SHINE

Solar Hands-on training and International Network of Exchange

Greening TVET for the solar energy sector in Nigeria

Case illustration and roadmap

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Author
Victoria Manya
Siri Lijfering

Supervisor
Anika Altaf

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Executive summary

Nigeria's renewable energy sector, underpinned by key policies such as the National Renewable Energy and Energy Efficiency Policy (NREEEP) of 2015, the Mini-Grid Regulation by the Nigerian Electricity Regulatory Commission (NERC), and the Renewable Energy Master Plan (REMP), has set ambitious targets for integrating solar energy into its energy mix. Despite this policy framework and initiatives like the Energizing Education Programme (EEP), which aims to provide solar energy to 37 federal universities, significant gaps exist in workforce development, particularly in the alignment of technical skills with the needs of the solar industry.

One of the critical challenges in achieving Nigeria's solar energy goals is the absence of a standardized curriculum in Technical and Vocational Education and Training (TVET) programs. This gap has contributed to a lack of uniform job standards within the solar sector, hindering the industry's growth. To address this, the concept of *Greening TVET*—which integrates environmental sustainability into vocational training—becomes increasingly important. By doing so, Nigeria can equip the workforce with the necessary skills to support the rapidly expanding solar energy sector. However, Nigeria's current TVET landscape is fragmented, relying on outdated teaching methods and offering limited hands-on experience. These shortcomings hinder the creation of a skilled workforce essential for the country's transition to renewable energy.

The disconnect between TVET programs and industry requirements is particularly concerning in the context of Nigeria's high youth unemployment rate, estimated at 42.5% in 2022. With a growing population and limited job opportunities, aligning TVET with the solar industry needs offers a dual solution: addressing youth unemployment while supporting Nigeria's energy transition. Yet, without a unified approach to training and a focus on green skills, the solar industry continues to face a shortage of qualified technicians.

This report examines the current state of Nigeria's TVET ecosystem in the solar energy sector, identifying the gaps and challenges that hinder its ability to meet the demands of a low-carbon economy. It presents insights from existing literature and from interviews conducted during a study visit to Nigeria in April 2024, highlighting the misalignment between education and industry needs, and offers a roadmap for reforming TVET to support Nigeria's solar energy goals. The report provides actionable recommendations to integrate environmental sustainability into technical training, foster industry collaboration, and enhance the employability of Nigeria's youth in the rapidly growing renewable energy sector.

Energy transition: Landscape, policy & practice

In broad terms, Nigeria's energy consumption primarily relies on traditional biomass and waste, which represented a significant share of 73.5% of the nation's primary energy consumption in 2018, with fossil fuels contributing to 26.4% and hydropower accounting for the remaining 1%.[1] In 2022, however, renewable energy became part of the mix, reducing the share of traditional sources by contributing to the total electricity capacity.[2] In more specific terms, Nigeria's electricity generation is primarily reliant on non-renewable energy sources, The dominant source is gas, contributing 79.46% of total electricity generation. Hydropower is the second largest source, accounting for 20.37%. Solar energy makes up 0.12%, and bioenergy contributes 0.05%. This reflects Nigeria's heavy reliance on gas for electricity, with limited use

[1] INCLUDE,2023
[2] INCLUDE,2023

of renewable energy sources like solar and bioenergy, while fossil fuels continue to dominate overall energy consumption.y.[3]

In recent years, renewable energy development has focused on off-grid and mini-grid solar projects, but efforts to drive private sector-led on-grid renewable energy have seen limited success. This is highlighted by the slow progress of the 14 companies that signed Solar Power Purchase Agreements (PPAs) with the government, amounting to $1.75 billion to build 1,125 MW of renewable energy capacity.Actual power generation is often significantly lower due to infrastructure challenges, with rural areas particularly underserved .[4] This gap between demand and supply has led to widespread use of informal energy sources, particularly diesel and petrol powered generators, which contribute significantly to environmental degradation and high energy costs .[5]

Recognizing the inefficiency in terms of cost and accessibility and environmental impact of these informal energy solutions, Nigeria made significant reforms in 2013 by privatizing 11 distribution companies (DISCOs) and six generating companies (GENCOs). Despite this shift toward privatization, the country continues to struggle with meeting its growing energy demand. For instance, only 60% of the population has access to electricity, leaving over 85 million people without it, necessitating substantial investment—estimated at $100 billion over the next 20 years.[6] The country also engages in power export, supplying electricity to neighboring countries like Benin, Togo, and Niger. Efforts to diversify and expand energy production include renewable sources, such as solar and hydro, with ongoing projects like the 3,050 MW Mambilla hydro plant and various solar initiatives aimed at increasing off-grid capacity.[7] Significant international support, including over $1 billion from the World Bank and African Development Bank, underscores the sector's importance, yet challenges remain in achieving reliable and sufficient power supply.

In light of these challenges, efforts to diversify Nigeria's energy sources are gaining momentum, particularly with the gradual shift toward renewable energy. Solar power, in particular, has emerged as a promising alternative,[8] driven by both public and private sector initiatives.[9] The decentralized nature of renewable energy solutions, such as off-grid solar home systems and mini-grids, makes them particularly effective for rural electrification, where access to the national grid is often limited,[10] and in urban areas where they offer flexible, scalable, and reliable electricity in regions with an unreliable national grid. The Rural Electrification Agency (REA), has been instrumental in promoting these decentralized solutions. This is crucial because traditional grid expansion is costly and slow in remote regions, while decentralized solar systems are more cost-effective, faster to deploy, and provide immediate energy access.[11]At a limited scale, the REA's initiatives stimulate local economic growth by powering small businesses, schools, and healthcare facilities, creating employment opportunities within the solar industry, and attracting private sector investments by supporting programs for solar energy development. In 2023, over 100 solar mini-grids had

[3] Statista,2024
[4] NERC, 2022,World Bank, 2023
[5] Nnodim, 2021
[6] International Trade Administration,2023)
[7] International Trade Administration,2023)
[8] INCLUDE,2023
[9] Osunmuyiwa & Kalfagianni,2017
[10] Olanipekun & Adelakun, 2020
[11] REA interview

been deployed in rural areas, providing electricity to previously underserved communities.[12] The private sector has also played a crucial role, with solar companies leading the way in delivering solar energy solutions to both urban and rural populations.[13]

Identifying skills gaps and opportunities for learning

The solar industry in Nigeria is poised for significant growth, driven by the country's urgent need to diversify its energy sources and close the energy access gap, particularly in underserved areas.[14] This sector presents diverse opportunities for different segments of the workforce, each requiring specific skills and qualifications. Understanding these needs is crucial for developing a workforce that can sustain and expand the industry.[15] During the course of the study visits, participants, especially companies, shared hard skills such as installation and commissioning, marketing, maintenance, project management, and leadership, alongside soft skills like communication, interpersonal skills, and time management for effective teamwork and project success as the most relevant skills to have within the solar industry. They further mention the following as lacking in many TVET graduates:

Hard Skills

- Energy system design: Beyond installation, professionals should be able to design solar energy systems, calculating energy requirements based on consumption patterns, determining optimal panel placement, and sizing the systems appropriately to meet energy needs. A significant challenge in Nigeria's solar sector is the lack of expertise in *energy system design*. This issue arises due to gaps in TVET programs, where training often focuses on basic installation without covering advanced design skills, leaving technicians unprepared to create efficient, tailored solar energy solutions for diverse environments.
- Knowledge of industry standards and regulations: A strong grasp of national and international regulations and standards for solar energy is necessary to ensure installations meet safety, quality, and legal requirements. In Nigeria, study visits reveal that while basic safety tips are adhered to, the lack of adequate knowledge of national and international regulations and standards, which is essential for ensuring safe, high-quality, and legally compliant installations have led to some damages to installation sites. This gap is caused by the absence of standardized training in TVET programs and solar jobs, leading to technicians being insufficiently prepared to meet industry demands and regulatory requirements.
- Solar Installation and Maintenance: in Nigeria, there is a critical need for hands-on skills in solar installation and maintenance, particularly in rural and off-grid areas where solar systems are essential for services like water supply. A lack of knowledge about basic maintenance, such as cleaning solar panels, often leads to system failures. As one member of the House of Representatives noted, "A notable example is the misdiagnosis of a malfunctioning water pump powered by solar energy; the panels had simply become too dirty to generate sufficient power, but without the awareness of proper maintenance, the system was dismantled by unskilled hands, exacerbating the

[12] REA, 2023
[13] Ogunleye, 2021
[14] HBS interview
[15] REA interview

problem." Technicians must be trained not only in the installation of solar systems but also in routine maintenance and troubleshooting to ensure long-term performance, particularly in regions with limited access to technical support.

- **Energy auditing and analysis:** Many of the TVET graduates are unable to conduct energy audits to analyze how much energy is being used and how solar systems can be sized and configured to meet that demand. This is because they have not been adequately taught by skilled trainers trained in data collection, analysis, and long-term system performance evaluation.
- **Performance monitoring and optimization:** Solar professionals need to be able to monitor the performance of solar systems over time, analyzing data to detect inefficiencies or malfunctions, and suggest improvements. However, another key challenge in Nigeria's solar sector is the limited focus on *performance monitoring and optimization*. This gap is due to insufficient training in TVET programs, which often prioritize installation over the ongoing analysis and optimization of solar systems. As a result, technicians may lack the necessary expertise to maintain system efficiency and longevity, leading to reduced effectiveness of solar installations.

Soft Skills

- **Problem-solving and critical thinking:** Companies explained that when some TVET graduates face unexpected challenges such as equipment failures, weather impacts, or logistical problems they tend to lose control and panic due to the absence of preparedness and difficulty following troubleshooting protocols. Some companies attributed this to the lack of critical and analytical thinking which is necessary to troubleshoot these issues effectively.
- **Attention to Detail**: In both system design and maintenance, attention to detail is essential for ensuring accuracy in energy calculations, panel placement, and compliance with regulations. This has proven a challenge for many TVET graduates as they often experience pockets of small issues as a result of negligence that escalate into larger problems, revealing the lack of attention to details.

