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Implementation and Evaluation of the First Renewable Energy Systems Technical Course in Brazil

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ABSTRACT Availability of skilled labor in renewable energies (REs) is a necessity for countries that, in search of sustainable development, intend to invest in this segment. Experiences with the training of this professional have been little reported in the literature, being more frequent studies contemplating superior level formation. In this paper, we describe the Brazilian experience with professional training of technicians in the RE sector. An overview of the public–professional education, the report, and the evaluation of the implementation of the first face-to-face technician course in RE systems in Brazil are presented. The course was offered in the Brazilian northeastern region, which stands out for the largest installed capacity in the country of solar and wind power plants (8223 MW); additionally, this region is characterized by social challenges, as a low Human Development Index (0.656), the lowest among the Brazilian regions. We also propose an updated teaching program with the indication of a reference curricular matrix.

INDEX TERMS Curriculum development, educational institutions, educational programs, sustainable development vocational training.

I. INTRODUCTION

According to the International Renewable Energy Agency (IRENA), the world's RE sector employed 10.3 million people in 2017 - an increase of 5.3% over 2016. China, Brazil, the United States, India, Japan and Germany represent more than 70% of such jobs [1].

Developing and mastering Renewable Energy (RE) technologies, in addition to meeting the countries' own demands, is also a business opportunity abroad in both the surplus energy trade and the export of technologies and services in a growing market, especially in developing countries. RE participation in the energy matrix of countries depends on a number of variables, such as political interest, availability of natural resources, financial resources and skilled labor.

Vocational education at a technical level, especially in the RE field, is scarcely mentioned in the literature, and higher education is more frequent, although it is relevant for the training of managers and decision makers. However, in a natural distribution of jobs, the demand for craftsmen, technicians and supervisors is greater. A search was made in different journals for papers dealing with professional training in RE. As a result, 19 papers were selected but only 6 mention explicitly technical courses. However, many experiences described in these papers are useful as a reference when planning a technical course. Hence, our review follows chronologically starting from the year 1996.

The oldest experience, among the articles selected, is that reported by Ruzinsky *et al.* [2]. In the text a brief report on research, development and teaching of RE in regular undergraduate courses of the Technical University of Slovakia is described. The topics covered in the course can be used as guides in the composition of the role of the specific disciplines in the curricular matrix of a RE technical course.

Kandpal and Garg [3] comment on the need to introduce the topic of RE at all levels of education, from elementary to post-graduate education. With respect to the training of technicians, the authors suggest the main desirable skills in the training of technicians prepared to act with RE: to collect, analyze and organize information; communicate ideas and information; plan and organize activities; work in teams; use

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mathematical ideas and techniques; solve problems; have practical skills in installation, operation, repair and maintenance in different RE technologies and systems.

Othman and Sopian [4] analyze the RE training in undergraduate courses in the economic bloc of the Association of Southeast Asian Countries (ASEAN). The authors reiterate the need for more resources and funding, both in the bloc and in developing countries, for RE learning and specialization. Additionally, a suggestion of a discipline plan, accompanied by laboratory practices, is introduced.

Benchikh [5] emphasizes that the professional formation in RE requires a general knowledge of diversified technologies and its adaptations to different contexts, in different fields of application. The author notes the lack of specific university training programs, or even for secondary schools, which are able to capture the interest of young people in order to guide them towards a realistic career choice. Training needs in the field of RE are seldom well known, as little information is available regarding the required programs: practical technical courses, intensive courses, continuing education, specific courses and summer schools.

Bhattacharya [6] addresses the presence of subjects in higher education, particularly in the United States of America, characterized by lack of uniformity in terms of duration, courses and emphasis on research.

Jain *et al.* [7] describe the results of a survey demanded by the Ministry of Mineral, Energy and Water Affairs of the Botswana government, based on interviews and questionnaires across the country, directed to three specific groups: commercial, consumer and training institutes. The results pointed out that the greatest national potentials are for solar energy and biomass; however, the authors identified the lack of education of the consumers, as well as the absence of skilled labor in RE. Hence, a RE education program for all segments of society, through short-term training, specializations at technical and higher levels is suggested.

Bojic [8] describes a research conducted through surveys and questionnaires applied to teachers from 88 colleges and 13 research centers in Serbia and Montenegro. The author identifies that there is no course devoted entirely to RE and few teachers dedicated to specific technologies, with RE topics as subitems inserted in traditional subjects.

Zografakis *et al.* [9] presents the results of education on energy efficiency and sustainable energy in elementary and middle schools in Crete, evaluating the student's perception of the subject and the multiplier effect of this learning with the students' parents. The author concludes that there was an evolution in the interest and energetic behavior of those involved and strongly recommends the official inclusion of the subject as a discipline in all stages of elementary and secondary education in Greece.

Jennings *et al.* [10] argue that the RE industry is growing rapidly, leading to a rapid increase in demand for RE specialists capable of designing, installing and maintaining such systems. The study targeted universities in Australia and New Zealand. The authors note that RE education is a relatively new field having its own identity, with special techniques, standards, and requirements that are not usually found in other disciplines. The incentive to the professional education in RE as a part of public policies is suggested.

Considering the Turkish scenario, Acikgoz [11] advocates the creation of disciplines involving as much renewable sources as possible and at all levels of education. Programs must be prioritized for local specificities, not forgetting the national plan, being flexible and dynamic. A careful review of course content in teaching / training programs on RE sources has revealed that, for the most part, the curriculum is strongly driven by the experience of the available teachers, rather than by the content needed to be passed to the students.

Skardon [12] describes an experience of integrating clean energy projects into the high school curriculum in the Southeast of the United States of America. A challenge is the need of substantial technical support to ensure that student's design projects are age and skill appropriate and safe for the class, keeping at the same time student's engagement.

