Development of regional quality infrastructure frameworks for solar photovoltaics products and services in the East African Community and the Pacific Community

Baseline Assessment on Existing Solar QI Frameworks and Management Systems in EAC and SPC

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April 2024

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List of Abbreviations

ACCSQ	ASEAN Consultative Committee for Standards and Quality
AESC	African Electrotechnical Standardisation Commission
BBN	Burundi Bureau of Standards and Quality Control
CENELEC	European Committee for Electrotechnical Standardisation
EAC	East African Community
EACREEE	East African Centre of Excellence for Renewable Energy and Efficiency
EASC	East African Standards Committee
ECOWAS	Economic Community of West African States
GN-SEC	Global Network of Sustainable Energy Centres
IEC	International Electrotechnical Commission
IRENA	International Renewable Energy Agency
ISA	International Solar Alliance
ISO	International Organisation for Standardisation
JASANZ	Joint Accreditation System of Australia and New Zealand

KEBs	Kenya Bureau of Standards
KEREA	Kenya Renewable Energy Association
LDCs	Least Developed Countries
MEPS	Minimum Energy Performance Standard
PCREEE	Pacific Centre for Renewable Energy and Energy Efficiency
PPA	Pacific Power Association
PRIF	Pacific Regional Infrastructure Facility
PV	Photovoltaic
QA	Quality Assurance
QI	Quality Infrastructure
QIER	Regional organization for quality infrastructure in the East African Community Region
QIPR	Regional organization for quality infrastructure in the Pacific Region
RSB	Rwanda Standards Board
RTC	Regional Technical Committees
SADC	Southern African Development Community
SC	Steering Committee
SEIAPI	Sustainable Energy Industry Association of Pacific Islands
SEIAPI	Sustainable Energy Industry Association of the Pacific Islands
SHC	Solar Heating and cooling
SIDs	Small Island Developing States
SNZ	Standards New Zealand
SPC	Pacific Community
SSNBS	South Sudan National Bureau of Standards
TBS	Tanzania Bureau of Standards
UNBS	Uganda National Bureau of Standards
UNIDO	United Nations Industrial Development Organisation
UNREEEA	Uganda National Renewable Energy and Energy Efficiency Alliance
USEA	Uganda Solar Energy Association
WELMEC	European Cooperation in Legal Metrology

Executive summary

The increasing demand for reliable and efficient solar photovoltaic (PV) systems has highlighted the importance of robust Quality Infrastructure (QI) frameworks across the globe as an essential prerequisite for economic development and competitiveness. QI frameworks play a pivotal role in ensuring the quality, safety, and sustainability of solar products and services. With the solar market facing significant challenges such as substandard products and unreliable imports, there is an urgent need to develop comprehensive QI frameworks that cater to the specific needs of growing markets such as Least Developed Countries (LDCs) and Small Island Developing States (SIDS).

Recognizing the critical role of QI in achieving sustainable development goals, it is imperative to conduct a Baseline Assessment of current QI frameworks in the East African Community (EAC) and the Pacific Community (SPC). An assessment that offers valuable insights into current regulations, standards, stakeholders, and capacities, paving the way for tailored QI frameworks and management systems. The findings of the baseline survey will guide the development of regional solar QI frameworks for the EAC and SPC, which will serve as crucial roadmaps to enhance QI capacities, foster collaboration, and promote international best practices in solar energy management.

The United Nations Industrial Development Organization (UNIDO) and the International Solar Alliance (ISA) have initiated a component called the "Development of regional quality infrastructure frameworks for solar photovoltaics products and services in the East African Community and the Pacific Community". It is part of the project "Structuring of an International Network of Solar Technology and Application Resource Centres (STAR C)" framework. Its objective is to strengthen institutional capacities within ISA Member States to enhance QI and promote solar energy markets, particularly in LDCs and SIDS. In collaboration with international advisors, UNIDO and ISA seek to support the development of regional QI frameworks and management systems for solar photovoltaic products and services in the EAC and SPC. This baseline assessment is a crucial component of the project, as it identifies the QI requirements to be integrated into the regional framework.

Chapter 1 of the report offers background information on Quality Infrastructure (QI) frameworks and the benefits of establishing a robust regional QI framework. In Chapter 2, you will find an overview of the methodology used and its limitations. This chapter also presents the status of solar QI frameworks in both regions, identifying and mapping key stakeholders, assessing compliance with international standards, and identifies gaps. Additionally, the chapter offers recommendations and a roadmap for designing an effective solar QI framework in both regions. In Chapter 3, critical stakeholders for roadmap implementation are discussed, while Chapter 4 outlines the capacity-building needs and resource requirements for the effective adoption and utilization of standards.

The comprehensive and collaborative assessment methodology involves multiple steps such as desk research, stakeholder consultation, data collection, gap analysis, conformity checks, and the formulation of recommendations. The desk research entailed exploring international and regional QI frameworks together insights into best practices. In the stakeholder consultation phase, key stakeholders are identified and interviewed to gather relevant information on existing solar QI frameworks. The results of these activities are then used to conduct a regional gap analysis and conformity check to identify disparities between current practices and international standards. Finally, based on the assessment findings, actionable recommendations are formulated to design and implement effective regional solar QI frameworks.

The key findings of the assessment differ across region. In the East African Community (EAC), the following were observed:

- Across the region, there is an understanding of the importance of a quality infrastructure. Each country has a Bureau of Standards, and there is a concerted effort to tailor international standards from bodies like the IEC to better suit local contexts through organizations such as the AFSEC. This adaptation ensures that standards are not only relevant but also effectively implemented. However, challenges persist in the adoption and enforcement of these standards, which hinders harmonization across borders.
- Testing facilities in some countries, such as Uganda, have significant discrepancies in availability and capacity. For instance, testing products like inverters and batteries, which are crucial components of solar energy systems, lack adequate facilities. This scarcity often leads to proposals for outsourcing testing to overcome the shortfall. However, initiatives like those led by CLASP and privately operated labs like Centre for Research in Energy and Energy Conservation (CREEC) at Makerere University contribute significantly to testing and certification efforts, though with varying focuses and capabilities.
- Accreditation processes for conformity assessment bodies, which are responsible for ensuring products meet specified standards, vary widely across countries within the region. Some countries like Kenya, have robust systems in place, while others face challenges in aligning their processes with international standards. This discrepancy complicates the mutual recognition of certifications, which is essential for facilitating trade and ensuring product quality across borders. Despite these challenges, national bodies such as the Uganda National Bureau of Standards (UNBS) and the Kenya Bureau of Standards (KEBS) collaborate to bridge these gaps, though they continue to face challenges in operational efficiency and communication within regional frameworks.
- There is a noticeable shortage of human resources dedicated to regional standardization efforts. Many countries have only a few individuals focusing on electrical equipment standards, which poses a significant obstacle to the harmonization of standards across borders. Additionally, the certification process for electrical professionals lacks clarity, leading to confusion and inefficiencies. Furthermore, market surveillance is impeded hindered by unofficial product which undermines consumer safety and confidence. However, these are initiatives underway to address these challenges, such as empowering consumers through toll-free platforms and awareness campaigns, aiming to improve market transparency and product safety.