Perception Paradox: The Stigma and Its Impact on TVET Uptake

The perception of TVET in Nigeria is shaped by the country's complex socio-economic landscape and the multifaceted technical needs of its citizens. There is a growing recognition that technical skills are crucial for addressing issues of inclusion and local content, especially in an economy with high levels of unemployment.[16]Generally, the public view on TVET in Nigeria reflects both optimism and skepticism. Here's a breakdown of the prevailing sentiments:

Optimism and interest

The optimism surrounding solar Technical and Vocational Education and Training (TVET) in Nigeria stems from several key factors that are intertwined with the country's broader energy and economic landscape.[17] As Nigeria continues to grapple with an unreliable power supply and frequent blackouts, the public has become increasingly aware of the need for alternative energy sources. Solar energy, in particular, has gained traction as a viable solution to these power challenges, offering a cleaner, more sustainable option. In this context, solar TVET is

[16] Akhuemokan & Raimi, 2013
[17] REA interview

seen as a critical tool for equipping Nigerians with the necessary skills to harness this renewable energy source.

Beyond addressing the energy crisis, solar TVET holds significant promise for job creation, a priority in a country facing high unemployment, especially among young people. The growing demand for solar technology has created an urgent need for skilled technicians who can install, maintain, and repair solar systems. Many Nigerians, particularly the youth, view solar TVET as a direct pathway to meaningful employment or entrepreneurship in the renewable energy sector. The practical nature of the training, which equips participants with immediately applicable skills, aligns well with the labor market's urgency, making it an attractive option for those seeking to secure their financial futures sooner than later.

Further bolstering the positive perception of solar TVET is the support from international organizations and government initiatives. Entities such as the World Bank, GIZ, and various arms of the Nigerian government have launched programs to promote capacity building in the renewable energy sector.[18] These efforts not only provide financial and technical assistance but also legitimize solar TVET as a crucial component of Nigeria's development strategy. By aligning with global trends toward sustainable energy and local efforts to foster skills development, these organizations help shape public attitudes, making solar TVET more widely accepted and respected. The involvement of respected international bodies underscores the importance of solar energy in Nigeria's future, encouraging more individuals to consider vocational training in this field as a viable and forward-thinking career choice.

Skepticism and challenges

While there is considerable optimism surrounding Solar TVET in Nigeria, skepticism due to challenges persist, limiting its full potential. One of the primary concerns is the **limited infrastructure and resources** available for solar TVET programs. Despite growing interest, many training centers are underfunded and lack the necessary equipment and modern facilities to provide hands-on experience with the latest solar technology.[19] The curriculum in many institutions is also outdated with solar as a mere module within the larger renewable energy scheme, failing to align with the current demands of the solar industry. As one student noted, "The problem is not just learning the theory, but we don't have enough access to real-life solar installations to practice what we've learned." This disconnect between education and practical application fuels doubts about whether TVET graduates will truly be prepared for the workforce, leaving some employers hesitant to hire them without additional on-the-job training.[20]

Another challenge is the **perceived low prestige** of vocational education, particularly in comparison to university degrees. In Nigeria, TVET programs often carry a stigma, seen as a last resort for those unable to gain admission into traditional universities.[21] This societal bias discourages many young people from pursuing solar TVET, even though it offers practical, in-demand skills. As one parent remarked, "Why should my child go into vocational training when a university degree is seen as more respectable? Even if TVET leads to a job, the respect isn't there." This perception problem is deep-rooted, affecting the overall enrollment and engagement with TVET programs.

[18] Breakfast dialgue with TVET and solar sector stakeholders
[19] Focus group with trainer at JOBITECH
[20] Trainer at JOBITECH
[21] **Opoko et al** 2018

In addition to stigma, **cost and accessibility** create significant barriers to solar TVET. Many training centers are located in urban areas, making them difficult to reach for those in rural communities where the need for solar energy is often greatest.[22] Furthermore, the fees associated with these programs can be prohibitive, particularly for lower-income families.[23] Without sufficient government subsidies or scholarship opportunities, many Nigerians who could benefit from solar TVET are unable to access it. This lack of inclusivity undermines the broader goals of job creation and energy access.

Finally, **uncertainty about long-term career pathways** in the solar industry adds to public skepticism. While the demand for solar energy technicians is growing, there are doubts about the stability and sustainability of these jobs, especially given Nigeria's slow adoption of renewable energy policies and the dominance of the fossil fuel industry. One industry insider commented, "The jobs are there now, but what happens in a few years if policies don't change fast enough to support large-scale solar adoption? Will these positions still exist, or will we be back to square one?"

Roadmap to greening TVET in Nigeria

Stakeholder Engagement and Coalition Building: Facilitate structured knowledge transfer between formal and informal stakeholders to address fragmented educational approaches in greening TVET. Establish a multi-stakeholder platform that integrates government agencies, private sector actors, and educational institutions, forming an industry-education council that will drive policy coherence. Develop a centralized national solar training hub to standardize access to cutting-edge technologies and training materials, ensuring alignment with industry demands.

Development of Green Skills Identification for the Solar Industry: Conduct a comprehensive assessment of existing skill sets and projected future needs in the solar industry to bridge workforce capability gaps and anticipate emerging demands. Implement a strategic skills gap analysis, foster collaborations with industry for apprenticeship programs, and develop forward-looking models to forecast labor market demands, with a focus on establishing competency-based standards in line with evolving technologies like IoT, energy storage, and grid integration.

Development of Green Curricula for the Solar Industry: Revise and harmonize solar-specific TVET curricula to incorporate contemporary technological advancements and sustainability principles. Conduct a national review of existing curricula, aligning it with modern solar technologies, and establish solar learning hubs across key regions. Introduce experiential learning modules such as sustainability workshops that focus on recycling, energy efficiency, and responsible resource management to instill environmental stewardship in students.

Supporting Inclusivity in TVET Institutes: Promote equitable access to solar education by fostering inclusivity for marginalized and underrepresented groups. Establish mentorship programs that connect women and marginalized communities with leaders in the solar industry, implement targeted scholarship schemes, and develop pathways for informal solar

[22] Trainer at JOBITECH
[23] Student at JOBITECH

practitioners to achieve formal certification through Recognition of Prior Learning (RPL) programs, thus expanding the diversity of the workforce.

Capacity Building for TVET Trainers: Enhance the capacity of TVET trainers by equipping them with the latest solar technology knowledge and sustainable practices. Conduct a nationwide audit of trainers to assess competency levels and identify gaps in proficiency. Develop a digital Continuous Professional Development (CPD) platform to provide ongoing training in advanced solar technologies, hybrid systems, and sustainable energy practices, ensuring that trainers stay at the forefront of industry developments.

Facilitating Green Job Creation and Employment in the Solar Industry: Create an enabling environment that catalyzes green job creation and investment in the solar industry. Implement fiscal incentives such as tax exemptions and reduced import duties on solar components to reduce operational costs. Encourage local manufacturing to promote self-reliance, and launch awareness campaigns that highlight career opportunities in the solar sector, fostering greater participation in the renewable energy workforce.

Enabling Policy and Funding Environment for the Solar Industry: Formulate and implement policy frameworks that support TVET for solar energy, reducing regulatory bottlenecks and fostering a seamless transition to a green economy. Align national TVET policies with the Renewable Energy Action Plan (REAP) and Economic Sustainability Plan (ESP), while introducing streamlined regulatory measures to facilitate solar energy projects and incentivize local content development.

Raising Awareness and Shifting Perceptions for Solar Adoption: Deploy targeted awareness campaigns aimed at rebuilding public trust in solar technology and promoting gender diversity within technical roles. Partner with NGOs and community organizations to implement grassroots campaigns that emphasize the socio-economic benefits of solar adoption and highlight success stories, particularly from female solar entrepreneurs, to inspire broader participation and cultural shifts in the renewable energy sector.

About SHINE

SHINE is a Capacity Building project funded by the EU Commission that seeks to drive the green transition and enhance energy Access in Africa. A European African consortium, involving VET providers and stakeholders from education, industry, and policy makers, is collaboratively redesigning a market-oriented VET program focused on solar panel technology.

Starting in January 2024 and for 36 months, the SHINE project gathers 10 organizations from Europe and Africa active in the field of TVET and education and experts in the solar energy industry. It is constituted by VET providers and their networks (CIFP Usurbil LHII - ZubiGune Foundation in Spain, AKMI in Greece, Jobitech in Nigeria, Suame Technical Institute in Ghana, and Kiryandongo TI & Huys Link VTC in Uganda), Universities, research and business development centers (Start-up SMEs Centre, SSC, in Ghana, Pan-Atlantic University in Lagos, Nigeria and Universiteit Leiden with their Dutch-African knowledge platform of researchers, INCLUDE). All of them led by Mundus, an Spanish organization with a wide experience in the African continent and presence in more than 25 countries through capacity building initiatives.

The main objective is to deliver an innovative capacity building program in Solar Training in Africa and the specific objectives include:

1. To strengthen the evidence-base around green skills in the solar industry in Africa
2. To develop a hybrid capacity building program for VET teachers
3. To redesign and pilot Solar Panel technology program
4. To promote the employability and self- employment of learners
5. To encourage long- lasting international partnerships

To achieve this ambitious goal, the working methodology is divided into three distinct phases: The first phase is focused on research, during which study visits, interviews, and meetings with key stakeholders in TVET, employment, and the energy sector (schools, universities, government bodies, and the private sector) are conducted to map out the current state of solar energy and training, identifying the main challenges and opportunities.

Once the context is understood, capacity-building pathways are designed to upskill trainers in VET centres in Nigeria, Ghana, and Uganda, with specific training provided in centres of excellence in Europe.

Finally, based on the groundwork, the training for educators, and collaboration with key stakeholders, the curriculum is co-created and redesigned to align with market needs.

Below is one of the key outcomes of the project's first phase, where the solar energy landscape and the sector's needs in terms of skills, strategies, and policies were thoroughly analyzed.

