the future Brazil may become a sustainable world power.

Brazil is "ready" for the future a snail's pace, with some incentives to research new forms and sustainable energy source, and most of these surveys are being developed by Solar Power Reference Center Wind Sergio Salvo Brito, CRESEB . However, these incentives are limited only to research. There is almost no incentive for the use, sale and use of these technologies. These surveys are based on renewable energy sources and hybrid systems.

Brazil has great wind and solar potential, this potential which enables the use of wind power generation systems, solar power generation system and even hybrid systems for wind-solar energy generation. Perhaps this is one of the ways that Brazil needs to go at the future without going through some kind of energy shortage, thus avoiding possible blackouts, energy shortages and even a national chaos. Thus, Brazil would walk briskly to become increasingly sustainable country, leaving the world an example and a way to help prevent future climate disasters.

Thus, this paper aims to make a historical review of the use of solar energy and its use to combat future energy demands, as well as demonstrate how the analysis would be the area for installing a solar photovoltaic system, identifying items capability system installation region, area of sunlight available for installing cards, etc. This work is part of the initial findings of a project that aims to analyze the technical and financial viability for the future installation of a photovoltaic system to meet João Carlos de Almeida Mielli Library, the Redeemer University Society, a system that can be easily expanded to whole building of the institution.

LITERATURE REVIEW

Solar Energy in the World

Thus, this paper aims to make a historical review of the use of solar energy and its use to combat future energy demands, as well as demonstrate how the analysis would be the area for installing a solar photovoltaic system, identifying items capability system installation region, area of sunlight available for installing cards, etc. This work is part of the initial findings of a project that aims to analyze the technical and financial viability for the future installation of a photovoltaic system to meet João Carlos de Almeida Mielli Library, the Redeemer University Society, a system that can be easily expanded to whole building of the institution.

The intense and indiscriminate exploitation of non-renewable fossil fuel reserves well as environmental damage elapsed from use of these energy resources implies a worrying scenario. Thus, the emergence of new sources of alternative energy, in particular renewable and non-polluting, such as solar and wind, waves for a new time.

For economic reasons the interest of the United States and Europe for solar energy use has grown in the last two decades, especially after the crisis of the 70s in the oil sector.

Currently, there is spoken only in the application of this radiation as a source of clean and renewable energy, but also the climate of knowledge and its changes (Souza, 2011).

Solar energy can be divided into two categories, solar photothermal and solar photovoltaic (CRESESB, 2006).

The photothermal solar energy is based on the amount of energy that a given body is able to absorb in the form of heat from solar radiation. This principle is used in solar water tanks and distillation. This method of desalinization through the sun compared to other desalination methods as: Electrodialysis, which is the removal of salt ions by electric field application, and the freezing method offers the best value benefit cost and greater efficiency; The photothermal solar energy is also used in water heating systems, which may be heating passive and active. Being passive solar heating used in tanks, as mentioned above, this direct heating by solar radiation, however presents low efficiency. (Aldabó, 2002).

In 1839, Edmond Becquerel noticed an appearance of a difference at the extremes of a semiconductor material structure produced by absorption of light, it was from this observation that came the concept of the photovoltaic effect. From there it moved to the development of this concept to reach the use of solar energy as a means of obtaining electricity. The apex of the development of this technology was given at the time of the space race and the use of satellites, whose principal source of energy in the sunlight. Thus, this technology was a little more polished, within the limitations of the time, as a source of energy for the spacecraft because the space was the easiest way to get energy without burdening the aircraft with fuel tanks (CRESESB, 2006) .

With the energy crisis of 1973, the development of this technology has gained momentum. Several American companies oil business of diversified their investments into new ways of obtaining energy and solar energy was the most received investment. With the expansion of the research and development of such technology, it turned out that the sun was rich source of energy, about 10.000 times the energy consumed at the time, approximately 1.5 x 1018 kWh (Farida B, Iniyan S. and GOIC R., 2011).

Gone is then improving the facilities and their efficiency, resulting in the photovoltaic cell, used to absorb energy from the sun. Over time and with new studies, it was realized in silicon the potential of a better material to be used in photovoltaic cells, and this conclusion rather importance for further investments in this technology because silicon is the second element most abundant of the globe (LANDI, 2010).

In 1993 the production of energy through the sun reached a record of 60 MWp (CRESESB, 2006). In the year 2000, that number was three (3) times, and several countries

have been using this technology, even countries not very suitable for the use of this technology.

With the growing demand for energy, rose another factor is the possible end of fossil fuels, which can generate an energetic chaos and thus hatch numerous wars and conflicts for obtaining such an important black gold (CRESESB, 2006).

In the coming decades all countries of the world have to halve the level of emissions of greenhouse gases, but this reduction should not reflect on the production of electricity, since the potential energy of a country can not decrease because it could cause serious damage and blackouts in such countries (CRESESB, 2006).

Because of this scenario several solutions have been proposed, some of which are already too many known of the world's population, such as photovoltaic panels, which have great use in European countries with the Netherlands and Germany and water heaters, replacing the electric showers and heated by natural gas and have their use already far more widespread throughout the world. However, there are other projects and prototypes which in a way can be availed as being future: SES (Solar Power Satellite), Solar Two, SSM (Solar System Maritime) and Phoebus, etc.

