

## Occupational safety training for the systems installer course photovoltaic

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### ABSTRACT

*This paper discusses and systematizes the occupational safety content contained in the training of professionals in the course for Electricians-installers of photovoltaic systems, offered by the national program "Pronatec – EnergIF", and carried out in Rio Grande do Norte by the Federal Institute of Rio Grande do Norte – IFRN. The installer course has a total of 200 hours, and part of the course load is dedicated precisely to the basic content of occupational safety, and more specifically, safety in electrical installations and services, working at heights and machines and equipment. With practical classes on panel installations being held on a teaching roof, there is direct application of all occupational safety topics developed here.*

**Keywords:** Photovoltaic systems. Work at height. Dangerousness. Electrical installations. Machines and equipment.

### I. INTRODUCTION

Renewable energy is gaining an increasing share in the national energy matrix, although in the past, energy generation was carried out through large generating units, such as giant hydroelectric plants or large thermal generation facilities.

In contrast, distributed generation uses almost all photovoltaic systems to generate energy, and since the panels used are modular, the use of these modules to generate energy on a smaller scale, according to customer demand, has become widespread. This type of generation has come to be called micro-generation of energy, and today it is present on the roofs of countless houses and residences.

In relation to medium and small-sized residential or commercial photovoltaic systems, the installation service is a relatively simple procedure, and through the National Program for Access to Technical Education and Employment – PRONATEC, the federal government encouraged the creation of short-term courses for "Renewable Energy Systems Electrician", in some places also called "Photovoltaic Systems Installer".

It is a short course, with a total of 200 hours, with a practical focus, including practical installation classes, climbing on a teaching roof designed specifically for this purpose. One of the subjects is occupational safety, which has the important mission of introducing the student-worker to this framework of standards and providing them with minimal instruction on how to perform a safe and effective installation, using all the necessary safety items.

That said, this work has the general objective of discussing and systematizing the occupational safety content contained in the training of professionals in the course for Electricians-Installers of Photovoltaic Systems, offered by the national program "Pronatec – EnergIF"

As specific objectives, we can list:

- Present the PRONATEC-ENERGIF program;
- Indicate the main regulatory standards for professionals;
- Report the use of the educational roof for installation and safety classes;

In order to achieve these objectives, immediately after the introduction, we have a chapter that details the design of the Renewable Energy Systems Electrician course in the context of ENERGIF and the energy sector. The following chapter details the main regulatory standards that professionals must have access to and be minimally trained in. The fourth chapter presents the educational roof, its design and use as an important teaching tool for safety. Immediately afterwards, the conclusions conclude this course completion work.

## **II. MATERIAL AND METHODS**

In the last decades, if you saw to grow the wide use of wind generators in your extensive parks wind power, mainly in the Northeast region. All these ventures began to be classified as generation centralized (of energy). They are always large units, occupying one vast area, and connected to the entire one substation and transmission line infrastructure.

In fact, the country lived one expansion fast of this follow-up, which is still in place in growth. In this process of expansion, it is necessary one workforce specialized, which does not he was formed in the decades previous. To train an Energy Engineer, by example, it takes time and high investments, mainly in a area of knowledge that is in full expansion and evolution technological. No very far from this reality, is the training of high-level professionals technical or graduation technological, because they are two and three courses years in duration.

Sousa (2012) highlights the difficulty found to obtain labor qualified, and how you plant implementation processes solar they are attracting professionals from other States and Countries, therefore, the training of professionals is essential and urgent.