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1. Introduction

Nigeria's renewable energy sector is supported by a range of policy frameworks aimed at promoting sustainable energy development.[24] The National Renewable Energy and Energy Efficiency Policy (NREEEP) of 2015 lays the foundation for the expansion of renewable energy, including specific targets for solar energy integration.[25]The Nigerian Electricity Regulatory Commission's (NERC) Mini-Grid Regulation, first introduced in 2017 and revised in 2023, facilitates the deployment of mini-grids and encourages private sector participation by simplifying regulatory processes.[26] The Renewable Energy Master Plan (REMP), developed by the Energy Commission of Nigeria, outlines the strategic goals for achieving a more sustainable energy mix by 2030, emphasizing the importance of solar energy.[27]This sustainable energy mix has been piloted with the Nigeria's Energising Education Programme (EEP), aiming to transition 37 federal universities off the national grid by providing clean solar energy.[28] Supported by a $550 million initiative from the World Bank and the African Development Bank, the program targets continuous electricity to approximately 350,000 students and 50,000 lecturers across the targeted institutions.[29]

Though these policy and infrastructure developments are crucial, achieving the full potential of solar energy in Nigeria also requires a well-trained workforce.[30] This is where the concept of *greening* TVET– the integration of environmental and sustainability concepts into vocational training programs to prepare a workforce capable of meeting the demands of a sustainable energy sector[13] –for solar energy becomes critical. Greening TVET equips the workforce with the necessary technical expertise and integrating green skills into TVET programs will help build a skilled labor force capable of meeting the growing demands of the solar industry, ensuring that Nigeria's energy transition is both sustainable and inclusive.[31] Consequently, the NBTE[32] has been saddled with the responsibility to align TVET curricula with the needs of the renewable energy sector, focusing on the development of skills in areas such as solar energy installation, maintenance, and system management[14]. However, providing students with practical, hands-on experience that is aligned with industry requirements has been a significant challenge.[33]

While efforts to align TVET with the renewable energy sector are essential for a sustainable energy future, they also intersect with another pressing issue: the high rate of youth unemployment in Nigeria.[34] As of 2022, the youth unemployment rate in Nigeria was estimated at 42.5%, with underemployment affecting an additional 21% of the youth population.The high unemployment rate among Nigerian youth is driven by a combination of factors, including a rapidly growing population, insufficient job creation, and a mismatch between the skills acquired through the education system and the needs of the labor market.[35]Given this context,

[24] REA interview
[25] Federal Ministry of Power, 2015
[26] NERC, 2023
[27] Energy Commission of Nigeria, 2015
[28] https://www.pvknowhow.com/15-federal-universities-benefit-from-solar-grids/
[29] https://www.universityworldnews.com/post.php?story=20231212102320684
[30] NABTEB interview
[31] NERC interview
[32] National Board for Technical Education
[33] NAPTIN interview
[34] Heinrich *Böll* Stiftung interview
[35] Adebayo, 2021

the role of Technical and Vocational Education and Training (TVET) in addressing these challenges cannot be overstated.[36]

In this study, drawing from existing research and empirical data from study visits between April and June 2024, we find that Nigeria has not successfully integrated environmental sustainability into its TVET programs for the solar sector due to the absence of a standardized curriculum and a lack of job standardization. This gap has resulted in fragmented educational efforts that fail to incorporate ecological responsibility into technical training.[37] Without a unified curriculum that aligns with both industry standards and sustainable practices, private sector-driven initiatives have led to inconsistent approaches to training, producing technicians with varying skills and competencies.[38] This lack of coordination has hindered the development of a workforce that is both technically proficient and environmentally conscious, which is essential for fostering sustainable energy practices. Furthermore, the absence of clear national standards for solar installations has exacerbated these issues, making it difficult to build a cohesive strategy for embedding sustainability into TVET. The result is a disconnect between the skills needed for a low-carbon economy and the training provided, which delays Nigeria's progress toward developing a workforce capable of supporting and adopting sustainable energy solutions on a national scale.

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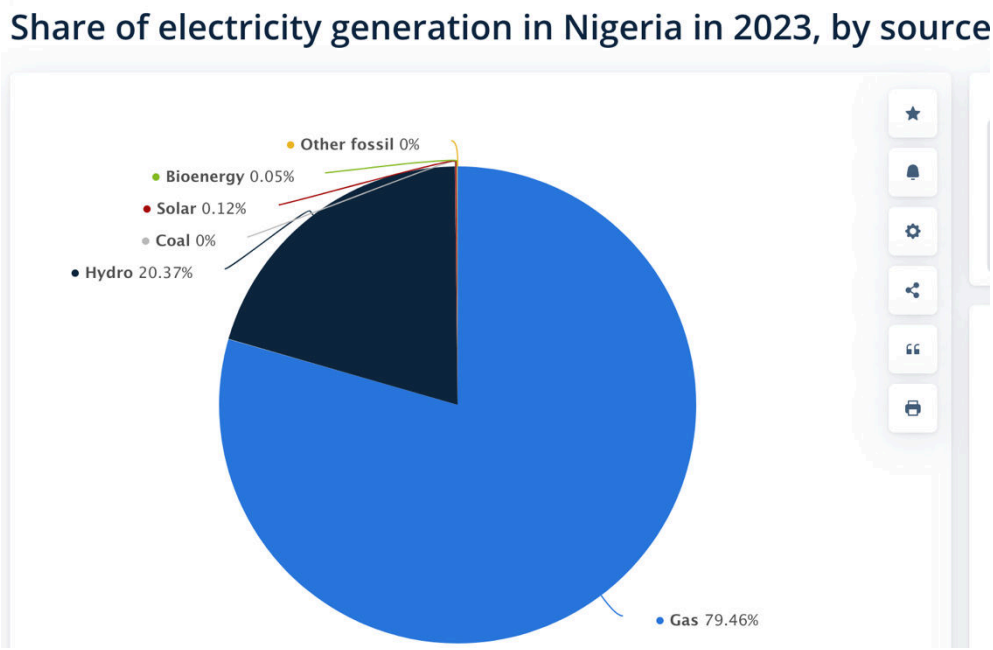
In broad terms, Nigeria's energy consumption primarily relies on traditional biomass and waste, which represented a significant share of 73.5% of the nation's primary energy consumption in 2018, with fossil fuels contributing to 26.4% and hydropower accounting for the remaining 1%.[39] In 2022, however, renewable energy became part of the mix, reducing the share of traditional sources by contributing to the total electricity capacity.[40] In more specific terms, Nigeria's electricity generation is primarily reliant on non-renewable energy sources, The dominant source is gas, contributing 79.46% of total electricity generation. Hydropower is the second largest source, accounting for 20.37%. Solar energy makes up 0.12%, and bioenergy contributes 0.05%. This reflects Nigeria's heavy reliance on gas for electricity, with limited use of renewable energy sources like solar and bioenergy, while fossil fuels continue to dominate overall energy consumption.y.[41]

[36] Abdulhakim,2021
[37] Heinrich *Böll* Stiftung interview
[38] NABTEB interview
[39] INCLUDE,2023
[40] INCLUDE,2023
[41] Statista,2024



Source: Statista,2024

In recent years, renewable energy development has focused on off-grid and mini-grid solar projects, but efforts to drive private sector-led on-grid renewable energy have seen limited success.[42] This is highlighted by the slow progress of the 14 companies that signed Solar Power Purchase Agreements (PPAs) with the government, amounting to $1.75 billion to build 1,125 MW of renewable energy capacity.However, actual power generation is often significantly lower due to infrastructure challenges, with rural areas particularly underserved. [43]This gap between demand and supply has led to widespread use of informal energy sources, particularly diesel and petrol powered generators, which contribute significantly to environmental degradation and high energy costs. [44]

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[42] REA interview
[43] NERC, 2022
[44] Nnodim, 2021
[45] International Trade Administration,2023)
[46] International Trade Administration,2023)

In light of these challenges, efforts to diversify Nigeria's energy sources are gaining momentum, particularly with the gradual shift toward renewable energy. Solar power, in particular, has emerged as a promising alternative,[47] driven by both public and private sector initiatives.[48] The decentralized nature of renewable energy solutions, such as off-grid solar home systems and mini-grids, makes them particularly effective for rural electrification, where access to the national grid is often limited,[49] and in urban areas where they offer flexible, scalable, and reliable electricity in regions with an unreliable national grid. The Rural Electrification Agency (REA), has been instrumental in promoting these decentralized solutions. This is crucial because traditional grid expansion is costly and slow in remote regions, while decentralized solar systems are more cost-effective, faster to deploy, and provide immediate energy access. The REA's initiatives stimulate local economic growth by powering small businesses, schools, and healthcare facilities, creating employment opportunities within the solar industry, and attracting private sector investments by supporting programs for solar energy development. In 2023, over 100 solar mini-grids had been deployed in rural areas, providing electricity to previously underserved communities. [50] The private sector has also played a crucial role, with solar companies leading the way in delivering solar energy solutions to both urban and rural populations.[51]

2. An overview of the TVET ecosystem in Nigeria

With its TVET related policies and reliance on TVET for economic mobility, Nigeria should typically produce a significant and sufficient number of seasoned artisans to address the need of its local industry and youth unemployment. However, the reverse appears to be the case.[52] This is attributed to a host of reasons including deficiencies in terms of funding, geographical proximity, affordability, quality of infrastructure, availability of trained instructors, inclusivity in admission policies, and alignment of programs with industry needs and the responsiveness of TVET curricula to the changing labour market dynamics. Unpacking these challenges,[53] writers have observed curricular related irrelevance to skills required by the labour market, the decline in the quality of training facilities at all levels of education and in particular, within the technical and vocational institutions.[54] Other challenges include skills related misdirection[55],erratic policy regimes and in more recent study, the growing obsolescence of training methods, facilities, instructional methods and curriculum.[56] In this section, we consider the overview of Nigeria's TVET ecosystem with more granularity.

a. Fragmented frameworks: navigating the structure and regulation of TVET in Nigeria

TVET in Nigeria is characterized by a lack of cohesive structure, with initiatives being largely driven by stakeholders in both the public and private sectors on an ad-hoc basis. Traditionally, institutions such as technical training centers and polytechnics have been the primary providers of TVET. However, these institutions have struggled over the years to keep pace with the

[47] INCLUDE,2023
[48] Osunmuyiwa & Kalfagianni,2017
[49] Olanipekun & Adelakun, 2020
[50] REA, 2023
[51] Ogunleye et al, 2022
[52] Oviawe,2018
[53] Oranu,1998; Akpan, et al,2013
[54] Okafor ,2000; Akpan, et al,2013; Osidipe, 2017
[55] Osidipe, 2017
[56] Adewale ,2021

evolving standards and curricula necessary to equip the younger generation with the skills needed in today's workforce.[57]

Research notes that one of the key objectives of TVET is to impart a range of cognitive, affective, and psychomotor skills that enable direct participation in technical and scientific activities.[58] To achieve this goal, the Nigerian government integrated skill-based education within the Basic Education structure, incorporating subjects such as Basic Science and Technology (BST), Information Technology, and Prevocational Studies. At the tertiary level, vocational institutions, polytechnics, and monotechnics are responsible for delivering TVET programs under the guidelines set by the NBTE. Additionally, government efforts in TVET have been supported by the National Commission for Mass Literacy, Adult, and Non-formal Education which plays a significant role in policy formulation and curriculum development[59].