Phoebus is a European consortium that aimed to install in Jordan one term Solar Plant of 30 MW using volumetric receivers. These receptors, as its name implies, receive heat and serve as means of transport to drive a generating turbine power.

The Solar System Marine, SSM, which would be used to assist in getting out of the ship, has its operation based on the use of the electrolysis of water. Hydrogen is one of the final products of electrolysis would be forwarded to the conventional boiler, can also be recombined with oxygen in combustion chambers for heated steam and drive the turbines.

The Solar Two Project is a power generation project, with a potential of 10 MW, located in the Mojave Desert - California - USA, using a solar energy harvesting technology tower type, capture this that is innovative, where the tower it is responsible for housing the receiver. This plant has been in operation since 1997, and the Two numbers are very good, with a monthly average of 1633 MWh. The receiver efficiency is around 88%. The highest yield of the turbine was 11.6 MW. The storage system has a very high efficiency of 97% and higher availability achieved was 94% in 1998.

However, the project that draws the most attention is the SES Satellite Solar Energy. This project draws attention due to the great innovation proposal regarding the capture of solar energy. Conventional solar energy harvesting is one that focuses on the land. In the method

thought to the SES capture this energy would take place in the orbit of the earth. The Solar Power Satellite would be placed in orbit the earth and send the energy generated by microwave. However, this idea has caused great controversy both in regard to the technical branch says, as in social and political areas. With regard to technical and political issues are questioned numerous factors, because due to its size of approximately 50 square kilometers, weight of 90,000 tons and a capacity of energy generation to 10,000 MW, so would cause major impacts on raw materials available in earth, being very difficult to place an apparatus of such size in orbit. But the biggest controversy arises in the social sphere. The big question raised is about the damage caused by exposure to low-frequency steadily radiation waves.

The big advantage of solar generating system is that, in addition to large capacity power generation, there is a constancy in this generation, 24 (twenty four) hours, as the satellite is in orbit of the earth. However, this system has major disadvantages and technical difficulties. Besides the controversy has caused, for receiving energy to build a tower of 50 square kilometers would be required in addition to the protection area against incidence of microwaves around the antenna. The cost of this project amounts to US gross domestic product and to transport such a structure would need thousands of people and high-capacity ships. Such investment would have a very short useful life of only 10 years, because of a great deterioration, about 10%, damage to the conductors of the photovoltaic surface. (Aldabó, 2002).

Solar Energy in Brazil

Nationally, photothermal technology began discreetly being used only in some homes and later in kindergartens and schools. Today, industries, hotels and condominiums have adopted the technology and the trend is that more and more this energy is used, because of the benefits to the environment and especially the economy for whom employs.

Photovoltaic technology is gaining space quickly. On the last day 30/06/2011 Brazil won its first solar power plant, which is located in Taua, 344 km from Fortaleza, with a generating capacity of 1MW, which expects to serve about 1500 families, such investment is the EBX group. (INEE, 2011).

In upstate Rio de Janeiro, in the city of Macae, this city considered the heart of the state of development of Rio de Janeiro, residential air conditioning companies are offering air conditioned devices with power by photovoltaic panels. (Souza and Cerqueira, 2011). The trend is that this technology is increasingly diffused. Some parks and public places already have their photovoltaic facilities such as the Ecological Station Juréia, Green Porto Sauipe Park, Rio de Janeiro Park. There is also a federal program, Light for everyone, it takes solar

energy to the inhabitants of remote locations and the solar photovoltaic system will be used. (Tolmasquim, 2003).

Soon solar energy has all the requirements to combat future energy demands due to their availability, employability and being a renewable source.

ANALYSIS OF AVAILABLE AREA

For the definition and collection of available area data, some funds were used with database help of APOLLO 11, CRESESB, Google Earth and other aid instruments. In Figure 1, you are shown a map of the state of Rio de Janeiro.

