



## TVET for Energy Access in Sub-Saharan Africa: Innovations in off-grid and Renewable Energy Training

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### Abstract

*Access to energy remains a critical challenge in Sub-Saharan Africa, particularly in remote areas where grid infrastructure is limited. Technical and Vocational Education and Training (TVET) programs play a vital role in addressing this energy gap by equipping individuals with the skills necessary for off-grid and renewable energy solutions. This paper, therefore focuses on the innovations and advancements in TVET for energy access in Sub-Saharan Africa. The abstract explores the importance of English language proficiency within TVET programs and its relevance to the topic. English serves as a medium of instruction, facilitating knowledge transfer and technical skill development. Furthermore, it enables access to international resources, collaboration opportunities, standardization of technical terminology, and certification frameworks. By examining various TVET initiatives, the abstract highlights the impact of these programs on sustainable development. It discusses innovative approaches such as hands-on training, practical experience, and incorporation of renewable energy technologies in the curriculum. These strategies not only enhance technical competencies but also promote entrepreneurship and local innovation. The abstract concludes by emphasizing the role of English language proficiency in enabling market integration and enhancing employability prospects for TVET graduates. Proficiency in English facilitates global engagement, knowledge, and dissemination of locally developed solutions in renewable energy.*

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### Introduction

Access to reliable and affordable energy is crucial for driving socio-economic development and improving the quality of life in any region. However, Sub-Saharan Africa continues to face significant challenges in ensuring widespread energy access, particularly in remote and underserved areas. The limited reach of traditional grid infrastructure necessitates the exploration of alternative solutions, such as off-grid and renewable energy systems. In

this context, Technical and Vocational Education and Training (TVET) programs have emerged as a vital catalyst for equipping individuals with the necessary skills and knowledge to support the development and maintenance of such energy solutions.

This paper delves into the topic of TVET for energy access in Sub-Saharan Africa, focusing on the innovations and advancements in off-grid and renewable energy training. By examining the role of TVET in promoting sustainable energy solutions, the



paper explores how these programs contribute to bridging the energy gap and fostering socio-economic growth in the region. Additionally, the paper highlights the relevance of English language proficiency within TVET programs, considering its impact on effective instruction, international collaboration, and standardized certification frameworks.

Through a comprehensive analysis of various TVET initiatives, the paper uncovers the strategies employed to enhance technical competencies and entrepreneurial skills in the context of energy access. It explores hands-on training methodologies, practical experience, and the integration of renewable energy technologies into the curriculum. Furthermore, the paper emphasizes the role of English language proficiency in facilitating market integration, global engagement, and knowledge exchange, which ultimately enhance employment prospects for TVET graduates.

By shedding light on the importance of TVET for energy access and the significance of English language proficiency, this paper seeks to contribute to the ongoing discourse on sustainable energy development in Sub-Saharan Africa. It calls for continued collaboration, innovation, and investment in TVET programs to empower individuals, strengthen local communities, and drive the transition towards a sustainable energy future.

### **The Energy Access Challenge in Sub-Saharan Africa**

The Energy Access Challenge in Sub-Saharan Africa refers to the significant lack of access to reliable and affordable energy services faced by a large portion of the population in the region. Sub-Saharan Africa has one of the lowest electrification rates in the world, with around 580 million people lacking access to electricity, according to the International Energy Agency (IEA) (IEA, 2020).

Several factors contribute to the energy access challenge in Sub-Saharan Africa. Firstly, the region

has a high rural population, and extending electricity infrastructure to remote areas is often challenging and costly (World Bank, 2021). Additionally, limited financial resources, inadequate policy frameworks, and weak institutional capacity hinder the development and deployment of energy infrastructure (International Renewable Energy Agency [IREA], 2020).

The lack of energy access in Sub-Saharan Africa has profound implications for various aspects of people's lives. It hampers economic development by impeding productivity and limiting opportunities for income generation. Access to electricity plays a crucial role in education and healthcare, as it enables efficient lighting, access to information and communication technologies (ICTs), and refrigeration for vaccines and medicines (World Bank, 2021).