Regulation of TVET falls under the statutory responsibility of the NBTE, which uses a standard-based quality assurance framework to oversee and regulate TVET institutions in Nigeria. Like other regulatory bodies such as the National Universities Commission (NUC) and the National Commission for Colleges of Education (NCCE), NBTE is tasked with formulating guidelines, issuing licenses, conducting inspections, and ensuring compliance with established standards[60]. Despite these frameworks, the solar TVET ecosystem in Nigeria remains fragmented, with occasional initiatives led by private sector players, NGOs, and government agencies as part of corporate social responsibility (CSR) or efforts to expand the skilled workforce.

Despite these established frameworks, the regulation and coordination of TVET—particularly in the solar sector—remains fragmented.[61] The NBTE is responsible for overseeing quality assurance and compliance, but its efforts are often disjointed from the actions of private sector players, NGOs, and government agencies, which frequently launch solar TVET programs as part of corporate social responsibility (CSR) or isolated workforce development efforts.[62] This lack of integration has resulted in inconsistent training standards, outdated practices, and limited job opportunities, undermining the goal of creating a skilled workforce to support Nigeria's solar energy transition.

b. Perception paradox: The stigma and Its impact on TVET uptake

The perception of TVET in Nigeria is shaped by the country's complex socio-economic landscape and the multifaceted technical needs of its citizens. There is a growing recognition that technical skills are crucial for addressing issues of inclusion and local content, especially in an economy with high levels of unemployment.[63] Increasingly, young Nigerians are turning to digital and technical skills to drive entrepreneurial ventures within the digital economy, underscoring the importance of TVET in contemporary society. According to a 2020 report by the NBS,[64] Nigeria's youth unemployment rate stood at 42.5%, prompting many young people to turn to the digital economy for opportunities. Additionally, the NBTE, in 2022, revealed that

[57] Chibueze, 2016
[58] Chibueze 2016
[59] Okorafor & Nnajiofo, 2015
[60] Bello et al., 2023
[61] REA interview
[62] Interview with head of department in Kogi state polytechnic
[63] Akhuemokan & Raimi, 2013
[64] National Bureau of Statistics

Nigeria had approximately 1.8 million students enrolled in TVET institutions across the country, including polytechnics, monotechnics, and innovative enterprise institutions. A more nuanced report by the UNESCO-UNEVOC reports that over 70% of TVET students in Nigeria are under the age of 25, demonstrating significant youth participation in vocational and technical training. Further, data from the NBS in 2021 show that about 10% of Nigerian students pursue TVET-related courses after secondary education, although the percentage of TVET enrollment remains lower compared to general academic education pathways. This is in part due to the challenges relating to the quality of TVET education and the low employability prospects for TVET graduates. Generally, the public view on Solar TVET in Nigeria reflects both optimism and skepticism noted in TVET education overall in Nigeria. Here's a breakdown of the prevailing sentiments:

Optimism and interest

The optimism surrounding solar TVET in Nigeria stems from several key factors that are intertwined with the country's broader energy and economic landscape. As Nigeria continues to grapple with an unreliable power supply and frequent blackouts, the public has become increasingly aware of the need for alternative energy sources. Solar energy, in particular, has gained traction as a viable solution to these power challenges, offering a cleaner, more sustainable option. In this context, solar TVET is seen as a critical tool for equipping Nigerians with the necessary skills to harness this renewable energy source.[65]

Beyond addressing the energy crisis, solar TVET holds significant promise for job creation, a priority in a country facing high unemployment, especially among young people. The growing demand for solar technology has created an urgent need for skilled technicians who can install, maintain, and repair solar systems. Many Nigerians, particularly the youth, view solar TVET as a direct pathway to meaningful employment or entrepreneurship in the renewable energy sector. The practical nature of the training, which equips participants with immediately applicable skills, aligns well with the labor market's needs, making it an attractive option for those seeking to secure their financial futures in an expanding industry.[66]

Further bolstering the positive perception of solar TVET is the support from international organizations and government initiatives. Entities such as the World Bank, GIZ, and various arms of the Nigerian government have launched programs to promote capacity building in the renewable energy sector. These efforts not only provide financial and technical assistance but also legitimize solar TVET as a crucial component of Nigeria's development strategy. By aligning with global trends toward sustainable energy and local efforts to foster skills development, these organizations help shape public attitudes, making solar TVET more widely accepted and respected. The involvement of respected international bodies underscores the importance of solar energy in Nigeria's future, encouraging more individuals to consider vocational training in this field as a viable and forward-thinking career choice.

Skepticism and challenges

While there is considerable optimism surrounding Solar TVET in Nigeria, skepticism due to challenges persist, limiting its full potential. One of the primary concerns is the **limited**

[65] Interview NABTEB director
[66] REA interview

infrastructure and resources available for solar TVET programs. Despite growing interest, many training centers are underfunded and lack the necessary equipment and modern facilities to provide hands-on experience with the latest solar technology.[67] The curriculum in many institutions is also outdated with solar as a mere module within the larger renewable energy scheme, failing to align with the current demands of the solar industry. As one student noted, "The problem is not just learning the theory, but we don't have enough access to real-life solar installations to practice what we've learned." This disconnect between education and practical application fuels doubts about whether TVET graduates will truly be prepared for the workforce, leaving some employers hesitant to hire them without additional on-the-job training.[68]

Another challenge is the **perceived low prestige** of vocational education, particularly in comparison to university degrees. In Nigeria, TVET programs often carry a stigma, seen as a last resort for those unable to gain admission into traditional universities.[69] This societal bias discourages many young people from pursuing solar TVET, even though it offers practical, in-demand skills. As one parent remarked, "Why should my child go into vocational training when a university degree is seen as more respectable? Even if TVET leads to a job, the respect isn't there." This perception problem is deep-rooted, affecting the overall enrollment and engagement with TVET programs.

In addition to stigma, **cost and accessibility** create significant barriers to solar TVET. Many training centers are located in urban areas, making them difficult to reach for those in rural communities where the need for solar energy is often greatest.[70] Furthermore, the fees associated with these programs can be prohibitive, particularly for lower-income families.[71] Without sufficient government subsidies or scholarship opportunities, many Nigerians who could benefit from solar TVET are unable to access it. This lack of inclusivity undermines the broader goals of job creation and energy access.

Finally, **uncertainty about long-term career pathways** in the solar industry adds to public skepticism. While the demand for solar energy technicians is growing, there are doubts about the stability and sustainability of these jobs, especially given Nigeria's slow adoption of renewable energy policies and the dominance of the fossil fuel industry. One industry insider commented, "The jobs are there now, but what happens in a few years if policies don't change fast enough to support large-scale solar adoption? Will these positions still exist, or will we be back to square one?"

c. Formal and informal TVET pathways in a developing economy

In Nigeria, both formal and informal TVET are critical in addressing the country's growing demand for skilled labor in the solar energy sector.[72] Formal TVET is an integral part of Nigeria's educational system, overseen by the NBTE, which regulates polytechnics, monotechnics, and Innovative Enterprise Institutions (IEIs). However, despite solar energy's critical role in Nigeria's renewable energy goals, few TVET institutions offer specialized courses focused exclusively on solar technology. This is owing to the fact that most

[67] Focus group with trainer at JOBITECH
[68] Trainer at JOBITECH
[69] Opoko et al 2018
[70] Trainer at JOBITECH
[71] Student at JOBITECH
[72] REA interview

solar-related subjects are embedded within broader renewable energy programs. For instance, in the 2023 NUCs[73] CCMAS[74] for engineering, there is a compulsory module on renewable energy systems which only addresses solar as one component.[75]

On the other hand, informal TVET programs are highly significant in filling the gaps left by formal education in Nigeria's solar sector.[76] Informal training pathways are often characterized by apprenticeships, short-term courses, and hands-on training organized by private institutions, non-governmental organizations (NGOs), or solar companies.[77] These programs provide practical training in solar installation and maintenance, making them accessible to a wider range of individuals, particularly those who cannot afford or access formal education.[78]Study participants highlight that Informal TVET programs play an important role in improving the technical capacity of solar technicians, particularly in rural areas where demand for off-grid solar solutions is increasing[79]. For instance, some of the private sector led training programs focus on empowering women with solar sales and maintenance skills, not only addressing the technical skills gap but also promoting gender inclusivity within the solar workforce.[80] As one participant aptly put it, *"While formal education is still figuring out how to catch the sun, informal programs are already out there installing solar panels – and empowering women to do it too!"*[81]

Further nuances by study participants emphasized the flexibility of informal TVET programs compared to the more rigid formal education system, which has gaps in solar education[82]. The limited inclusion of solar energy in formal curricula has hindered quick adaptation to industry needs as they lack the skeletal framing to facilitate the evolution with fast paced technology. Solar, as a fast-evolving field, often requires new technologies that formal institutions, like those governed by NBTE, are slower to integrate. In contrast, informal programs from NGOs and private players are more responsive, quickly updating training to reflect the latest solar developments, ensuring students acquire relevant skills[83]. This has led to the reliance on solar installers and maintenance technicians produced by the informal track.[84]

Additionally, informal TVET programs play a crucial role in reaching underserved groups, particularly adults and women, who are often excluded from formal education pathways due to barriers such as time constraints, financial limitations, or lack of access. While formal institutions typically attract younger students seeking diplomas, informal programs in Nigeria offer flexible, shorter-term training options tailored to older learners needing more accessible alternatives. In Nigeria's solar sector, informal TVET programs typically last for 6 months to 2 years, making them an effective tool for expanding access to technical education and fostering a more inclusive workforce.

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[73] Nigerian Universities Commission
[74] Core Curriculum Minimum Academic Standard
[75] NBTE, 2023
[76] Abdulhakim,2021
[77] Heinrich *Böll* Stiftung interview
[78] Solar Sisters, 2022
[79] REA interview
[80] Solar Sisters, 2022
[81] Senior Lecturer Kogi state polytechnic
[82] Focus group discussions with solar TVET trainers
[83] Edomah, 2021.
[84] ESMAP/World Bank, 2017

Finally on the formal and informal TVET dynamics, both face challenges, yet they complement each other in addressing Nigeria's solar energy needs.[85] While formal TVET institutions are constrained by rigid curricula and a lack of specialized solar programs, informal programs are often underfunded and less recognized by industry standards. However, collaborations between the two sectors are emerging as a promising solution. For example, the John Bosco Institute of Technology (JOBITECH) and the Institute for Industrial Technology (IIT) both offer TVET programs that integrate formal instruction with practical, on-the-job training through partnerships with industry players.[86] These collaborations enable the continuous updating of curricula–though in silos and at varying degrees by private sector players– to meet industry needs while providing hands-on experience to students.[87]

3. Labour market context: key system players, ownership, and size

The solar energy sector in Nigeria is predominantly driven by private sector initiatives, with the government providing policy guidance and saddled with the responsibility of creating an enabling environment for investments.[88]Historically, the Nigerian energy market was monopolized by the government, which played dual roles as both policy maker and service provider. [89]However, this has evolved significantly, with the government now focusing on regulation and facilitation, while private entities—including multinational enterprises (MNEs) and local small and medium-sized enterprises (SMEs)—are leading the sector's expansion.[90]

When asked, study respondents explained that key system players include a mix of large multinational corporations, local energy service providers, and SMEs.[91] These players are involved in various aspects of the solar energy value chain, including solar home system (SHS) distribution, mini-grid development, and commercial and industrial (C&I) solar installations. Larger companies often dominate the market due to their ability to secure significant financing and scale operations, while SMEs play a crucial role in reaching underserved rural communities with customized energy solutions. Some of the key players are highlighted in figure 2 below.