  One major challenge faced by the domestic solar energy sector is the lack of support from the government. This lack of support impedes companies from investing in quality standards and assurance procedures, resulting in deficiency in specialized quality infrastructure, jeopardizing the dependability and longevity of solar installations within the region.

To address these identified gaps, the following actions are recommended:

- Develop regional standardization organisation and focus on capacity building, technical assistance, and raising awareness among stakeholders like National Standards Bureaus (e.g., KEBS), it's essential to provide a clear plan of action. Capacity building includes outlining specific training programs for regulators, testing laboratories, and industry professionals. For instance, training sessions could cover topics such as the interpretation and application of standards, quality assurance processes, and regulatory compliance to enhance their understanding and proficiency in adhering to and enforcing standards.

- Advocate for mutual recognition of certifications among EAC member states, drawing inspiration from the successful implementation of Kenya Bureau of Standards (KEBS) mandatory certification scheme. KEBS ensures products meet specified standards before market entry, serving as a commendable model for regional standardization efforts. By harmonizing certification processes and standards with KEBS' approach, member states can simplify trade procedures and eliminate duplication of conformity assessment requirements. For instance, if a product receives certification from KEBS in Kenya, it should be readily acknowledged and accepted across neighbouring EAC countries without the need for additional certification. This streamlined approach promises to enhance trade efficiency, foster regional economic integration, and alleviate administrative burdens for businesses operating within the EAC.
- Support the diversification of testing capabilities of existing laboratories like CREEC to include a broader range of solar products. Encourage privately-run labs to complement the efforts of government agencies and academic institutions in testing and certification endeavours.
- Providing dynamic support to the local value chain associated with solar PV through tax incentives, subsidies and financing.
- Actively encourage the promotion of research and development through the provision of financial and logistical support to local research institutions and universities

In the Pacific Community (SPC), the following observations were noted:

- A significant gap in established technical regulations governing the quality of solar PV products and services. For example, specific standards for aspects such as solar panel efficiency or inverter performance are lacking. This absence of clear regulations leads to inconsistency and uncertainty in the quality of solar products across the region, posing risks to consumer trust and market growth.
- Crucially, key bodies such as national standards, accreditation, and conformity assessment bodies are absent in many Pacific countries. The establishment of these bodies is essential for standardizing quality assurance processes and building confidence in solar products and services. Without a standardized approach to quality assessment, there is a risk of substandard products entering the market, which could undermine the credibility of the solar industry.
- The deficiency of a robust metrology infrastructure in the Pacific region further exacerbates the challenges in ensuring quality standards for solar products. Accurate measurements and standards compliance are essential across the solar supply chain, from manufacturing to installation and maintenance. Insufficient metrology capabilities can lead to inaccuracies in measuring the energy output of solar panels or assessing their performance, impacting overall system efficiency and reliability.

- The outdated legal metrology program raises concerns about measurement standards enforcement and product integrity, highlighting the need for modernization to maintain trust in the solar industry.

As a result of these identified gaps, it is recommended to take the following actions:

- Establish a regional standardization organization for the Pacific, beginning with the formation of a regional technical committee (RTC) comprising representatives from national standard bodies and technical associations.
- Develop new regional guidelines for standardization based on SEIAPI's PV system design and installation guidelines, and standards from Australia and New Zealand. Assess and incorporate relevant international standards such as IEC 61646, 62109, 62093, 62548, 60464, 61724, 62257, 62738, and ISO/IEC 17025 into these guidelines.
- Develop tailored technical regulations and practices through collaborative efforts involving governmental agencies, industry experts, and stakeholders. Regular updates should be implemented to keep pace with industry advancements, ensuring consistency and certainty in product quality and safety standards.
- Invest in specialized training programs, infrastructure, and partnerships with certification bodies and educational institutions.
- Promote collaboration and networking events between international standardization experts and regional stakeholders to facilitate knowledge exchange and capacity building.

Table 0-1 below shows a comparative analysis of the key findings and recommendation for the EAC and the SPC regions regarding QI for solar products and services.

Table 0-1. Overview of main findings and recommendations

Aspect	East African Community (EAC) Findings	Recommendations for EAC	Pacific Communities (SPC) Findings	Recommendations for SPC
Technical Regulations and standardization	Each country has a Bureau of standards.	Establish a regional standardization organization and provide a clear plan of action standard implementation.	Significant deficiency in established technical regulations.	Establish a regional standardization organization and provide a clear plan of action standard implementation.
	Efforts to tailor international standards to local contexts through organizations like AFSEC.	Advocate for mutual recognition of standards among member states.	Existence of regional guidelines for standardization but not implemented	Develop new regional guidelines for standardization.
Testing Facilities	Notable discrepancies in testing facilities availability and capacity.	Support diversification of testing capabilities of existing laboratories.	Limited capacity and availability of testing infrastructures	establish new testing laboratories and foster partnerships with private sector and academic institutions.
	Some countries lack adequate facilities for	Advocate for collaborative efforts	Lack facilities for testing crucial components like	Invest on local and regional testing infrastructure

Aspect	East African Community (EAC) Findings	Recommendations for EAC	Pacific Communities (SPC) Findings	Recommendations for SPC
	testing crucial components like inverters and batteries.	among member states	inverters and batteries.	
	Initiatives led by CLASP and CREEC contribute significantly to testing and certification efforts.	Encourage privately-run labs to complement the efforts of government agencies	Absence of private run laboratory for solar system products	Encourage privately-run labs to complement the efforts of government agencies
Accreditation Processes	Accreditation process varies widely across countries in the region.	Establish a harmonized accreditation process framework that aligns with international standards and facilitates mutual recognition of certifications among countries in the region.	Key bodies such as national standards and conformity assessment bodies are absent.	Establish National standards bodies and establish a harmonized accreditation process framework that aligns with international standards and facilitates mutual recognition of certifications among countries in the region.
Human Resources and Certification Clarity	Shortage of expertise dedicated to regional standardization.	Focus on capacity building, technical assistance, and raising awareness among stakeholders	Lack of human resources dedicated to regional standardization.	Invest in specialized training programs and infrastructure.
	Lack of clarity in certification processes for professionals.	Simplify certification processes for professionals	Lack of clarity in certification processes for professionals	Simplify certification processes for professionals

1 Introduction

1.1 Background

Quality infrastructure (QI) stands as the bedrock of reliability, efficiency, and sustainability across diverse industries including the solar sector. As a requirement for economic development and global competitiveness, QI plays a pivotal role in shaping industries, enhancing safety, and paving the way for innovation [1]. Therefore, establishing standards for the quality of products and services is an essential prerequisite for the long-term sustainability of solar markets and investments. For instance, it provides a benchmark for assessing the reliability, performance, and safety of solar products and services. With standardized quality criteria in place, consumers can make informed decisions, confident that the products they purchase will meet their expectations and deliver the promised benefits. Moreover, standardized quality assurance processes build trust among consumers, suppliers, and financiers alike. When consumers have confidence in the quality of solar products, they are more likely to invest in solar energy systems for their homes or businesses. Similarly, suppliers and financiers are more inclined to participate in solar markets when there are clear quality standards in place, as this reduces the risk of investing in substandard or unreliable products.