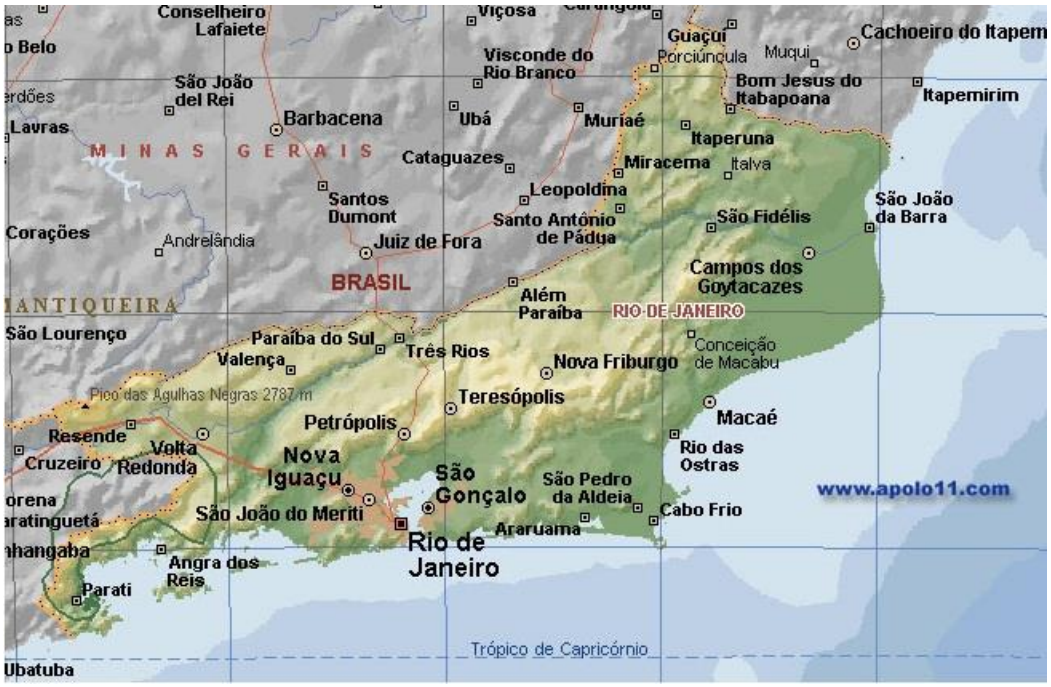

Figure 1: State's Map of Rio de Janeiro
Source: APOLLO II, 2012

Bounded on the region of the city's location, departed to the survey of spatial data Redeemer College location using Google Earth (Figures 2 and 3).

Figure 1: localization's Photo of Redeemer University Society.
Source: Google Earth (Upper View).

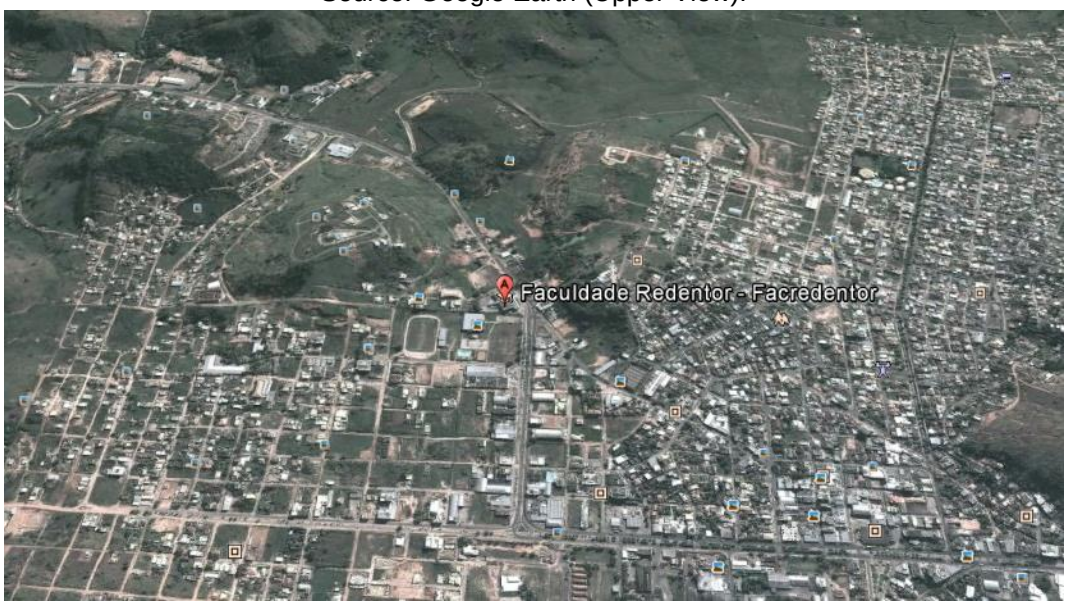

Figure 3: localization's Photo of Redeemer University Society.
Source: Google Earth (Panoramic View).

With Google Earth's aid, defined the location completely. The institution is located margin of BR-356, with the following data:

- Latitude: -21º 12 '18' 'South.
- Longitude: -41º 53 '16' 'West.
- Elevation: 108 meters.

In addition to the influences caused by the location, there are the influences caused by the characteristics of the solar geometry, as can be seen in Figure 4.