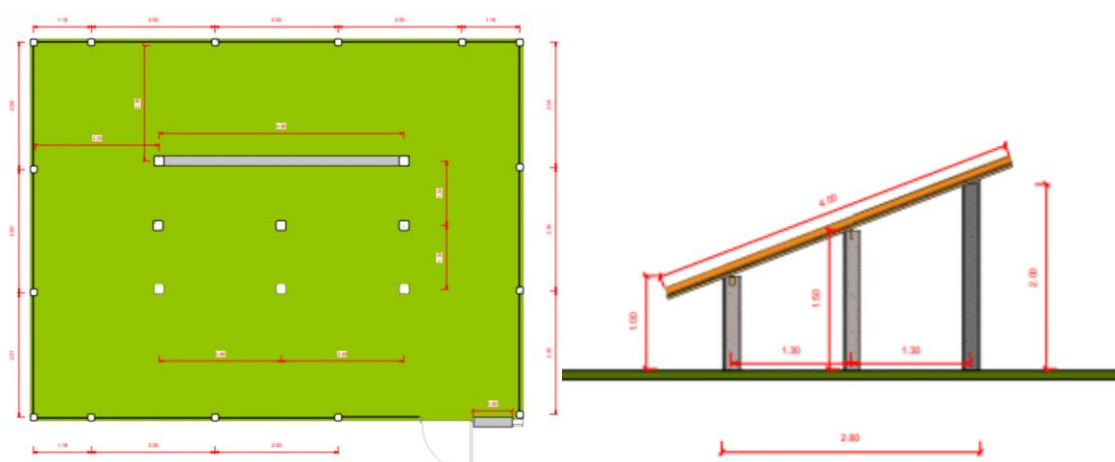
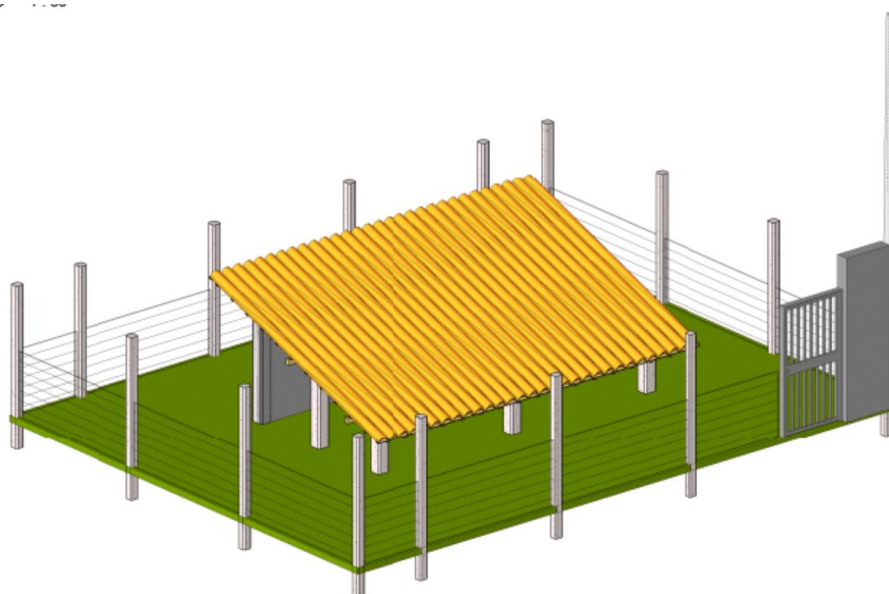
In this context, the program for development emerged in 2016 in energies renewables and efficiency energetics in the Federal Education Department Professional, Scientific and Technological, whose acronym is "EnergIF". The program has the role of forming professionals in the sector, in more different areas of activity. Coordinates and ministers put through the Institutes Federal one series of itineraries training, mainly to form teachers who can be multipliers of the content in your own cities and regions. For the photovoltaic sector it is a fundamental action, therefore, in Brazil, in any place of the territory national is possible, and also viable, the installation of systems solar, whether to allow the economy / reduction of consumption of generation sources primary, whether to take energy to places remote and more away.

One of those itineraries, is the "Renewable Energy Systems Electrician" course, which was linked simultaneously to another federal program, in this case the "National Access Program Technical Education and Employment – PRONATEC. These are 200-hour courses, with classes in the shift night, in the case of IFRN, Natal Central campus. In 10 weeks you student-workers already they are certified and qualified the execution of the installation of the systems photovoltaic. Obviously, a professional of level technical in electrical engineering (or similar) or engineering electrical or energy engineering must be responsible for the signature of responsibility installation design technique.

Among these 200h, the contents they are developed in three cores distinct. This reality may change slightly for institutions different from the IFRN, to better adapt to local reality. The fundamental core provides notion Basic Reading and Text Production and Mathematics Applied. The core technological, where they are concentrated the main course subjects, of a character technical and practical, being them: Electricity Basic applied to Photovoltaic Systems; Fundamentals of Photovoltaic Solar Energy; Technology Photovoltaic: modules, arrays and cells; Photovoltaic Systems: isolated, grid-connected, hybrid, and water pumping; Photovoltaic Systems Assembly.

