Solar Tracking System Installed in Modules with PV Panels to Connection Grid Tie Low Voltage

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Abstract – The electricity is an essential factor in everyday society, and this consumption is increasing exponentially. Beyond this fact, there is also concern about the impacts suffered by the environment, caused by the current system of generation electric power system. In order to meet this growing energy demand and reduce environmental impacts, several governments are investing in alternative energy sources, applying the concept of sustainable development for population and awareness about environmentally policies. A system for solar, renewable and clean energy is one of the most used and implemented around the globe. This article presents a proposal for a solar tracking system installed in module with PV panels to connection Grid Tie low voltage, named Sunflower. The goal of the installation Sunflower is the gain in the generation of electricity by the PV panels, by tracking the sun. Therefore, enabling the implementation of solar energy system in Brazilian residence.

Keywords: PV, tracking, residences.

1. Introduction

Nowadays, renewable energy sources provide approximately 8% of world energy (increasing to 22% if we include all uses of biomass) in many parts of the world this percentage is increasing significantly. Wind energy is the energy source whose use is increasing faster in the world. Then comes to PV, with 24% growth per year in the world. Some recent studies indicate that renewable sources should increase its share to 30% to 40% of the total in 2050, assuming global efforts in public policies for environmental issues, especially those related to climate change [1], [2].

The Grid-Tie concept, attributed to solar energy, tries to enable the implementation of PV systems to connect of the electricity transmission grid, promoting economic growth, improving the living conditions of the population and as an important factor in generating employment [2].

PV systems are composed of modules, inverters, protective devices, system of fasteners and cable. In addition to the usual components of a PV system, the Sunflower because of its logical tracking also has linear actuator, auxiliary relays, PLC (Programmable Logic Controller), power supply, single-pole circuit breakers, among other features.

The dimensioning of a PV system for Residences is done in order to produce part or all of the electricity consumed, and can exchange the surplus of energy in credits of kW. In the case of residence export energy, its electricity generation ends up benefiting other consumers, who use the energy injected into the utility distribution network [2], [4].

Typically, it can be conceptualize as follows:

- When the residence consumes more than the PV system is generating, the part of the consumption is lacking is supplied by the power gird [2].

- When the PV system generates more than is being consumed by the residence, the excess energy is automatically injected into the grid. The meter records this energy and the client shall be in kW credits to utility [2].

The use of PV systems in all Brazilian households could reduce energy deficit and sustain the Brazilian industrial growth in the coming years, as households could generate power during the day, precisely at a time when residential consumption is lower and the industries demand more energy [1], [2].

The next sections of this article will be organized as follows: section 2 will address the development and the operation principle of Sunflower. Section 2.1 will present the development of a prototype small-scale and their results. Section 3 will present a projection of the results of the prototype and their strategies for achieving the Sunflower. Finally, in section 4 will be the final considerations.

2. Development and Operation Principle

To develop the Sunflower was necessary to consider the inclination of the axis of rotation of the earth relative to the elliptical orbit around the Sun, forming an angle of 23.45°, approximately, that determines the seasons depending on the position of the planet in its translational trajectory [3]. The Sunflower through its operating principle ensures full tracking of the azimuthal angle during the daily period of higher solar radiation and through a system of mechanical actuation, corrects over the course of the seasons (Winter Solstice will Midsummer) solar declination, according illustrated in Figure 1.

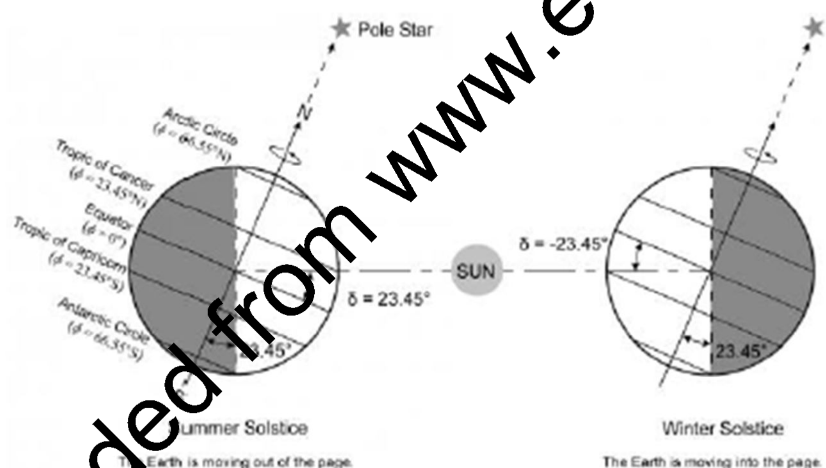

Figure 1. Solar Declination Illustrated.

The energy provided by panels into DC (direct current) converted to AC (Alternating Current) through the inverter, in the proper tension (the same as the grid) with frequency and waveform more close of electrical current of grid [4]. For safety and reliability of the system, between the equipment above a single-pole circuit breaker installed to ensure that no peak voltage and / or current can damage the inverter.