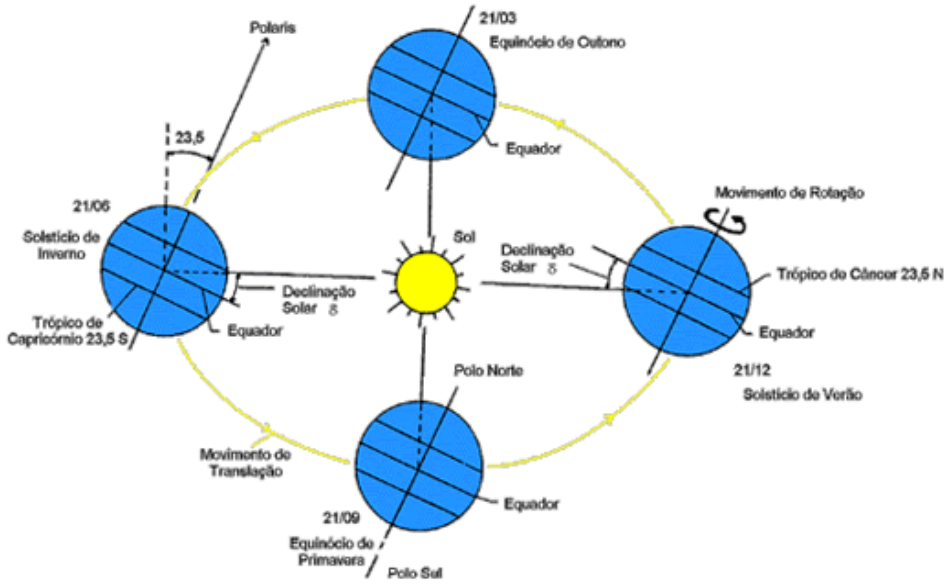

Figure 2: Earth's orbit around the Sun illustration.
Source: CRESESB

- The sun rises in the east and sets in the west.
- The Earth's orbit is an elliptical orbit around the sun and the axis of Earth's rotation makes an angle of 23.5 ° with the normal to the ellipse plane of Earth's orbit.
- Solar slope varies between values: -23,45º 23,45º.
- The Surface Azimuth angle varies between 180 ° -180 °.
- Solar radiation intensity that reaches the Earth is about 1.3 KW / m².

By knowing the Rayleigh and Mie theory which says that influences the air mass through the effect of absorption and scattering of solar radiation. Relationship (simplified) this defining that:

$$AM = \frac{1}{Cos\theta} \qquad AM = \frac{1}{Sen\alpha}$$

Where:

AM is the air mass.

θ and α are the angles of incidence.

It is noteworthy that air pollution interferes with the results.

Defined locality of data, began the definition of climate data that influence the potential for solar power generation (Table 1).

Table 1 - Weather Itaperuna - RJ.

Tabela Climática de Itaperuna-RJ.												
	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez
Máx	32ºC	33ºC	32ºC	30ºC	28ºC	27ºC	27ºC	28ºC	28ºC	29ºC	29ºC	31ºC
Mín	22ºC	22ºC	21ºC	19ºC	17ºC	16ºC	15ºC	16ºC	17ºC	19ºC	20ºC	21ºC
Média	27ºC	27ºC	27ºC	25ºC	23ºC	22ºC	21ºC	22ºC	23ºC	24ºC	25ºC	26ºC
Precip (mm)	188	97	104	91	46	23	30	30	56	109	196	208

Source: INMET, 2012

Based on climate Itaperuna table (Table 1) it is concluded that February presents the highest temperature, 33º C, and June has the lowest minimum temperature, 15º C and the lowest average 21º C. The months of January and February have the highest minimum temperatures, 22º C. Already the months of highest average temperature is in January, February and March. The month of December was the month with the highest rainfall index about 208 mm. The incidence of ultraviolet radiation is very high, 9 UV level on a scale that goes up to the maximum of 14.

The next step was to define the solar radiation potential of Itaperuna - RJ locale, this potential takes into account:

- radiation to the soil level
- Extraterrestrial radiation.
- calculations Mathematical Methods.
- Location.

The data obtained in CRESEB are shown in Table 2 and the Figure 5 graph.

Table 2 - Daily radiation Itaperuna

Radiação Diária Média [Kwh/m².dia].												
Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez	Média
6,06	5,89	5,28	4,39	4	3,53	3,75	4,47	4,28	4,86	5,25	5,83	4,80