Additionally, standardized quality assurance frameworks help mobilize both the supply and demand sides of the solar market. On the supply side, manufacturers and service providers are incentivized to meet or exceed quality standards to remain competitive in the market. This fosters innovation and drives improvements in product quality over time. On the demand side, consumers are more likely to embrace solar energy solutions when they have confidence in the quality and reliability of the products available to them. This leads to increased adoption of solar technologies, driving market growth and expansion. As per the International Renewable Energy Agency (IRENA), QI frameworks include a comprehensive institutional framework, incorporating both public and private sectors, along with corresponding legal regulations. The National Metrology Institute of Germany illustrates this infrastructure visually (See Figure 1-1 below).

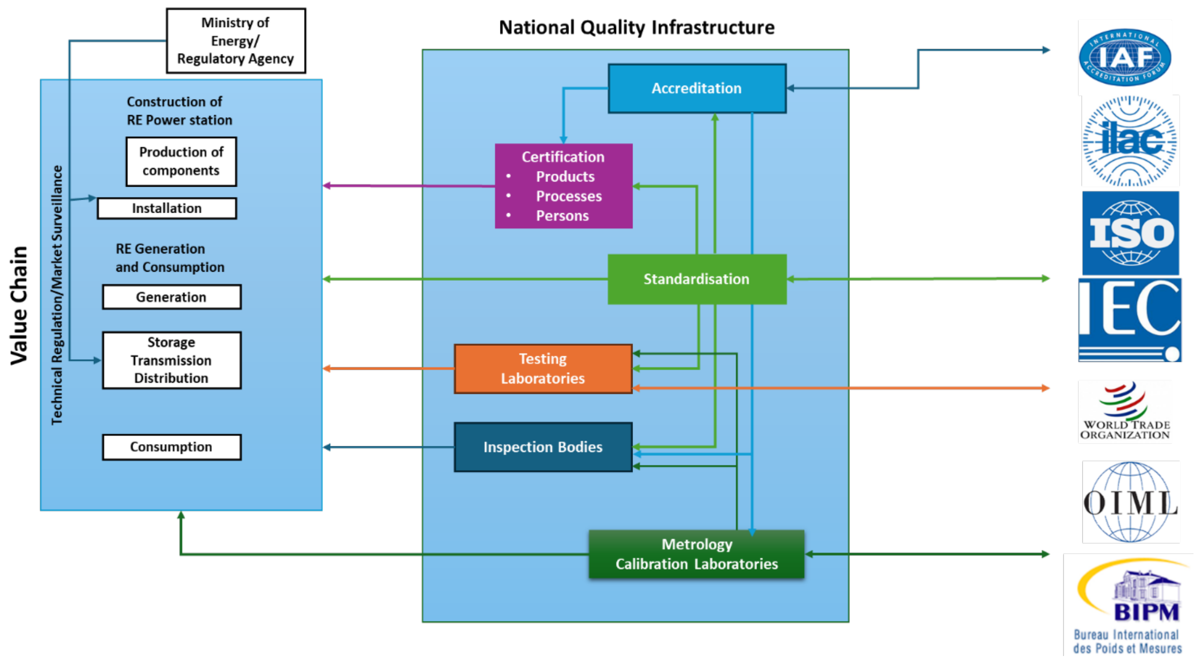

Figure 1-1. Components of quality infrastructure frameworks [2]

A typical QI framework designed for solar photovoltaics (PV) encompass various institutions responsible for metrology, standardization, accreditation, conformity assessment, and market surveillance. A well-designed qualification framework can foster local employment opportunities in the solar sector, generating income, and enabling domestic enterprises to engage in the global or regional value chains of solar manufacturing and servicing [3]. The worldwide solar market faces significant hurdles arising from substandard, unreliable, fake, and faulty product, hindering the adoption and advancement of renewable energy technology. In 2015, TÜV Rheinland revealed that almost 30% of approximately 100 scrutinized projects globally displayed considerable defects and numerous issues [2].

Substandard products fail to meet quality and performance standards, undermining consumer trust and industry growth while unreliable products result in inconsistent performance and increased maintenance costs, hindering the reliability of solar energy systems. The proliferation of counterfeit solar products poses safety risks and tarnishes the reputation of genuine manufacturers and faulty products, pursued by manufacturing defects, jeopardize consumer safety and property integrity.

In growing solar markets such as Least Developed Countries (LDCs) and Small Island Developing States (SIDS), ensuring the quality of products and services is vital for products and services along the entire supply chain of solar photovoltaic (PV) systems. This necessity arises because these countries often have limited or no local manufacturers, leading to most PV modules, inverters, and batteries being imported. Nevertheless, there remains a deficiency in quality control for imported off-grid, distributed, or utility-scale solar products, leaving the market vulnerable to substandard imports [3]. To tackle these challenges, it is crucial to allocate resources towards reliable and specialized qualification and certification programs. Additionally, embracing international best practices is essential to guarantee quality and safety within the sector, while simultaneously working towards the establishment, harmonisation, and improvement of national and regional quality infrastructure (QI) frameworks.

The European Union serves as an example of effective collaboration among nations in legal metrology, accomplished through the framework of European Cooperation in Legal Metrology (WELMEC) [4]. This collaborative initiative not only ensures precision and uniformity in measurements and standards but also fosters cooperation, facilitates the exchange of information, and promotes the harmonization of legal metrology practices across its member countries. The success of this collaborative approach within the EU highlights the value of shared efforts in maintaining accuracy and consistency in the field of metrology. This collaborative precision and uniformity directly contribute to higher revenues for all the actors in the supply chain by enhancing product quality, reducing errors, and increasing overall efficiency in various industries. An additional example can be found in the Asian Pacific region, where the Association of Southeast Asian Nations (ASEAN) Consultative Committee for Standards and Quality (ACCSQ) exemplifies effective collaboration, showcasing how similar metrological approaches lead to tangible economic benefits and improved financial outcomes for businesses and stakeholders alike.