[85] JOBITECH trainer
[86] UNESCO, 2019
[87] Okeke, 2023
[88] Anyanwu, 2009
[89] Anyanwu, 2009
[90] Osinbajo, 2022
[91] CEO Solfa power

Source:[92]

To address the challenges of a rapidly evolving solar market, many key players are taking the initiative to provide hands-on training alongside their main operations.[93] With the market saturated by a mix of varying solar models, these companies are ensuring that technicians are well-versed in the unique requirements of their products. As one industry insider put it, *"In a market flooded with diverse solar models, companies are training technicians on the side to ensure their specific technologies shine the brightest."* This approach ensures that both the products and the technicians are well-prepared to meet market demands.

Ownership in the sector is diverse, with private sector participation accounting for the majority of solar projects.[94] Many firms operate under a mix of equity, debt, and grant funding from both concessional and commercial investors.[95] The Solar Power Naija initiative, for instance, has seen widespread involvement from private firms in deploying SHS and mini-grid solutions to rural areas.[96] However, as highlighted in interviews and secondary sources,[97] the market remains highly consolidated, with a small number of large players employing 91% of the sector's workforce. This increased private sector participation in Nigeria's renewable energy sector is critical for achieving the nation's Energy Transition Plan, as highlighted by Osinbajo[98] the former vice president of Nigeria. This is because, Public-Private Partnerships (PPPs) have been identified as a vital mechanism for promoting green initiatives across the country.[99]

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[92] https://markwideresearch.com/nigeria-renewable-energy-market/
[93] Job placement officer,JOBITECH Abuja
[94] Interview REA
[95] CEO Solfa power
[96] The Solar Power Naija initiative, part of Nigeria's Economic Sustainability Plan, aims to expand energy access to 25 million people by providing 5 million solar-based connections, boost local manufacturing in the off-grid solar value chain, and create 250,000 new jobs, while generating significant tax revenues and import substitution benefits.
[97] *Powering Jobs Census 2022/Interview with CEO solfa power limited, Lagos*
[98] Osinbajo 2022
[99] USAID, 2023

According to USAID,[100]over 180 companies have committed more than $40 billion to African energy markets, including Nigeria, demonstrating the significant role of private investment in driving the sector's growth.

Another category of key players is the Local SMEs that have increasingly become central in the solar sector, slowly gaining acceptance as solar PV (Photovoltaic) vendors and installation service providers due to their access to small international grants, and technical assistance[101] from development organizations. Programs such as the Global Cleantech Innovation Programme (GCIP), led by the United Nations Industrial Development Organization (UNIDO) and funded by the Global Environment Facility (GEF), have been instrumental in promoting cleantech innovation and entrepreneurship in Nigeria.[102] Additionally, the Central Bank of Nigeria's MSME Development Fund, established with a share capital of N220 billion (€129.41 million), has been pivotal in bridging the financing gap for micro, small, and medium enterprises in the solar sector.[103]

Multinational companies have also shown increasing interest in the Nigerian renewable energy market, setting up clean energy subsidiaries and forming strategic partnerships with government entities and private sector players to accelerate the adoption of solar technology.[104]The future outlook for renewable energy adoption by multinational energy companies is influenced by various factors, including Nigeria's strategic position and abundant solar resources, which present significant opportunities for investment.[105]

Market development and employment potential

Nigeria's solar energy market, as of December 2018, was primarily driven by solar stand-alone systems, with a total installed capacity of 4.47 megawatts. Out of this, 3.99 megawatts ,approximately 89% were accessed through a Pay-As-You-Go (PAYGO) model, while the remaining 0.48 megawatts, about 11% were acquired through cash sales. The potential for solar mini-grids, however, remains largely untapped, with only 30 mini-grids installed, totaling 1 megawatt and serving over 6,000 customers. According to a 2018 assessment by the African Development Bank (AfDB), the mini-grid market in Nigeria has the potential to generate $994 million in annual revenue, with 92% of this opportunity located in northern Nigeria."Solar energy is proving to be a more competitive and accessible alternative,"[106] remarked one participant in the study, emphasizing the price advantages of solar compared to traditional diesel and petrol-powered generators.

Following the widespread use of costly diesel and petrol generators, Nigerians spend roughly 3.5 trillion naira annually to power their 14-gigawatt capacity decentralized generators. In comparison, solar energy costs per unit range from $0.26 to $0.50 per kWh, while generator costs hover around $0.50 per kWh. "The potential for cost savings is evident," said a study participant[107], emphasizing how the competitive pricing of solar energy could sway consumer preferences. Furthermore, the solar market offers significant environmental benefits, with

[100]Ibid
[101] UNIDO, 2023
[102] ibid
[103] CBN, 2013
[104] Ukoba et al., 2018
[105] Odunaiya et al., 2024
[106] Professor at Bayero University Kano
[107] Freelance Solar installer and maintenance expert

potential reductions in GHG emissions ranging from 31.24 kgCO2eq to 7,456.44 kgCO2eq annually as more residential PV systems are adopted.[108]

Over the past decade, the solar industry in Nigeria has experienced steady but slow growth, driven by the expanding energy access gap and the improved enabling environment for private sector participation.[109] Government agencies like the REA leverage solar technologies to fulfill their mandate of rural electrification across the nation.[110] Private sector players and renewable energy service companies are also breaking ground by providing solutions such as solar mini-grids, Solar Home Systems, Pico solar system and solar-powered irrigation pumps to governments, institutions, and individuals.[111]

Nigeria's geographical location offers abundant solar resources, with over 2,600 hours of sunlight annually, making it an ideal market for solar energy investment.[112]The World Bank estimates that investing in solar power could significantly increase electricity access for nearly 80 million Nigerians who currently lack reliable energy.[113] The proliferation of solar hybrid mini-grids, with more than 200 systems deployed in rural communities, highlights the market's growth potential.[114] The preference for solar mini-grids stems from its large, dispersed rural population, unreliable central grid, and donor support through performance-based grants. Additionally, mini-grids offer market potential for private investment and are adaptable to local energy needs, making them a practical solution.These developments have been supported by performance-based grants and output-based funds, which have helped scale(though minimally) solar energy projects across Nigeria.[115]

The solar industry in Nigeria offers significant opportunities for employment, particularly as the country strives to meet its universal electrification targets by 2040. According to insights shared by stakeholders in this study,the demand for solar home systems (SHS) and mini-grids is growing, particularly in rural and peri-urban areas, where grid connectivity is scarce or unreliable. [116] SHS, with an annual sales growth of 18% between 2016 and 2021, continues to dominate the solar market and presents substantial job creation potential. The SHS market is not only expected to generate jobs in installation and maintenance but also in sales and distribution, especially as demand for Pay-As-You-Go (PayGo) systems increases.[117] According to observations from stakeholders in this study, there is a significant latent demand for solar lanterns and multi-light systems, particularly in underserved regions.[118] The ongoing plan by vendors is to unlock this demand through focused investment and distribution networks which they believe could make SHS products a major driver of employment. Moreover, some respondents explained that hybrid systems combining solar with other energy sources are gaining traction, creating further opportunities for technicians skilled in the operation and maintenance of these systems.[119]

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[108] ibid
[109] REA, 2023
[110] REA, 2023
[111] Okeke, 2023
[112] World Bank, 2023
[113] 2023
[114] ESMAP/World Bank, 2017
[115] World Bank, 2017
[116]Head of Component, Capacity Development, GIZ Nigeria in a multistakeholder discussion organized for the shine project
[117] Focus group discussions with SHS vendors
[118] Interview with solar lantern distributor in Kano state
[119] Heinrich *Böll* Stiftung interview

The potential for entrepreneurship in Nigeria's solar market is another key opportunity. As access to decentralized energy solutions grows, there is room for youth empowerment through the establishment of small solar businesses, particularly in off-grid areas. These businesses could provide solar-powered appliances, energy storage systems, and small-scale mini-grid installations, contributing to local economic growth while expanding energy access. With strong government and donor support, such as the Rural Electrification Agency (REA), these opportunities are expected to flourish and further drive job creation across the country.[120]

Challenges facing the labour market in Nigeria's solar sector

Though the demand for renewable energy is growing rapidly, the employment potential in the solar industry remains underutilized. Nigeria's youth population, which makes up over 70% of the total population presents vast opportunities for employment in the solar sector.[121] Yet, the lack of targeted TVET programs tailored to these needs continues to hinder the full realization of the employment potential in the solar industry. [122]"*We're missing a huge opportunity to employ young people in the solar industry because there aren't enough targeted TVET programs to equip them with the right skills,*" said one study participant.[123] Study participants identified policy gaps, limited industry-academia collaboration, inadequate awareness and infrastructure, funding constraints, and a cultural bias favoring academic degrees over vocational training as the reasons for the absence of targeted TVET programs.[124]

While the solar industry in Nigeria presents substantial opportunities for employment, significant challenges remain in aligning labor market supply with demand. Study participants indicate that a critical challenge is the lack of specialized TVET programs tailored to the solar sector. Nigeria's educational institutions often provide general training in electrical engineering but lack the specific, hands-on training required for solar technicians to meet industry demands.[125] As a result, many solar firms find that they need to invest heavily in on-the-job training to bridge the skills gap, which increases operational costs and slows the pace of growth.[126] Though institutes like JOBITECH have adopted hands-on training, students noted during a study visit that the small-scale solar boards used in their training differ significantly from the larger real-world installations. This discrepancy often leaves them confused and unable to apply what they've learned when working on actual customer projects.[127]