The third is core articulator, which are knowledge that narrows you bonds of knowledge technician with the world of work and the practices of execution and management. In this core they are containing the following subjects: Society, Environment and Energy; World of Work and Business Feasibility Study; Information Technology Applied; and by end, Occupational Safety Measures Applied to the Sector Photovoltaic. In this final course work, the focus is on the subject of "Occupational Safety Measures". Applied to the Sector Photovoltaic and also the discipline technique that articulates quite a lot with this one, which is "Photovoltaic Systems Assembly". Because the highlight of the course is the assembly of the modules photovoltaic and the connection to the inverter.

For this final and fundamental stage of the course, was built a roof didactic. Including the construction of the roof didactic (or already possess this equipment) is a condition necessary to be considered us Pronatec - EnergIF notices, which have parameters that must be followed put all, as per you schemes detailed in the figures 1 and 2.



This roof is 1 meter high at the lowest side and 2 meters high at the highest side, with no construction or use of any kind on the lower part of the roof. The purpose of these dimensions is to make the roof safe for student workers and to allow them to access the lower part without difficulty, thus avoiding excessive use of ladders and reducing the risk of accidents.

Two roofing models are adopted. One with ceramic tiles, quite common in residences, and another model with fiber cement roofs, more common in warehouses and commercial facilities, and can also be found in some residences. In the case of IFRN, there are both models. The first was built in 2022 and the second throughout 2023.

Obviously, the roof has photovoltaic modules (figure 3-A), in this case, 8 modules with approximate dimensions of 1m x 2m, and a power of 500 kWp (kilowatt-peak). The set also consists of a 5Kw power frequency inverter (figure 3-B) and is connected to the electrical grid, following all usage standards, including a bidirectional energy consumption meter (figure 3-C). The complete system is perfectly identical to any residential and functional installation.



**Figure 3- Roof didactic installed at IFRN**

### **III. WORK SAFETY AND ESSENTIAL STANDARDS**

As Maas et al (2018) reinforce, the “Regulatory Standards are for execution mandatory put part of the companies private, being able to generate serious offence punishable by a fine or not compliance with the provisions in the legislation”. That said, full knowledge and compliance with such standards is essential, especially by the professionals involved in processes of execution of works and services, and in this case it is not about only engineers, doctors or occupational safety technicians, but of all you professionals, including energy system installers renewables.

In the course proposed for the program national ENERGIF, according to already mentioned, there is one small workload, which is extremely challenging, by possess as the main objective insert the student to the world of Regulatory Standards and occupational safety, so that the same may have, at least, notions fundamental and essential, to make worth you your rights and equal way, preserve your health and physical integrity.

Therefore, some standards they are essential, others they are important and some others, we will call here in this peripheral work. Obviously, all they are important, but due to the limited time allocated to these themes, some end put to assume bigger degree (or order) of importance than others, with NR-10 and NR-35 at the “top” of the priority list, which can be validated by Ronchi (2014) and by Sila Filho (2021), which reinforces in your research that, from the point of view of system installation workers photovoltaic, the risk of falling due to the height and also the risk associated to the shock electric are, evidently, what makes the exercise of their activity dangerous, possibly qualifying in NR-16, which deals with the issue of dangerousness.

In this way, it is up to here present, even if in a synthetic form, the main standards regulatory frameworks that underpin the professional's work energy systems installer renewables, which essentially come down to to the panel installation process photovoltaic for residential and commercial purposes in small and medium facilities commercial, since the big systems photovoltaic and the several systems wind turbines fit into in the high category power (above 75 KVA installed) and require substations and various other additions technicians who suggest professionals good more qualified for execution.