The inverters have a MPPT algorithm (Maximum Power Point Tracking), in order to optimize the operation of the equipment and ensure that maximum power is achieved in PV panels. The inverter and responsible for the direct connection to the power meter bidirectional, which performs the measurement of consumption and generation system [2], [4].

The metal frame was sized as you can see in Figure 2, in order to behave panels and other components, consisting of a system of joints and pulleys that allow movement of the PV panels, performing the tracking of apparent motion sun (including solar declination) [3].

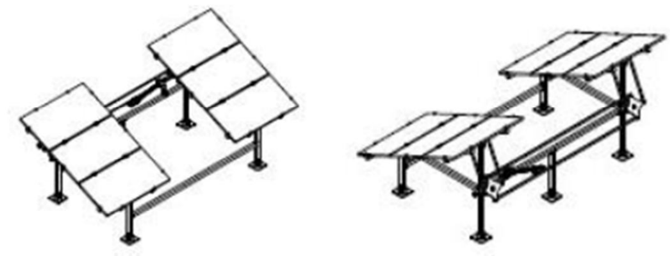

Figure 2. Metal Frame Sunflower.

Simplistically, we can describe the position of the drive system of pulleys and the course of the actuator stem as Fig 3.

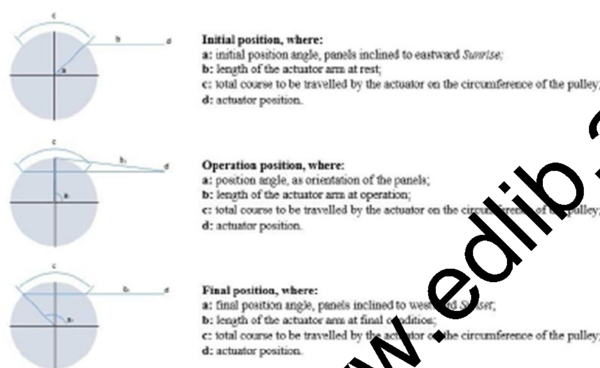

Figure 3. Representation of Cinematic Actuation Pulleys.

Structural analysis was performed as following considerations:

- Materials and dimensions used in all profiles;
- Mass of PV panels and all other materials;
- Wind action with reference to NBR 6123 (1988);
- Application of wind power in each PV panel in the horizontal direction.

Through the Von Mises graph [5], [8], according Figure 4 e 5, has been found maximum values of 14,3MPa or 1,47e⁷ N/m², less than the yield stress of the material used in the structures of the module who is from 210MPa for carbon steel and low alloy value.

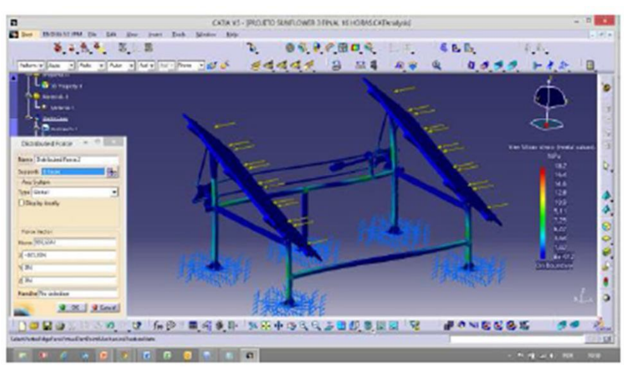

Figure 4. Analysis of Strain on Structure.

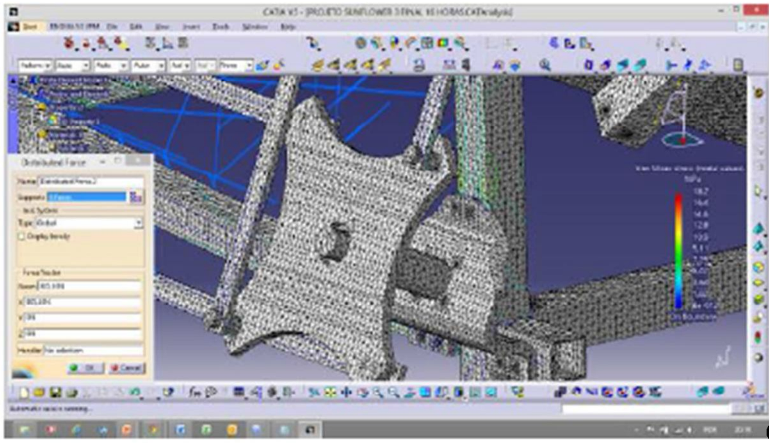

Figure 5. Analysis of Strain on Structure.

The solar tracking is possible through automation, consisting of a PLC, which performs the function of control over the linear actuator, responsible for actuation the joints and pulleys system. Was developed a logic of time control, to meet the need to control and the linear actuator for the period from 10:00am to 16:00pm hours where we have the highest levels of solar radiation and consequently also the period of greatest generation energy [1], [3], [3].