Within ACCSQ, there is a concerted effort to harmonise national standards with international standards. This harmonisation process extends to the implementation of mutual recognition arrangements for conformity assessment. The overarching aim of ACCSQ is encapsulated in the principle of "One Standard, One Test, Accepted Everywhere”. This approach reflects a commitment to achieving consistency and acceptance of standards across the member nations, demonstrating the power of collaborative initiatives in standardization and quality assurance within the ASEAN region. Furthermore, within the Americas, the Council for Harmonization of Electro-technical Standards in the Nations of the Americas (CANENA) plays a crucial role in fostering cooperation among industry entities, standards creators, testing laboratories, regulatory bodies, and various stakeholders across Canada, Mexico, the Caribbean, and Central/South America [5]. Serving as a pivotal centre for harmonizing electro-technical standards, CANENA actively encourages the exchange of information and provides support to technical committees in each participating country. Developing this type of harmonised framework in the East African Community and Pacific Community requires, as a first step, the conduction of a Baseline Assessment of the current solar quality infrastructure frameworks and management systems in these regions.

1.2 Justification

The Baseline Assessment detailed in this document is fundamental for establishing the broader regional quality infrastructure framework for solar PV products and services in the East African Community (EAC) and the Pacific Community (SPC). The primary goal of this assessment is to conduct a comprehensive evaluation of the existing regulations, standards, stakeholders, and capacities at regional level. The baseline assessment results from exploring the QI publications, global standards, and international regulatory frameworks, thus analysing the alignment of local practices in the EAC and SPC regions with established international IEC/ISO solar product and service standards, as well as best practices from other regions like the EU and Mediterranean regions. Additionally, the assessment considers the distinctiveness of each region, considering key stakeholders. This approach ensures that the ensuing recommendations and frameworks are customized to address the specific challenges and opportunities unique to each region.

The findings from the baseline assessment will serve as a roadmap for the upcoming project stages. These subsequent phases will receive specific direction, notably through the development of two documents focused on the development of regional solar Quality Infrastructure (QI) frameworks and management systems. These documents will play a crucial role in guiding the activities within the Economic Communities of East African Community (EAC) and the Pacific Community (SPC) in the foreseeable years.

1.3 Objectives of the Baseline Assessment

The specific objectives of the baseline assessment for the solar QI frameworks and management systems in the EAC and SPC regions are as follows:

- **Evaluate existing solar QI frameworks and management systems:** Involving a thorough examination of the current solar QI frameworks and management systems in the EAC and SPC regions. This assessment will utilize established international QI frameworks and methodologies as benchmarks to evaluate the effectiveness and efficiency of existing systems, providing a baseline understanding of the strengths and weaknesses in place.
- **Examine regulations, standards, and capacities:** This objective focuses on a comprehensive review of the regulatory landscape, standards adherence, and institutional capacities related to solar QI. The assessment will examine national, regional, and continental levels in Africa, shedding light on the regulatory environment and the roles and capabilities of key actors within the solar

energy sector. By understanding the existing frameworks and capacities, the study aims to identify areas where regulatory improvements and capacity-building efforts are required.

- **Assess compliance with IEC/ISO standards and identify gaps:** Evaluating the extent to which current solar QI practices align with established International Electrotechnical Commission (IEC) and International Organization for Standardization (ISO) standards. Through a meticulous analysis, the assessment will identify gaps in compliance, providing insights into areas where adjustments are necessary to meet international benchmarks.
- **Recommendations for designing an effective solar QI framework:** Building upon the assessment findings, this objective aims to provide actionable recommendations for the design of an effective solar QI framework. Drawing on best practices from global, regional, and national standards bodies, the recommendations will address the identified gaps and weaknesses in existing frameworks. The goal is to propose practical and feasible strategies for enhancing the quality assurance processes within the solar energy sector.
- **Establish contacts and highlight key players:** The final objective focuses on creating a comprehensive overview of contacts for key players involved in the solar QI process. This includes stakeholders at the national and regional levels, as well as metrological centres, universities, ensuring at lease a 40% women participation and a 30% youth participation certification bodies, training institutes, industrial companies, and large importers of solar components. Establishing these contacts is vital for fostering collaboration, sharing expertise, and building a network of stakeholders committed to advancing solar quality improvement initiatives in the specified regions.

2 Assessment methodology

This chapter outlines the systematic approach employed to conduct the baseline assessment, including data collection and analysis methods and limitations of the methodology.

The methodology includes a step-by-step (see Figure 2-1 below) plan detailing how each objective was achieved. This encompasses activities such as desk research on international and regional QI frameworks, stakeholder identification, survey and interview guide design, data collection through stakeholder engagements, gap analysis, and the formulation of recommendations.

