# Basic Solar Energy Installation and Maintenance Skills Required by Students in Technical Colleges for Sustainable Employment and Job Security in Enugu State

**by**
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**Abstract**
*The study was set to determine the basic solar energy installation and maintenance skills required by students in technical colleges for sustainable employment and job security in Enugu State. The study was essential due to the urgent need for clean and renewable energy and the need for stable power supply and sustainability of job security among graduates. Two research questions and two null hypotheses guided the study. A survey research design was adopted while the population was 126 respondents (39 Trade Teachers and 87 solar Technologists) sampled purposively from 11 technical colleges used for the study. Instrument for data collection was structured questionnaire which was made up of two sections according to the research questions that guided the study. The questionnaire has a total of 27 item statements designed in 4 points response categories of very highly required, highly required, slightly required, and not required with numerical values of 4, 3, 2 and 1 respectively. Mean was used to answer the two research questions while t-test was used to test the three null hypotheses at .05 level of significance. The findings of the study showed that Skills in wiring solar panels, inverters, and batteries, ability to Implement safety measures while working with electrical systems, Knowledge of local building and electrical codes related to solar installations and securing cables to ensure efficiency and safety among others are the basic installation skills required by students. Also, it was found that t Proficient in using the right tools and equipment specific to solar installation, Skills in replacing faulty components (e.g., panels, batteries) and Ability to analyse potential risks during maintenance tasks among others are the maintenance skills required among others Recommendation were made which include to update the existing curriculum to include comprehensive modules on solar energy technology, installation, maintenance, and policy.*
**Keywords:** solar energy, installation, maintenance, skills, sustainable employment.

## Introduction

The increasing global shift towards renewable sources of energy for efficiency and environmental conservation has presented a unique opportunity for students, teachers and captains of industry. These emerging technologies minimized environmental impact and promote energy efficiency especially in solar energy in order to contribute to the advancement of sustainable job security. The major objective of education is to prepare the recipient of such programmes for the world of work. Igbojionu (2008) stated that such aim is achievable when the students acquire relevant literate and numerable skills and competencies that will promote satisfaction brought about by successful self-employment and to enable them function well in the society. Igbojionu maintained that this satisfaction will be brought about by the acquisition of entrepreneurial competencies such that the recipient will recognize the social and economic benefits accruing to the entrepreneur. Also, Alio & Uzor (2010) opined that the accelerating pace of technology development has made a large number of jobs and skills obsolete

However, skills in both installation and maintenance of solar energy systems are essential not only for the technical performance of renewable energy technologies but also for fostering sustainable self-employment and enhanced job security among technical college graduates (Ejiofor, & Okoye, 2025).They further stated that these skills include practical skills in solar panel assembly, electrical system understanding, and routine maintenance tasks, which together form the foundation of a resilient and employable workforce in the growing solar energy sector. It is central to success of school learning or acquisition of skill, knowledge and attitude in informal school setting especially in solar energy, electrical power.

Electrical power is the rate at which electrical energy is converted, supplied and consumed in an electrical circuit per unit time (Onoh &Agu, 2018). They opined that due to the fact that source of conventional means of energy generation (Coal, Fossil fuel and gas) are very expensive, most homes and industrialized countries have started resorting to the use of solar energy as a renewable source of energy. Oluka & Onyebuenyi (2017) opined that Solar energy is radiant light and heat from the sun that can be harnessed using a range of ever evolving technologies like solar photovoltaic and solar thermal energy. They further stated that Solar energy system has not only emerged as a renewable energy source but it has generated large job opportunities in Enugu state and the Nation at large in the design, harvesting, installation and maintenance of solar energy programs can as well be thought in technical colleges. Onoh & Agu (2018) opined that Solar power installation involves the assempledge of solar power component which include solar panel, charge controller, battery, inverter and etc. for efficient and effective performance.

However, technical college is a post primary education institution established for enrollment of students specifically for practical oriented skill acquisition for sustainable job security. Technical colleges According to Abdulkadir (2011) the responsibilities of technical college education in Nigeria include: provision of full time or part-time courses of instruction and training in technology, applied science and commerce, in such other field of applied learning, relevant to the needs of the development of Nigeria in the areas of industrial, commercial and vocational agriculture, professional studies in engineering and other technologies and perform such other functions as in the opinion of the society as may serve to promote the objectives of the technical colleges for acquisition of competency skills.

