



TVET SKILLS FOR RENEWABLE ENERGY AND GREEN HYDROGEN IN NAMIBIA

Annexure 1: Electrical Engineering

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CONTENTS

Acronyms	1
Analytical report	2
1.1 Status Quo: Overview of Existing Training Measures and Training Providers	2
1.2 Stakeholder Mapping and Needs Analysis	4
1.3 International Benchmarking in Relation to Electrical Engineering	6
1.4 Skills Gap Analysis in the Field of Electrical Engineering	9
2 Recommendations for Necessary Training Measures in Electrical Engineering	11
2.1 Computer and Data Literacy Short Courses	11
2.2 Medium and High Voltage Switching Short Course	13
2.3 Hydrogen Systems and Safety Short Course	14
2.4 Photovoltaics Short Course.	16
2.5 Power Electronics, Inverters, Batteries and Storage Short Course	17
2.6 Programmable Logic Controller (PLC): Handling, Diagnosis and Programming Short Course	18
2.7 Mechatronic / Interdisciplinary System Thinking Short Course	19
3 Conclusions and Recommendations	20
4 Literature and Documents Used	21

ACRONYMS

ATEX	Atmosphères Explosibles (Explosion Protection Standard)
CBET	Competency-Based Education and Training
CHIETA	Chemical Industries Education and Training Authority
CoC	Certificates of Compliance
DSO	Distribution System Operator
ECB	Electricity Control Board
ECN	Engineering Council of Namibia
EE	Electrical Engineering
EMS	Energy Management System
EPC	Engineering, Procurement, and Construction
EU	European Union
EWSETA	Energy and Water Sector Education and Training Authority
GH2	Green Hydrogen
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Development Agency)
GWh	Gigawatt-hour
GWO	Global Wind Organisation
HSE	Health, Safety, and Environment
HV	High Voltage
HVAC	Heating, Ventilation, and Air Conditioning
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission
IHK	Industrie und Handelskammer
ILO	International Labour Organisation
IPP	Independent Power Producer
ISO	International Organization for Standardization
KFW	Kreditanstalt für Wiederaufbau (German Development Bank)
kWh	Kilowatt-hour
LV	Low Voltage
MoJLR	Ministry of Justice and Labour Relations
MV	Medium Voltage
MW	Megawatt
NESC	Namibia Electricity Safety Code
NamPower	Namibia Power Corporation
NTA	Namibia Training Authority
NTC	National Trade Certificate
NQA	Namibia Qualifications Authority
NQF	National Qualifications Framework
NVC	National Vocational Certificate
OPITO	Offshore Petroleum Industry Training Organisation
PLC	Programmable Logic Controller
PV	Photovoltaic
Q&M	Operation and Maintenance
RE	Renewable Energy
SANS	South African National Standards
SARETEC	South African Renewable Energy Technology Centre
SCADA	Supervisory Control and Data Acquisition
TSO	Transmission System Operator
TÜV	Technischer Überwachungsverein
TVET	Technical Vocational Education and Training
UNIREP	United Nations Industrial Development Programme
VTC	Vocational Training Centre
VTP	Vocational Training Provider

1

ANALYTICAL REPORT

1.1 Status Quo: Overview of Existing Training Measures and Training Providers

This section provides an overview of existing qualifications, training programs, and short courses in the field of Electrical Engineering (EE) available in Namibia and neighbouring regions. The focus is on the institutions offering these programs, their capacity, and any identified gaps.

Existing Qualifications and Training Programs in Namibia

Namibia offers a range of Electrical Engineering programs across various educational institutions, including public and private universities, state-owned vocational training centres (VTCs), private vocational training providers (VTPs) and colleges.

The Namibia Training Authority (NTA) oversees multiple VTCs across the country, and the NQA has accredited several institutions that offer programs in Electrical Engineering as well as Solar Equipment Installation and Maintenance. In line with Namibia's TVET Policy, efforts have been made to shift from traditional curriculum-based training to Competency-Based Education and Training (CBET). However, not all training providers have fully transitioned to unit standard-based programs.

According to the Namibia Qualifications Authority (NQA), the "NQA Accredited Namibian Institutions 2025" document, Technical Vocational Education and Training (TVET) programs in Electrical Engineering in Namibia offer a range of qualifications tailored to industry needs.

These programs include National Vocational Certificates (NVCs) in Electrical Engineering (Levels 1 to 5), focusing on electrical installation, maintenance, and industrial wiring. Additionally, NVCs registered on the National Qualifications Framework (NQF) provide specialisations in Electrical General (Level 4), Electronics (Level 4), Instrumentation (Level 3), Air Conditioning and Refrigeration (Level 3), Millwright (Level 3) and Electrical Energy (Level 5). These specialisations equip trainees with skills in electrical circuit design, automation, fault detection, control systems, and refrigeration technology, ensuring a diverse skill set aligned with industry demands.

However, with limited solar training available at just two state-owned VTCs (Windhoek Vocational Training Centre (WVTC) and Eenhana Vocational Training Centre (EVTCC)) at NQF Level 3 and one private training provider (Ondangwa Commercial College) offering NQF Levels 1 to 5, and the lack of programs currently available for electrolyser installation, operations and maintenance and hydrogen-related technologies highlights a critical gap in aligning training with Namibia's emerging green energy industry.

There are different providers that offer qualifications in the field of Electrical Engineering:

Private Vocational Training Providers (VTPs)

- ▶ VTPs provide Electrical Engineering training from Level 4 to Level 6 on the NQF.
- ▶ These institutions incorporate industrial placements into their programs, though challenges exist in securing sufficient placement opportunities for trainees.
- ▶ Short courses in renewable energy (RE) are under development to address emerging industry needs.

State-Owned Vocational Training Centres (VTCs)

- ▶ Several state-owned VTCs across Namibia offer Electrical General programs, focusing on practical skills development.
- ▶ Courses in Electrical General are offered up to Level 4.
- ▶ Solar Equipment Installation and Maintenance is provided as a separate program, typically up to Level 3, although Level 4 and 5 qualifications exist on the NQF.
- ▶ Training is primarily focused on low and medium-voltage applications with limited exposure to high-voltage (HV) systems.
- ▶ Some programs follow local and international electrical installation standards.

Public Universities

- ▶ Public universities in Namibia offer engineering programs that include Electrical Engineering, providing a balance of theoretical knowledge and practical training.
- ▶ These programs cover key aspects such as power systems, automation, and RE integration.
- ▶ Industry engagement is incorporated through research partnerships and industrial attachments.

Training providers across distinct categories implement various Electrical Engineering qualifications and short courses:

- ▶ Most VTPs, VTCs and public universities align their programs with national qualification frameworks.
- ▶ State-owned VTCs follow unit standards that are periodically reviewed but may not always align with emerging industry needs, such as dealing with modern digital technologies. A review of the existing qualifications revealed that several unit standards have failed to keep pace with fast-evolving industry technologies, particularly in automation, power electronics, and data systems. While trainees are expected to complete practical assessments, training centres often lack access to the latest equipment and tools, limiting the trainees' exposure to modern industry practices. This results in a gap between assessed competencies and real-world expectations in high-tech work environments.
- ▶ Private VTPs engage in some cases more in curriculum development that is based on industry feedback and international benchmarks.

Evaluation of Training Providers' Capacity and General Gaps Identified Curriculum Gaps

Renewable Energy Integration: Training programs lack comprehensive coverage of RE technologies such as solar, wind, and green hydrogen (GH₂). Although some programs briefly mention these topics, they lack the necessary detailed training.

Advanced Electrical Training: Most training is limited to low and medium-voltage applications, with minimal exposure to high-voltage systems. Advanced voltage training is limited to select institutions like NamPower, CenoRED, ErongoRED, NoRED, City of Windhoek and some large power users, especially within the mining sector, making it inaccessible to many trainees.