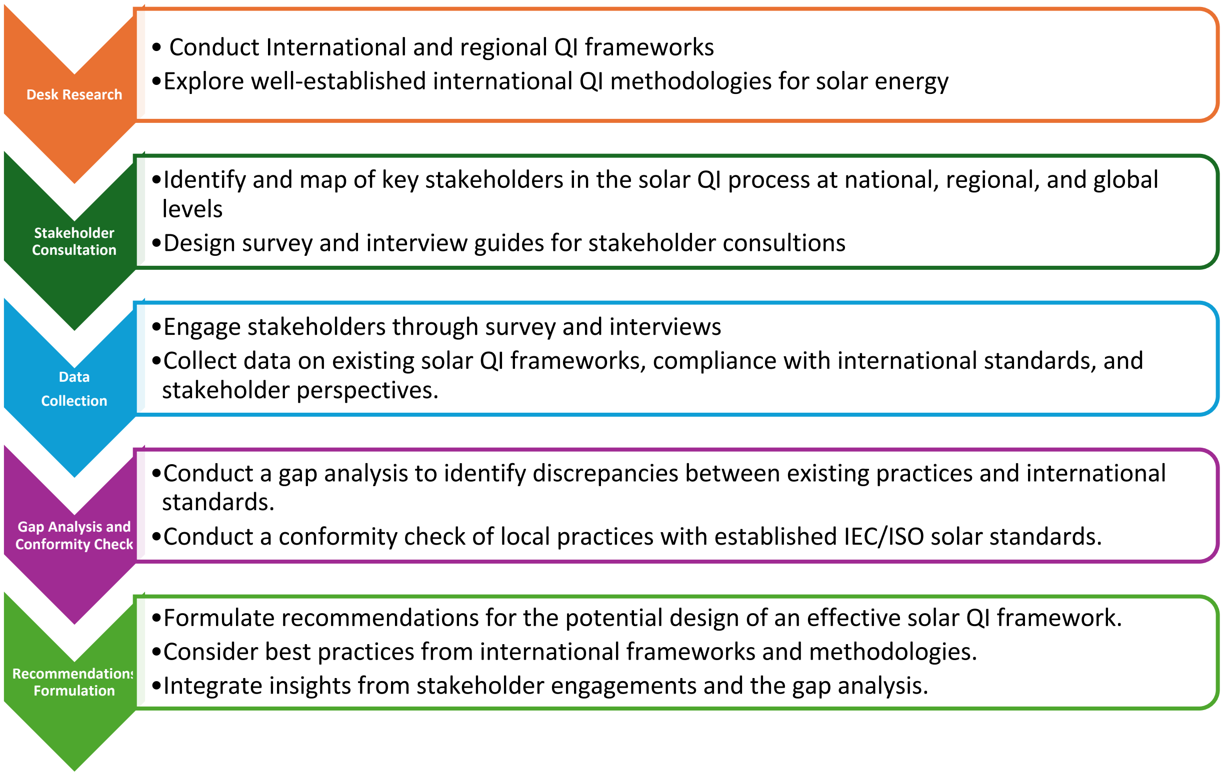

Figure 2-1. Methodological approach

The methodology underscores the importance of utilizing well-established international QI frameworks and methodologies as benchmarks for evaluation. It also acknowledges potential challenges, such as limited availability of solar QI documents in the Global Network of Sustainable Energy Centres (GN-SEC) regions and proposes solutions such as online surveys and interviews facilitated by key organizations like UNIDO, ISA, and the GN-SEC centres. A key aspect is the conformity check of local practices with international IEC/ISO solar standards and the consideration of climate and market maturity conditions in the analysis.

2.1 Data Collection Methods

This section includes methods used for primary and second data collection. These included desk research for secondary data collection and stakeholder consultation for primary data collection.

2.1.1 Secondary data collection

Secondary data was collected through desk review. The desk research step involved an in-depth exploration of secondary data on the international and regional QI frameworks. The literature reviewed included technical documents, publications, and standards issued by global organizations like the IEC and ISO. The goal of desk review was to gather secondary data about the best practices, criteria, and methodologies endorsed globally for ensuring the quality of solar products and services. Information data that was not available through desk review was collected using primary data collection methods.

2.1.2 Primary data collection

- Primary data collection was conducted through **Stakeholder Consultation:** Identifying key stakeholders *(See Annex III - A. Interview schedule for SPC and Gender inclusion and Annex III - B. Interview schedule for EAC and Gender inclusion)* and designing effective survey and interview guides are crucial components of stakeholder engagement. This step aims to capture diverse perspectives from individuals and organizations involved in the solar QI process. By collaborating with key organizations, this study ensures a streamlined and facilitated approach to engaging with stakeholders. Designing comprehensive interview guides ensures that the information gathered aligns with the objectives of the study. This stage will also serve as a base to understand the dynamics of regional cooperation in areas of QI and standardization and facilitate the elaboration of recommendations along regional and international cooperation.

2.2 Data analysis

- **Gap Analysis and Conformity Check:** The gap analysis step involves analysing the collected data obtained via desk research and stakeholder interviews to identify disparities between existing practices and international standards. This critical examination helps pinpoint areas where improvements are needed. Simultaneously, the conformity check assesses the alignment of local practices with established IEC/ISO solar standards.
- **Formulation of recommendations:** This step involves formulating recommendations based on the assessment findings, the recommendations were established along the key components of QI frameworks, furthermore, these recommendations were categorized in short-, medium- and long-term interventions with the aim of providing a clear regional roadmap. The result of this study will provide actionable suggestions for designing and implement effective regional solar QI frameworks.

2.3 Limitations of the assessment

Understanding the limitations of the methodology of the baseline assessment was crucial for interpreting its findings and recommendations. These limitations include:

- **Limited availability of solar QI documents**: The scarcity and difficulty in accessing solar QI documents in the GN-SEC regions impeded the comprehensive gathering of information. This limitation affected the depth of the desk research and hindered a thorough understanding of the existing solar QI frameworks.
- **Data availability and quality:** The assessment's reliability was influenced by the availability of data. Incomplete or outdated data impacted the accuracy of the findings, leading to incomplete assessments of existing solar QI frameworks.
- **Biases in stakeholder responses:** The interview process is susceptible to biases in stakeholder responses. Some responses could have been influenced by personal perspectives or organizational interests, leading to a lack of objectivity in the data collected.

- **Limited representation in stakeholder engagement**: Due to the regional scope of the assignment, there was a high number of stakeholder active and relevant to QI for solar PV products and services, thus, by shortlisting a limited number of stakeholders, there is a risk to leave perspectives or groups within the solar energy sector underrepresented.
- **Resource and time constraints:** The assessment's thoroughness and depth were constrained by limitations in resources and time.

3 Status quo - Solar QI Frameworks and management systems

3.1 International frameworks on solar QI frameworks

A core set of global standards, established by the International Electrotechnical Commission (IEC), are widely embraced worldwide. Moreover, many country-specific standards typically derived from these global norms include all aspects of the PV value chain, from manufacturing system components to the technology's end-of-life stage. However, national, or regional standards are generally adaptations of international or foreign national standards, depending on the market maturity and system complexity.

In 2013, IRENA conducted an inventory that identified over 570 standards associated with renewable energy technologies. Predominantly, these standards pertained to manufacturing and products, encompassing test methods and performance assessment. Given the growing significance of globalisation in the trade and implementation of renewable energy, the observation that fewer standards are established at the national level compared to the international level, as indicated by the gap analysis, is unsurprising [1]. This trend aligns with the increasing inclination of countries to adopt regional and international standards. A crucial takeaway from this analysis underscores the necessity for the international standardization pathway to include all regional, demographic, technical, societal, and environmental dimensions of utilisation if standards are to maintain global relevance [1]. This imperative is especially pertinent in developing nations, where constraints such as cost, capacity, or resource availability hinder their full participation in the comprehensive international standards development process.

On a worldwide scale, the IEC and ISO have released more than a hundred global standards in the domain of renewable energy technologies. A significant proportion of these standards are tailored to provide guidance on PV technologies. This encompasses a wide spectrum of features within PV energy systems, ranging from the conversion of solar radiation into electricity by solar cells to the manufacturing of solar panels and the management PV systems [3].

PV panels have become one of the most standardized forms of renewable energy technologies, adhering to a total of 121 identified standards. Notably advanced in terms of manufacturing and testing criteria, these panels stand out for their robust adherence to established standards. Approximately 90% of these standards are dedicated to various elements of PV panel components, covering tasks such as demonstrating performance, validating claims through testing procedures, ensuring adherence to manufacturing standards, and addressing safety concerns associated with component integration [1].