Skills are the abilities or knowledge that someone has acquired through training, practice, or experience. Agu (2018) stated that skills are the ability of an individual to perform a task using his theoretical knowledge, practical skills, and experience. Agu further explained that skills deal with specific task required to perform successfully in a given situation. Hence, Skill acquisition according to Aliozor (2004) is the process by which individuals are expected to learn and continuous practice in particular task till the learner becomes proficient in the operation and can perform them when required. Fadairo (2010) further explained that possession of skill is to demonstrate the habit of acting, thinking or behaving in a specific activity, which has become so natural to the individual through repetition or practice such that it becomes automatic. Skills can be more general, like communication skills, problem-solving skills, or leadership skills. Developing a diverse set of skills can help individuals succeed in various aspects of their personal and professional lives. Skills can also be specific to a certain job or task, such as coding, accounting, woodworking, building construction, electrical installation and maintenance, repair of radio and television and electronics works, refrigeration and air conditioning, winding of electrical machines, installation of solar energy etc for sustainable job security.

Job security refers to the probability that an individual will keep their job without the risk of becoming unemployed. It is a measure of the

stability and predictability of employment in a particular position or industry. High job security means a lower likelihood of job loss, while low job security indicates a higher risk of unemployment. Here are the key aspects of job security. Job security has become a national concern today as it concerns itself with job satisfaction requirements. Onyebuenyi and Mbah (2018) perceived job security as job assurance. They added that, it involves all the favourable conditions that may surround a specific job while it lasts. Olubunmi (2015) noted that many jobs can be created through solar installation and running of solar energy system. To enhance job security for technical college students specializing in solar energy, a comprehensive approach is essential which ensures that students are well-prepared and equipped with necessary skills to excel in the field of solar. These will not only benefit the students in terms of job security but also contribute to the sustainable development of Nigeria by providing clean and renewable energy sources.

However, sustainability is a holistic approach that balances environmental health, economic prosperity, and social well-being to create a viable and thriving future for all. Sustainable job security in this context, according to Okonkwo, Onyebuenyi, & Okoye (2022), entails securities surrounding a particular job while the job lasts. They further explained that for there to be sustainable job security among graduates of technical colleges, there is a need for skill enhancement. Solar energy, being a pivotal component of the renewable energy sector, offers significant potential for sustainable job creation. To harness this potential, it is imperative to reinforce solar energy installation and maintenance skills among technical college students in Enugu State.

## Statement of the Problem

There is a growing recognition of the importance of renewable energy sources, particularly solar energy, in addressing both energy needs and environmental sustainability. Despite this, there is a significant gap in the solar energy installation and maintenance skills among technical college students, which poses a challenge to their sustainable job security in the rapidly evolving energy sector. Most technical colleges in Nigeria often lack the infrastructure and resources necessary to provide students with hands-on experience in solar energy technologies. This deficiency limits the students' ability to acquire the practical skills essential for effective installation, maintenance, and troubleshooting of solar energy systems. The existing curriculum in many technical colleges does not adequately cover the latest advancements in solar energy technology. Without updated educational materials and methods, students are ill-prepared to meet current industry demands, reducing their employability in the solar sector.

There is also a lack of collaboration between technical colleges and the solar industry in Enugu State. Partnerships with industry stakeholders are crucial for providing students with real-world experience through internships, apprenticeships, and exposure to industry-standard Economic challenges and inadequate policy support for renewable energy education and employment hinder the development of robust training programs. This affects the ability of technical colleges to invest in state-of-the-art training facilities and resources necessary for comprehensive solar energy education for sustainable job security in Enugu State.

## Purpose of the Study

This study was set to identify the reinforcement of solar energy competency skills among technical college students for sustainable job security in Enugu State. Specifically, the study sought to identify;

1. The basic solar energy installation skills required by technical college students for sustainable employment and job security in Enugu State.
2. The basic solar energy maintenance skills required for technical college students for

sustainable employment and job security in Enugu State.

**Research Questions**

1. What are the basic solar energy installation skills required by technical college students for sustainable employment and job security in Enugu State?
2. What are the basic solar energy maintenance skills required by technical college students for sustainable employment and job security in Enugu State?

**Hypotheses**

1. There is no significant difference between the mean responses of Trade Teachers and solar Technologists on the basic solar energy installation skills required by technical college students for sustainable employment and job security in Enugu State.
2. There is no significant difference between the mean responses of Trade Teachers and solar Technologists on the basic solar energy maintenance skills required for technical college students for sustainable employment and job security in Enugu State.