Certification Gaps in Electrical Training: Namibia lacks a structured, industry-recognised certification program for electricians. Essential certifications like ECB, ISO, and OPITO, which enhance workforce readiness, are not integrated into existing training programs.

Industry Collaboration

Limited Engagement: With RE and GH₂ production being amongst emerging industries, there is insufficient collaboration between training institutions and industry, leading to curricula that do not fully align with industry requirements.

Industrial Attachment Challenges: Trainees face difficulties securing industrial attachments due to limited industry placements, affecting their practical exposure.

Uncoordinated Skills Gap Studies: Industry reports that multiple skills gap studies are funded by international organisations (EU, Dutch Government, UNIREP, ILO, GIZ, KFW) without coordinated implementation. Stakeholders advocate using existing reports as a baseline instead of conducting repetitive studies.

Trainer and Assessor Development

Practical Experience: Many trainers and assessors lack hands-on experience with emerging technologies such as RE and GH₂, which could hinder the effective knowledge transfer and ensure consistent assessment of trainees. Training-of-Trainer (ToT) initiatives should therefore be prioritised to ensure sustainability in implementing courses related to emerging industries.

Lack of Continuous Development: To keep up with evolving industry needs, the Continuous Professional Development (CPD) of TVET Trainers and Assessors is a crucial component for matching skills demand with supply.

Technological Resources

Outdated Equipment: Training centres often lack the necessary modern equipment for current industry practices, limiting practical training opportunities for trainees. Although practical assessments are part of standard requirements, the absence of up-to-date training equipment means that trainees often perform tasks on outdated systems, which do not represent current tools and practices in the workplace. This compromises the authenticity of assessments and the industry-readiness of graduates.

Industry Slow to Respond: There is a disconnect between industry and training institutions in terms of equipment needs. Many industrial partners have equipment that is no longer fit for service but could still be useful for training. However, due to insufficient coordination, such equipment is often sent for recycling instead of being repurposed for training. For example, a 2-meter medium-voltage cable holds little value for an industrial company, except to be sold as scrap. However, for a training provider, it is worth far more than its scrap value in terms of educational use.

Equipment Without Trained Trainers: In some instances, training institutions have acquired modern equipment, but trainers are not capacitated to utilise it effectively. This renders the equipment underutilised or completely unused, limiting trainees' exposure to industry-relevant tools and technologies.

High Costs of Accreditation: The expense of obtaining internationally recognised certifications (ISO, OPITO) poses a significant barrier for institutions, limiting their ability to offer these essential qualifications.

Digital Literacy

Basic Computer Skills: A notable deficiency in digital literacy affects trainees' ability to adapt to automated systems prevalent in modern electrical engineering roles.

Summary of Training Landscape and Priority Areas for Improvement

Namibia offers a diverse range of Electrical Engineering training programs through public universities, state-owned VTCs, and VTPs. However, significant gaps remain in curricula content. Industry collaboration, trainer development, technological resources, and digital literacy are limiting the effectiveness of these programs in meeting industry demands. As a result, graduates could lack the necessary practical experience for immediate employability in the workforce.

For those specialising in RE, short courses in Solar Equipment Installation and Maintenance provide foundational skills in solar photovoltaic (PV) system design, installation, and servicing. These programs are increasingly sought after due to the region's transition toward sustainable energy solutions. However, further investment is needed to expand advanced training in battery storage, grid integration, and hybrid renewable systems to fully equip technicians for the evolving energy sector.

To address these challenges, strengthening industry partnerships, modernising training facilities, and aligning curricula with emerging trends will ensure training programs that effectively support career readiness and economic growth in the Electrical Engineering and energy sectors.

1.2 Stakeholder Mapping and Needs Analysis

Namibia's energy system is dominated by the National Transmission System Operator, NamPower, which is responsible for most of the country's generation and transmission and, until recently, was the sole buyer of electricity. NamPower operates significant generation assets, including the Ruacana Hydroelectric Power Station, the coal-fired Van Eck Power Station in Windhoek, and diesel-powered stations like Anixas and Paratus.

Despite these facilities, Namibia imports a significant portion of its electricity from neighbouring countries to meet domestic demand, highlighting the need for greater energy independence and diversification through RE sources.

To address this, Namibia has been actively expanding its RE capacity, particularly in solar and wind energy. The first wind farm, the 5 MW Ombepo Wind Farm, was commissioned in 2017 near Lüderitz. Since then, several large-scale wind projects have emerged, including the 50 MW Cerim Lüderitz Wind Power Station and the 44 MW Diaz Wind Power Station.

For solar energy, Namibia's first large-scale solar power plant was the 4.5 MW InnoSun Solar Power Plant, commissioned in 2015. HOPSOL is another player in the solar industry. Subsequently, the sector grew significantly with multiple utility-scale projects. Additionally, independent power producers (IPPs) have been active in off-grid and grid-connected solar solutions, contributing to energy security and sustainability.

Namibia is developing GH₂ projects to strengthen its RE portfolio, leveraging its solar and wind resources. The Hyphen Hydrogen Energy project is planned within the Tsau/Khaeb National Park and aims to produce GH₂ for export and local industrial use. In the field of GH₂, the companies Cleanergy Solutions Namibia and HDF-Energy should also be mentioned.

The skills required in Namibia's RE and GH₂ sectors vary between the construction and operation phases of the projects. Industry stakeholders, including wind, solar, and hydrogen project developers, require a mix of electrical, mechanical, instrumentation and control, as well as safety-related skills to ensure efficient project execution and long-term sustainability.

As part of the stakeholder engagement process, consultations were held with RE and GH₂ sector stakeholders, including Cleanergy Solutions Namibia, InnoSun/InnoVent, HOPSOL, Hyphen Hydrogen Energy, and HDF Energy.

On the training side, engagements included the Namibia Institute of Mining and Technology (NIMT), Triumphant College, WVTC, Namibia University of Science and Technology (NUST), and MAPAC VTC. Additional insights were drawn from the national technical experts' prior technical and operational experience at Central Northern Regional Electricity Distributor (CENORED) and NamPower in Namibia.

These perspectives provided grounded input on institutional readiness, technical capacity, and evolving workforce requirements from utility and Engineering, Procurement, and Construction (EPC) perspectives.

Construction Phase: High Labour Demand

During construction, RE and GH₂ projects require a large workforce to establish infrastructure, install equipment, and set up supporting systems. Most jobs in this phase are temporary but provide valuable experience and skills development for workers and trainees on industrial equipment.

Earthmoving and Site Preparation: Operating excavators, bulldozers, graders, and compactors to clear land for project development.

Civil Works and Infrastructure: Foundation construction, trenching, road building, drainage systems, and site stabilisation for solar farms, wind turbines, and hydrogen plants.

Structural Engineering and Concrete Works: Reinforced foundations for wind turbines, substation buildings, and solar panel mounting structures.

Water Supply and Management Systems: Installation of pipelines, pumps, and reservoirs for electrolysis, hydrogen cooling, and fire suppression.

Water Purification and Desalination: Treatment of seawater or brackish water for electrolysis in hydrogen production plants.

Electrical Installation and Wiring: LV, MV, and HV installations, transformers, circuit breakers, and grounding techniques.

Solar and Wind System: Installation of solar PV panels, wind turbines, battery storage systems, and power inverters.

Instrumentation and Control Systems: Installation of sensors, process control instruments, SCADA systems, and automation components to monitor and regulate RE and hydrogen production processes.

Basic ICT and Networking: Installation of communication systems for remote monitoring, industrial networking, and smart grid integration.

Mechanical and Structural Work: Assembly of wind turbine towers, steel structures, solar panel racking systems, and mounting hardware.

Health, Safety and Environmental (HSE) Compliance: Occupational safety, working at heights (wind turbines), fire safety, and emergency response (ATEX certification for explosive environments).

Heavy Equipment Operation: Use of cranes, forklifts, and drilling machines for foundation construction and lifting equipment.