The absence of a standardized national curriculum for solar energy further compounds the problem.[128] Solar training is typically bundled into broader engineering courses, without sufficient focus on the specific skills required for solar installations and maintenance. This misalignment between the educational system and the solar industry's needs has led to a workforce that lacks the technical proficiency required to handle complex solar installations. According to industry stakeholders, this skills gap is particularly acute in the mini-grid and

[120] REA interview
[121] IRENA, 2023
[122] Chikumbo et al., 2023
[123] TVET trainer
[124] Director at NABTEB
[125] Focus group discussion with TVET trainers
[126] JOBITECH in Interview
[127] Focus group discussion with JOBITECH students
[128] Ministry of Education Interview

commercial & industrial (C&I) segments, where the technical demands are greater, but training programs are less developed. "The lack of a dedicated solar curriculum leaves workers underprepared for the technical demands, especially in the mini-grid and C&I segments," noted one industry stakeholder.[129]

Another challenge facing the Nigerian solar market is the fragmentation of training efforts. While many private sector firms have initiated their own training programs, these efforts are often inconsistent and lack standardization, leading to uneven skill levels among workers. The lack of a unified certification process means that solar technicians have varying degrees of competency, which has negatively impacted the quality of solar installations. This lack of uniformity not only hampers operational efficiency but also undermines trust in solar energy as a reliable solution, particularly in rural areas where energy needs are most critical. *"I had one installer set up my solar system, but when it didn't work, I called a second installer who couldn't figure out what had been done, so he installed his own system. When that didn't work well either, I brought in a third installer, and he couldn't understand what the first two had done, so he suggested starting over with his own setup,"* shared one frustrated study participant who quoted his and his friends experiences with Solar installation.

Gender disparity also remains a challenge in the Nigerian solar sector. Women currently account for 35% of the workforce in the RE sector, a figure that lags behind the national average of 44% for women's participation in the overall economy. Despite this, there has been progress in increasing women's representation in the sector, particularly in the SHS subsector, where women now make up 45% of the workforce. However, there is still a long way to go in ensuring that women have equal access to technical roles, especially in the male-dominated mini-grid and C&I segments. *"While I've seen more women in solar, especially in the SHS subsector, it's still tough to break into technical roles in the mini-grid space. It feels like those jobs are reserved for men,"* said one female solar technician.[130]

Identifying skills gaps and opportunities for learning

The solar industry in Nigeria is poised for significant growth, driven by the country's urgent need to diversify its energy sources and close the energy access gap, particularly in underserved areas. This sector presents diverse opportunities for different segments of the workforce, each requiring specific skills and qualifications. Understanding these needs is crucial for developing a workforce that can sustain and expand the industry.[131] During the course of the study visits, participants, especially companies shared hard skills such as installation and commissioning, marketing, maintenance, project management, and leadership, alongside soft skills like communication, interpersonal skills, and time management for effective teamwork and project success as the most relevant skills to have. They further mention the following as lacking in many TVET graduates:

Hard Skills

- **Energy system design:** Beyond installation, professionals should be able to design solar energy systems, calculating energy requirements based on consumption patterns, determining optimal panel placement, and sizing the systems appropriately to meet

[129] REA interview
[130] Rita Interview
[131] REA interview

energy needs.A significant challenge in Nigeria's solar sector is the lack of expertise in *energy system design*. This issue arises due to gaps in Technical and Vocational Education and Training (TVET) programs, where training often focuses on basic installation without covering advanced design skills, leaving technicians unprepared to create efficient, tailored solar energy solutions for diverse environments.

- **Knowledge of industry standards and regulations:** A strong grasp of national and international regulations and standards for solar energy is necessary to ensure installations meet safety, quality, and legal requirements.In Nigeria study visits reveal that while basic safety tips are adhered to, the lack of adequate knowledge of national and international regulations and standards, which is essential for ensuring safe, high-quality, and legally compliant installations have led to some damages to installation sites. This gap is caused by the absence of standardized training in Technical and Vocational Education and Training (TVET) programs, leading to technicians being insufficiently prepared to meet industry demands and regulatory requirements.
- **Solar Installation and Maintenance:In Nigeria, there is a critical need for hands-on skills in solar installation and maintenance**, particularly in rural and off-grid areas where solar systems are essential for services like water supply. A lack of knowledge about basic maintenance, such as cleaning solar panels, often leads to system failures. As one member of the House of Representatives noted, "A notable example is the misdiagnosis of a malfunctioning water pump powered by solar energy; the panels had simply become too dirty to generate sufficient power, but without the awareness of proper maintenance, the system was dismantled by unskilled hands, exacerbating the problem." Technicians must be trained not only in the installation of solar systems but also in routine maintenance and troubleshooting to ensure long-term performance, particularly in regions with limited access to technical support.
- **Energy auditing and analysis:** Many of the TVET graduates are unable to conduct energy audits to analyze how much energy is being used and how solar systems can be sized and configured to meet that demand. This is because they have not been adequately thought by skilled trainers trained in data collection, analysis, and long-term system performance evaluation.
- **Performance monitoring and optimization:** Solar professionals need to be able to monitor the performance of solar systems over time, analyzing data to detect inefficiencies or malfunctions, and suggest improvements.However, another key challenge in Nigeria's solar sector is the limited focus on *performance monitoring and optimization*. This gap is due to insufficient training in Technical and Vocational Education and Training (TVET) programs, which often prioritize installation over the ongoing analysis and optimization of solar systems. As a result, technicians may lack the necessary expertise to maintain system efficiency and longevity, leading to reduced effectiveness of solar installations.

Soft Skills

- **Problem-solving and critical thinking:** Companies explained that when TVET graduates face unexpected challenges such as equipment failures, weather impacts, or logistical problems they tend to lose control and panic due to the absence of preparedness and difficulty following troubleshooting protocols. Some companies attributed this to the lack of analytical thinking which is necessary to troubleshoot these issues effectively.
- **Attention to Detail**: In both system design and maintenance, attention to detail is essential for ensuring accuracy in energy calculations, panel placement, and

compliance with regulations. This has proven a challenge for any TVET graduates as they often experience pockets of small issues that escalate into larger problems, revealing the lack of attention to details.

4. Challenges in Greening TVET for Solar in Nigeria

Despite the growing recognition of the importance of TVET to the solar industry, several key challenges continue to impede progress. This section delves into the significant barriers that hinder the advancement of TVET programs in greening the solar energy sector. These include but are not limited to integrating an environmental curriculum, providing adequate hands-on training, fostering industry collaboration, and overcoming socio-economic barriers.

- Challenges in integrating environmental curriculum: One of the significant challenges in greening TVET for solar energy in Nigeria is the integration of environmental curriculum into existing training programs. Despite the growing recognition of the importance of sustainability, energy efficiency, and environmental impact, these subjects are often inadequately covered or completely absent from the curriculum. The lack of a standardized national curriculum that incorporates these critical areas means that students are not sufficiently educated on the broader environmental implications of solar energy projects. This gap not only limits their ability to implement sustainable practices but also contributes to the poor reputation of solar energy due to inconsistent and subpar installations. The absence of these crucial elements in the curriculum is exacerbated by the overabundance of varied inputs from private and development sector initiatives, leading to a fragmented educational approach that lacks cohesion and consistency.

- Lack of hands-on experience with solar training : Providing students with practical, hands-on experience using the latest eco-friendly solar technologies and equipment is another major challenge. Many TVET institutions lack access to modern training facilities and equipment due to a mix of reasons– including limited funding, inadequate government support, and insufficient partnerships with industries for apprenticeships, which hinders their ability to keep up with technological advancements– which hampers the ability of students to gain real-world experience. This deficiency is particularly problematic as the solar industry is rapidly evolving, with new technologies such as energy storage systems, smart grids, and IoT(internet of things) applications becoming increasingly important.[132] Without adequate exposure to these technologies, students graduate without the necessary skills to meet industry demands, further perpetuating the skills gap in the solar sector. The lack of practical training also limits the ability of students to fully understand and adopt sustainable practices such as efficient energy use, eco-friendly manufacturing, responsible installation, recycling, regular maintenance, and community engagement to ensure long-term viability and environmental benefits., which are crucial for the long-term success of solar energy initiatives.

- Barriers to promoting sustainable practices: Encouraging the adoption of sustainable practices within TVET programs is critical but faces significant obstacles. While the

[132] An engineering professor and study participant explained that IoT applications use connected devices to automate processes, optimize efficiency, and improve decision-making in areas like smart homes, healthcare, agriculture, industrial operations, smart cities, transportation, and energy management.

importance of sustainability is recognized, there is often a disconnect between theory and practice. Workshops and training sessions frequently lack a focus on reducing waste, recycling, and using energy-efficient tools, largely due to outdated equipment and methodologies. Additionally, the absence of a standardized approach means that sustainable practices are not consistently taught or implemented across different institutions. This inconsistency contributes to the negative perception of solar energy, as poorly executed installations and projects fail to demonstrate the environmental benefits that solar technology can offer. Promoting sustainability within the training environment is essential to reversing this trend and ensuring that graduates are prepared to implement green solutions effectively.

- Limited collaboration with green industries: Building strong partnerships with green companies and organizations to offer internships, job placements, and hands-on experience in sustainable solar energy solutions is another area where challenges arise. While collaboration between industry and educational institutions is crucial for bridging the skills gap, such partnerships are often underdeveloped in Nigeria. caused by several factors, including unclear regulatory frameworks, limited communication between stakeholders, bureaucratic inefficiencies, and competing interests among government agencies, private companies, and educational institutions. The lack of coordination among government agencies, private sector players, and educational institutions also leads to fragmented efforts in developing the solar sector. This siloed approach results in overlapping initiatives and missed opportunities for synergy.

- Insufficient teacher training and development: Equipping instructors with the latest knowledge and skills in green technologies is essential for effective teaching, yet it remains a significant challenge. Many TVET instructors in Nigeria have not received adequate training in the latest solar technologies or sustainable practices, which limits their ability to provide high-quality education. The primary reason many TVET instructors in Nigeria have not received adequate training in the latest solar technologies or sustainable practices is due to the lack of investment in teacher training and professional development programs. Limited funding for education, especially in technical and vocational fields, means that institutions often cannot afford to send instructors for upskilling or certification in the latest industry trends.