For instance, the most relevant international standards related to PV system components, installation, and operation which are crucial for obtaining project approvals or facilitating engineering assessments for financiers, are summarized in Table 1 below. Furthermore, for a comprehensive reference, *Annex IV. Complete list* of *existing standards* for solar PV documentation provides an exhaustive list of international standards specifically applicable to PV systems on a global scale.

Despite that the international standards cover a wide range in the field of PV, there are still gaps in certain areas: for example, region-specific conditions such as sand abrasion in deserts and corrosion in coastal regions are not adequately addressed by IEC 62446:Photovoltaic (PV) systems - Requirements for testing, documentation, and maintenance - Part 1: Grid-connected systems -

Documentation, commissioning tests, and inspection and IEC 62548:Photovoltaic (PV) arrays - Design requirements .Notably, the standards do not include module degradation over time, which can significantly affect the performance of a PV project.

This module degradation refers to the gradual decline in the performance of solar panels over their operational lifespan. Without standards specifically addressing this issue, there's a lack of guidance on monitoring, assessing, and mitigating the impact of degradation on PV system performance. This oversight can lead to decreased energy output, reduced system efficiency, and shorter lifespans for solar installations. Examples of module degradation effects may include "snail tracks," which are visible patterns of degradation caused by potential-induced degradation (PID), as well as other forms of degradation such as corrosion, delamination, and cell cracking. These failures highlight the need for comprehensive standards that include the long-term performance and durability of PV modules to ensure the reliability and effectiveness of solar energy systems.

Table 3-1. Identified relevant international QI elements for PV systems

Standards	Country / publisher	Standard description	Other aspects of QI	Source
IEC 61215 Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval.	Global/IEC	The test sequence is to determine the electrical characteristics of the module and to show, as far as possible within reasonable constraints of cost and time, that the module is capable of withstanding prolonged exposure outdoors. Accelerated test conditions are empirically based on those necessary to reproduce selected observed field failures and are applied equally across module types.	**Conformity assessment**: Specifies design qualifications for terrestrial photovoltaic modules for extended use in open-air climates. The certified service life depends on factors like design, environmental conditions, and operational parameters. In climates with temperatures exceeding 70 °C at the 98th percentile, testing under elevated temperatures is recommended.	IEC webstore
IEC 62446 Grid-connected photovoltaic systems – Minimum requirements for system documentation, commissioning tests and inspection	Global/IEC	Defines the minimal information and documentation required to be handed over to a customer following the installation of a grid-connected PV system. Also describes the minimum commissioning tests, inspection criteria and documentation expected to verify the safe installation and correct operation of the system. Is written for grid-connected PV systems only	**Metrology:** Check if the PV module and electrical supply connections have been wired up correctly, the electrical insulation is good and also ensuring that there has been no damage to cables during installation.	IEC webstore
IEC 62548 Photovoltaic (PV) arrays – Design requirements	Global/IEC	Establishes design safety requirements for photovoltaic (PV) arrays, including DC array wiring, electrical protection, switching, and earthing. It addresses safety concerns arising from the unique characteristics of PV systems, focusing on potential hazards associated with direct current, with specific attention to power conversion equipment in cases involving DC safety issues. The standard also includes provisions for the interconnection of small DC conditioning units linked to PV modules.	**Technical regulation:** Provisions for systems including DC to DC conditioning units. Considerable revision of Clause 6 on safety issues which includes provisions for protection against electric shock including array insulation monitoring and earth fault detection.	IEC webstore
IEC 61730-1 Photovoltaic (PV) module safety qualification – Part 1:	Global/IEC	Outlines essential construction requirements for photovoltaic (PV) modules to ensure their safe electrical and mechanical functioning. It addresses	**Metrology:** This document is intended to apply to all terrestrial flat plate module materials. It also lays down requirements for long-term	IEC webstore

Standards	Country / publisher	Standard description	Other aspects of QI	Source
Requirements for construction		concerns like electrical shock, fire hazards, and physical harm from mechanical and environmental factors. This standard focuses on construction specifics, with testing requirements detailed in IEC 61730-2. For modules with altered construction, qualification follows the guidelines in IEC TS 62915.	operation in open-air climates with 98th percentile module operating temperature of 70°C or less.	
IEC 61829- Photovoltaic (PV) array – On-site measurement of current-voltage characteristics	Global/IEC	Specifies procedures for on-site measurement of flat-plate photovoltaic (PV) array characteristics, the accompanying meteorological conditions, and use of these for translating to standard test conditions (STC) or other selected conditions.	**Metrology: Measurements of PV array current-voltage (I-V) characteristics under actual on-site conditions and their translation to reference test conditions (RTC).**	IEC webstore
IEC 61730-2 Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing	Global/IEC	Specifies testing requirements for photovoltaic modules to ensure safe electrical and mechanical performance over their anticipated lifespan. Focuses on averting electrical shock, fire risks, and physical harm from mechanical and environmental stress. To be applied alongside IEC 61215 or IEC 61646.	**Technical requirement:** This document outlines a testing sequence to confirm the safety of PV modules evaluated under IEC 61730-1. The tests identify potential failures in internal and external components that could lead to fire, electric shock, or personal injury, with specified pass criteria.	IEC webstore
ISO/IEC 17000 Conformity assessment – Vocabulary and general principles	Global/ ISO/IEC	Provides key terms and definitions for conformity assessment, including the accreditation of assessment bodies and the application of conformity assessment to support trade. It includes a functional approach to enhance understanding for users, assessment bodies, and accreditation bodies in voluntary and regulatory contexts.	**Technical requirement:** This document provides a collection of definitions and general principles for assessing conformance. It lays the groundwork for understanding fundamental topics in the discipline.	ISO webpage
AS/NZS 5139 Electrical installations—Safety of battery systems for use with power conversion equipment	Australia and New Zealand / Australia standards	Sets out general installation and safety requirements for battery energy storage systems (BESSs), where the battery system is installed in a location, such as a dedicated enclosure or room, and relates to power conversion equipment (PCE) to supply electric power to		Standard New Zealand webstore