Source: CRESEB, 2012

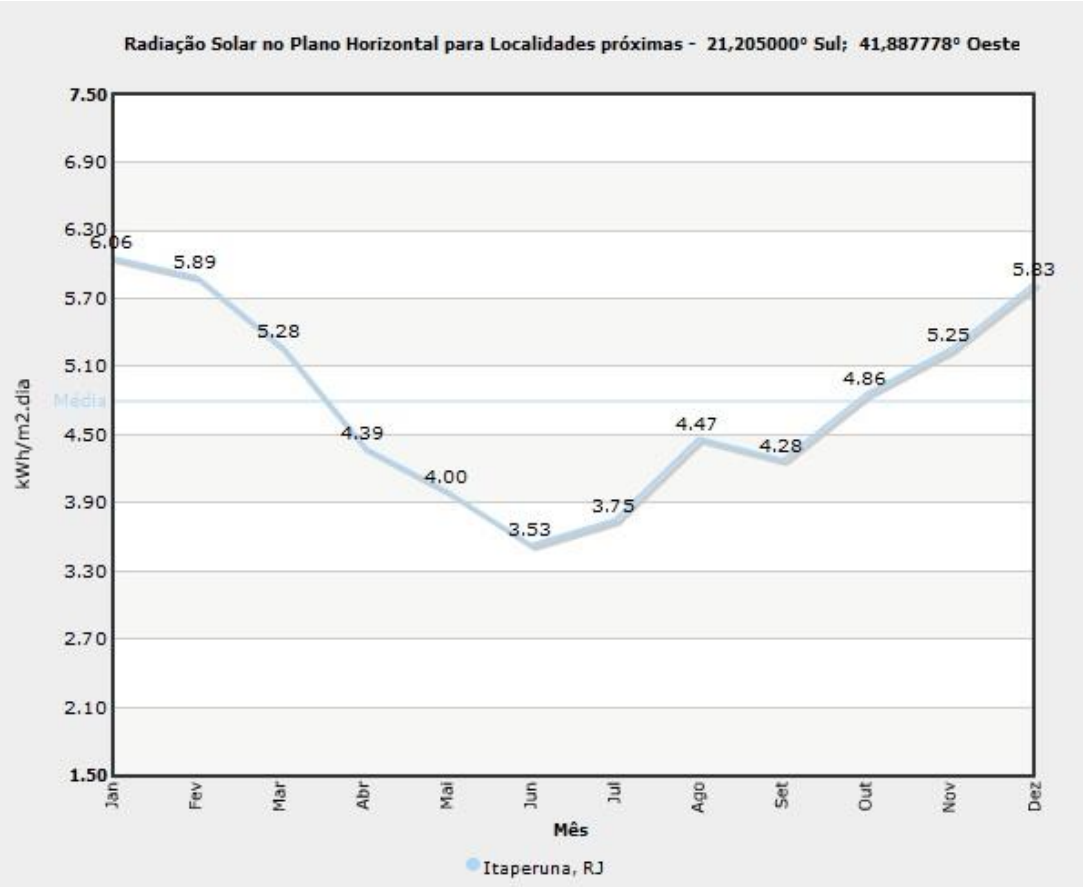

Figure 3: Graph of solar radiation in Itaperuna.
Source: CRESEB, 2012

In Table 2, as in the Figure 5 graph, it is clear that the month with the highest level of solar radiation is the month of January, with 6,06 kWh/m².dia. The month of June has the lowest level of solar radiation, with 3,53 kWh/m².dia. The average radiation level was between 4,50 and 5,10 kWh/m².dia. This is evident with the good level of solar radiation, which enables its use in the region.

These data become reliable when the results are compared with the Solarimetric Atlas Annual Brazil (Figure 6), since the results of the survey hit with the results obtained in the Atlas.

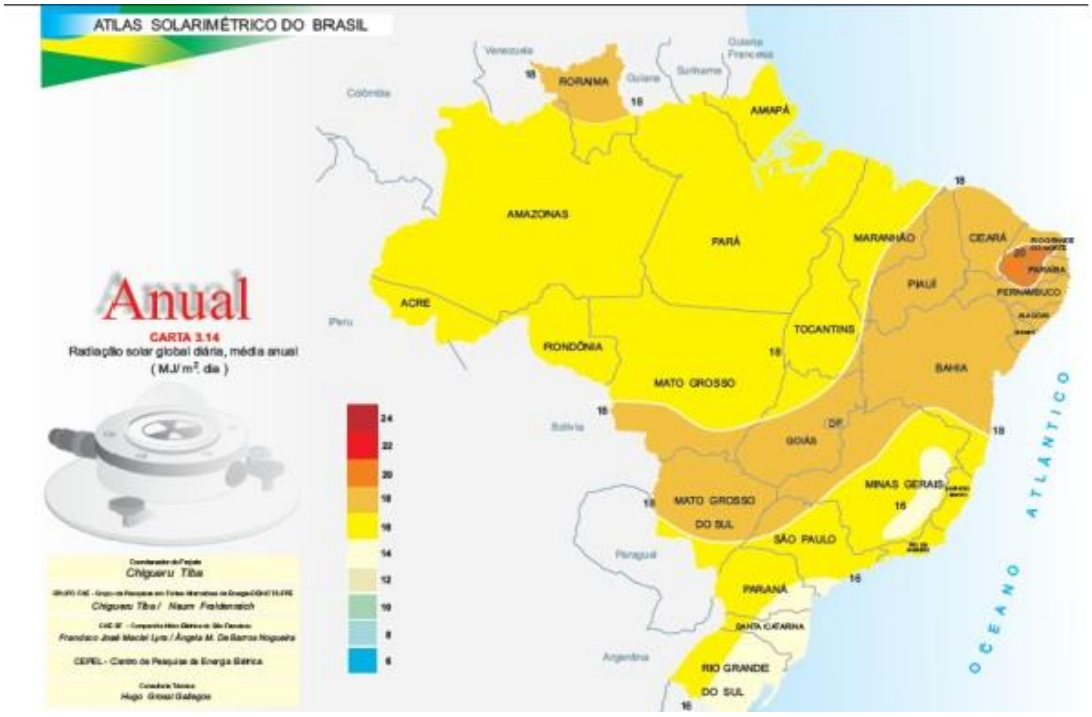

Figure 6: Map of Solar Radiation Global Daily.
Source: Atlas Solarimetric in Brazil, 2011.

The next step was to consider likely radiation levels for possible inclinations in the premises of the PV modules (Table 3).

Table 3: Daily Radiation Itaperuna with Inclination.

Radiação Diária Média [Kwh/m².dia].															
Ang.	Inclin	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez	Média	Delta
P. Horizontal	0° N	6,06	5,89	5,28	4,39	4	3,53	3,75	4,47	4,28	4,86	5,25	5,83	4,80	2,53
Ang. Igual a Latitude	21ºN	5,50	5,63	5,41	4,89	4,85	4,45	4,65	5,19	4,5	4,74	4,85	5,23	4,99	1,18
Maior Média Anual	19ºN	5,57	5,67	5,42	4,86	4,79	4,38	4,58	5,14	4,5	4,77	4,99	5,31	4,99	1,30
Maior Mínimo Mensal	23º	5,42	5,57	5,4	4,91	4,91	4,51	4,71	5,23	4,5	4,71	4,79	5,15	4,98	1,08

Source: CRESEB, 2012

In the Figure 7 graph the data with respect to solar radiation on the inclined plane for the city of Itaperuna are presented.