  Additionally, there is insufficient collaboration between the solar industry and educational institutions, which leads to a disconnect between what is taught and the current demands of the solar sector. This results in instructors who are not fully equipped to provide high-quality, relevant education to their students. This issue is compounded by the absence of a standardized curriculum that emphasizes the importance of environmental and sustainable practices. As a result, instructors may not be well-versed in the most current industry trends or technologies, leading to outdated and less effective teaching methods. This gap in teacher training and development directly impacts the quality of education that students receive, further contributing to the broader challenges of skills mismatch and under-preparedness for the solar industry. While some trainers invest in relevant training, they often charge high fees for their technical expertise, making their services accessible to only a few institutions—primarily those with international backing or ownership that can afford the cost.

Additionally, many trainers in TVET institutions are driven by necessity rather than specialization, leading to subpar training quality. This lack of specialized expertise exacerbates the skills gap, as trainers may not have the in-depth knowledge required to teach the latest solar technologies effectively. Compounding this issue is attrition, which results in teaching methods varying from one trainer to the next. When a trainer leaves—often for better-paying jobs, even outside the sector—their replacement typically adopts a different approach, leading to inconsistencies in how the material is taught. This lack of continuity affects the overall quality of instruction and makes it difficult to maintain a standardized teaching method across the institution. As one student remarked: "Every time a new trainer comes in, they teach differently from the last, and it feels like we're starting over again. It's hard to keep up when the methods and expectations keep changing. We need consistency to really understand the material."

- Ineffective community outreach and awareness: Engaging with local communities to raise awareness about the benefits of solar energy and sustainable practices is vital but challenging, especially given the bad reputation that solar energy has earned in some areas due to the lack of standardization. Ineffective community outreach and awareness negatively impact the greening of TVET for solar by limiting public trust and adoption of solar energy, reducing the demand for skilled professionals in the industry. Before effective community outreach can occur, it is necessary to address the root causes of this negative perception. Poorly executed solar projects, driven by inadequately trained technicians and inconsistent standards, have led to a lack of trust in solar solutions.

- Socio-economic barriers: Socio-economic barriers significantly limit access to training for low-income individuals thereby reducing the supply of skilled professionals essential for the solar industry's growth. This constrains both the development of a skilled workforce and the broader adoption of solar technologies. Economic challenges such as poverty, play a pivotal role in this dynamic, preventing many individuals from accessing quality training due to the high costs associated with these programs. While some students indicated that female students in certain institutes receive scholarships, these are often limited to tuition fees, leaving other expenses—such as books, transportation, and practical projects—on the students to cover. As one female student shared, *"Even with the scholarship, I still struggle to afford transportation and materials for my projects. It's hard to focus on learning when you're constantly worrying about money."*[133] This challenge is especially difficult for female students suffering from multidimensional poverty, making it hard for them to meet these financial obligations. As a result, the pool of skilled professionals needed to meet the growing demands of the solar industry remains insufficient.

- TVET institutions operating without licensing: Some institutions operate without formal licensing, leaving their students without the certificates required to secure jobs in the solar sector. This absence of recognized credentials exacerbates solar job insecurity and widens the journey to greening TVET, as graduates from these institutions receive subpar trainings and struggle to find stable employment. For these schools the institutors are solely profit-making ventures. As a result, many potential entrants are discouraged from pursuing careers in solar, which perpetuates the skills

[133] Student interview

gap and stalls the development of a skilled and environmentally aware workforce.As one student noted, "After completing my training, I found out the institution wasn't licensed, so I couldn't get a proper certificate. Now, it's hard to even get an interview for a solar job."[134]

- Cultural barriers and gender stereotypes: Cultural barriers and gender stereotypes continue to restrict the participation of women and marginalized groups in the solar workforce.This limits the potential talent pool for a diverse and skilled labor force in the solar industry. In many cases, societal expectations dictate that technical roles, especially in industries like solar energy, are seen as "male" jobs, which discourages women from pursuing these opportunities. As one female trainee shared, "*Even though I'm qualified, people often assume I'm not capable of handling solar installations just because I'm a woman. It's frustrating, but I'm determined to prove that women can succeed in this field."*[135] By dismantling these cultural and gender barriers, the solar sector can tap into a wider talent pool, ensuring a more diverse and skilled workforce.

- Regulatory uncertainty: In Nigeria, the absence of clear and consistent government policies around renewable energy creates significant confusion for investors and businesses, stalling the growth of the solar industry. Majorly, it discourages investment in training programs and infrastructure development, limiting opportunities to build a skilled workforce for the solar industry. Without well-defined regulations and long-term commitments from the government, both local and international investors hesitate to commit resources to solar projects. This uncertainty makes it difficult for businesses to plan and scale their operations, slowing the development of the industry and hindering its potential to meet the country's energy needs. As the CEO of Solfa Power noted, "*We're ready to expand, but the lack of a stable regulatory framework makes it risky to invest heavily in solar infrastructure. Clear policies would give us the confidence we need to scale up and meet the growing demand."* This inconsistency in policy also affects the availability of incentives and support mechanisms, further discouraging investment in the sector.solar sector.

- Infrastructure and resource constraints: Nigeria's solar industry faces significant challenges stemming from infrastructure and resource constraints, which severely impede its growth and wider adoption. A lack of adequate infrastructure limit access to practical training, local expertise, and affordable solar technology, hindering the development of a skilled domestic workforce.Furthermore, the high upfront costs of solar technology, coupled with limited access to financing options, make it difficult for many businesses and individuals to invest in solar energy solutions. Additionally, a shortage of skilled labor and technical expertise in solar system installation and maintenance further slows the industry's progress and increases cost of operation for companies . This is because they often resort to importing expensive foreign labor from other countries.

- Corruption and vandalism: A significant challenge to the adoption of solar energy in large institutions arises from sabotage by entrenched interests in the fossil fuel industry, particularly those involved in procuring diesel for electricity generation in higher institutions.[136] These agents, often benefiting from kickbacks associated with

[134] Interview with solar graduate turned electrician
[135] Student Interview
[136] Government official

diesel procurement, view solar installations as a direct threat to their financial gains. In response, they resort to sabotaging solar infrastructure, such as by vandalizing installations. This not only undermines efforts to promote renewable energy but disrupts solar adoption and discourages investment in the necessary skills for local manufacturing and sustainable energy development.

Additionally, the potential for local content development and value addition within Nigeria's solar industry remains largely untapped. TVET programs do not sufficiently emphasize the skills needed for domestic manufacturing, supply chain management, and value-added services, which are crucial for creating a self-sustaining solar industry that can drive economic growth and job creation. Addressing these infrastructure and resource challenges is essential for realizing the full potential of Nigeria's solar industry and ensuring its contribution to sustainable development.

- Challenges in offering certifications in green skills: Offering certifications that specifically recognize expertise in sustainable and green practices within the solar industry is crucial but complicated by the current state of the TVET curriculum. The overabundance of curricula and the lack of standardization create challenges in establishing certifications that are widely recognized and respected by the industry. Without a unified approach to certification, the process becomes fragmented, leading to inconsistencies in the skills and knowledge that certified technicians possess. This fragmentation undermines the credibility of certifications and makes it difficult for employers to trust that certified individuals have the necessary expertise. To address this challenge, there is a need for a streamlined certification process that aligns with industry standards and ensures that all certified professionals are equipped with the skills needed to implement sustainable solar solutions effectively.

- High import duty: A major challenge in Nigeria's solar energy sector is the high import duty on solar components, which significantly raises the cost of solar installations and hampers the growth of the industry. The high import duty on solar components increases costs, making it harder to integrate affordable solar technologies into Technical and Vocational Education and Training (TVET) programs for solar, thus hindering the greening of TVET in Nigeria.This also presents a dilemma for private sector players who struggle to remain competitive while facing inflated costs. At the same time, the Federal Government is cautious about reducing import duties, as it seeks to prevent Nigeria from becoming a "dumping ground" for low-quality or excess solar components from other countries. As one industry expert noted, "Balancing the need to promote clean energy with the protection of local industries is a delicate task that requires nuanced policy solutions." This tension between fostering solar energy adoption and protecting the domestic market remains a critical issue in Nigeria's energy landscape. However, study participants noted that some Pico solar system vendors design their own product prototypes and send them to China for manufacturing, which helps reduce design costs. Despite this, they express a strong desire to further cut expenses by gaining access to local manufacturing infrastructure.

5. Best Practices

Two notable programs that are making a significant impact on preparing young people to participate in Nigeria's solar industry are the John Bosco Institute of Technology's (JOBITECH) solar initiative and the Institute for Industrial Technology (IIT), both of which offer Technical Vocational Education and Training (TVET) with an emphasis on solar energy. These initiatives are unique in their approach to combining industry needs with educational rigor, making them prime examples of greening TVET in Nigeria.

Powered by solar for solar trainings: John Bosco Institute of technology (JOBITECH)

JOBITECH has distinguished itself by utilizing solar energy as the primary source of power for the institution, creating an immersive learning environment where students engage with solar energy daily.[137] This hands-on experience prepares them not just to understand but to operate and maintain solar energy systems, an essential skill for Nigeria's growing solar market. The institutional adoption of solar power ensures that learners are exposed to the technology in real-time, integrating theory with practice in a way that directly mirrors industry challenges.[138]

What makes JOBITECH particularly innovative is its industry partnerships. Collaborating with solar companies and energy experts, the institute has developed an internship scheme which allows placements of students in partner organizations that can both teach and pay students a decent wage.[139] These partnerships provide students with access to the latest technologies and trends outside the school environment, ensuring they are industry-ready upon graduation. Inclusivity is another hallmark of JOBITECH's program, as the institute actively recruits students from underserved communities, providing them with scholarship opportunities and mentorship to thrive in the solar industry.[140] The program has had a significant impact, with many graduates referring other women to join. These graduates have also contributed directly to the solar industry, either by starting their own businesses or by working on local solar projects. [141]

Institute for Industrial Technology (IIT)

The Institute for Industrial Technology (IIT) has taken a holistic approach to greening TVET for the solar industry, focusing not only on technical skills but also on developing problem-solving abilities, critical thinking, and entrepreneurship among students. IIT's solar energy curriculum emphasizes industry-relevant skills through a blend of classroom instruction and practical workshops. By partnering with major players in Nigeria's renewable energy space, IIT ensures that its students work with cutting-edge equipment and software, preparing them to meet the complex demands of the solar sector.

IIT's focus on gender inclusivity through targeted programs for young women in STEM is also noteworthy. While the solar industry has traditionally been male-dominated, IIT actively recruits women, offering tailored training to bridge gender gaps in technical fields. This is inspirational as it directly addresses societal inequalities and opens up new opportunities for women in the renewable energy sector. Additionally, the institute's social innovation training encourages students to think beyond just technical installations, inspiring them to develop

[137] Director JOBITECH Obosi
[138] Trainer JOBITECH Obosi
[139] Interview with placement officer at JOBITECH Obosi
[140] Interview with JOBITECH trainer
[141] Current student at JOBITECH Obosi

solutions that can address the energy needs of Nigeria's most remote and underserved communities.