Industries requiring these skills, Occupations and Companies

- ▶ Wind and Solar Developers
- ▶ Grid integration companies
- ▶ Construction and Civil Engineering Firms (e.g., earthmoving companies, roadworks contractors)
- ▶ Hydrogen Production Facilities
- ▶ Water Infrastructure and Desalination Plants (supporting electrolysis-based hydrogen production)

Operational Phase: Specialised Technical Skills and Automation

Once RE or GH2 plants are operational, automation, monitoring, and system maintenance become the focus. Compared to the construction phase, fewer workers are needed, but these jobs require higher expertise, advanced training, and specialised certifications.

Key Skills and Workforce Needs

SCADA and Process Automation: Supervisory Control and Data Acquisition (SCADA) systems for remote monitoring, industrial process automation, and real-time optimisation of wind, solar, and hydrogen plants.

Power Electronics and Inverter Maintenance: Troubleshooting and repairing solar inverters, battery management systems, power converters, and electrical faults.

Hydrogen System Operations and Safety: Handling electrolyzers, hydrogen storage, high-pressure systems (500 bar), explosion-proof electrical setups (ATEX zones), and hydrogen fire safety protocols.

Predictive and Preventive Maintenance: Using condition monitoring tools, vibration analysis, infrared thermography, and diagnostics to reduce downtime in wind turbines, solar farms, and hydrogen plants.

High-Voltage Switching and Grid Integration: Operation of MV/HV substations, transformers, switchgear, relay protection systems, and grid synchronisation for RE plants.

Instrumentation and Control Systems: Installation, calibration, and maintenance of sensors, pressure gauges, flow meters, and automated control systems to optimise energy production.

Water Treatment and Purification Systems: Managing desalination plants, filtration units, and water recycling systems for electrolysis-based hydrogen production and cooling processes in power plants.

Data Analytics and Performance Optimisation: Big data analysis, machine learning, and IoT-driven diagnostics for maximising efficiency and troubleshooting performance issues in RE systems.

Advanced ICT and Networking: Cloud-based energy management systems (EMS), industrial cybersecurity, remote sensing, and real-time data logging for smart grid applications.

Industries requiring these skills, Occupations and Companies

Wind and Solar Plant Operators: Managing and maintaining large-scale RE farms, handling power dispatch, grid balancing, and MV/HV network operations.

Hydrogen Production Facilities: Overseeing electrolyser operations, hydrogen compression, and distribution systems.

Water and Utility Companies: Supporting desalination, wastewater management, and cooling water supply systems for hydrogen electrolysis plants.

Large Power Users with Solar Plants: Mines, industrial parks, and manufacturing facilities operating grid-connected or off-grid solar PV and battery storage systems.

Facilities Management Companies: Overseeing commercial properties' maintenance and energy efficiency with solar and hybrid power solutions.

Facilities Management Companies: Overseeing commercial properties' maintenance and energy efficiency with solar and hybrid power solutions.

Operation and Maintenance (O&M) Service Providers: Companies specialising in ongoing monitoring, servicing, and troubleshooting of RE installations.

Hotels, Guesthouses, and Tourism Operators: Managing solar PV and energy storage systems in remote locations with limited grid access.

DSOs and TSOs (Distribution and Transmission System Operators): Controlling, balancing, and integrating RE sources into the national and regional grids.

1.3 International Benchmarking in Relation to Electrical Engineering

Training Programs in Neighbouring Regions

In the broader Southern African region, National Certificate (N1–N6) programs remain the standard for electrical training in the TVET sector. These programs cover core subjects such as Electrical Trade Theory, Industrial Electronics, Electrotechnics, and Power Machines, equipping trainees with skills for industrial and domestic electrical installations. Practical training is often incorporated through apprenticeships and trade tests.

Initiatives in South Africa

In South Africa, the national “Just Energy Transition” Strategy aims to reduce the country's dependence on fossil fuels while addressing unemployment and energy insecurity. Therefore, RE and GH₂ are increasingly integrated into the country's TVET system.

Several initiatives reflect this shift in curriculum development. For example, lecturers at Nkangala TVET College have received training in RE technologies, such as solar PV, wind power and battery storage, through a programme led by the Energy and Water Sector Education and Training Authority (EWSETA) in partnership with RES4Africa (Renewable Energy Solutions for Africa).

Similarly, the South African RE Technology Centre (SARETEC) offers programmes tailored to the local market's needs, such as training for solar PV technicians. A notable industry standard in solar PV training is the PV GreenCard, a quality assurance initiative that certifies installers and promotes safe, standardised practices in installing photovoltaic systems. It helps ensure that training programmes are aligned with national safety and performance requirements.

The focus on green skills is also evident in hydrogen-related training. The Chemical Industries Education and Training Authority (CHIETA) is establishing a GH₂ Skills Centre to train workers across the hydrogen value chain.

The private sector also plays a vital role in vocational training. Eskom, the national power utility, is partnering with SARETEC to transform its Komati power station into a RE training centre to retrain existing staff and train new technicians. These examples show how South Africa is actively adapting its vocational training system to meet the emerging needs of a green economy, combining curricula reform, skills development and public-private collaboration.

Germany as Benchmark

Regulations

Key regulatory frameworks in the field of Electrical Engineering in Germany are established by the VDE (Association for Electrical, Electronic & Information Technologies). For example, the DIN VDE 0100 standard applies to the low-voltage sector. Furthermore, accident prevention regulations issued by the DGUV (German Social Accident Insurance) also play a central role.

Vocational Education and Training

Electrical Engineering encompasses a vast field with various specialisations, making it nearly impossible for a single individual or training program to cover all aspects. In Germany, an initial distinction is made between industry and trade, with the industry sector being particularly relevant for this analysis.

In the industrial sector, different Electrical Engineering training professions are identified. The training for an “Industry Electrician” (Industrieelektriker) is a two-year dual apprenticeship, offering specialisations in either operating technology (Betriebstechnik) or devices and systems (Geräte und Systeme). Beyond this, there are various three- to three-and-a-half-year dual apprenticeships for “Electronics Technicians” (Elektroniker) specialising in different fields. For instance, “Electronics Technician for Automation Technology” focuses on control and regulation technology, programming of control systems, and drive technology. While the “Electronics Technician for Devices and Systems” primarily deal with the assembly and repair of electronic devices. Thus, specialisation is determined at the stage of choosing the training profession.

After completing training as an Industry Electrician specialising in operating technology, there is the possibility of continuing education to become an “Electronics Technician for Industrial Engineering” (Elektroniker für Betriebstechnik).

For international benchmarking, the analysis primarily considers the Industry Electrician specialising in operating technology and, by extension, the Electronics Technician for Industrial Engineering. This profession has by far the highest number of trainees and is widely represented across various industries.

Qualification Levels

In Germany, qualification levels in Electrical Engineering are standardised (DIN VDE 1000-10). An “Electrically Instructed Person” (EuP) is allowed to perform simple electrical tasks under supervision. The “Electrically Skilled Person for Specific Tasks” (EfKfT) can independently carry out defined, recurring tasks after specific training. A “Qualified Electrician” (EFK) has completed formal training in Electrical Engineering and is authorised to work independently on electrical installations.

The “Responsible Electrical Specialist” (VEFK) requires several years of experience as a Qualified Electrician and is responsible for ensuring compliance with safety regulations and the technical organisation within a company.

While completing an Electrical Engineering apprenticeship meets a key criterion for becoming a Qualified Electrician, practical experience in the relevant field and continuous professional development in current norms, regulations, and technological advancements are also required. The decision on whether an individual is sufficiently qualified to work independently as a Qualified Electrician is ultimately made by the respective supervisor.

National Certification and Regulatory Framework in Namibia

While international benchmarks such as Germany's VDE and DIN-VDE certification systems establish structured qualification pathways for electricians, Namibia has its own evolving certification framework, primarily regulated through the Ministry of Justice and Labour Relations (MoJLR) under the Labour Act and the Electricity Control Board (ECB). Although these frameworks are not widely adopted by industry and required for industrial partners, they are mostly applicable to installations that interface with distributors, mostly at the LV level.