Kandpal and Broman in [13] list the desirable characteristics in a RE education program:

a) It must cover all RE resources, respecting local specificities and availability of resources;

b) It shall cover all aspects relevant to the development and dissemination of RE technologies, such as (i) resource assessment, (ii) design, fabrication, installation, performance monitoring, troubleshooting and maintenance of technologies; iii) financial, economic and energy aspects of the use of renewable technology, iv) sociocultural acceptability and v) evaluation of the associated environmental impacts;

c) It should establish synergy with the conservation of energy and the contributions related to the environment-environment interaction for students;

d) It should provide a balance between theory and practical aspects. Therefore, the curricula should include inputs into laboratory and demonstration experiments, hands-on training, problem solving, design and manufacturing of inputs in addition to lectures, tutorials, papers and seminars;

e) It must be flexible and dynamic, thus allowing future improvements in the content and structure of the teaching / training program;

f) preferably, for better acceptance and efficacy good teaching-learning materials in local languages at affordable prices.

In [14] the evaluation of the curricular matrix of the only undergraduate course in RE in activity in Greece is made, compared to the courses recognized in the United Kingdom. The focus is on the international mobility and the employability of graduates of the course offered by the Institute of Technological Education of Athens, the so-called Energy Technology.

According to Sooriyaarachchi *et al.* [15], the potential contribution of the RE and Energy Efficiency (EE) sectors to create new jobs affects public policy, as well as the allocation of public resources to promote related activities. The authors advocate continuing education at all levels of education in order to keep abreast of technological advances and provide the lay public with a basic understanding of technology issues as well as a better understanding of their commercial, regulatory and legal implications.

In [16] the authors affirm that professional education is increasingly seen as a viable path to higher education and, not only, a direct route to the labor market. Additionally, this article studies the relationship between the secondary school pathway frequented by Chilean students (professional or academic) and their subsequent results in access and persistence in post-secondary vocational programs. According to the authors, students who continued in the same area of vocational training, between the secondary and post-secondary levels, performed better than students with a strictly academic background.

The results of a thorough review of almost all the curricula of existing courses of various disciplines, engineering of public and private universities in Jordan are described in [17], [18]. A questionnaire was applied in a random sample of senior students and questions were included on the energy situation in Jordan, EE, RE use and applications. The authors concluded that the lack of energy awareness and superficial knowledge about energy and RE technologies among senior students in engineering colleges were significant aspects. Finally, they reiterate that: without removing these barriers, the market will continue to suffer from engineers and technicians who are ill-prepared to act in RE.

In turn, Srinivasan [19] addresses the importance of transdisciplinary concepts and the simulation use of real case studies in undergraduate courses in sustainable energy engineering. A holistic and integrated approach is considered in Maciejewski *et al*. [20] for the undergraduate electrical engineering course at Colorado State University.

Yasmin *et al.* [21] describes the success of introducing a multidisciplinary course in RE at Habib University for novice students with theoretical content but with different hands-on activities. An evaluation with the students revealed that the majority of students (89%) were satisfied about the experience.

Hence, this paper describes the Brazilian experience with professional training of technicians in the RE sector. An overview of the public professional education, the report and evaluation of the experience of the implementation of the first face-to-face course of technician in RE systems in Brazil are presented. Additionally, there is also a proposal for an updated teaching program with the indication of a reference curricular matrix.

II. VOCATIONAL EDUCATION IN BRAZIL

Availability and professional qualification are fundamental for the support of actions with RE, not only for the need of installation and maintenance, but for the development of new technologies and the popularization of this knowledge. The limited initiatives were based on the Brazilian universities in which the researchers were able to carry out their postgraduate studies in other countries that already had a higher degree of development in the theme, mostly on 90's.

Research lines were established in large universities, however, associated with their graduate programs. The first Bachelor of Energy Engineering, originated in 2003 at State University of Rio Grande do Sul (UERGS in Portuguese), the others usually emerged from traditional courses such as: Electrical, Mechanical and Civil Engineering.

According to the Brazilian Ministry of Education [22], 27 courses of Energy Engineering or Renewable Energy Engineering are recognized and offered in Brazil in 2018, with an average duration of 5 years, and 2 higher courses of Technology in Renewable Energies, with duration of 3 years. These courses are distributed by Brazilian region, percentage of population and installed capacity of wind and solar electricity generation in Fig. 1 [23], [24]:

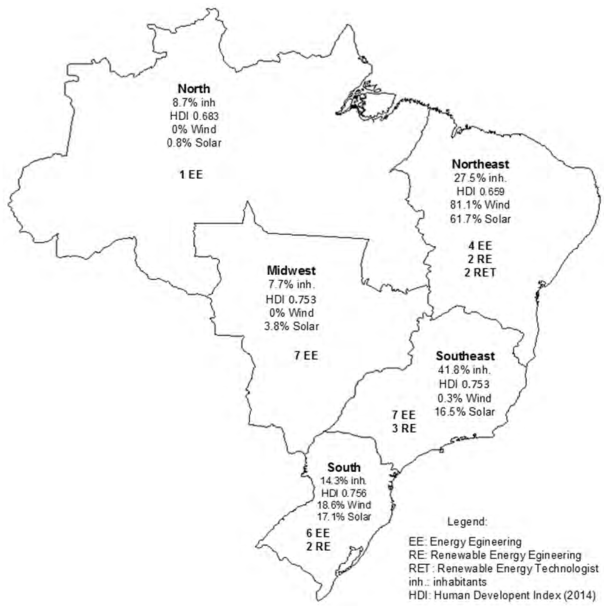

FIGURE 1. Undergraduate courses offer in energies and renewable energies in brazil by region [22]–[24].