To address the energy access challenge in Sub-Saharan Africa, various initiatives and programs have been implemented. The United Nations Sustainable Development Goal 7 aims to ensure universal access to affordable, reliable, sustainable, and modern energy by 2030 (United Nations, n.d.). The African Union launched the New Deal on Energy for Africa initiative to accelerate energy access across the continent (African Union Commission, n.d.). Furthermore, international organizations, governments, and private sector entities are investing in renewable energy projects, decentralized energy solutions, and off-grid systems to expand energy access in the region (IREA, 2020).

The energy access challenge in Sub-Saharan Africa remains a significant obstacle to social and economic development in the region. However, various initiatives are underway to address this issue and improve energy access for millions of people.

### **Impacts of Limited Energy Access on Socio-economic Development**

The limited energy access in many regions, including Sub-Saharan Africa, has significant impacts on socio-economic development. The lack of reliable and



affordable energy services hampers progress in various sectors and affects the overall well-being of communities.

According to World Bank, (2021) limited energy access constrains economic productivity and hinders the growth of industries and businesses. Without access to electricity, businesses, especially small and medium-sized enterprises (SMEs), face challenges in operating machinery, processing goods, and delivering products and services efficiently. Similarly, IREA, (2020) submits that access to reliable energy services enables increased productivity, promotes economic diversification, and creates employment opportunities.

Moreso, UNESCO, (2020) reports that limited energy access contributes to the education and digital divide. Without electricity, schools in rural areas struggle to provide adequate lighting, operate computers, and use audio-visual aids for teaching. This lack of access to educational resources and technology limits educational outcomes and perpetuates disparities. Moreover, the digital divide is exacerbated as energy is crucial for powering internet connectivity and ICT devices, denying access to online learning and information sharing (World Bank, 2021).

Energy access plays a critical role in healthcare services. Without electricity, medical facilities face challenges in providing basic services such as lighting, refrigeration for vaccines and medicines, sterilization of equipment, and running essential medical devices (IREA, 2020). Limited energy access hinders the delivery of quality healthcare, negatively impacting the health outcomes of communities.

Limited energy access disproportionately affects women and girls. In households without electricity, women often spend substantial time and effort on tasks such as collecting firewood, cooking with inefficient stoves, and manually processing food (World Bank, 2021). Access to modern energy services can alleviate the burden on women, create opportunities for income generation, and contribute

to gender equality and women's empowerment (UNDP, 2020).

The lack of energy access often leads to reliance on traditional and inefficient energy sources such as biomass, kerosene, and diesel generators, resulting in harmful environmental impacts, deforestation, and indoor air pollution (IREA, 2020). Transitioning to cleaner and more sustainable energy sources can mitigate these environmental challenges and contribute to a greener and healthier future.

Addressing the energy access challenge is crucial for achieving sustainable development goals and fostering inclusive growth in affected regions.

### **Importance of TVET in Addressing the Energy Access-Challenge.**

Technical and Vocational Education and Training (TVET) plays a crucial role in addressing the energy access challenge by developing a skilled workforce capable of meeting the demands of the energy sector. TVET programs provide specialized training and knowledge in areas such as renewable energy technologies, electrical installation, energy efficiency, and maintenance of energy systems. The importance of TVET in addressing the energy access challenge can be understood through the following points:

**Skilled Workforce:** TVET programs equip individuals with the necessary skills and knowledge to work in the energy sector. By providing training in areas such as solar panel installation, wind turbine maintenance, and grid management, TVET institutions help create a pool of skilled workers who can contribute to the expansion and maintenance of energy infrastructure (UNESCO-UNEVOC, 2018).

**Local Capacity Building:** TVET programs focus on building local capacity by training individuals within their own communities. This approach promotes local employment and empowerment, enabling communities to take ownership of energy projects and contribute to their sustainable development (IREA, 2020).



**Technology Transfer:** TVET institutions facilitate technology transfer by equipping learners with knowledge of modern energy technologies and their application. This knowledge can be utilized to adopt and adapt innovative energy solutions, fostering the deployment of clean and sustainable energy systems (UNESCO-UNEVOC, 2018).

**Entrepreneurship and Innovation:** TVET programs often incorporate entrepreneurship and innovation components, encouraging learners to develop and implement their own energy projects. This entrepreneurial mindset can stimulate local economic development, create job opportunities, and contribute to the growth of the energy sector (IREA, 2020).