Regulatory standard no. 16 – NR-16, deals with specifically of dangerousness, but there is an article of the standard, which seems to be the only one that workers see, or by the less usually no forget, which is exactly what the employers try forget, or many times “dribble” in some way, because imply in earnings financial, or costs, depending on which side you are on in the employment relationship. In order not to leave room for interpretation various, item 16.2 of the aforementioned standard is reproduced:

16.2 The work exercise in dangerous conditions ensures to the worker to receive an additional 30% (thirty percent), incident about the salary, without you additions resulting from bonuses, prizes or participation us company profits. (NR-16, item 16.2. BRAZIL, 2024)

In simple terms, to live up to the hazard pay implies in some level of “compensation” or compensation financial at the end of the month for the worker. In addition of this, Gomes (2020) in remember that, in parallel, it is still possible account for the work exercised with the risk electricity as “special time” for social security purposes, by less until the pension reform of November 13, 2019.

Reinforcing that Annex 4 of the aforementioned standard highlights that:

1. Have right to the hazard pay you workers :
  - a) that execute activities or operations in facilities or equipment electrical energized in high tension ;



b) that carry out activities or operations with work in proximity , as per establishes NR-10. (NR-16, Annex 4. BRAZIL, 2024)

Within this perspective , still it is not clear and/ or objective if the systems installer photovoltaic lives up to the national dangerousness , a once the system is assembled and installed disconnected from the power grid , and in this point many argue no to do justice. However , the system , in some is effectively connected in the power grid of the energy distributor . And even before this , the own panels , already exposed to solar radiation , already pass and possess high power differences in your terminals , which , in itself , would justify the “ risk electric , and by consequence , the dangerousness , according to highlights Kurata (2016, p.21).

NR -16 itself does various references to NR-10, which specifically deals with Safety in Facilities and Services in Electricity . In addition to NR-10, only NR-20 ( Liquids) Flammables ) is cited explicitly and only one time , in the NR-16 standard.

It is worth noting here that a training basic NR-10, according to annex 3 of the same Regulatory Standard it has a workload minimum of 40 hours, which is much higher than the face Workplace Safety class schedule contained within the installer and energy systems course renewables proposed by ENERGIF- IFRN. Although this fact weigh against the course , it does not become one failure , a since , according to item 10.8.8.1, the NR-10 course is the responsibility of the company contractor . In terms practical , evidently already Having completed the NR-10 course (40h) is a differentiator at the time of hiring .

This is content more important to be treated in the scarce occupational safety discipline , and one of the objectives is precisely highlight the importance of taking an NR-10 course (40h), a since the course workload , alone and not even linked with other components curricular , is not enough to supply that demand formative .

Obviously , this regulatory standard is, by far , the most important , a since it literally implies the ability of the individual-student to stay alive. Even if not there is connection in the electrical grid during the installation of systems photovoltaic , or that this procedure is reserved to those who hold the position/ function of technicians and engineers , it is not possible deny , in no way , that the insistent solar stewardship manages one potential difference considerable during the system installation photovoltaic .

Still in form more evident that the risk of shock electrical , is the risk of falling , as per evidence Lima Filho (2021) and this can be observed put all you agents involved us processes , even those who do not act directly in the ( electrical ) installation itself . The regulatory standard # 35 is dedicated the this work theme in height .

The roof is, literally , the installer 's field of work residential and commercial , and this structure , as a rule , does not this ready to receive you workers , because not it has previously you anchor points or fixing the lifeline , which requires workers attention redoubled . Lima (2022) emphasizes that, although no exist big difficulties for the implementation of the anchoring system in roofs residential , the workers do little use of safety standards for work in height .

Tiecher (2017) still reinforces that NR-35, in this installation aspect photovoltaic , walks in conjunction with NR-18, which deals with the conditions and environment work environment in the construction industry , and in its item 18.18, specifically some details on you works carried out on the roof . And if it is a place subject to to the various weather conditions , such as sun, rain , fog , among others, it is necessary to take a look attentive to NR-21, which establishes standards and rules for “ open- air work ”, protecting the worker in days with a possibility of rain and lightning , and also us days more sunny , to avoid sunstroke , burns and others interurrences similar .

Beyond the rules cited , Silva (2020) still reinforces the importance of use correct use of Personal Protective Equipment , the subject of NR-6, still more in a dynamics of many negligence of PPE and standards in the installation sector , which basically is not inspected , as it is a “ work ” of rapid execution , during just some few days , depending on the size of the system . In systems residences , many times , it is concluded the installation in just one day , for example .