Brazilian Northeast region stands out due to the greatest attractiveness of wind and photovoltaic projects in the country. The total installed capacity of electric power generation from wind power is 10,124 MW and 24 MW of solar energy in the country; in the Northeast region these projects represent 8,208 MW and 15 MW, respectively. Considering social aspects, the region shows the lowest human development index (HDI) in Brazil: 0.659 while the country is 0.755. Hence, there is a disproportionality in the offer of courses directed to RE.

Among the institutions that offer undergraduate courses, 31% are private and 63% of the offer concentrated in the Southeast and South regions of the country. Three Bachelor's courses in Environmental Engineering and Renewable Energies were identified, of which two in the northern region in a public institution and one in the Southeast region in a private institution.

Taking into account that such engineers and technologists are ultimately targeted for planning and management activities, there is a lack of professionals for intermediate, operational and maintenance activities. In general, these posts must be occupied by technicians, who in turn commands teams of entry level professionals such as electricians and mechanics.

Federal Institutes develop teaching, research and extension with strong technological characteristics and possibilities of partnership with the labor market. In general, they present smaller physical and administrative structures and autonomy to adapt the offer of professionals, in a situation more agile than the universities.

Technician certification in Brazil can be obtained through different routes shown in the flow chart of Fig. 2. In the case of technician of secondary level any candidate must have completed the initial nine years of regular study, from then on, in function of your age to choose the mode available by the school namely:

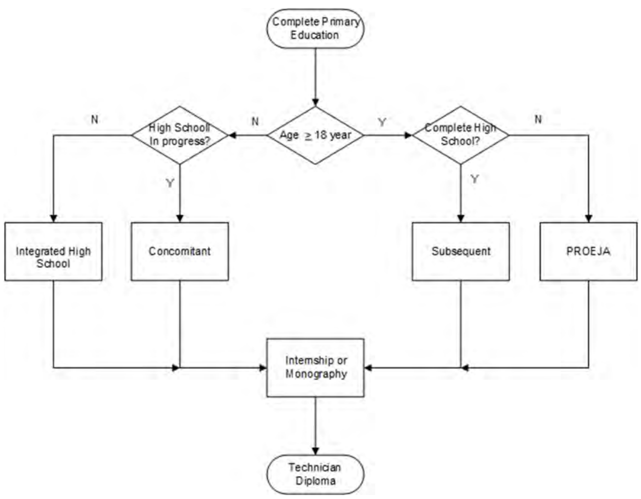

FIGURE 2. Routes for the training of technicians in brazil school.

Integrated Education: for candidates aged 13 to 17 years who continue their studies for a period between 3 to 4 years and whose diploma of technician allows the equivalence to the certificate of traditional high school;

Concomitant Education: intended for candidates aged 13 to 17 years who have already completed the first year of high school. The students attend the technical subjects in a shift opposite to the technical education and after completion, both will be entitled to the diploma of technician;

Subsequent Education: modality destined to those candidates with certificates of secondary education, or equivalent. They need to study only the technical subjects of the course, obtaining in 1 or 2 years the diploma of technician;

PROEJA: professional education program for youth and adults. The modality is offered in no less than 10% of the vacancies of the technical courses of the institution, destined to the students already adults (over 18 years), who did not finish the High School within the estimated age range. Usually offered on the night shift with a minimum work load of 2,400h.

III. TRAINING OF TECHNICIANS IN RE SYSTEMS

National Catalog of Technical Courses 2012 edition [25], of the Brazilian Ministry of Education, officially included the training of technician in RE Systems and described it as the professional that: performs the design, installation and maintenance of home and commercial renewable energy systems. It proposes and coordinates energy use and conservation activities emphasizing the use of alternative sources such as wind and solar energy. It elaborates projects of viability of the use of alternative energy sources in substitution of the conventional sources of energy having as motivation the reduction of the environmental impact. Conduct sizing, installation and maintenance of renewable energy systems.

The first class, in Brazil, was offered in 2013 by the Instituto Federal Sertão Pernambucano (IFSertão-PE) in the municipality of Petrolina, state of Pernambuco [26].

The region has a semi-arid climate, and in the last 50 years it has stood out in the country for agricultural production accounting for up to 40% of the fresh fruit exported to Brazil. It is the result of irrigation from the pumping of water from one of the largest Brazilian rivers, the São Francisco River.

The format of the technical course in RE systems of the IFSertão-PE, like the creation of the first Brazilian courses of energy engineering, was created from the course already existing in the institution for 25 years, the technician in Electrotechnology.

It was fundamental the expertise in training of technicians and basic infrastructure of laboratories in the technical courses of electrotechnology, chemistry, buildings, computers also fund from the National Program of Access to Technical Education and Employment (PRONATEC in Portuguese).

A. COURSE CHARACTERIZATION

The course was offered by the Petrolina campus of the IFSertão-PE, in the concomitant modality with students who had already completed the first year of the conventional high school and had active enrollment in public schools of the state network. The IFSertão had no interference in the choice of candidates, it was limited to receiving and enrolling the list forwarded by the state government.

All students received a scholarship grant, sufficient to fund transportation to campus and food expenses. The scholarship value varied according to individual expenses, and was limited to the school days, on average the students received R$200 per month (85 US$ - exchange rate in 12/31/2013). They also received uniforms, personal use materials such as handbags, notebooks and pens.

This assistance was considered necessary and relevant, since typically 60% of students enrolled in the campus, 4% had a family income equal to or less than 1 minimum salary in the country (254 US$), only 1.7% had a family income higher than 3 wages minimum [27].

The first group started in March 2013, afternoon shift, and a second class in March 2014 in the morning, both with 30 seats. The 1,200 hours workload, of which at least 480 hours devoted to practical activities in the laboratory (Fig. 3-4), or even in outdoor classes (Fig. 5).