**Methodology**

The study was carried out in Enugu State with a population of 126 respondents (39 Trade Teachers and 87 solar Technologists) sampled purposively from 11 technical colleges used for the study. The instrument for data collection was a questionnaire which consisted of 27 items statements structured in a four-point rating scale of Very Highly Required (VHR), Highly Required (HR), Slightly Required (SR) and Not Required (NR) with weighting values of 4, 3, 2, and 1 point respectively. The instrument for data collection was face validated by three experts, two experts are in the area of the electrical/electronics (tech) education while one expert is in measurement and evaluation all in the Faculty of Education Enugu State University of Science and Technology (ESUT). The reliability of the instrument was determined by administering it to 5 Trade Teachers and 5 Solar Technologists in Imo State. The data collected was analyzed using Cronbach Alpha formula to establish the reliability index which was found to be 0.79 indicating that the instrument was reliable and, hence used to collect data for the study.93 copies of questionnaire were distributed, completed and returned, hence representing 100% return rate. The researcher carried out this exercise with the help of two research assistants. Thus, the decision was that if the t-calculatedis greater or equal to t-table value at 0.05 level on analyzing the data collected, mean and standard deviation were used to answer the research questions. Upper and lower limits of the mean were used as the basis for decision making, thus; Very Highly Required (VHR): 3.50 -4.00, Highly Required (HR): 2.50 - 3.49, Slightly Required (SR): 1.50 - 2.49, Not Required (NR): 1.00 - 1.49. The null hypotheses were tested at the .05 level of significance and appropriate degrees of freedom using the t-test. The null hypotheses were rejected when t-calculated was greater than t-critical value and were not rejected when t-calculated value was less than t-critical value. significance, the null hypothesis will be rejected otherwise, it will not be rejected.

**Results**

The results in line with the research questions and corresponding null hypotheses that guided the study are presented below.

**Research questions 1**

What are the basic solar energy installation skills required by technical college students for sustainable employment and job security in Enugu State?

**Table 1**

**Mean and standard deviation of respondents regarding the basic solar energy installation skills required by technical college students for sustainable employment and job security in Enugu State**

| SN | Basic solar energy installation skills required by technical college students includes: | Solar Technologies (87) | | Trade Teachers (39) | | Overall (126) | | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | $\overline{X}_1$ | $SD_1$ | $\overline{X}_2$ | $SD_2$ | $\overline{X}$ | SD | |
| **1.** | Understanding the components and layout of solar energy systems | 3.45 | 0.61 | 3.51 | 0.52 | 3.48 | 0.37 | HR |
| **2.** | Skills in wiring solar panels, inverters, and batteries. | 3.62 | 0.70 | 3.49 | 0.51 | 3.56 | 0.61 | VHR |
| **3.** | Ability to evaluate locations for optimal solar panel placement. | 3.31 | 0.67 | 3.34 | 0.60 | 3.33 | 0.64 | HR |
| **4.** | Ability to Implement safety measures while working with electrical systems. | 3.50 | 0.70 | 3.56 | 0.51 | 3.53 | 0.61 | VHR |
| **5.** | **Ability to understand the sun's trajectory to optimize solar panel placement.** | **3.07** | **1.08** | **3.28** | **0.77** | **3.18** | **0.93** | **HR** |
| **6.** | Ability to understand how to incorporate battery storage in solar systems. | 3.12 | 0.82 | 3.03 | 0.75 | 3.07 | 0.79 | HR |
| **7.** | Ability to identify and resolving installation issues or faults. | 3.38 | 0.68 | 3.23 | 0.70 | 3.31 | 0.69 | HR |
| **8.** | Skills in finalizing and testing solar systems before they go live. | 3.48 | 0.62 | 3.44 | 0.62 | 3.49 | 0.62 | HR |
| **9.** | Knowledge of local building and electrical codes related to solar installations. | 3.52 | 0.72 | 3.66 | 0.54 | 3.59 | 0.63 | VHR |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **10.** | Setting up systems for tracking energy production and performance. | 3.49 | 0.70 | 3.51 | 0.69 | 3.50 | 0.69 | VHR |
| **11.** | Proper techniques for handling and installing solar modules. | 3.11 | 0.91 | 3.26 | 0.83 | 3.22 | 0.49 | HR |
| **12.** | Organizing and securing cables to ensure efficiency and safety. | 3.18 | 0.70 | 3.28 | 0.77 | 3.23 | 1.47 | HR |
| **13.** | Skills in explaining solar energy benefits to customers. | 3.31 | 0.67 | 3.34 | 0.60 | 3.33 | 0.64 | HR |
| **14.** | Ability to assess project costs and budget accordingly. | 3.45 | 0.61 | 3.64 | 0.50 | 3.55 | 0.56 | VHR |
| **15.** | Skills in creating manuals and documentation for solar installations. | 3.29 | 0.60 | 3.41 | 0.49 | 3.35 | 0.56 | HR |
| | **GRAND MEAN** | **3.36** | **0.67** | **3.40** | **0.63** | **3.38** | **0.65** | **HR** |