The Ministry, through the Chief Inspector, plays a central role in:

- ▶ Registering electricians under categories such as Electrical Tester for Single Phase, Installation Electrician, and Master Installation Electrician;

- ▶ Issuing Certificates of Compliance (CoCs) for electrical installations;
- ▶ Authorising inspection authorities (in partnership with SANAS or equivalent) responsible for enforcing technical standards;
- ▶ Maintaining a national database of certified practitioners and compliance documents;
- ▶ Enforcing adherence to safety regulations through inspections and, where necessary, disconnections or sanctions for non-compliance;
- ▶ Mandating that CoCs and test reports are aligned with approved regulatory forms and safety standards.
This certification structure forms the legal basis for electrical work in Namibia and ensures alignment with safety requirements such as those set out in the Namibia Electricity Safety Code (NESC).

However, unlike Germany's multi-tiered and industry-integrated vocational framework:

- ▶ Namibia's system is less modular, with limited formal pathways for continuous professional development;
- ▶ There is no structured upskilling route from NQF-registered qualifications to Ministry certification, causing gaps in recognition and employability;
- ▶ Soft skills, interdisciplinary system thinking, and emerging topics like hydrogen and automation are not yet embedded into formal certification.

There is a need for strengthening Namibia's national certification systems in line with international best practice in order to:

- ▶ Bridge gaps between NQF qualifications and Ministry registration requirements, creating a more seamless skills-to-certification articulation.
- ▶ Develop modular, industry-recognised short courses (e.g., in MV switching, ATEX compliance, hydrogen safety) that MoJLR recognises for upskilling and re-certification;
- ▶ Formalise Trainer of Trainer (ToT) programs to upskill trainers, inspectors and educators in emerging technologies.

Integrating the Ministry's certification regime into the benchmarking narrative ensures that recommendations reflect international best practices and the national legal context, enhancing policy coherence and implementation feasibility.

A related issue raised by practitioners is the absence of local pathways for electricians to gain legal authority to sign off on electrical installations. As a result, many Namibian electricians with NQF Level 3 qualifications pursue the South African Red Seal certification, which confers skills recognition and the legal right to certify electrical work, especially in line with standards such as SANS 10142.

This reliance on foreign certification underscores a policy and regulatory gap within Namibia's own system. While the MoJLR regulates and certifies electricians, the current framework lacks a clear and accessible route from NQF-registered/accredited training to full installation signing authority. Addressing this gap would enhance workforce mobility and recognition and ensure that national qualifications lead to practical, professional rights in the domestic market.

Further Education and Training in Germany

After completing vocational training, further education and training opportunities include advancement to specialist positions, technical qualifications, or industrial foreman (Industriemeister) certification, as well as university studies in Electrical or Energy Engineering.

Beyond formal training, additional certifications are required for specific tasks. These include qualifications for installing and operating electrical systems in explosive environments (IECEX-, ATEX compliance), as well as for fire alarm or lightning protection systems. Specialised training is also available for working on live electrical systems (AUS) and obtaining switching authorisation for 1-36 kV networks. These certifications are provided by institutions such as the BFE (Bildungszentrum für Elektrotechnik) und der TÜV/TCEE (Technischer Überwachungsverein).

Renewable Energy and Green Hydrogen in Germany

Specialised RE and GH₂ skills are not part of the core training curriculum for Electronics Technicians for Industrial Engineering. However, depending on the training provider, training content could be adapted to these areas. Trainees in companies with a strong focus on RE or GH₂ technology are more exposed to these topics than those in other sectors.

For instance, a local energy provider involved in photovoltaic system installation and hydrogen-related projects incorporates these topics into their training programs through dedicated training modules, simulation kits, and expert-led workshops. The primary goal is to raise awareness, provide fundamental knowledge, and sensitise trainees to these emerging fields rather than deliver specific qualifications. In the RE sector, further training opportunities include, for example, courses on photovoltaic system inspections.

Hydrogen-related programs are offered by various training providers. The IHK (Chamber of Industry and Commerce) provides a certification program for "Hydrogen Application Specialists," covering topics from basic principles to applied knowledge along the entire value chain. Other organisations, such as the Fraunhofer Society and the DVGW (German Technical and Scientific Association for Gas and Water), also provide a range of courses, from basic knowledge to specialised training along the value chain. However, these programs are not specifically tailored to electrical engineering professionals.

Comparison of German Standards with Namibian Unit Standards

The following table lists the contents of the German Industrial Electronics Technician training programme for which there is no direct equivalent in the Namibian Unit Standards.

Contents of the German Industrial Electronics Technician training that are not represented by any Namibian Unit Standard of the Electrical Engineering Programme (Level 2-5)	Remarks
Detailed aspects of the digitalisation of work, data protection and information security (data maintenance, data protection regulations, use of IT systems for order processing, research in digital networks, digital learning media, information technology protection goals, company guidelines for IT use).	The Namibian standards mention "fundamental computer literacy skills", but do not match the level of detail.
Detailed aspects of operational and technical communication (conduct situation-appropriate conversations and record results, present and demonstrate facts, also evaluate and apply technical English terms and documents in detail).	The Namibian Unit Standard is less detailed within "Communication in an electrical work environment".
Planning and organising work and evaluating work results (record and analyse work orders, obtain and assess information, plan work steps in detail, provide material, plan deadlines in detail, comprehensively set up the workplace considering safety and ergonomic aspects, check technical feasibility, record and evaluate business data, identify and apply quality improvement, identify qualification deficits and use qualification opportunities).	The Namibian standards do not reflect the depth reflected in these aspects.
Development of personal and social competence (living and shaping social relationships, social responsibility and solidarity, ability to criticise, self-confidence, reliability, sense of responsibility and duty, development of values)	The overarching goals of German training are not explicitly formulated in the Namibian standards.
Methodological and learning competence.	The overarching goals of German training are not explicitly formulated in the Namibian standards.

The comparison highlights the digital competencies as being more emphasised within the German training system than in the Namibian unit standards. While fundamental computer literacy skills are mentioned in the Namibian standards, they are not described in detail. A strong foundational understanding of digitalised work processes, information systems, and programmable logic controllers (PLCs) is essential for working in the RE and hydrogen sectors.

For example, in the operational phase of RE plants, collecting, analysing, and documenting data using information systems is crucial. Modern facilities are highly interconnected, digitalised, and automated.

Consequently, diagnostic and maintenance tasks require proficiency in software tools and a basic understanding of IT processes.

Since a few employees are responsible for running plants during the operational phase, they must work independently and ensure the quality of their work. The competences required for this are not reflected in the current Namibian unit standards.



1.4 Skills Gap Analysis in the Field of Electrical Engineering

Analysis Method

To analyse the needs and gaps, semi-structured interviews were conducted with industry stakeholders (Cleanergy Solutions Namibia, InnoSun/InnoVent, Hyphen, HOPSOL, HDF-Energy) as well as training providers and institutions (NIMT, Triumphant College, WVTC, NUST, MAPAC). The interviews covered the following topics:

Industry Stakeholders

- ▶ Core work processes and areas in Electrical Engineering related to RE and GH₂
- ▶ Required skills, competencies, and technical knowledge for these processes and areas
- ▶ Expected skills, competencies, and technical knowledge to be covered in training programs
- ▶ Current recruitment practices and requirements
- ▶ National and international regulations and necessary certifications for these work processes and areas
- ▶ Training institutions currently utilised

Training Providers

- ▶ Training programs and core topics in Electrical Engineering related to RE and GH₂
- ▶ Industrial influences on the training curriculum
- ▶ Career paths and employment status of graduates
- ▶ Institutional resources for integrating these new topics in terms of equipment and personnel
- ▶ National and international regulations and standards covered in training programs

Summary and Results

Industrial Statements, Experience, and Requirements

Regarding core work processes and areas in Electrical Engineering related to RE and GH₂, essential tasks can be identified during construction and operational phases. The required skills and workforce demand vary between these phases.