FIGURE 3. Thermal machinery laboratory classes.

FIGURE 4. Use of tools at practical classes.

FIGURE 5. Outdoor georeferencing Class.

The practical approach is necessary not only for skills development of the future technician, but is valuable at any level of training, as described by Pantchenko *et al.* [28], which identified a 43% evolution of student learning after a hands-on course on solar concentrators.

The RE systems technician course was divided into 4 semester modules, from a more comprehensive array possible, and distributed in the following configuration:

First module: Applied Mathematics, Communication and Expression, Ethics and Citizenship, Instrumental English, Electricity I, Basic Mechanics;

Second module: Applied Computing, Principles of Thermodynamics, Fluid Mechanics, Work Hygiene and Safety, Electricity II, Electrical Installations, Energy and Environment. The student at the end of the second module could initiate, if there was availability, the obligatory professional internship with a minimum duration of 200 hours.

Third module: Electric Machines, Thermal Machinery, Solar-Heating Energy, Electronics I, Wind Energy, Entrepreneurship, CAD.

Fourth module: Hydraulic Power, Photovoltaic Solar Energy, Power Electronics, Biomass, Economic Engineering, Project Management, Innovation and Technology.

During the course the students were led to participate in workshops, seminars, lectures and short courses related to topics of interest that occurred during their stay on campus. They had the opportunity of technical visits to projects under construction or in operation, such as wind farms (Fig. 6), hydroelectric plants, thermoelectric plants, ethanol plants and applications of solar heating systems (Fig. 7).

FIGURE 6. Wind farm visit in casa nova-bahia-brazil.

In the academic field, two projects with the participation of students of the course deserved prominence: an extension project and a scientific initiation.

The extension, led by one of the graduates, who is now an employee of an energy concessionaire, installed a demonstration unit of an urban vegetable garden, irrigated from photovoltaic pumping. The installation, which was carried out at the Petrolina campus, in a large circulation area, remained active for 12 months, open to all community visits, as well as didactic for the activities in the course. The project resulted in publication in proceedings of scientific events [29].

FIGURE 7. Solar heating systems visit in petrolina-pernambuco-brazil.

In turn, the project of scientific initiation was led by two students of the technical course in renewable energies. Also, from a photovoltaic pumping system, they investigated the emergence of sunflower seeds under saline stress. The region whose IFSertão is inserted has a high salinity content in the subsoil water. The research presented relevant results for the eventual cultivation of this plant in the region and, besides the registration in proceedings of scientific events, resulted in a publication in periodical [30]. The students who conducted this project, when graduating, chose not to enter the job market immediately and continued their studies at a higher level, however, in Pedagogy course.

B. MAIN RESULTS

Sixty students were enrolled, of which only half completed the course on time. 45% were filled by female students, of which 44% were successful. In turn, the male audience had a course completion rate of 55% (Fig. 8). A maintained gender balance, while higher to the general campus audience, whose women account for 40.7% [27]

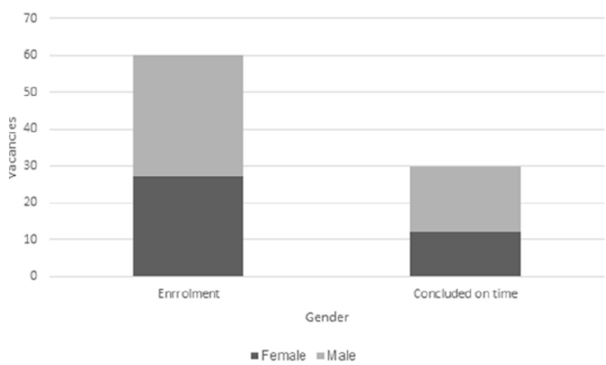

FIGURE 8. Flow of enrollments and students certified in regular term.

A questionnaire was carried out in December 2017 among the students who enrolled in the technical course on renewable energies of IFSertão-PE as a way to investigate from the point of view of the course. However, only 6% of those who did not complete the course returned the survey, saying that dropping out was due to the need to work at the same time of the course.

One of the difficulties encountered throughout the research was the location of the alumni, since the contact information was outdated, especially those who gave up the course. Thus, for the students' point of view, it was necessary to have a second research done afterwards, after finding a more significant number of students dropping out, is described in subsection 2.

1) ALUMNI POINT OF VIEW

The research initially sought to identify the motivation for choosing the course, represented in Fig. 9. The results regarding the motivation of the course choice are reflected by the lack of dissemination of the renewable energy segment, as well as the potential or demand by professionals. The choice of course because there are no other options or simply by chance, may also have contributed to the non-identification with the course and consequent evasion rate (50%).

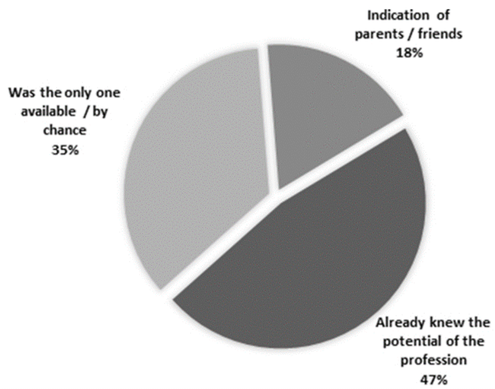

FIGURE 9. Reason for choosing the course.

With regard to the absorption of these technicians by the labor market, until the moment of the research, there was no record of hiring. Asked about the reasons for the difficulty of absorption by the market: the majority (52.9%) believe in lack of knowledge on the part of companies of the availability of this technical professional (Fig. 10).