**NB: VHR= Very Highly Required, HR= Highly Required, X = Mean, SD= Standard Deviation.**

Data presented in the table 1 showed that the mean responses at the respondents on the items number 2,4,9,10, and 14 are 3.56, 3.53, 3.59, 3.50 and 3.50 respectively indicating very highly needed responses while items number 1,3,5,6,7,8,11,12,13 and 15 were highly required basic solar energy installation skills required by technical college students for sustainable employment and job security in Enugu State with aggregate scores range of 3.07 to 3.49.

**Hypothesis One**

There is no significant difference between the mean responses of Teachers and Administrators of technical colleges on the basic solar energy installation skills required by technical college students for sustainable employment and job security in Enugu State.

**Table 2**

**t-test analysis between solar technologists and trade teachers regarding the basic solar energy installation skills required by technical college students for sustainable employment and job security in Enugu State.**

| Respondents | N | $\overline{X}$ | SD | DF | P. | t-cal | t-tab | Decision |
|---|---|---|---|---|---|---|---|---|
| Solar Technologist | 87 | 3.36 | 0.67 | 119 | 0.05 | 0.326 | 1.980 | NS |
| Trade Teachers | 39 | 3.40 | 0.63 | | | | | |

**NB: NS: Not Significant. SD: Standard deviation. DF: Degree of freedom**

Data in Table 2 revealed that no significant difference exists in the mean ratings between technical college trade teachers and solar technologists regarding the basic solar energy installation skills required by technical college students for sustainable employment and job security in Enugu State as t-Calculated value of 0.326 was obtained against t-tabulated value of 1.980 at 119 degree of freedom and 0.05 level of significant.

**Research Question Two**

What are the basic solar energy maintenance skills required by technical college students for sustainable employment and job security in Enugu State?

**Table 3**

**Mean and Standard deviation of respondent regarding the basic solar energy maintenance skills required by technical college students for sustainable employment and job security in Enugu State**

| SN | Solar energy maintenance skills required by students of technical colleges include: | Solar Technologies (87) | | Trade Teachers (39) | | Overall (126) | | Decision |
|---|---|---|---|---|---|---|---|---|
| | | $\overline{X}_1$ | $SD_1$ | $\overline{X}_2$ | $SD_2$ | $\overline{X}$ | SD | |
| 16 | Ability to perform a routine check to ensure system integrity and performance. | 3.20 | 0.79 | 3.35 | 0.52 | 3.28 | 0.66 | HR |
| 17 | Skills in checking and maintaining battery health and longevity. | 3.22 | 0.86 | 3.32 | 0.60 | 3.27 | 0.73 | HR |
| 18 | Regular inspection of electrical connections and wiring integrity. | 3.45 | 0.16 | 3.51 | 0.52 | 3.48 | 0.57 | HR |
| 19 | Following safety measures during maintenance work. | 3.18 | 0.19 | 3.28 | 0.77 | 3.23 | 0.84 | HR |
| 20 | Proficient in using the right tools and equipment specific to solar installation | 3.20 | 0.50 | 3.70 | 0.55 | 3.60 | 0.64 | VHR |
| 21 | Skills in replacing faulty components (e.g., panels, batteries) | 3.50 | 0.50 | 3.57 | 0.49 | 3.54 | 0.50 | VHR |
| 22 | Ability to analyse and evaluate system performance to identify areas for improvement and optimization | 3.29 | 0.60 | 3.34 | 0.60 | 3.32 | 0.60 | HR |
| 23 | Awareness of environmental issues related to energy generation and benefits of renewable energy sources | 3.21 | 0.76 | 3.46 | 0.51 | 3.34 | 0.64 | HR |
| 24 | Ability to keep maintenance records and documentation accurate. | 3.37 | 0.82 | 3.49 | 0.51 | 3.43 | 0.67 | HR |
| 25 | Ability to analyse potential risks during maintenance tasks. | 3.61 | 0.70 | 3.77 | 0.41 | 3.69 | 0.56 | VHR |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 26 | Working with teams or clients during maintenance projects. | 3.14 | 0.80 | 3.35 | 0.52 | 3.25 | 0.66 | HR |
| 27 | Knowledge of how to handle emergencies related to solar systems. | 3.32 | 0.92 | 3.33 | 0.60 | 3.25 | 0.76 | HR |
| | **Grand total** | **3.32** | **0.75** | **3.46** | **0.55** | **3.39** | **0.65** | **HR** |

**NB: VHR= Very Highly Required, HR= Highly Required, X = Mean, SD= Standard Deviation.**

Data presentation in table 3 showed that the mean responses of the respondent on the items number 20, 21, and 25 are 3.60, 3.54, and 3.69 respectively indicating very highly required responses while items number 16, 17, 18, 19, 22, 23, 26 and 27 were highly required basic solar energy maintenance skills required by technical college students for sustainable employment and job security in Enugu State with an aggregate score range from 3.23 to 3.48.