During the construction phase, there is a high demand for labour for installation work. In contrast, interviewees consistently estimated a need for 4–5 employees per facility during the operational phase. These operational facilities are often highly automated, requiring specialised personnel for monitoring, data processing, optimisation, maintenance, diagnostics, troubleshooting, component replacement, and repairs. In the field of GH₂, additional expertise is needed, such as awareness of high-pressure pipelines, explosion protection measures, and a strong safety mindset.

There is a broad consensus regarding the required skills, competencies, and technical knowledge for these work processes. While fundamental electrical engineering knowledge is essential, it alone is considered insufficient. A broader technical understanding, including mechanical principles and ICT, is also required. Employees in operational roles must be multi-skilled technicians with interdisciplinary system-thinking capabilities. Proficiency in computer use is regarded as indispensable.

This includes basic operation of office software for reporting and spreadsheet-based calculations. However, a more advanced understanding of networking (IP, WiFi) and command-line navigation is also expected. While fundamental computer literacy is included in unit standards and training programs, industry representatives repeatedly noted that these skills are not sufficiently developed in practice.

A basic understanding of RE (solar, wind, battery storage) and GH₂ (e.g., handling procedures) is advantageous. Additionally, safety awareness (especially electrical safety), teamwork, communication skills, adherence to checklists, and reporting are emphasised. Competence in fault analysis, conducting measurements, handling measurement instruments, and, most importantly, interpreting measurement results is particularly highlighted. Building on this, knowledge in data analysis is also considered relevant. Due to the high level of automation, skills in PLCs (programming, diagnostics) are considered beneficial.

The expected skills, competencies, and technical knowledge to be covered in training programs largely align with industry needs. The importance of establishing a solid technical foundation in training programs is emphasised to ensure that trainees acquire fundamental knowledge before expanding into industry-specific technologies.

There is a demand for training in PLC programming, power electronics (inverters), medium- and high-voltage technology, and battery technology. Hands-on experience through practical exercises with real systems and industry attachments is essential. Awareness training on hydrogen safety should also be part of the curriculum.

Regarding recruitment practices, the industry primarily hires graduates with NQF Level 3 qualifications, preferably with work experience. The NIMT is cited as a key source of skilled labour. During the construction phase, unskilled workers are also locally recruited. The industry values practical experience and the ability to adapt to new technologies, noting that formal qualifications do not always reflect actual competencies.

Various national and international regulations and necessary certifications were mentioned, including ATEX certifications for explosive environments, IEC standards, and South African National Standards (SANS). A distinction is made between applying European/IEC standards within facilities and SANS outside of them. For specific sectors, such as wind energy, additional certifications (e.g., GWO) are considered relevant.

However, several industry stakeholders emphasised that broad technical understanding and the willingness to acquire new knowledge are more important than formal certifications. In contrast, it is also mentioned that a higher degree of comparability can be created through certificates. The industry sees itself as partly responsible for providing necessary training and certifications in highly specialised and sometimes product-specific work areas.

Training measures currently utilised include in-company training, and training programs offered at NIMT and the NUST Safety Institute. External training from OEMs or national distributors is also used for product-specific knowledge. Additionally, collaborations exist with international institutions such as the University of Bremen and Fraunhofer for training development.

Training Programs and Institutional Challenges

Core topics in Electrical Engineering training programs include installation, motor controls, troubleshooting, and protection technology. Some training providers are planning or are already offering specialisations in RE (solar installation, electrical energy focusing on renewables and high voltage) and automation/PLC. However, integrating RE and GH₂ into existing curricula presents challenges regarding content and resources. Graduate employment trends indicate that Electrical Engineering graduates often find jobs in household installations or distribution companies. Solar Installation graduates frequently struggle to find employment in their field, as well-trained electricians are often preferred. There is concern that the number of graduates could exceed demand in the RE sector for operational roles.

Institutional resources for integrating new topics, both in terms of equipment and personnel, are considered insufficient, especially in specialised areas such as wind turbines, PLCs, inverters, and battery technology. Financial constraints hinder the acquisition of new equipment. Additionally, training staff often lack expertise in emerging technologies, and systematic professional development programs for trainers are largely absent.

National and international regulations and standards covered in training programs include a mix of South African, U.S., and international standards (SANS). State institutions are required to align curricula with the guidelines set by the Namibia Training Authority (NTA) and the Namibia Qualifications Authority (NQA).

Identified Gaps in Hard Skills

Based on the interviews, status quo analysis, and international benchmarking, the following gaps in hard skills have been identified in addition to the need for stronger industry integration, enhanced practical experience, and soft skills such as housekeeping and ESG:

- ▶ **Computer Skills / Computer Literacy:** Basic understanding, command-line usage
- ▶ **Office Software** for reporting or calculations in a Spreadsheet
- ▶ **Networking:** Setting up network communications, IP addressing, WIFI, Internet, Modbus
- ▶ **Mid- and High-Voltage Switching:** Namibian Electricity Safety Code
- ▶ **Power Electronics:** Basic understanding, inverters, motor controllers
- ▶ **Diagnosis and Fault Finding:** Selecting, carrying out and interpreting measurements; recording and analysing data; recognising, eliminating, and documenting root causes of faults;
- ▶ **Mechanical Principles and Interdisciplinary System Thinking:** Knowledge of mechanical principles, even for electricians
- ▶ **PLC Programming and Monitoring (IEC 61131):** Including diagnosis and fault finding
- ▶ **GH₂:** Basic understanding, supply chain, safety and hazards

- ▶ **GH₂:** Special considerations for electrical work
- ▶ **Batteries and Storage:** Basic understanding, battery types, handling
- ▶ **Working at Heights**

Conclusion

There is agreement between industry and training providers regarding the fundamental skills required. However, the parties recognise gaps in current training programs concerning specific technologies, practical experience, and institutional resources. Collaboration between industry and training providers is crucial in order to better align training with industry needs and improve graduate employability. The necessity for practical training, industry attachments, and further education and training opportunities is emphasised by all stakeholders.

Additionally, numerous studies on skills gap analyses, often funded by different organisations, have been conducted. However, there is a lack of implementation. Stakeholders from industry and training institutions feel overwhelmed by studies and surveys while seeing little concrete follow-up actions.



2

RECOMMENDATIONS FOR NECESSARY TRAINING MEASURES IN ELECTRICAL ENGINEERING

This section describes the recommended short courses on the listed topics needed to close the identified gaps:

1. Computer and Data Literacy
2. Medium and High Voltage Switching
3. Hydrogen Systems and Safety
4. Photovoltaic
5. Power electronics, Inverters, Batteries and Storage
6. Programmable Logic Controller (PLC) – Handling, Diagnosis and Programming
7. Mechatronic / Interdisciplinary System Thinking

2.1 Computer and Data Literacy Short Courses

A short course or a series of short courses on Computer and Data Literacy is recommended to address identified gaps in general computer usage, software tools, and digital work environments.

These skills are essential in Electrical Engineering and RE sectors, as installed components and systems are networked and require configuration and diagnostics through computers and specialised software. Furthermore, particularly in operational settings, employees must be able to collect, analyse, and report data, as well as communicate effectively with higher-level support teams. The short course series should be highly practical and include the following topics.

- ▶ Basic Computer Skills (Windows/Linux command line, file management)
- ▶ Office Software (e.g. Word, Excel)
- ▶ Networking (Topologies, IP addressing, Wi-Fi, Modbus)
- ▶ Data Monitoring, Logging, and Analysis (e.g., data tracing from PLCs, visualisation in Excel, fault finding)
- ▶ Visual Basic Programming, Excel/Macros, etc

Existing Training Measures Related to the Short Course

There are already various general training programs available for computer basics, office software, and networking. However, there is a lack of specialised courses that are practically tailored to the needs of the Electrical Engineering and RE sectors. This short course series aims to fill this gap by providing practical content for direct application in the workplace.