**Collaboration with Industry:** TVET institutions collaborate closely with the energy industry to align their training programs with industry needs. This collaboration ensures that graduates possess the skills and competencies required by employers, facilitating smoother transitions into the workforce (UNESCO-UNEVOC, 2018).

By emphasizing practical skills and providing hands-on training, TVET programs contribute to the development of a capable workforce that can effectively address the energy access challenge in various ways.

### **Off-Grid Energy Systems and its importance**

Off-grid energy systems refer to decentralized energy solutions that operate independently of the main power grid. These systems typically include renewable energy sources such as solar panels, wind turbines, or small-scale hydropower, combined with energy storage technologies and energy management systems. Off-grid energy systems are designed to provide electricity to communities, households, or businesses that are not connected to the centralized grid infrastructure (Bhattacharyya & Palit, 2017).

The importance of off-grid energy systems can be understood through the following aspects:

**Energy Access:** Off-grid energy systems play a crucial role in providing electricity to remote and underserved areas where extending the main grid infrastructure is challenging and expensive (Bhattacharyya & Palit, 2017). These systems offer an immediate solution to bridge the energy access gap, enabling communities to have reliable and affordable electricity for lighting, productive activities, education, healthcare, and communication.

**Sustainable Development:** Off-grid energy systems contribute to sustainable development by promoting clean and renewable energy sources. They help reduce reliance on fossil fuels and mitigate environmental impacts such as greenhouse gas emissions and air pollution (International Renewable Energy Agency [IREA], 2020). By harnessing local renewable resources, off-grid systems offer a sustainable and climate-friendly energy solution.

**Resilience and Reliability:** Off-grid energy systems enhance energy resilience and reliability in areas prone to power outages or grid instability (Bhattacharyya & Palit, 2017). By incorporating energy storage technologies, these systems can store excess energy generated during favourable conditions and provide power during periods of low renewable energy generation or grid failures.

**Economic Empowerment:** Off-grid energy systems contribute to economic empowerment by enabling income-generating activities and promoting entrepreneurship (IREA, 2020). Access to electricity facilitates the establishment of small businesses, agricultural processing, and the use of productive equipment and machinery, thereby creating job opportunities and boosting local economies.

**Energy Independence:** Off-grid energy systems provide communities with energy independence and control over their energy supply (Bhattacharyya & Palit, 2017). Rather than relying on external sources for electricity, communities can generate their own power, reducing dependence on centralized utilities and increasing self-sufficiency. Off-grid energy systems are a vital tool in achieving universal energy



access, promoting sustainable development, and empowering communities with reliable and clean energy sources.

### **Integrating English Language Proficiency in Renewable Energy Training.**

Integrating English language proficiency in renewable energy training programs is crucial for ensuring effective communication, comprehension, and knowledge transfer in the context of the renewable energy sector. English language proficiency plays a significant role in enabling individuals to understand technical concepts, engage in collaborative work, and effectively communicate within the global renewable energy community.

Sarkodie-Mensah et al., (2020) identify “Technical Understanding” as a tool for acquiring English proficiency. That it allows learners to comprehend technical terminology, scientific principles, and industry-specific jargon used in the renewable energy field. This enhances their ability to understand and apply concepts related to renewable energy technologies, systems, and processes

Also, Andres et al., (2019) on the other hand, believe ‘Knowledge Exchange’ is a crucial role in acquiring English language proficiency which facilitates effective communication and knowledge exchange among professionals and stakeholders in the renewable energy sector. It enables individuals to share experiences, ideas, and best practices, leading to enhanced collaboration, innovation, and learning.

Proficiency in English opens doors to international networking opportunities within the renewable energy community. English is widely used as a common language for conferences, seminars, and research publications in the field. Strong English language skills enable professionals to engage in global discussions, access research literature, and establish connections with experts from diverse backgrounds (Lopez-Arceiz & Lofgren, 2021).

English language proficiency enhances career prospects in the renewable energy industry. Many job

positions, especially those with an international focus, require strong English communication skills. By integrating English language training, renewable energy programs prepare learners for global employment opportunities and career advancement (Andres et al., 2019).

From the foregoing, to integrate English language proficiency into renewable energy training programs, various approaches can be adopted. These may include dedicated English language courses, technical materials and resources in English, interactive language practice activities, and real-world simulations to enhance English communication skills in renewable energy contexts.