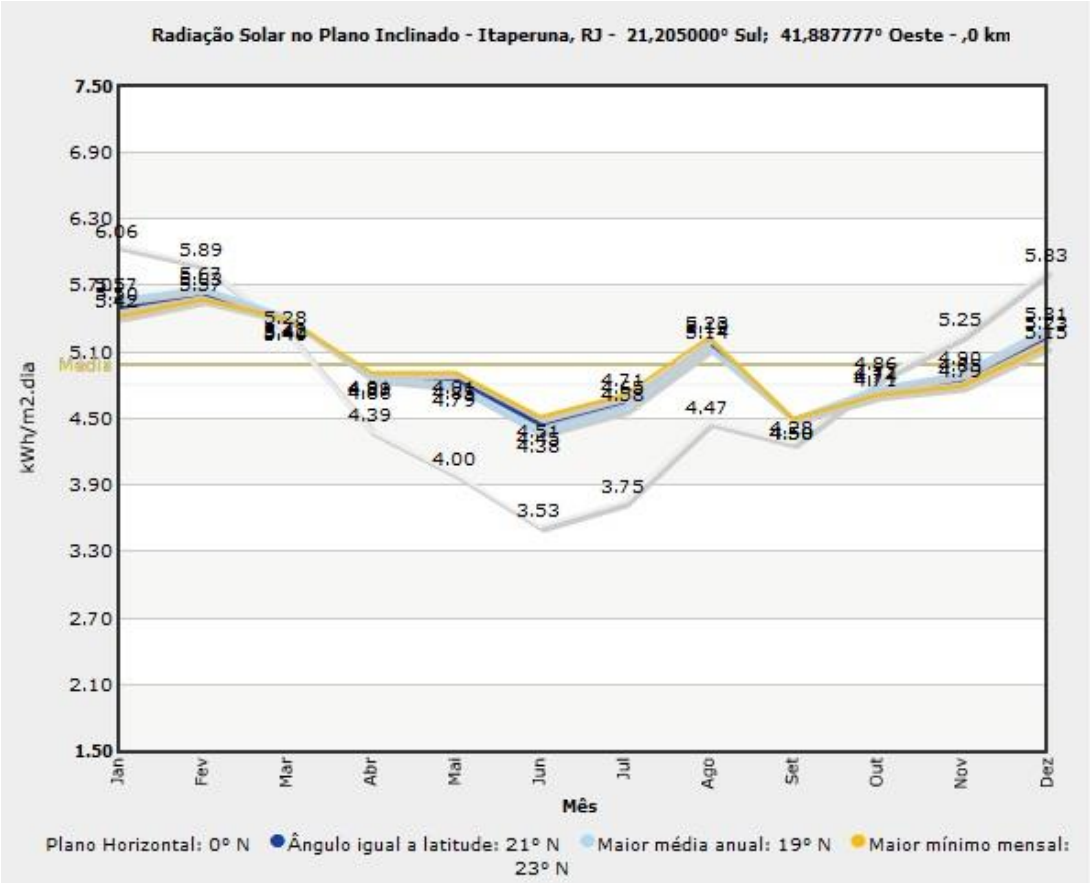

Figure 7: Graph of Daily Radiation in Itaperuna with inclination.
Source: CRESEB, 2012

Analyzed the feasibility of possibilities for using photovoltaics in the city of Itaperuna, it moved the task of identifying the best inclination for the project, always seeking the best technical and economical solution. It is worth noting that the average solar radiation for inclined planes was higher than the average of the horizontal planes.

Solar radiation is not constant, it fluctuates during the day but has its most intense at midday-sun, time of day that the sunlight is perpendicular and the photovoltaic system has its maximum power generation, which is called time solar peak. During the day the solar radiation varies, but in a certain part of the day it goes from minimum to maximum, returning later in the day to the minimum in the evening.

Knowledge of the peak hours of the location where you want to install a PV system is of great importance because it is at such times of peak sun photovoltaic panel will be generating as much energy during the day. This period is usually between two to three hours before and after the solar noon, which is different from half a day (12 h) hours. The medium solar day is when the sun's rays are projecting on the north-south direction, the local meridian, it varies from location to location and also the time of year. Therefore, in Itaperuna, here is a period of insolation approximately eight (8) hours and four (4) hours of peak hours.

It is clear peak period of time in the graph Irradiation X hours (Figure 8). (CRESESB, 2012).

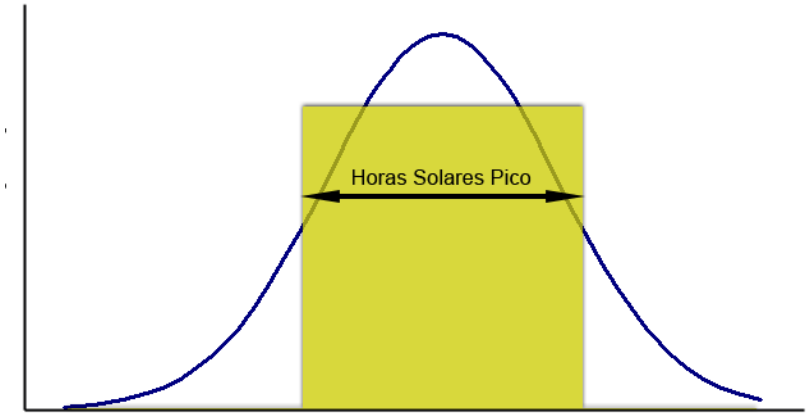

Figure 4: Graph of Hours Solar Peak.
Source: HM Systems, 2011.