Brief Outline of Skills/Competencies Required

The training series could consist of three consecutive short courses:

Basic Computer Skills and Office Software

Content: Basic computer usage (Windows/Linux, file management), office software (Word, Excel), fundamental command line operations

Duration: approx. 2-3 days

Target group: Technical trainees, professionals in Electrical Engineering/ Renewable Energy, Trainers

Networking

Content: Network fundamentals (topologies, IP addressing, Wi-Fi, Modbus), network setup and troubleshooting

Duration: approx. 3-4 days

Target group: Qualified Electricians, TVET NQF Level 3–4 graduates, Industrial Electrical Technicians, Mechatronics Technicians, Instrumentation Technicians, Automation Technicians, Senior Technicians and personnel involved in the operation and maintenance of medium- and high-voltage (MV/HV) systems, Senior Technicians and personnel involved in the operation and maintenance of hydrogen facilities, TVET Trainers in Electrical Engineering and RE fields

Data Monitoring, Logging and Analysis

Content: Data acquisition, visualisation and analysis (e.g. SCADA, data logging from PLCs, Excel VBA Programming), visualisation in Excel, fault detection, and diagnosis

Duration: approx. 3-4 days

Target group: Technical professionals in maintenance, commissioning, and process monitoring, Trainers

Certification Outlook: Participants should receive a certificate of attendance upon completing each short course. After the third course, a final examination can lead to an advanced certificate verifying the training series.

Participants should have basic technical understanding, but no extensive prior knowledge is required. However, courses should be taken in sequence, as each build upon the skills acquired in the previous course. This training program is designed for graduates and trainees in technical fields with an Electrical Engineering background (e.g., General Electrical Engineering, Millwrights, Solar Installation, Instrumentation) to prepare them for operational roles in maintenance and plant commissioning.

Needs Related to the Short Courses

To implement the training, the following minimum requirements for equipment and personnel should be met.

Equipment

- ▶ Computers (Windows/Linux) with relevant software tools
- ▶ Networking equipment (router, switch, hub, cables)
- ▶ Network-enabled “smart devices” (e.g., smart sensors, solar inverters) to be integrated within networking topics and serve as data sources for monitoring and analysis
- ▶ Optional: Analysis devices, external data loggers/tracers

Personnel

- ▶ Qualified trainers with expertise in networking, data analysis, and digital process control
- ▶ Practical experience in applying software tools for analysis and diagnostics in Electrical Engineering and RE fields

Qualified training personnel are required to conduct these short courses. The equipment setup can be kept modular and compact, enabling a mobile training approach.

Recommendations for Potential Partnerships

It is recommended to partner with the UNAM and NUST Computer Science departments for curriculum input, access to facilities, and qualified trainers. In addition, Namibia has a wide range of private Computer and IT training providers that can support delivery, especially in basic and intermediate-level modules, where there are no computer lab facilities in TVET Centres.

The training program should also leverage MOOCs (Massive Open Online Courses) and open-source resources to enrich content, improve accessibility, and keep up with advances in the field. Additionally, a partnership with ITB could be considered beneficial, as ITB already has experience in the international development of training programs in the ICT sector (see, for example, the DEVISE4KE project).



2.2 Medium and High Voltage Switching Short Course

A short course on Medium and High Voltage (MV/HV) Switching is recommended to address critical skills gaps in the safe operation, control, and isolation of MV/HV systems. This is essential for electricians responsible for operating or maintaining distribution and transmission infrastructure. According to the Namibia Electricity Safety Code (NESC), only competent and authorised persons may conduct switching and isolation procedures on energised systems. The course will ensure compliance with safety requirements, minimise operational risks, and promote safe working practices.

Existing Training Measures Related to the Short Course

MV/HV switching is often handled through internal utility training, for example, by NamPower training centre, OEM-specific training or some South African training providers. However, there is a need for a nationally recognised, standardised short course that aligns with NESC and industry best practices for Namibia. This proposed course aims to fill that gap by formalising knowledge and practical skills in MV/HV switching and safety protocols, ensuring that the license conditions of the electricity infrastructure holders with the ECB can be adhered to.

Brief Outline of Skills/Competencies required

Medium and High Voltage Switching and Safety Procedures

Content:

- ▶ Electrical system basics (MV/HV networks and equipment)
- ▶ Safety procedures per NESC (e.g., isolation, earthing, lock-out tag-out, test-before-touch)
- ▶ Switching operations and permit-to-work systems
- ▶ Fault response and coordination with control centres
- ▶ Practical switching exercises (simulated or in supervised environments)

Duration: approx. 4–5 days

Target Group: Qualified Electricians, Senior Technicians and personnel involved in the operation and maintenance of medium- and high-voltage (MV/HV) systems, TVET Trainers in Electrical Engineering and RE fields

Certification Outlook: Participants receive a certificate of competence upon passing a practical and written assessment. Recognition by a regulatory or professional body (e.g., ECB or ECN and the MoJLR) is encouraged.

Needs related to the Short Course

To implement the course, the following prerequisites are needed:

Equipment

- ▶ Decommissioned MV/HV panels or training substation setups, or simulators
- ▶ Safety gear (arc flash PPE, voltage detectors, grounding sets)
- ▶ Lock-out tag-out kits and switching logs

Personnel

- ▶ Certified switching instructors with field experience, who are familiar with NESC and utility operational procedures from REDs, NamPower or Large Power Users

The course can be run on-site or at selected training facilities from the REDs and NamPower, or with appropriate simulation equipment and supervision.

The course can be run on-site or at selected training facilities from the REDs and NamPower, or with appropriate simulation equipment and supervision.

Recommendations for Potential Partnerships

It is recommended to collaborate with the MoJLR, ECB, NamPower, ErongoRED, Cenored, Nored and some large power users like the mines, UNAM and NUST for course development and training delivery. This also ensures alignment with national utility practices and safety code requirements. Private training centres with electrical simulation labs can also support the training.



2.3 Hydrogen Systems and Safety Short Course

This short course is designed for electricians and technicians working in or preparing for roles within GH₂ production facilities. It addresses the unique safety and technical requirements when handling electrical installations in hydrogen environments.

Given the high flammability of hydrogen gas and its low ignition energy, proper training is critical to ensure safe installation, maintenance, and operation of electrical systems in such settings. The course supports Namibia's emerging hydrogen sector, including projects like Hyphen and Cleanergy Solutions Namibia.

Existing Training Measures Related to the Short Course

No formal hydrogen safety or installation training exists locally for electricians. However, this course can be anchored through the Cleanergy Solutions Namibia's H₂ Academy and supported by existing training providers such as NIMT.

International examples, such as IHK's "Hydrogen Application Specialist," Fraunhofer training modules, and ATEX compliance standards, can inform course design and localisation for Namibia.