### **Innovations in TVET Curriculum for Renewable Energy Training**

Innovations in Technical and Vocational Education and Training (TVET) curriculum for renewable energy training have been introduced to enhance the effectiveness of English language instruction in this field in various English-speaking parts of the African continent. These innovations aim to equip learners with the necessary technical skills and English language proficiency required for successful participation in the renewable energy industry.

One innovative approach is the integration of project-based learning (PBL) into the TVET curriculum. PBL engages learners in real-world renewable energy projects where they apply their technical knowledge while practicing English language skills in a practical context (Rahman et al., 2020). Through PBL, students collaborate, solve problems, and communicate their ideas and findings in English, thereby developing both their technical expertise and language proficiency.

Another innovation is the use of blended learning methods that combine traditional classroom instruction with online resources and interactive platforms. Blended learning allows students to access renewable energy content in English through multimedia materials, interactive modules, and



virtual simulations (Sloan et al., 2021). This approach provides flexibility and self-paced learning opportunities while promoting English language acquisition.

Furthermore, the incorporation of authentic materials in the TVET curriculum enhances English language learning in the context of renewable energy. Authentic materials include industry reports, case studies, technical manuals, and research articles, which expose learners to the language used in professional settings (Bennett, 2018). By engaging with authentic materials, students develop their language skills while gaining insights into renewable energy practices and challenges.

To foster language acquisition, TVET institutions are also adopting communicative language teaching (CLT) methodologies. CLT emphasizes interactive and task-based activities that require learners to communicate and collaborate in English (Alkahtani, 2020). In the context of renewable energy training, CLT encourages students to discuss and present renewable energy topics, engage in role-plays, and participate in group projects, thereby enhancing their language proficiency and technical knowledge simultaneously.

These innovations in TVET curriculum for renewable energy training, integrating English language instruction, contribute to the development of a competent and globally competitive workforce in the renewable energy sector.

### **Incorporating Practical Hands-On Training in TVET Programs.**

Incorporating practical hands-on training is a crucial component of Technical and Vocational Education and Training (TVET) programs, as it enhances the effectiveness of learning by providing students with real-world experiences and skills development opportunities (Aminu, 2021). Practical training allows students to apply theoretical knowledge to practical situations, improving their problem-solving

abilities, technical proficiency, and overall competence in the energy sector.

One of the key benefits of practical hands-on training is the development of technical skills. Through practical exercises and simulations, students gain valuable experience in using tools, equipment, and technologies relevant to the energy field (Aminu, 2021). This hands-on approach enables them to develop the necessary skills and competencies required for careers in renewable energy, electrical engineering, or other energy-related disciplines.

Additionally, practical training helps students develop critical thinking and decision-making skills. By engaging in hands-on activities, students are exposed to real-life scenarios and challenges commonly encountered in the energy industry (Juntunen et al., 2020). They learn to analyze problems, develop solutions, and make informed decisions, thereby preparing them for the dynamic and evolving nature of the energy sector.

Furthermore, practical training enhances students' teamwork and collaboration skills. In many energy projects, teamwork is essential for successful implementation and completion. By working on practical assignments and projects, students learn to communicate effectively, collaborate with their peers, and contribute to collective goals (Juntunen et al., 2020). These interpersonal skills are vital in the energy industry, where teamwork and coordination are often required for efficient project execution.

To ensure the successful incorporation of practical hands-on training in TVET programs, certain considerations should be taken into account. Adequate infrastructure, tools, and equipment must be provided to create a conducive learning environment (Aminu, 2021). Industry partnerships and collaborations can also play a significant role in providing students with access to real-life projects, internships, or apprenticeships, enabling them to gain practical experience directly from the industry (Juntunen et al., 2020).



In conclusion, incorporating practical hands-on training in TVET programs is essential for equipping students with the necessary skills, competencies, and practical experiences needed for the energy sector. By engaging in real-world scenarios, students develop technical skills, critical thinking abilities, and teamwork capabilities. The integration of practical training requires adequate infrastructure and industry collaborations to ensure a holistic learning experience that prepares students for successful careers in the energy field.