#### **IV. USE OF THE EDUCATIONAL ROOF AND SAFETY RULES**

The roof didactic is a installation fully functional , has all you elements of a installation conventional of a residence , with a generating power average estimated 750 kw.h / month . The panels , inverters and all the installation part they are composed of elements commercials , then the experience practice provides , reproduces faithfully what you will find in the job market . Higher education systems power only will have more plates and more inverters , but the procedure it will be exactly the same .

The discipline of assembly has the largest course load . Of the 200 hours of the course , 48 hours are intended just this curricular component . The subject of Occupational Safety it has only 10 hours long , however , part of its content develops in the assembly of the panels , where you students experience the use of personal

protective equipment , the standards and rules for carrying out the work in height . In figures 4 and 5, there are registered some of the moments of the practical classes of system assembly .



**Figure 4 - System assembly photovoltaic on the roof didactic .**



**Figure 5 - System assembly photovoltaic on the roof tile didactic ceramics**

For many of the students , it is the first contact with the PPEs more basics , such as helmet , gloves , boots and the like . And even for those who have some experience in the area , ends being the first time they use the seat belt type parachutist . There is high expectation in climb onto the roof and start assembly , but this always occurs in steps , and the first of them is precisely to dress up with the due safety items , carry out the ladder tying and preparing you attachment points for lifelines .

Despite the side low be 1 meter tall , all student access to the roof occurs for the high side , which is 2 meters high . They use the ladders with the due procedures recommended by NR-35. Separate all the material for use , such as wrenches , drill (24V) and similar before going up and check everything before going down . Also hoist with ropes and with the support of ladders you modules and panels . The installation in if it is quite simple , both the fixing part as the part electrical . Essentially , the class ends for being a big experience occupational safety practices for installer services .

The course is held in the shift nocturnal , and precisely put these are the assembly classes they are executed to the Saturdays . However , the roof installation site is illuminated put reflectors , allowing that also be possible classes in the same turn nocturnal , as per record of figure 6. However , this possibility is only for situations sporadic , and even this is more common for disassembly practices , because , after all the installation is complete and verify that the system this operational , we have the last class which is precisely all disassembly .



**Figure 6 – Assembly class being carried out in the shift nocturnal**

Other aspects of order practice quite important also they are learned in these classes, as no break the tiles , move between the wooden structures ( lines , rafters and slats ) , drill correctly and several other details that are not there is as be available in books and manuals .

## **V. DISCUSSION AND CONCLUSION**

Occupational safety is a small subject in a course that already has a somewhat reduced workload, as the objective has always been to quickly train this student-worker so that he or she can enter as quickly as possible a job market that is saturated with demand for facilities, but still very lacking in qualified professionals.

However, it is precisely the practice of assembly and disassembly carried out on the teaching roof that involves all the safety elements necessary for the professional's daily routine. Students use PPE and carry out all the necessary safety procedures. Even the simplest ones, such as using sunscreen as indicated in NR-21 or having tools organized and stored properly according to NR-12.

Obviously, the most detailed standards are NR-10 and NR-35, especially because the risks of shocks and falls from heights are the highest, but they can be fully avoided with the proper use of the standards. It is important to highlight that the safety discipline contained in the renewable energy systems and installer course does not replace the specific training of the regulatory standards.

It is essential that the worker seeks to do, or that companies provide, NR-10 training – basic (40h) and NR-35 (08h), as detailed in the respective standards. The discipline has, then, this role of instructing student-workers, so that they are aware that these standards exist, that there are courses that they should seek to do, and not just once, but that they should also update/recycle themselves periodically.

It is also a content that points to workers' rights, not only a right to financial compensation, such as the hazard pay indicated in NR-16, but the right to have one's life preserved and always put first. There is enormous social value added to the knowledge of rights and duties, as a worker must also demand that PPE be provided not only, but that it be of good quality. Knowing that rushing can cost one's own life by not anchoring the ladder, or failing to use the lifeline.

Finally, we understand the importance of the practical component, of occupational safety in a practical way, providing the job market with technically capable professionals with excellent work practices, always putting safety first.

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