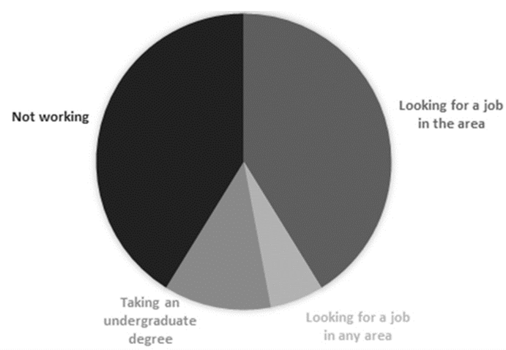

FIGURE 10. Occupation of alumni (Dec, 2017).

Although the research reflects a reality, different hiring opportunities arose, even intermediated by IFSertão-PE itself. However, in all, there was a requirement to register the Regional Council of Engineering and Agronomy (CREA in Portuguese).

Each of the 27 Brazilian states is represented by CREA, which in turn is linked to a central body by the Federal Engineering Council (CONFEA in Portuguese) and governed by Law 5,194 of 1966. They also represent geographers, geologists, meteorologists, technologists of these modalities, industrial and agricultural technicians and their specializations, in a total of hundreds of professional titles. They regulate and supervise the professional practice of those who work in the areas they represent [31].

IFSertão-PE, also submitted in 2014, the necessary documentation to open registration with CREA of the state of Pernambuco, to which it is under the jurisdiction, of those who would complete the technical course on renewable energy systems. However, provisional registration of technician in Electrotechnics was granted, starting in July 2017, while CONFEA level is being processed to include this new professional training. Among the graduates, 81% stated that they had not yet applied for registration in the class council due to lack of financial resources to pay the fees.

When asked to complete their studies, 81% stated that they were willing to take a degree in the area of energy, while 100% stated that they were willing to take further courses in renewable energy (Fig. 11).

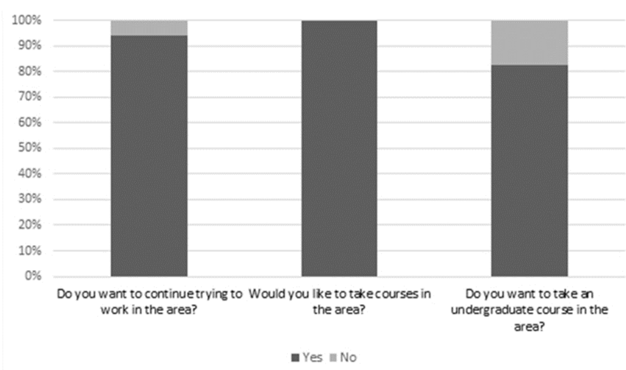

FIGURE 11. Level of interest in continuing in the RE area.

In June 2018, five graduates who declared that they were working, including three connected to the energy sector, were located and interviewed.

Asked about the importance of the course in their personal trajectory, they were unanimous in affirming that it was relevant. However, two who do not work in the area believe that the diploma contributed but was not determining their current occupations, however they are expected to be able to act in the energy segment.

Consulted about which curricular components were the most difficult and which of them could be reduced or even suppressed from the course, were pointed out as difficult: basic mechanics, electricity I and II and electric machines. In turn, Basic Informatics and Entrepreneurship were considered irrelevant. Finally, they suggested that they could have an increase in the time for the specific disciplines of renewable energies group.

2) DROP OUT STUDENTS' POINT OF VIEW

School dropout in vocational education is a recent and recurring theme of discussion in different educational institutions [32]. According to Padoim and Amorim [33], the causes of evasion in Brazil can be organized into three groups:

Individual/ personal: no identification with course, family structure, schedules mismatch, inconsistent previous training;

External causes: Poor urban / rural mobility, poor public safety, the labor market;

Internal causes: Facilities (infrastructure), didactic organization, teaching methodologies, effective monitoring of the various institution sectors of the institution (Coordination, pedagogues, social sector, health sector).

In the different studies carried out among students who have dropped out from technical courses, the following elements are usually found: lack of identification with the course (> 50%), lack of knowledge about the area of action, learning difficulties or methodology [34]–[37].

A major challenge faced by this stage of the present research was to find students who dropped out, due to outdated registration data. Still, the effort allowed contact with 12 of these students in November 2018.

For this research stage it was decided to make use of the Likert scale, since is applied as one of the most fundamental and frequently used psychometric tools in educational and social sciences research.

The original Likert scale is a set of statements (items) offered for a real or hypothetical situation under study. Participants are asked to show their level of agreement (from strongly disagree to strongly agree) with the given statement (items). The combination of results reveals the specific dimension of the attitude towards the issue, hence, necessarily interlinked with each other [38].

A set of 24 statements was presented to the interviewee who had to choose, on a five-point scale (strongly disagree, disagree, neutral, agree, strongly agree) their degree of agreement in each of them. The statements are shown in the Table 1.

The results were divides by groups, aiming to facilitate the understanding. The first group (Fig. 12) intends to gather individual/ personal information, or externalities.

Knowledge about the profession, job market, course identification, or family causes are reasons discarded by most respondents.

Otherwise the self-assessment carried out in the Q5 statements is highlighted, where there is an indication of the students' difficulties in fundamental subjects associated to the RE technical courses. Well as the level of maturity of the students at the time of leaving the course (Q06).

TABLE 1. Drop out survey statements.