### **Leveraging Technology for TVET Advancement in Sub-Saharan Africa**

Leveraging technology for the advancement of Technical and Vocational Education and Training (TVET) in Sub-Saharan Africa presents significant opportunities to enhance the quality and effectiveness of education, including the integration of English language instruction. Technology can support English language learning, provide access to digital resources, and facilitate interactive learning experiences for TVET students.

One way technology can support English language instruction is through the use of language learning apps and platforms. Mobile applications like Duolingo, Babbel, and Rosetta Stone offer English language courses that students can access on their smartphones or tablets (Dong & Zhang, 2021). These apps provide interactive exercises, vocabulary drills, and pronunciation practice, allowing TVET students to improve their English language skills at their own pace.

Furthermore, online platforms and learning management systems (LMS) can be utilized to deliver English language courses or integrate language components into existing TVET programs. These platforms offer multimedia resources, video lectures, and interactive modules that cater to different learning styles and engage students in English language acquisition (Koroma et al., 2020). Additionally, LMS platforms enable teachers to monitor students' progress, provide feedback, and

facilitate online discussions to enhance language learning outcomes.

Virtual reality (VR) and augmented reality (AR) technologies also have the potential to enhance English language instruction in TVET. Immersive VR and AR experiences can simulate real-world scenarios where students practice English language skills in authentic contexts, such as interacting with English-speaking avatars or participating in virtual job interviews (Yucel & Yucel, 2019). These technologies provide a unique and engaging environment for language learning, promoting both language acquisition and vocational skills development.

Moreover, online language exchange programs can connect TVET students with English language learners from other countries. Through video conferencing tools and language exchange platforms, students can engage in conversations with native English speakers, improving their speaking and listening skills while gaining cultural understanding (Shirvani et al., 2020). Such interactions offer valuable opportunities for TVET students to practice English in real-world settings, enhancing their language proficiency and global communication skills.

### **Industry Partnerships and Collaboration in TVET for Energy Access incorporate**

Industry partnerships and collaboration play a crucial role in Technical and Vocational Education and Training (TVET) programs aimed at addressing energy access challenges. These partnerships provide valuable opportunities for students to acquire practical skills, industry-specific knowledge, and exposure to English language usage in real-world contexts with the aim of gaining knowledge transfer.

Collaborating with industry partners allows TVET institutions to align their training programs with the needs of the energy sector. Industry input helps ensure that the curriculum reflects current industry practices, standards, and emerging technologies



(Brophy et al., 2021). In these partnerships, English language proficiency becomes essential as it enables effective communication and collaboration between students and industry professionals.

Through industry partnerships, TVET institutions can offer students internships, apprenticeships, or work-based learning experiences. These opportunities allow students to apply their technical knowledge and English language skills in authentic work environments (Zubairu et al., 2021). Engaging in workplace settings enhances students' understanding of industry-specific terminology, communication protocols, and professional expectations.

Moreover, industry partnerships can facilitate the delivery of English language training programs tailored to the energy sector. Collaborating with energy companies or organizations that operate in English-speaking contexts provides opportunities for students to practice English in a vocational context, preparing them for international job opportunities or collaborations (Bygate & Samuda, 2020). This integration of English language instruction in collaboration with industry partners equips students with the language skills necessary for effective communication within the energy sector.

Furthermore, industry partnerships can support the establishment of industry-led advisory boards or committees that provide guidance on curriculum development, teaching methodologies, and English language integration. These advisory boards ensure that TVET programs remain responsive to industry trends and requirements, including the emphasis on English language skills (Brophy et al., 2021).

Generally, industry partnerships and collaboration in TVET programs for energy access foster the integration of English language instruction, align curricula with industry needs, provide work-based learning opportunities, and enhance students' language skills and employability in the energy sector.

### **Overcoming Challenges and Barriers in TVET for Energy Access**

Overcoming challenges and barriers in Technical and Vocational Education and Training (TVET) programs for energy access involves addressing various factors that can hinder the effective integration of English language instruction. These challenges include limited resources, inadequate teacher training, language barriers, and access to quality learning materials (Brophy et al., 2021).

One of the primary challenges is the availability of resources for English language instruction. TVET institutions may face constraints in terms of qualified English language teachers, appropriate teaching materials, and technological infrastructure to support language learning (Tadesse et al., 2021). Addressing this challenge requires investment in teacher professional development programs and the provision of adequate resources for English language training.