Brief Outline of Skills/Competencies Required

Hydrogen Systems and Electrical Safety for Electricians and Technicians:

Content

- Introduction to GH₂ systems: production, storage, and safety risks

- Properties and hazards of hydrogen: invisible flames, no odour, low ignition energy
- Safe electrical installation principles for hydrogen environments:
 - Electrical cables must be routed below hydrogen equipment to reduce risk during leak events (since H₂ rises)
 - Use of intrinsically safe (non-sparking) tools
 - ATEX-rated electrical equipment and enclosures
- Personal Protective Equipment (PPE) requirements:
 - Flame-resistant clothing, anti-static gloves, hydrogen-rated gas detectors, and eye/face protection
 - Lockout/tagout, earthing, and bonding practices in hydrogen zones
- Emergency response protocols: leak detection, evacuation, and fire control
- Practical demonstration: using safe simulation tools or demo rigs

Duration: 4–5 days

Target Group: Qualified Electricians, TVET Level 3–4 graduates, Industrial

Electrical Technicians, Senior Technicians and personnel involved in the operation and maintenance of hydrogen facilities, TVET Trainers in Electrical Engineering and RE fields

Certification Outlook: Certificate of Competence in Hydrogen Electrical Safety (Technician-Level), with potential endorsement by Cleanergy Solutions Namibia, NTA, or ECN

Needs Related to the Short Course

Equipment

- ▶ Hydrogen-safe personal protective equipment (PPE) (anti-static, flame-retardant gear)
- ▶ Hydrogen leak detectors and alarm systems
- ▶ Demo electrolyser systems (low-pressure for training)
- ▶ ATEX-compliant switches, enclosures, glands, and tools
- ▶ Training boards for safe cable routing demonstrations (below vs. above hazard points)

Personnel

- ▶ Trainers qualified in hydrogen facility operations and electrical installation in explosive atmospheres
- ▶ Possible secondment from Cleanergy Solutions Namibia or international partners for trainer capacity building

Delivery Mode

Mobile or facility-based delivery at H₂ Academy (Walvis Bay), NIMT, or selected training centres, consider setting up regional training laboratories

Recommendations for Potential Partnerships

Recommended partners for developing and delivering the Hydrogen Systems and Safety course include the Cleanergy Solutions Namibia's H₂ Academy, which can serve as the core delivery partner given its access to hydrogen technologies and safety expertise. Hyphen Hydrogen Energy is also identified as a key industrial partner to ensure alignment with current project requirements and to potentially offer industrial attachment opportunities for trainees.

The NIMT and other VTCs can be crucial in recruiting suitable candidates and integrating the course into their programme offerings. To ensure formal recognition and quality assurance, collaboration with the NTA is necessary. Additionally, the Engineering Departments of UNAM and NUST can support content development and provide training-of-trainer programs. Finally, partnerships with original equipment manufacturers (OEMs) and electrical safety suppliers will be important for the provision of ATEX-compliant tools, components, and demonstration gear.



2.4 Photovoltaics Short Course

Photovoltaic (PV) systems, both grid-connected and off-grid, are playing an increasingly important role in decentralised energy supply and electrification. The objective of this short course is to provide a foundational understanding of PV systems, including their basic operation, required components, installation and wiring procedures, as well as measurement and diagnostic techniques. The course is designed to enable trainers and, ultimately, trainees to acquire practical competencies that are directly applicable in the field.

Existing Training Measures Related to the Short Course

Comprehensive training programs for Solar Installation and Maintenance already exist; however, they are typically developed and delivered separately from the formal training pathways of Electrical Engineering. As a result, photovoltaic-specific knowledge and competencies are often not integrated into the core curriculum for electricians.

This short course is intended to bridge that gap by embedding essential PV-related content into the vocational education framework of Electrical Engineering. It aims to enhance the relevance and applicability of existing electrician training by aligning it more closely with current technological developments in the RE sector.

Comparable approaches can be observed in South Africa, where 5-day practical training courses are offered as part of the PV GreenCard. These courses are recognised as an industry standard for qualifying PV installers.

Brief Outline of Skills/Competencies Required

The course should be structured as a practical, hands-on training with supplementary theoretical sessions, focusing on the following key topics:

Photovoltaic Fundamentals

Contents: Basic principles of photovoltaic energy, power output and efficiency.

PV System Components

Contents: Overview of core components (modules, inverters, charge controllers, batteries, mounting systems), functional roles within the system, typical configurations (on-grid and off-grid).

Installation and Wiring

Contents: Safe handling and mounting of PV modules, cabling and protection components, electrical safety standards and national regulations, best practices for installation.

Measurements, Fault Detection and Diagnostics

Duration: 5 days

Target Group: Qualified Electricians, TVET Level 3–4 graduates, Industrial Electrical Technicians, Mechatronics Technicians, Instrumentation Technicians, Automation Technicians, TVET Trainers in Electrical Engineering and RE fields

Certification Outlook: Certificate of participation, including a detailed overview of the acquired competencies and training content

Needs Related to the Short Course

To implement the course, the following infrastructure and personnel are required:

Equipment

- ▶ PV training modules or real-life installation mock-ups (roof and ground-mounted)
- ▶ Inverters (hybrid, grid-tied, off-grid) from various OEMs
- ▶ Battery systems for energy storage (lithium-based) including controllers
- ▶ System monitoring devices
- ▶ Measurement equipment
- ▶ PCs with relevant software for system monitoring and configuration

Training sites such as the VTCs in Windhoek and Eenhana are potential hosts, already possessing relevant technical infrastructure and expertise in the PV domain.

Personnel

Trainers with didactic competence and practical experience in installing, measuring, configuring, and troubleshooting PV systems. Local capacity for ongoing support and adaptation of training content to new technologies and standards.

Recommendations for potential partnerships

The Windhoek and Eenhana VTCs already have practical experience and basic equipment that could serve as regional hubs for training and further course development. Partnerships with OEMs and national distributors (e.g., Victron, SMA, Sungrow) as well as with the leading national PV companies like Innosun and HOPSOL could enable access to demonstration equipment, updated training materials, technical support, and direct feedback. Based on experience from similar PV-related courses, a partnership with DeNa Education can also be useful. This approach ensures that the course is not only relevant and up to date but also aligned with the relevant contextual needs of vocational education and training in the region

2.5 Power Electronics, Inverters, Batteries and Storage Short Course

Power electronics, including inverters, batteries, and storage systems, are essential components of RE systems. The objective of this recommended short course is to provide a foundational understanding of these topics, serving as a solid basis for further specialised or product-specific training. The course can also be seen as an advanced course for the foundational course on photovoltaics.

Existing Training Measures Related to the Short Course

Training programs in this field are primarily product-specific and are offered by OEMs or national distributors of these systems (e.g., SMA, Victron, Sungrow). However, there is currently no training available providing a broader, technology-independent understanding based on the latest advancements in the field.

Brief Outline of Skills/Competencies Required

The course should be offered as a hands-on course focusing on practical skills development regarding the following topics.

Electronics

Contents: Basic circuits, components, performing and interpreting measurements

Inverters (e.g. for PV or for motor controls)

Contents: Functionality and general structure, monitoring, parametrisation, and diagnostics measurements

Batteries and Storage

Contents: Functionality and general structure, battery types and their characteristics, system integration, monitoring, parametrisation, and diagnostics

Duration: 5-10 days

Target Group: Qualified Electricians, TVET NQF Level 3-4 graduates, Industrial Electrical Technicians, Mechatronics Technicians, Instrumentation Technicians, Automation Technicians, TVET Trainers in Electrical Engineering and RE fields

Certification Outlook: A certificate of participation listing the covered topics can be issued.

Needs Related to the Short Course

To implement the course, the following equipment and personnel requirements must be met:

Equipment

- ▶ Components for assembling power semiconductor circuits (electronic components, breadboards)
- ▶ Measurement instruments (multimeters, oscilloscopes)
- ▶ Inverters from various OEMs

- ▶ State-of-the-art storage systems (LFP / LiFePo4 batteries, high-voltage batteries)
- ▶ PCs with the necessary software tools

While some training facilities have relevant systems available, they are currently used for power supply rather than training.

Personnel

- ▶ Qualified trainers with experience in power electronics, inverters, storage systems
- ▶ Practical expertise in the integration, measurement, monitoring, parametrisation, and diagnostics of various inverter and storage systems

Recommendations for potential partnerships

In some cases, expensive equipment is needed to run this course. A partnership with the manufacturers/OEMs or their national distributors could be helpful, as some of them already offer courses, even if they tend to specialise in their products. A partnership with the EVTC could also be useful, as this training provider already has experience and equipment in the photovoltaic sector.

2.6 Programmable Logic Controller (PLC): Handling, Diagnosis and Programming Short Course

The recommended course is a hands-on course focused on the handling, diagnostics, and programming of Programmable Logic Controllers (PLCs). Due to the high level of automation in modern industrial plants, a need for training in this area has been identified.