ITEM	STATEMENTS
Q01	When I enrolled for the course, I already knew the activities of the profession.
Q02	I identify with the course.
Q03	My family had no influence on my decision to drop the course.
Q04	My relationship with my classmates had no influence on my decision to drop out.
Q05	My previous knowledge of math and physics was enough for the course.
Q06	I had the maturity to decide my renounce of the course.
Q07	The course met my expectations.
Q08	It is easy to get move to the Petrolina campus.
Q09	It is safe the surroundings of the Petrolina campus.
Q10	The job market is excellent for the RE Systems Technician
Q11	The schedule offered for my class was adequate.
Q12	The facilities at the Petrolina campus, classrooms and laboratories, are excellent.
Q13	Campus Petrolina, in general, is a pleasant place to go.
Q14	The library services (collection, loans and service) are sufficient.
Q15	The coordination of the course was always present and available to the students.
Q16	The pedagogues' support is satisfactory.
Q17	The methodology adopted by the teachers is adequate.
Q18	Scholarship is indispensable.
Q19	The distributed educational material (uniforms, purses, pens, pen drive, notebooks) is adequate and sufficient.
Q20	The curricula (subjects) are well dimensioned for professional training.
Q21	IFSertão-PE is considered a public institution of excellence.
Q22	The course subjects require that the student have a good previous training.
Q23	I would recommend the course to friends or family.
Q24	If there is a possibility, I will return to the course.

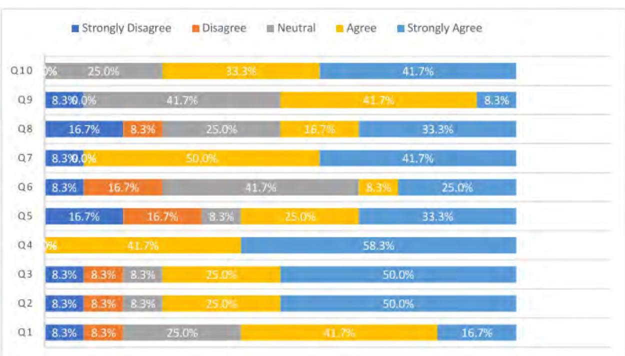

FIGURE 12. Answers distribution of responses to the survey form: Externalities (Nov, 2018).

A second set of statements was directed to internal causes. The answers distribution of the answers is shown in Fig.13.

It is noteworthy in the second set of responses that the internal causes had less influence, for students who dropped out. A slight emphasis is found on statement Q11, which deals with the class schedule, considering that it competes with the usual schedule of formal employment.

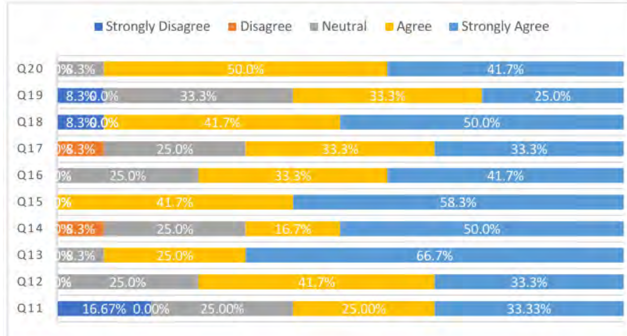

FIGURE 13. Answers distribution to the survey form: Internal causes (Nov, 2018).

The third set of statements, shown in Fig. 14, attempts to identify broader questions about the student's view of the institution, as well as interest in returning to course activities.

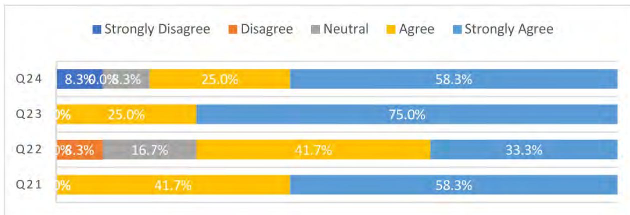

FIGURE 14. Answers distribution of to the survey form: Resilience (Nov, 2018).

The answers show that the institution has the recognition and respect from the point of view of the students and their willingness to come back to complete the RE technical course if they have the opportunity.

3) TEACHERS' POINT OF VIEW

The teachers who acted in the course, also received an aid grant in the amount of R$50 (21.5 US$) per hour of class given. They were selected from a public announcement that prioritized the training, professional experience in the area, as well as, the teaching experience. The initiative allowed non-permanent teachers of IFSertão to be hired. It was necessary to outsource 25% of the course workload, essentially due to the permanent faculty's unavailability of taking disciplines in the period or time, demanded at the time.

Nine teachers who participated in the course were interviewed, of whom two did not belong to the permanent staff. However, the group was responsible for offering 77.5% of the course hours, notably in the last 3 periods. Teachers distribution according to their degree is represented in Fig. 15. With all postgraduate students, the Doctorate, Master and Specialist fields are included those already graduated and those who, at the time, were still candidates for the respective degree.

In Fig. 16, teachers are distributed according to their experience as teacher in years in three ranges: less than 5 years,

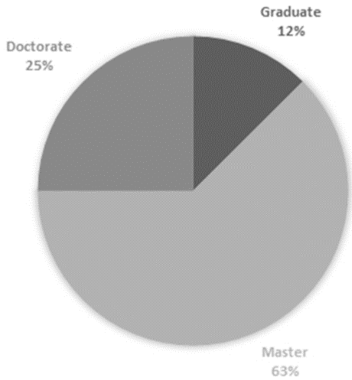

FIGURE 15. Teachers distribution according to their degree.

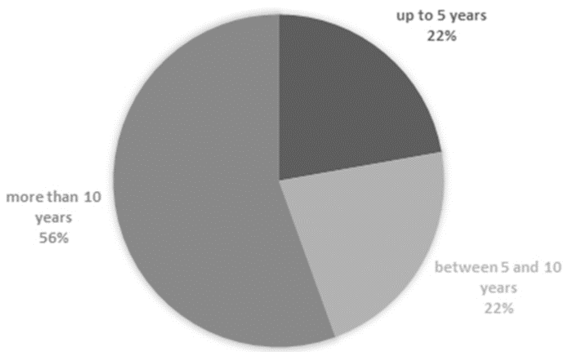

FIGURE 16. Teachers distribution based on classroom experience.