Language barriers can pose challenges for both instructors and students. In many Sub-Saharan African countries, English is often taught as a second language, and students may have varying levels of proficiency. To overcome this barrier, TVET programs can incorporate English language support mechanisms, such as language support classes, language tutoring, and the use of bilingual materials (Tadesse et al., 2021). Creating a supportive language learning environment can help students improve their English language skills while engaging with technical content.

Another barrier is the limited availability of quality learning materials in English. TVET institutions can collaborate with international organizations, industry partners, and online platforms to access high-quality English language resources related to renewable energy and technical subjects (Brophy et al., 2021). These resources can include online textbooks, instructional videos, interactive simulations, and e-learning platforms that facilitate self-paced language learning.





Inadequate teacher training in language instruction is another challenge that needs to be addressed. Teachers in TVET programs require specialized training that combines technical expertise with language teaching strategies (Tadesse et al., 2021). Professional development programs should focus on equipping instructors with the necessary skills to integrate English language instruction into their technical courses effectively. Training can include pedagogical approaches for teaching English as a second language, strategies for supporting English language learners, and the use of technology in language instruction.

Furthermore, ensuring equitable access to TVET programs and English language instruction is crucial. Efforts should be made to reduce gender disparities, geographical barriers, and socio-economic inequalities in accessing quality TVET education (Brophy et al., 2021). Providing scholarships, online learning opportunities, and mobile learning initiatives can help reach a wider range of students, including those in remote areas.

Overcoming challenges and barriers in TVET programs for energy access requires addressing resource limitations, enhancing teacher training, addressing language barriers, and improving access to quality learning materials. By investing in these areas, TVET institutions can effectively integrate English language instruction and provide students with the necessary skills for successful participation in the energy sector.

### **Promoting Gender Equality and Inclusivity in TVET Programs**

Promoting gender equality and inclusivity in Technical and Vocational Education and Training (TVET) programs is essential to ensure equal access, opportunities, and outcomes for all individuals regardless of their gender identity. By addressing gender disparities and creating an inclusive learning environment, TVET programs can contribute to a more equitable and diverse energy sector (Elander et al., 2021).

One approach to promoting gender equality in TVET is by implementing targeted recruitment strategies. Efforts should be made to actively encourage female participation in traditionally male-dominated fields within the energy sector, such as electrical engineering or renewable energy technology (Elander et al., 2021). Collaborating with schools, community organizations, and women empowerment initiatives can help raise awareness about the opportunities and benefits of pursuing careers in the energy industry.

To ensure inclusivity, TVET programs should also provide a supportive and respectful learning environment that values diversity. This can be achieved through the development of inclusive teaching materials, practices, and assessment methods that are sensitive to the needs and experiences of all students, regardless of their gender or background (Kolmos et al., 2020). Creating safe spaces for open dialogue, addressing unconscious biases, and promoting respect for diverse perspectives can foster an inclusive learning environment that encourages active participation and engagement from all students.

Furthermore, integrating gender-responsive curriculum content into TVET programs is crucial. This involves incorporating examples, case studies, and projects that highlight the contributions of women in the energy sector and address gender-related issues (Kolmos et al., 2020). By showcasing successful female role models and emphasizing the importance of gender equality, TVET programs can challenge stereotypes and empower students to pursue their aspirations without limitations.

Another aspect of promoting gender equality and inclusivity in TVET is providing support systems and mentorship opportunities for female students. Establishing mentoring programs, networking events, and career guidance initiatives can help create a supportive network and facilitate the professional development of women in the energy industry (Elander et al., 2021). Mentors can provide guidance, advice, and role modelling, assisting female students



in navigating their career paths and overcoming potential challenges.

Evaluation and monitoring mechanisms should also be implemented to assess the effectiveness of gender equality and inclusivity initiatives in TVET programs. Regular assessments can help identify areas for improvement and track progress towards achieving gender equality goals (Kolmos et al., 2020). Collecting and analyzing disaggregated data based on gender can provide valuable insights into the participation rates, retention rates, and employment outcomes of male and female students in TVET programs.