Standards	Country / publisher	Standard description	Other aspects of QI	Source
		other parts of an electrical installation.		
UL 2703: Standard for mounting, clamping, and grounding devices for flat-PV modules.	US	Defines requirements for mounting systems, mounting devices, clamping/retention devices, and ground lugs used with flat-plate photovoltaic modules and panels		
IEC 62257-All parts: renewable energy and hybrid systems for rural electrification	Global/IEC	Offers guidance on rural electrification projects, covering technical aspects of designing, constructing, testing, and maintaining off-grid renewable energy and hybrid systems with AC nominal voltage below 500 V, DC nominal voltage below 750 V, and nominal power below 100 kVA.	**Technical requirement**: set minimum standards for quality, durability, and truth in advertising, safeguarding consumers of stand-alone renewable energy products. The primary focus is to enhance the capacities of households and communities utilizing small renewable energy and hybrid off-grid systems.	IEC webstore
IEC 62093: Photovoltaic system power conversion equipment – Design qualification and type approval	Global/IEC	Lays down IEC requirements for the design qualification of power conversion equipment (PCE) suitable for long-term operation in terrestrial photovoltaic (PV) systems.		IEC webstore
IEC 62109-All parts: Safety of power converters for use in photovoltaic power systems	Global/IEC	Provides general and specific requirements for the design and manufacture of Power Converters Equipment (PCE).	**Technical requirement: defines the minimum requirements for the design and manufacture of PCE for protection against electric shock, energy, fire, mechanical and other hazards.**	IEC webstore
UL 1741- Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources	US	Covers requirements for inverter and converter equipment that are intended to convert DC power from a renewable energy source into AC power that can be used by the electrical grid or other electrical loads.	**Technical requirement:** sets out safety tests and performance requirements that inverters and converters must meet to ensure that they are safe and reliable for use in renewable energy systems.	Intertek

3.1.1 Existing IEC/ISO solar PV standards

This section investigates the current international standards (such as IEC/ISO) standards and regulations related to Quality Infrastructure of solar photovoltaic (PV) technologies. The objective of this examination is to enhance comprehension on the different standards involved in the implementation of a QI framework, a complete list of standards can be found in *Annex IV. Complete list of existing standards for solar PV documentation.*

Table 3-2. Relevant International and national standards for PV systems compiled by IRENA [2].

Country	PV module	Inverter	Design and installation	Commissioning	Performance and operation	Grid-code related	Off grid specific	Utility scale specific
international/IEC	IEC 61730 and IEC 61215, or IEC 61646 as applicable	IEC 62109-1, IEC 62109-2, IEC 62093 (Qualification)	IEC 62548 (Primary) and IEC 60364 series	IEC 62446	IEC 61724 Future IEC 62446-2 (2017)	Country specific, but grid function testing per IEC 62116, IEC 62910	IEC 62257 Series for off - grid and rural electrification	Future IEC 62738
Australia	Same as IEC	AS/NZS 4777, AS/NZS 3100	AS/NZS 5033	Same as IEC	Same as IEC	AS/NZS 4777	AS 4509	
China	National standards and IEC		GB 50797-2012	Same as IEC	Same as IEC			
United States	UL 1703 UL 61215/ IEC 61646	UL 1741, UL 62109	National Electrical Code (NEC) Article 690	Not specified; multiple industry group recommended practices	ASTM E2848, multiple industry recommended practices	IEEE 1547 and regional/ state requirement	N/A	Future NEC Article 691 (2017)

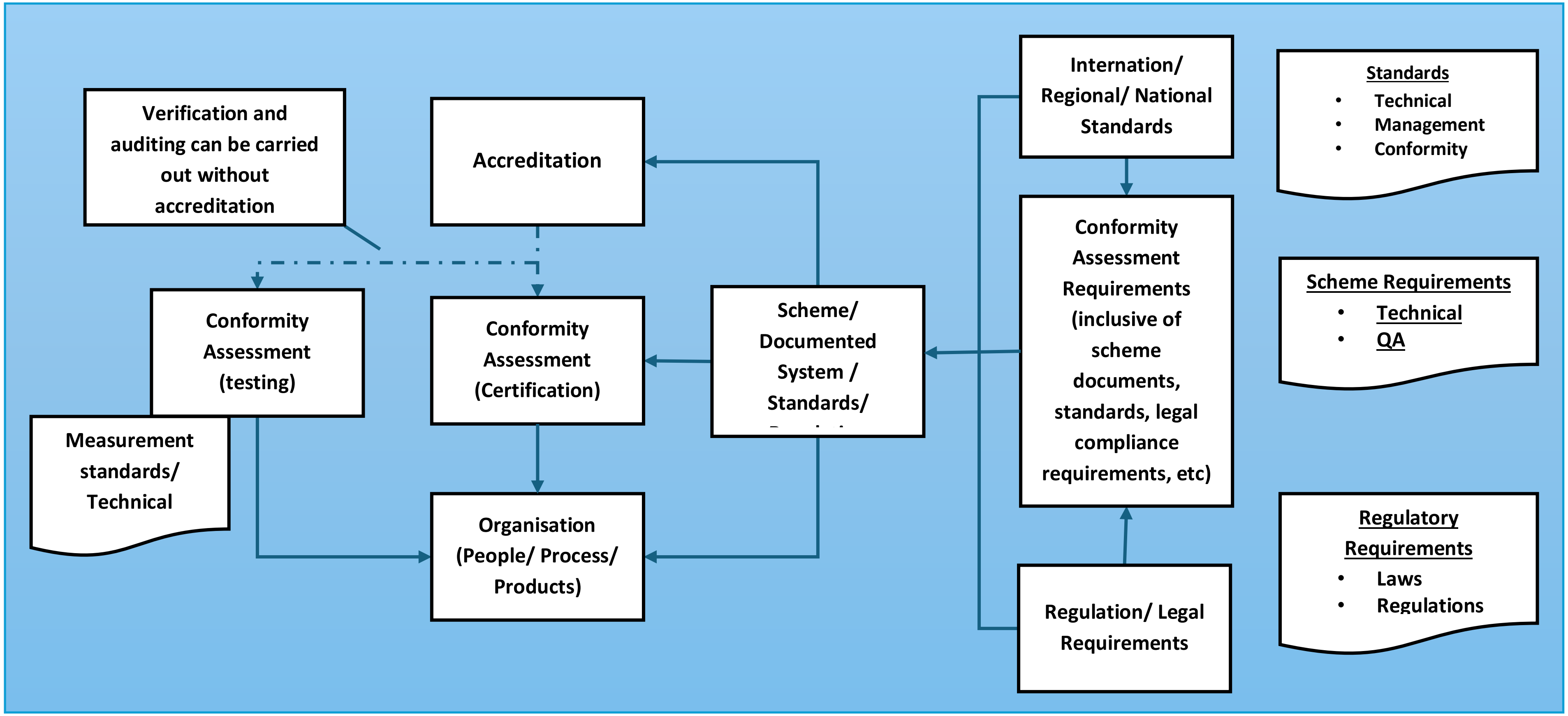

Figure 3-1. Typical quality infrastructure framework [1]