**Hypothesis Two**

There is no significant difference between the mean responses of Trade Teachers and solar Technologists on the basic solar energy maintenance skills required for technical college students for sustainable employment and job security in Enugu State.

**Table 4**

**t-test analysis between solar technologists and Trade Teachers regarding the basic solar energy maintenance skills required for technical college students for sustainable employment and job security in Enugu State.**

| Respondents | N | $\overline{X}$ | SD | DF | P. | t-cal | t-tab | Decision |
|---|---|---|---|---|---|---|---|---|
| Solar Technologist | 87 | 3.32 | 0.75 | 119 | 0.05 | 1.186 | 1.980 | NS |
| Trade Teachers | 39 | 3.46 | 0.55 | | | | | |

**NB: NS: Not Significant, SD: Standard deviation DF: Degree of freedom.**

Data in Table 4 revealed that there is no significance exist in the mean ratings between solar technologists and technical college Trade Teachers regarding the basic solar energy maintenance skills required for technical college students for sustainable employment and job security in Enugu State. As t-calculated value of 1.186 was gotten against t-tabulated value of 1.980 at 119 degree of freedom and 0.05 significance level

**Discussion of Findings**

Findings of the study according to research question one showed that the basic solar energy installation skills required by technical college students for sustainable employment and job security in Enugu State which includes; Skills in wiring solar panels, inverters, and batteries, ability to Implement safety measures while working with electrical systems, Knowledge of local building and electrical codes related to solar installations, Proper techniques for handling and installing solar modules and Organizing and securing cables to ensure efficiency and safety among others. The findings concur with Okonkwo, Onyebuenyi and Okoye (2022) revealed that making favourable educational polices, provision of tools, absorption of competent lab human resources, adequate funding, encouraging teachers via incentives and awards, provision of teacher's capacity development programmes are strategies for enhancing skill among technical college students for sustainable job security on graduation. However, the hypothesis test of no significant difference shows that there is no significant

difference in the mean ratings between solar energy Technologists and technical colleges trade teachers regarding the basic solar energy installation skills required by technical college students for sustainable employment and job security in Enugu State. Hence, the null hypothesis is therefore not rejected for these items. By implication, the status of the respondents has no significant influence in their opinions regarding the items.

The findings of these study also showed that Proficient in using the right tools and equipment specific to solar installation, Skills in replacing faulty components (e.g., panels, batteries) and Ability to analyse potential risks during maintenance tasks among others are the installation skills required by technical college students for sustainable employment and security in Enugu State. This agrees with Akpan (2003) opined that majority of the graduates are only interested in passing their exams and possessing degrees rather than acquiring the basic competencies required for self-employed. Hence the result of the corresponding hypothesis shows no significant difference in the mean ratings between solar energy Technologists and technical college trade teachers regarding basic solar energy maintenance skills required by technical college students for sustainable employment and job security in Enugu State. This shows that the t-calculated value gotten was low against the t-tabulated value at the appropriate degree of freedom and significance level.

**Conclusion**

Based on the findings of the study, it was concluded that students of technical colleges required skills in wiring solar panels, inverters, and batteries, ability to Implement safety measures while working with electrical systems, Knowledge of local building and electrical codes related to solar installations, Proper techniques for handling and installing solar modules and Organizing and securing cables to ensure efficiency and safety among others. among others. These skills will not only benefit the students in terms of job security but also contribute to the sustainable development of the Nigeria by providing clean and renewable energy sources.

**Recommendation**

Based on the findings and conclusion of the study, the following recommendations were made;

1. Update the existing curriculum to include comprehensive modules on solar energy technology, installation, maintenance, and policy.
2. Education authorities should provide a state-of-the-Art technical workshop that is well-equipped with latest tools and equipment used in the solar energy industry. where students can practice solar systems.
3. Organize workshops and seminars led by industry experts to keep students updated on the latest advancements in solar technology and industry trends.
4. Engage with the Private Sector to foster strong partnerships between technical colleges and solar energy companies. These partnerships can facilitate equipment donations, scholarship opportunities, and employment pathways for students.

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