In conclusion, promoting gender equality and inclusivity in TVET programs is crucial for creating a more equitable and diverse energy sector. By implementing targeted recruitment strategies, creating inclusive learning environments, integrating gender-responsive curriculum content, providing support systems, and implementing evaluation mechanisms, TVET programs can contribute to breaking gender barriers, empowering women, and fostering an inclusive learning environment that benefits all individuals.

#### **Evaluating the Impact of TVET in Energy Access.**

Evaluating the impact of Technical and Vocational Education and Training (TVET) in energy access requires a comprehensive assessment of various factors, including workforce development, employment outcomes, skill acquisition, and the contribution to sustainable energy initiatives. Through rigorous evaluation, policymakers, educators, and stakeholders can gain insights into the effectiveness and efficiency of TVET programs in addressing energy access challenges.

One aspect to evaluate is the extent to which TVET programs meet the skill requirements of the energy sector. This involves assessing whether the curriculum aligns with industry needs and whether graduates possess the necessary technical competencies and English language skills (Kunz &

Brugger, 2021). Evaluating the relevance of the training programs ensures that they are tailored to the specific demands of the energy industry, leading to a skilled workforce capable of contributing effectively to energy access initiatives.

Furthermore, evaluating the employment outcomes of TVET graduates provides insights into the impact of these programs on job placement and income generation. The evaluation can examine the percentage of graduates who secure employment in the energy sector, their job satisfaction levels, and the income levels they achieve (Ssekamanya et al., 2020). This analysis helps determine the effectiveness of TVET programs in facilitating access to employment opportunities and improving the socio-economic conditions of individuals.

Another aspect of evaluation is assessing the contribution of TVET programs to sustainable energy initiatives. This involves examining the extent to which graduates are involved in the development, installation, and maintenance of renewable energy systems (Nguyen et al., 2021). Evaluating the impact of TVET in promoting sustainable energy solutions provides valuable information on the effectiveness of these programs in addressing energy access challenges and advancing environmental sustainability goals.

To conduct a comprehensive evaluation, a mix of quantitative and qualitative methods can be employed. Surveys, interviews, focus group discussions, and case studies can be used to gather data from TVET graduates, employers, and industry representatives (Ssekamanya et al., 2020). This approach allows for a deeper understanding of the impact of TVET programs on individuals, communities, and the energy sector as a whole.

Therefore, evaluating the impact of TVET in energy access involves assessing the relevance of training programs, employment outcomes, and the contribution to sustainable energy initiatives. Through robust evaluation methods, stakeholders can make informed decisions, identify areas for



improvement, and enhance the effectiveness of TVET programs in addressing energy access challenges.

## Conclusion

The development of Technical and Vocational Education and Training (TVET) programs focused on energy access in Sub-Saharan Africa has become crucial for addressing the region's challenges in off-grid and renewable energy. Various innovations and approaches have emerged to enhance the training and skills development needed for the deployment and maintenance of renewable energy technologies.

The studies and resources examined highlight the importance of integrating practical hands-on training, project-based learning, and industry partnerships into TVET curricula. This approach enables students to acquire the necessary technical skills, knowledge, and competencies required to work in the renewable energy sector.

Furthermore, the inclusion of entrepreneurship and business management components in TVET programs is essential to empower individuals to start their own enterprises and contribute to the growth of the renewable energy market. Bridging the gap between technical skills and entrepreneurship fosters job creation, economic development, and sustainable energy access in Sub-Saharan Africa.

Language proficiency, particularly in English, has been identified as a critical factor in facilitating effective renewable energy education and training. Enhancing language skills, especially through online language exchange programs and digital platforms, can improve communication and knowledge sharing among learners and educators.

To ensure the long-term success of TVET programs, it is necessary to address challenges such as funding constraints, lack of infrastructure, and the need for continuous professional development for instructors. Collaboration among governments, educational institutions, industry stakeholders, and international

organizations is vital for sustaining and scaling up these initiatives.

Promoting gender equality and inclusion in renewable energy education and training is crucial. Efforts should be made to increase female participation, create safe learning environments, and provide targeted support to empower women in the renewable energy sector.

Generally, the implementation of innovative TVET programs for energy access in Sub-Saharan Africa has the potential to drive sustainable development, alleviate energy poverty, create employment opportunities, and contribute to the transition towards a cleaner and more resilient energy future for the region.

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