The goal of this training is to equip professionals with the necessary skills to effectively operate and troubleshoot PLC systems. The course is designed as a practical, hands-on program covering the following topics:

Basic Understanding: Purpose, wiring, I/O principle (Input-Processing-Output)

System Structure: Assembly of components, communication via bus systems

Programming: IEC-compliant programming

Diagnostics: Signal recording, output control, fault finding

Existing Training Measures Related to the Short Course

NIMT's training program already includes PLC modules, and appropriate equipment is available. Other institutions may not yet have the appropriate equipment and qualified trainers.

Brief Outline of Skills/Competencies Required

Participants should have basic Electrical Engineering knowledge, particularly in circuit technology, contactor circuits, and logical operations. Additionally, proficiency in using computers is essential for this course. The course should be offered as a hands-on course focusing on practical skills development regarding the following topics.

Fundamentals of PLC Technology

Content: Introduction to PLCs, I/O principle, wiring of components
System Structure and Bus Systems

Content: Structure and composition of PLC systems, communication via fieldbuses

Programming and Diagnostics

Content: IEC-compliant programming (IEC 61131-3), signal recording, fault analysis

Duration: approx. 9-10 days

Target group: Qualified Electricians, TVET NQF Level 3-4 graduates, Industrial Electrical Technicians, Mechatronics Technicians, Instrumentation Technicians, Automation Technicians, TVET Trainers in

Electrical Engineering and RE fields

Certification Outlook: A final examination can lead to an advanced certification verifying the full training in programming according to IEC 61131-3.

Needs Related to the Short Course

To implement the training, the following minimum requirements for equipment and personnel must be met:

Equipment

- ▶ Computers with relevant software tools
- ▶ PLCs, modules, bus cables
- ▶ Actuators and sensors for implementing example applications

Personnel

- ▶ Qualified trainers with experience in PLC programming, system integration, and fault diagnosis
- ▶ Practical expertise in applying control and automation technology

Similar to the other courses, modular and compact equipment setups should be considered to facilitate mobile training delivery.

Recommendations for potential partnerships

A potential partner for the development of a short course on PLC technology, especially in terms of a train-the-trainer programme, could be DeNa Education. DeNa Education has extensive experience in international training programmes and offers a network of experts in mechatronics and controls, which is valuable for developing the outlined course contents.



2.7 Mechatronic / Interdisciplinary System Thinking Short Course

Another recommended training measure addresses the need for mechatronic skills and interdisciplinary system thinking. Mechatronic systems are widely used in RE applications, such as solar panel tracking systems and wind turbines. A cross-disciplinary approach is required for installation, diagnostics, maintenance, and servicing of such systems.

Existing Training Measures Related to the Short Course

This course can reference the introduction of the Mechatronics occupations. Additionally, unit standards from other disciplines (e.g., mechanical engineering courses for electricians) could be opened as short courses for other trades.

A possible new short course could focus on the structure and practical diagnostics, including fault finding, of solar tracking systems, for instance, as they represent a typical example of mechatronic systems in the industry.

Brief Outline of Skills/Competencies Required

This training programme is aimed at qualified electricians in order to broaden their skills and meet the industry's demand for all-round technicians. The aim of the programme is to create an interdisciplinary awareness and mindset to break down traditional disciplinary boundaries. This could be demonstrated using practical short courses that include the following topics, among others

Mechanical Principles for Electricians

Content: Basic understanding of: Statics, kinematics, dynamics, strength, material science, forces, force transmission, levers (e.g. using the example of a solar tracker)

System Structures

Content: Mechatronic systems, sensors, actuators, drives, control technology (e.g. using the example of a solar tracker)

Diagnostics

Content: Fault finding and diagnosis in mechatronic systems (e.g. using the example of a solar tracker)

Mechanical material processing for electricians

Content: Basic skills for carrying out small mechanical repairs (e.g. drilling, cutting, joining, welding)

Duration: approx. 5-10 days

Target group: Qualified Electricians, NQF TVET Level 3–4 graduates, Industrial Electrical Technicians, Mechatronics Technicians, Instrumentation Technicians, Automation Technicians, TVET Trainers in Electrical Engineering and RE fields

Certification Outlook: A certificate of participation listing the covered topics can be issued.

Needs related to the Short Course

The necessary equipment, personnel and unit standards are largely in place to build on.

Recommendations for Potential Partnerships

The introduction of the profession of mechatronics technician has already been analysed elsewhere. It would potentially make sense to combine efforts in order to benefit from the developments.

The ITB of the University of Bremen as well as DeNa Education, amongst others, are involved in these developments, so it is recommended that these partners also be consulted for the development of such a training programme for qualified electricians. It is also recommended to join forces within the VTCs to establish mechanics courses for electricians, for example.



3

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The analysis highlights several key implications for the (TVET) system in the field of Electrical Engineering, particularly in response to the increasing demand for skills related to RE and GH₂ technologies.

A major finding is the urgent need to raise safety awareness among employees, especially regarding the risks associated with hydrogen. Due to the high level of automation in modern energy facilities, there is also a significant skills gap in computer and digital literacy when compared to international benchmarks. Addressing these gaps is essential to ensure that workers can operate, monitor, and maintain advanced systems effectively.

The analysis also reveals a substantial demand for skilled labourers during the construction phase of RE plants, whereas the need for workers in the operational phase is considerably lower. However, employees in operational roles require an interdisciplinary mindset and must be capable of handling various technical responsibilities. As a result, all-round technicians with a broad technical skill set are increasingly sought after. Additionally, there is a strong need for personal and social competencies, as well as a focus on ensuring the quality of one's own work. Employees must develop problem-solving skills, adaptability, and teamwork capabilities to contribute effectively to the evolving RE sector.

Despite ongoing studies and skills gap analyses, industry stakeholders do not recognise implementation efforts. A significant challenge is the lack of industry involvement in the training process.

Companies primarily focus on training and certifying workers for their specific products and fields, leaving the responsibility for broader fundamental knowledge to the TVET system. However, the current system struggles with outdated equipment and insufficient funding to keep up with technological advancements. Additionally, trainers often lack industry experience, and there are no structured development programs to familiarise them with emerging technologies.

Certificates play an important role in ensuring the comparability of skills, but they must accurately reflect actual competencies. While certification provides a benchmark, industry places greater value on practical work experience and a willingness to learn.

Addressing these challenges requires a collaborative approach involving industry stakeholders, training institutions, and policymakers to ensure that vocational education evolves in line with technological advancements and industry requirements.

Final Recommendations

Building on the findings of this analysis and the previously mentioned short course recommendations, the following measures are proposed to enhance vocational education and training in the RE and hydrogen sectors:

- ▶ Strengthen collaboration between TVET institutions and industry stakeholders to ensure training programs align with industry needs and technological advancements.
- ▶ Secure sufficient financial resources and provide modern training equipment to enable training institutions to keep up with the latest technological developments and industry standards.
- ▶ Establish local training hubs specialising in key topics or implement mobile training solutions to enhance accessibility and flexibility, particularly in emerging and rapidly evolving fields.
- ▶ Develop structured train-the-trainer programs to ensure trainers receive continuous professional development in emerging technologies, enabling them to effectively transfer relevant industry knowledge.
- ▶ Strengthen the legal and regulatory pathway for electricians by aligning NQF-registered qualifications with MoJLR certification requirements, enabling qualified electricians to gain authority to sign off on installations. This would reduce dependency on foreign certifications such as the South African Red Seal and enhance the professional standing of Namibian-trained electricians.
- ▶ Prioritise the modernisation of training equipment and alignment of practical assessments with current industry technologies, ensuring that trainees engage with tools and systems reflective of real-world applications in automation, data systems, and power electronics.

By implementing these measures, the TVET system can better prepare a skilled workforce capable of supporting the growing RE and hydrogen industries while ensuring long-term employability and industry competitiveness.

4

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