5 to 10 years and more than 10 years. Both distributions reveal a teaching staff with higher education than required for technical teaching, at least graduation, as well as an equally high degree of experience, since 78% of the group had been in the classroom for 5 years.

When asked about the adequacy of the workload available for their respective subjects, adjustments were suggested to expand the hours of the disciplines: electrical installations and wind generation. For Thermal Machines it was suggested a reduction of 25%. For the Biomass curricular component, it was suggested to divide into three: biogas, biofuels and biomass, the last one being dedicated to the direct use of coal and briquettes.

It was investigated to the interviewees if there was need to resort to additional studies, or complementary, to execute their subjects. teachers of Thermal Machines, Hydroelectricity and Thermal Solar were informed that they had to look for more information on the subject in books, periodicals and Internet. The others only needed enough basic information to contextualize their classes.

With respect to the infrastructure of laboratories, for the execution of their practical classes, all agreed that it was enough, however, can always be increased with new instruments and equipment.

Already the availability of didactic material in the library for students, declare unsatisfactory: Photovoltaic, Thermal Solar, Biomass and Thermal Machines. It was necessary to create specific didactic material to be used in the discipline. The others admitted the elaboration of complementary material and contextualization with the theme.

In fact, there were no specific books for such subjects in the campus library; however, checking the library's collection, at least two titles dealing with the subjects were identified, albeit in a more general way, both in Portuguese language, in sufficient quantity for use by the students. The availability of technical books in RE written in Portuguese for acquisition in the Brazilian market is still a barrier to be overcome.

The funding provided to support the course did not require book purchases. Still, buying books for the Federal Institutes' libraries requires a slow, bureaucratic process, which can sometimes take more than a year. Considering a pioneer course in which some subjects were offered for the first time in the institution, it was impossible to meet this demand in time.

Teachers involved were asked to report their evaluation in relation to their students, during their classes, three different aspects: the degree of interest, minimum or previous knowledge for the student's good development, and finally, its performance in the subject. The distribution is shown in Fig. 17.

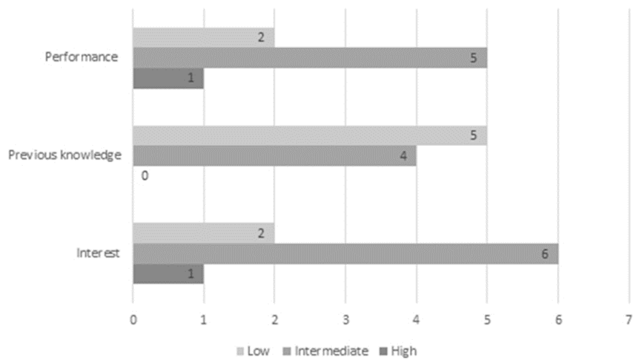

FIGURE 17. Critical analysis of teachers about their students.

The knowledge pre-parameter is highlighted, partially explained as a consequence of the deficient formation in the basic education of the public school in the region, compensated only by the median interest in the subjects and consequent use.

4) EMPLOYERS AND RE COMPANIES' POINT OF VIEW

A survey was conducted with employers from RE companies in the Brazilian Northeast region aiming to evaluate their point of view about the professional activities and the offer of technical courses in the RE sector.

The survey was answered by 14 companies, whose classification considering the number of employees is shown in Fig. 18.

Some companies work with more than one RE sector, according to Fig.19.

Particularly noteworthy are the PV and wind sectors (45% of the companies), modalities which are receiving significant investments in the mentioned region.

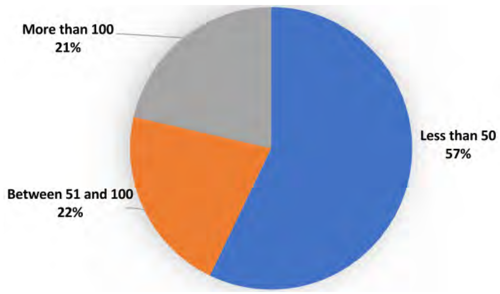

FIGURE 18. Classification of RE companies according to the number of employees.

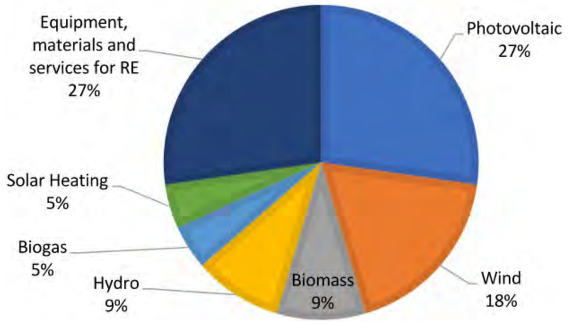

FIGURE 19. RE sectors of the surveyed companies.

Asked if the companies already knew the profession of technician in RE systems, 42.9% of them answered no, and they did not know of their offer by IFSertão-PE.

When asked if a RE technician could develop activities in the company, 87.5% answered positively and 92.5% stated that they would hire a professional with such training. 100% of the respondents believe that there is demand for a RE technician in the Brazilian market.

Among the surveyed companies, 4 of them reported that they have already owned, or have RE technicians in their teams. Requested to make a quality assessment of their respective RE technicians from a scale with 4 performance options (low, regular, good, excellent), 50% considered good performance, and 50% considered excellent performance.

5) SOME LEARNING LESSONS

Brazil has a high potential for the application of RE technologies and, therefore, a need for better qualified professionals to support this demand.