Already the map of Figure 9 presents annual insolation data.

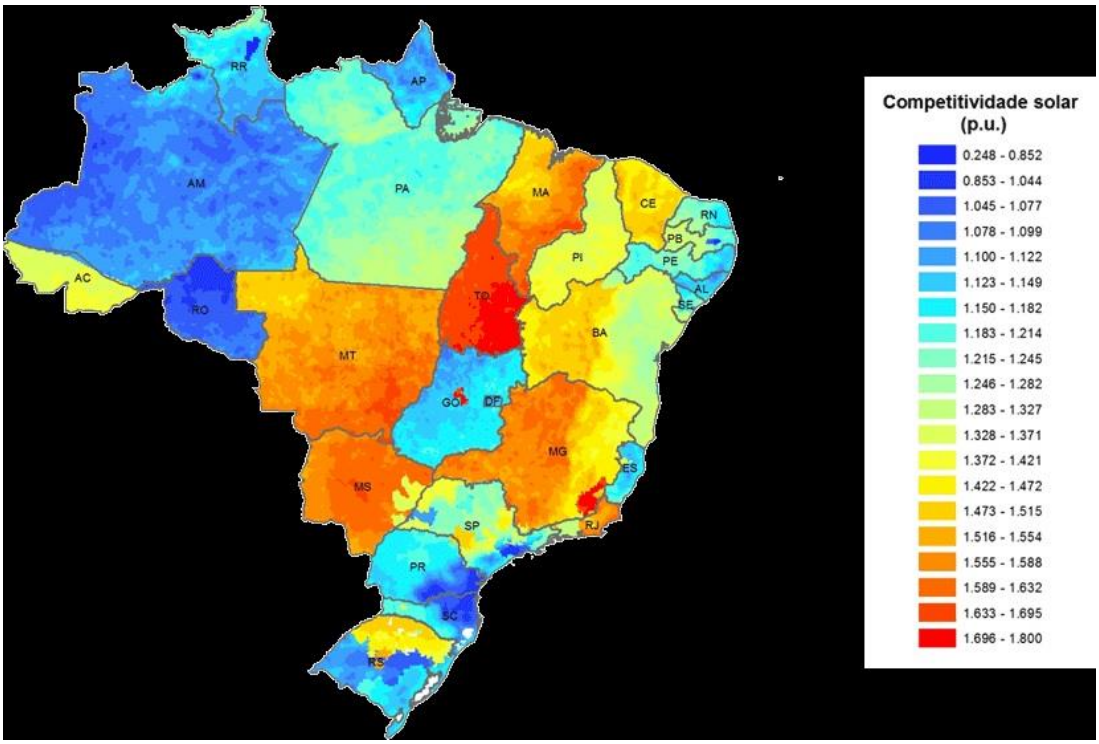

Figure 5: Map of Radiation Daily Insolation.
Source: CRESESB, 2011.

Defined geographical data, weather data and the solar potential, the next step is the analysis of the available area in the institution for the future installation of a photovoltaic system. Seen the possibilities, two were taken into consideration. One was the main facade of the building that houses the facilities of the institution (Figure 10) and the other was the top - cover (Figure 11).

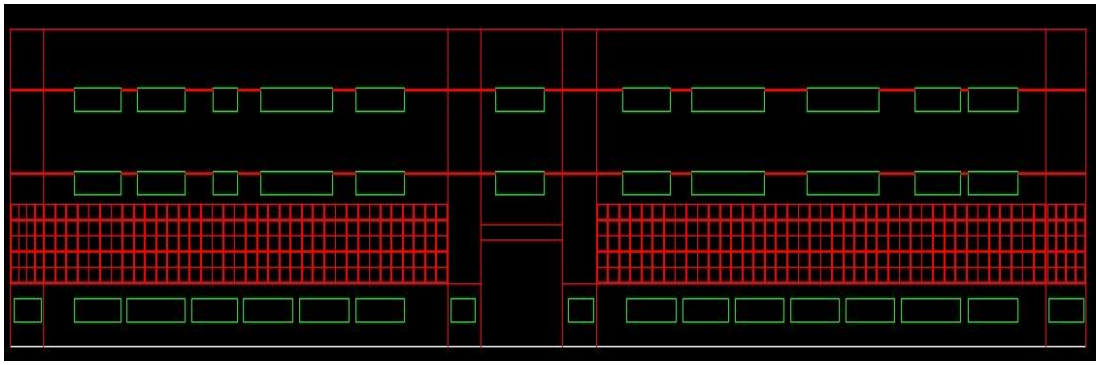

Figure 6: Front drawing.
Source: Redeemer University Society, 2011.