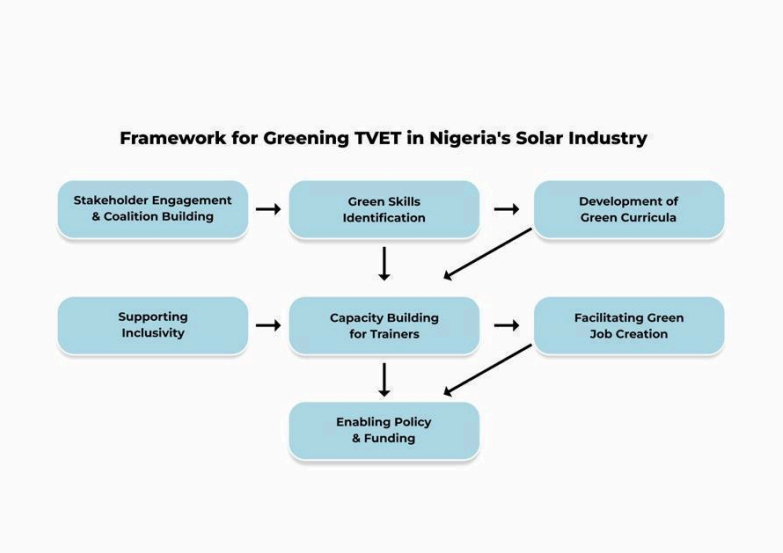
The *Day Release program at IIT* is a practical and structured approach that allows students to apply their in-class learning in real-world work environments. It serves as a bridge between academic training and professional experience, helping students solidify their skills by participating in internships and work placements while continuing their studies.
In concrete terms, here's how the program benefits students:

- Hands-on Experience: The program immerses students in real industry settings, allowing them to work on projects that involve the practical application of the concepts they learn in school. For example, students in electrical or mechanical engineering might find themselves installing solar panels or working on automation systems, gaining direct experience in their field.
- Skill Reinforcement: By working in real-time with professionals, students can deepen their understanding of key skills. In the case of the student mentioned, working with tools like inverters, cable sizing, and electrical safety devices helped them to reinforce skills that were introduced in the classroom.
- Continuous Feedback: The Day Release system allows students to receive regular feedback from both their employers and the school. This ensures that the training is aligned with industry standards and that students can address any skill gaps promptly. It keeps students connected to the academic side while they're in the field, providing a balanced learning experience.
- Industry Readiness: By the time students graduate, they already have substantial industry experience, making them more employable. In the example provided, the students were already hired by the company they interned with, even before completing their studies.
- Career Direction and Networking: Working in a real-world setting exposes students to various career paths they might not have considered. Additionally, students make valuable professional connections during their placements, which can lead to future job offers, as was the case with Sunhive Nigeria Limited.

6. Roadmap For greening TVET for solar industry in Nigeria

The roadmap for greening TVET in Nigeria's solar industry offers a comprehensive and integrated strategy to create a seamless nexus between curriculum development as the input and job standardization as the output. By aligning educational content with industry demands, the roadmap ensures that students acquire the skills necessary for emerging green jobs in the solar sector. This approach bridges the gap between technical education and workforce readiness, emphasizing the importance of standardized competency frameworks, hands-on training, and certification programs that directly meet the needs of employers. With a focus on sustainability and real-world applications, the roadmap provides a pathway where the curriculum serves as the foundation for producing highly skilled professionals, ensuring consistency in job performance and fostering growth within Nigeria's solar industry.

Figure: Framework for greening TVET for Nigeria's solar industry



Source: Illustration based on primary data collection

Stakeholder engagement and coalition building

- **Facilitate knowledge exchange between stakeholders**: Create a multi-stakeholder platform that integrates contributions from both formal and informal sectors, ensuring a cohesive approach to green TVET curricula. This platform should include government agencies like the Ministry of Environment, TVET institutions, industry representatives, and community leaders to address fragmented educational approaches.
- Create an **industry-education council** to foster collaboration between solar companies and educational institutions. Standardize internship and job placement programs, linking them to policy frameworks like Nigeria's renewable energy targets.
- **Ensure availability of resources and knowledge necessary for greening TVET**:Develop a national solar training hub that centralizes access to modern solar equipment and technologies. Utilize public-private partnerships to secure resources from both local and international green technology companies, ensuring that TVET institutions can access the latest tools and materials.

Development of green skills identification for the solar industry

- **Assess the current level of skills available in the solar industry:** Partner with local organizations, such as the Nigerian Energy Support Programme (NESP), to assess the skills gap in the solar workforce. Implement a national audit of solar projects to identify deficiencies in environmental and technical skills.
- **Identify the needs of employers and Youth:** Conduct youth surveys in collaboration with local tech incubators to assess what young professionals are seeking in the solar energy job market. Partner with companies such as but not limited to Lumos,JOBITECH,IIT and Daystar Power to co-create apprenticeships aligned with

industry demand for hands-on experience with cutting-edge solar technologies like IoT-enabled systems and energy storage solutions.

- **Forecast future of work needs:**Work with industry and labor market experts to develop forward-looking models that predict the emerging roles in solar technology, including data analytics for grid optimization, hybrid systems integration, and AI for energy management.
- **Develop competency standards** :Collaborate with the National Power Training Institute of Nigeria (NAPTIN) and NERC to develop competency standards and frameworks that reflect the latest advancements in the solar industry, including the integration of smart grids and off-grid systems. This framework can prioritize the integration of green skills into existing TVET programs.
- **Standardization of training content across TVET institutions** will ensure consistency in the quality of education and certification, making Nigerian graduates competitive both locally and internationally.

Development of green curricula for the solar industry

- **Review the curricula currently available nationally:** Form an inter-agency task force to review existing TVET curricula in partnership with the National Board for Technical Education (NBTE) and international partners to integrate sustainability and life cycle analysis into the curriculum.
- **Adapt curricula to new competency standards:**Implement a competency-based curriculum that includes emerging technologies like IoT in energy management and energy storage systems, with a strong focus on environmental sustainability and practical applications in both rural and urban settings.
- **Strengthen the regulatory framework** to ensure that only licensed institutions can operate solar training programs. Introduce a public registry of licensed TVET institutions, ensuring transparency for prospective students.
- **Establish solar learning hubs across Nigeria** that provide students access to modern technologies, including energy storage and smart grid applications. Offer industry-backed apprenticeships that allow students to gain hands-on experience in real-world solar projects. Students should be actively involved in the installation, maintenance, and management of solar systems on these campuses, allowing for real-world experience that supplements classroom learning.
- **Introduce sustainability workshops in TVET institutions**, focusing on recycling, waste reduction, and energy-efficient tools. Collaborate with private solar firms to demonstrate the environmental benefits of well-executed installations.
- Alongside technical skills, Nigeria's TVET programs should emphasize the **development of soft skills** such as problem-solving, teamwork, communication, and project management. These skills are essential for students to excel in the evolving renewable energy sector.
- TVET programs should offer **lifelong learning opportunities** that allow professionals to return and upskill or re-skill in solar and other green technologies. Offering flexible, part-time, or online courses will make this learning accessible to a broader audience, ensuring a constant flow of trained professionals to support the solar energy sector.

Supporting inclusivity in TVET institutes

- **Foster inclusivity within institutions and classrooms** :Implement a mentorship program that connects female students with women leaders in the solar industry, such as through partnerships with women groups, TVET institutions, private sector and

development partners. Additionally, provide targeted scholarships for women and marginalized groups, covering costs beyond tuition such as materials and transportation.

- **Develop courses on sustainability practices and the green economy:** Develop micro-courses on sustainability that are specifically tailored to the Nigerian context, addressing issues like desertification and deforestation, and their relation to renewable energy solutions.
- **Incorporate the Informal Sector** :Engage informal solar installers and technicians in a formalized recognition program (RPL) to bridge the gap between informal experience and formal certification, allowing skilled laborers to participate in TVET programs and contribute their expertise.
- **Develop a specialized CPD program for TVET trainers** focused on the latest solar technologies and sustainable practices. Ensure trainers undergo regular certifications with solar technology providers to stay updated.
- **Ensure that solar energy training is accessible to all,** especially women, youth, and marginalized groups. This can be achieved through targeted scholarships, mentorship programs, and awareness campaigns.
- **Encouraging diverse participation in solar energy training** can help Nigeria build a more inclusive workforce for the future of its green economy.

Capacity building for TVET trainers

- **Review the current level of trainers**:Just as the NBTE does for other fields,conduct a nationwide survey of TVET trainers to assess their proficiency with solar technology and sustainable practices. Identify categories and profiles of trainers that require upskilling, focusing on new areas such as hybrid systems, off-grid solutions, and sustainable energy storage.
- **Develop teacher training for the solar Industry:**Develop a digital learning platform for TVET trainers, providing continuous professional development (CPD) on green technologies and solar industry trends. Leverage e-learning to reduce the costs and logistical challenges of in-person training.

Facilitating green job creation and employment in the solar industry

- **Create a Conducive Business Environment in the Solar Industry**: Create tax exemptions on solar components and systems, as well as reduced import duties on essential solar equipment, while simultaneously promoting local manufacturing to reduce reliance on imports.
- **Raise awareness of youth and the public about opportunities in solar:**Launch public engagement campaigns through local media, targeting the youth with information about career opportunities in solar energy and the broader green economy. Collaborate with influencers and celebrities to champion green jobs.

Enabling policy and funding environment for the solar industry

- **Develop education and training policies and standards:** develop a national TVET solar energy framework that aligns with Nigeria's National Renewable Energy Action Plan (NREAP) and the Economic Sustainability Plan (ESP). Ensure that it includes funding mechanisms to support training programs.
- **Develop policies supporting the transition to a green economy:**Work with regulatory bodies to reduce bureaucratic delays and streamline the process for solar energy

projects. Encourage local content development by creating financial incentives for the manufacturing of solar components in Nigeria.

Raising awareness and shifting perceptions for solar adoption

- **Implement grassroots awareness campaigns** in partnership with community leaders and NGOs to rebuild trust in solar technology. Highlight successful solar installations and their long-term benefits.
- **Develop public campaigns** aimed at changing cultural perceptions of women in technical fields. Partner with successful female solar entrepreneurs to act as role models for future students.

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