The logic developed for the timed advancement of the linear actuator has the following function: PLC transmits 90 commands timed along the 6 hours of operation. These commands are divided into 90 actuation every 238.7 seconds with pulse duration of 1.3 seconds this means that every 4 minutes the panels to move 1 degree, and the total actuator stroke of 353.7 mm, that representing a 90 degree movement of the panels.

2.1. Development of Prototype

For the prototype, the operating principle follows the concept of Sunflower project however on a reduced scale (panel's 5W each). Not made use of inverters to obtain the load values, was used fan, compatible with the power of the panels were used to simulate the load operation.

To performance tests between Sunflower prototype and PV panels (5W), according Figure 6 e 7, to provide an analysis about efficiency of solar tracking.

Figure 6. Installation of Sunflower Prototype.

Figure 7. Installation of PV Panels.

The Figure 8 presents the comparison of the values obtained from the tests of PV panels (Blue) and Sunflower prototype (Orange), resulting from measurements made during the period from 06h: 00min am to 18h: 00min pm.

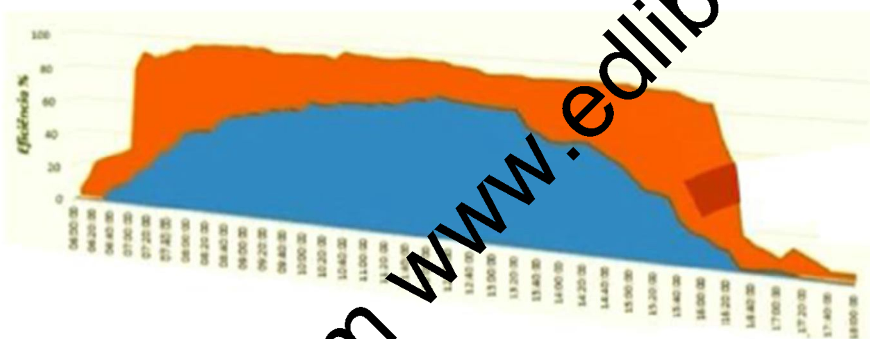

Figure 8. Comparison Results of the PV Panels and Sunflower Prototype.

3. Results

Through comparison analysis of the results obtained, it is possible to observe the difference in efficiency that according to the tracking system prototype Sunflower keeps completely perpendicular to the apparent motion of the sun panels. After conducting several tests, we observed a difference of 31% with a variation of + / - 0.8%, higher than the prototype Sunflower compared to PV panels.

This result already considers the following factors used in the sizing of PV systems for residences:

- Loss in power inverter DC to AC;
- Any shading on installation;
- Possible accumulation of dust or dirt on the modules, reducing the absorption capacity of the irradiation;
- Losses (Ohmic) in the wires, both in AC and DC side of the facility;
- Power consumption of the system.

The Figure 9, presents the cost of electricity production (R$ / kWh) for investment costs (X axis) and curves with capacity factors (FC) ranging between 12% and 18% bands, as caption at the top of the graph [2], [7].

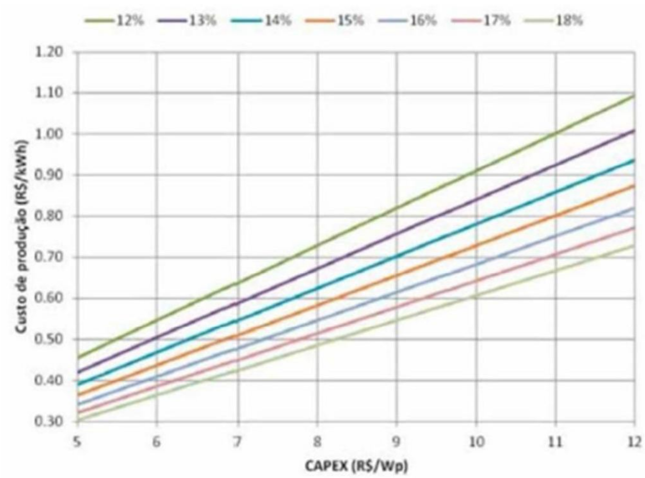

Figure 9. Production cost (R$/kWh) vs. CAPEX (R$/Wp) vs. Capacity Factor.

Through the graphical is perceived that an installation with 15% capacity factor (national reference), investment cost of 9 R$/Wp (projection of Sunflower project) has costs of energy production of 0.65 R$/kWh. This value is close to the order of magnitude as price of electricity for residential customers of different concessionaires in Brazil, including taxes and charges [7].

4. Conclusions

The Sunflower project in defining of their concept sought to following business models standard for PV energy by ANEEL (National Electric Energy Agency), scaling of electronic components targeting for money Is the, reliability and technical excellence in quality and the development of a product as an entrepreneur factor to generate employment, always focusing on residences. Especially considering the data of production costs, the Sunflower project is able to perform the installation in most Brazilian states [2], [7].

5. References

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