The experience described in this paper provided indicators of how technical courses in RE systems in Brazil can be conducted, reiterating the need for greater dissemination among companies in the sector. And it also presents a proposal of curricular matrix as a model for courses offered in the country, or even abroad.

Federal Network of Professional, Scientific and Technological Education of Brazil presents favorable conditions for this purpose, due to its expertise and distribution in the national territory. Even in the projects of teacher training courses, inserting disciplines, or even, putting in discussion the theme, contextualizing with its area of action.

Financial return is an important variable for the young student in choosing his career. Dedicating two years to a course unknown by society, turns out to be a challenge that requires patience and dedication. However, the very interdisciplinary and transversal characteristics of renewable energies favor the exercise of this professional in distinct but related areas such as electricity and mechanics.

Use of previous knowledge and skills is a possibility in the Brazilian education legislation. Students who already have training, or experience, with any course subjects can request that an assessment be done to prove their knowledge and thereby complete the course more quickly.

Partial certification of students, especially those who do not complete the course, in the matrices can be listed a set of subjects that, when completed, can be used to compose a professional certificate at the craftsman level, such as: electrician, photovoltaic assembler, solar heating systems assembler, etc.

It is possible to implement a technical course on RE from small modifications in the pre-existing infrastructure, team experience and the encouragement of partnerships between the public education institution and the private productive sector.

The course was created from the pre-existing infrastructure of the electrotechnical course. In the case of a new course there was the concern of the authors regarding the employability of these professionals, care was taken in the format of a curricular matrix that guaranteed professional knowledge that, at least, was able to act as an electrician. Compared with the curricular matrix of the technical course in Electrotechnology of Petrolina campus for the year 2019, there is a 62.5% similarity. Nevertheless, the teachers of the curricular components common to the courses, are oriented to contextualize the content according to the main training, electrotechnical or RE. A possibility of deepening specific segments of renewable energies is through technical specialization for those who have completed the RE technical course.

After the implementation of the first Brazilian experiences in the provision of technical courses in RE, thematic committees were set up within the Ministry of Education to guide vocational training policies at the national level. These committees were officially established by ordinance No. 12 Ministry of Education of the Ministry of Education on March 12, 2018 [39]. They are responsible, among other activities, for the elaboration of curricular reference matrices for technical specialization courses with a minimum duration of 300 hours to be offered by the Federal Education Network in the following priority segments: (I) Photovoltaic Energy, (II) Wind Energy, (III) Energy Efficiency - subarea industry, (IV) Energy Efficiency subarea buildings, (V) Biogas / Biomethane e (VI) Biofuels.

The experience in the implementation of the first classes of the technical course in RE systems in Brazil, after the

TABLE 2. Curricular guide matrix developed.

SUBJECTS		HOURS
Technical design		60
Electromagnetism		30
Instrumental English		30
Work Safety		30
Math		30
Instrumental Language (mother language)		30
Electricity DC		60
Environment		30
	Sub total	**300**
Technical mechanics		60
Technological Innovation and Entrepreneurship		30
Electricity AC		60
Transformers		30
Principles of Thermodynamics		30
Mechanics of fluids		30
Basic Meteorology		30
Computer aided design		30
	Sub total	**300**
Electric machinery		60
Practice at electrical installations		60
Electronics		60
Thermal machinery		30
Planning and Control of Maintenance		30
Design of electrical installations		60
	Sub total	**300**
Hydroelectricity		60
Heliothermic recovery		30
Biogas		30
Biofuels		30
Photovoltaics		60
Wind Energy		60
Energy Efficiency		30
	Sub total	**300**
	TOTAL	**1,200**

bibliographic review, evaluation with teachers, students, and companies of the RE sector, allowed the authors to elaborate the proposal of a new curricular matrix.

The suggested matrix, which can be used as a guide for other professional education institutions in the country, or even abroad, is described in Table 2.

However, despite the fact that the experiment did not make use of this resource, the authors strongly recommend that any new course projects be preceded by a survey with the ER companies and possible employers in the region, for adjustments and inclusion in the eventual curricular matrix demands of specific skills and competences.

The research of the experiment was carried out only after the conclusion of the classes and ended up generating some difficulties in the evaluation process. A good practice to be adopted would be real-time assessment as the disciplines, or modules, as they are conducted. This action would allow a more accurate assessment.

Future research is expected to adapt the proposed matrix, in other modalities of technical education such as the subsequent, integrated high school and PROEJA.

IV. CONCLUSION

Availability of specialized professionals is fundamental for the consolidation of policies of RE insertion in the energy matrix of any country. Offer of technical courses not only prepares professionals to the job market but also contributes to disseminate RE technologies knowledge.

Considering the social and economic context, the implementation of a RE technical course in the semiarid area of the Brazilian northeastern region was an initiative characterized by many challenges; this initiative is now showing the first results that can be considered satisfactory.

The acquired experience during the process allowed the authors to propose a new curricular matrix, which can be used in future course offers in Brazil, especially in the Northeast region. As mentioned, this region is characterized by climatic conditions that have attracted continuously large scale new RE projects.

The analyses show that the Federal Network of Professional, Scientific and Technological Education, due to its distribution in the country, combined with its expertise in professional training and infrastructure, has a high potential to meet any demand for RE technicians in Brazil. As an important condition for a future development, it is necessary that unit managers, teachers, community and entrepreneurs, express interest in the opportunities that RE has indicated.

Events promotion and lectures workshops with the presence of professionals and investors are important tools. Hence, the investigation of what kind of specific skills the RE companies need to meet the sector demands is a fundamental aspect to be considered.

The reinforcement of professional training programs should be permanently considered by the dissemination of courses, support to laboratories, motivation to research and extension activities and publication of texts and books in a language accessible to the respective education levels.

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