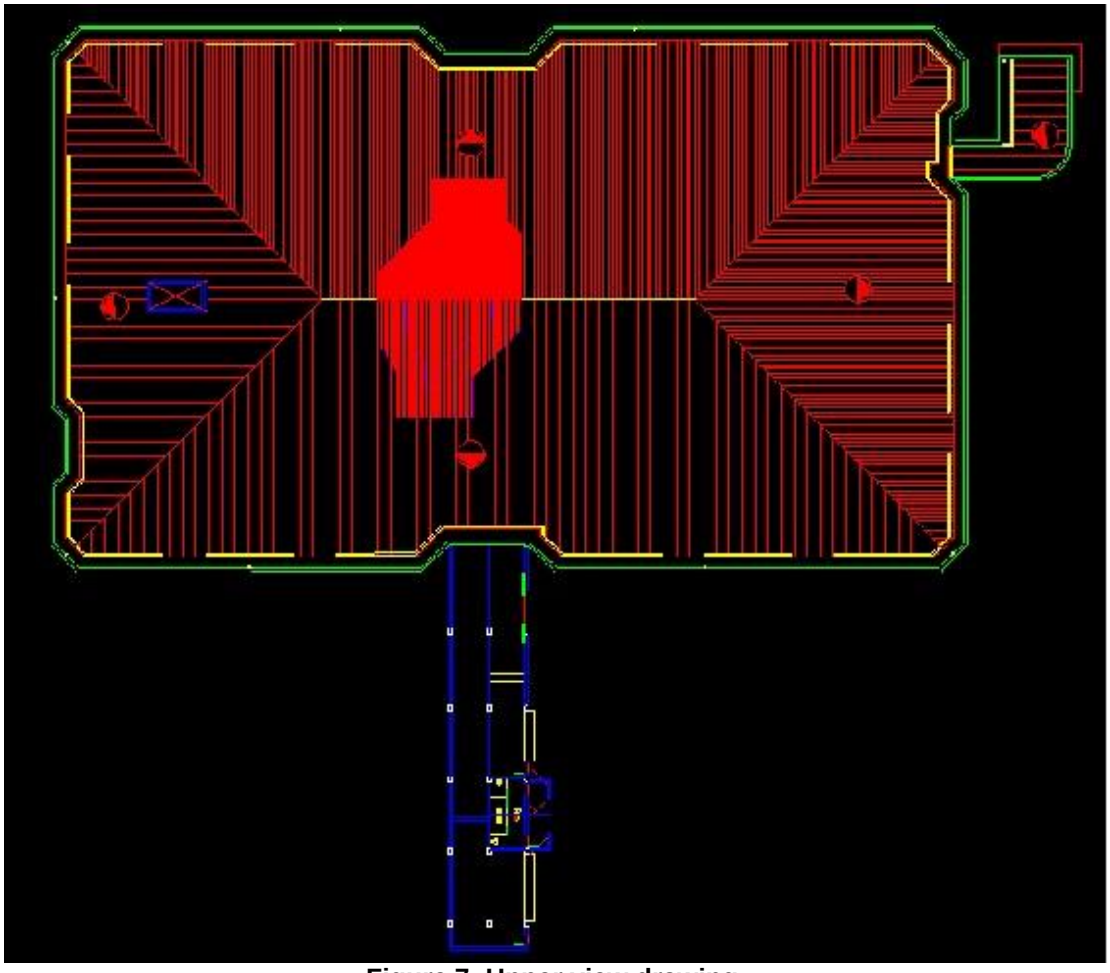

Figure 7: Upper view drawing.
Source: Redeemer University Society, 2011.

Raised the possibilities, identify an approximate area of 950 m² and 2700 m² facade of the upper area (cover) available for the installation of a large photovoltaic system. As the project proposal aims first meet the Library, but can easily be expanded in the future to other college facilities to make sustainable energy option, depending on the project's ambition, the top would meet fully. However, no technical obstacles to discard the use of the facade, with an area for their use much smaller compared with the top.

CONCLUSION

Based on the results of the available area of analysis, analyzing the region where is located the campus of the Redeemer University Society, it is concluded that this area has great potential to receive a photovoltaic system on/off. The average annual temperature of 33ºC, with a stable climate and high incidence of solar radiation, being its highest level in January approximately 6,1 kWh/m².day and the lowest 3,6 kWh/m².day June, with an average annual solar radiation between 5,10 and 4,5 kWh/m².day.

When compared with other countries that are much more dependent on solar energy as the Netherlands, Germany and Japan, Itaperuna presents an excellent level of solar radiation, with about twice the annual average sunlight of those countries.

Another key factor in sizing photovoltaic systems are the peak hours of the city where you want to install the system. In the analysis of the locality it was concluded that the availability is approximately four (4) hours of peak, which is excellent, not to mention that are approximately 8 hours of solar radiation.

Another conclusion that was reached was that the future slopes of the panels of the facilities should be close to 23 relative to ground level, thereby improving their income.

A given determinant to ensure the viability of use of photovoltaics in the premises of Redeemer University Society was presented to the available area, about 2700 m² at the top and 950 m² in the main facade. Therefore, a technical feasibility it has been for a future installation of a photovoltaic system in Redeemer University Society, and the installation of even limited to study questions of economic viability.

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