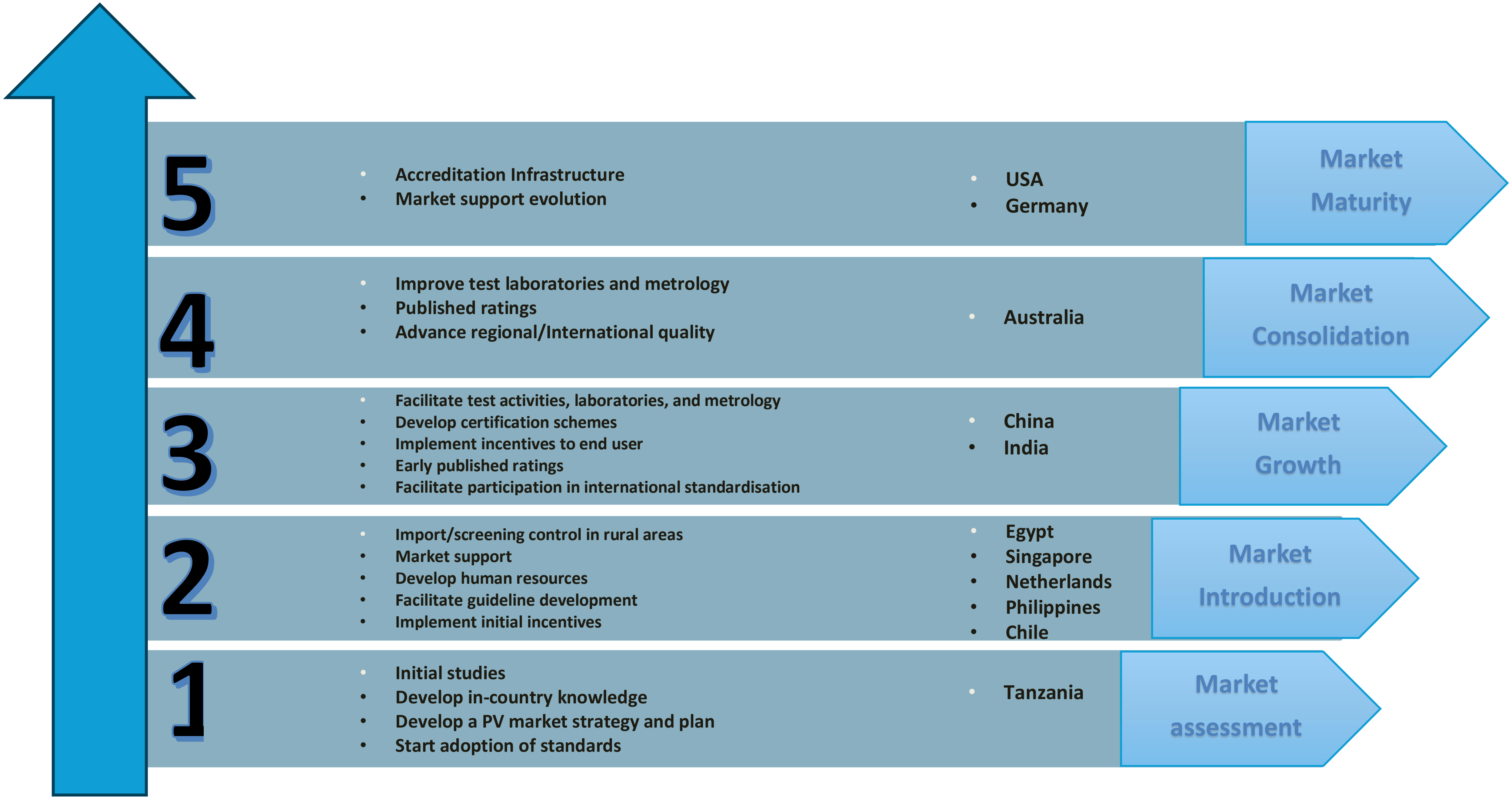

Figure 3-2. Measures for the long-term implementation of QI frameworks [2]

3.1.2 Mapping of international and transnational stakeholders

In developing regional QI frameworks for PV products and services within the EAC and SPC, a systematic stakeholder mapping and analysis is essential. This mapping is designed to provide a comprehensive understanding of the roles and relationships among stakeholders involved in standardizing solar products and services, both at the international and regional/national levels. Through this process, all key participants were identified, and their contributions and influence carefully assessed. Crucial stakeholder groups for the QI framework included policy makers, regulators, standards bodies, manufacturers, installers, investors, academia/NGOs, private enterprises, and end-users. The international-level mapping particularly emphasized standards bodies. Globally, there are four main tiers of standards makers organizations, namely international, regional, national, and standards-developing entities.

The pertinent international standards bodies in the field of renewable energy include the ISO and the IEC. These organizations for international standardization operate with membership-driven structures consisting of national standards bodies in the case of ISO and national committees within IEC, each representing one country. ISO is a self-governing, non-governmental global entity comprising 169 national standards bodies as of 2023. By uniting experts through its membership, the organization facilitates the exchange of expertise and collaboratively devises voluntary, consensus-driven, internationally applicable standards that promote innovation and offer solutions to worldwide challenges [6].

The IEC functions as a worldwide, non-profit association that unites over 170 countries and manages the collaboration of 20,000 experts on a global scale. It is responsible for formulating and releasing international standards encompassing electrical, electronic, and associated technologies. As of 2023, the IEC comprises 85 participants engaged in the organization's free program. Throughout the standard development process, member bodies have the option to choose between participating or observing roles [7].

The primary international stakeholders identified through desk research, including IEC and ISO, are categorized and mapped based on the elements of the QI framework (see Figure 5 below). Additional international bodies actively engaged in the standardization of solar products and services include:

- CARICOM Regional Organization for Standards and Quality (CROSQ)
- National Committee of the IEC (IEC NC)
- European Committee for Electrotechnical Standardization (CENELEC)
- American National Standards Institute (ANSI)
- ISO Committee on developing country matters (DEVCO)
- IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications (IECRE)
- ASEAN Consultative Committee for Standards and Quality (ACCSQ)
- IEEE Standards Association (IEEE SA)
- Standards Australia

Moreover, stakeholders directly involved in Conformity Assessment encompass:

- International Laboratory Accreditation Cooperation (ILAC)
- China National Accreditation Service for Conformity Assessment (CNAS)

- ISO Committee on conformity assessment (CASCO)
- IEC global conformity assessment System for Electrotechnical Equipment and Components (IECEE)
- Joint Accreditation System of Australia and New Zealand (JASANZ)

Those directly involved in Metrology include:

- International Organization of Legal Metrology (OIML)
- European Cooperation in Legal Metrology (WELMEC)

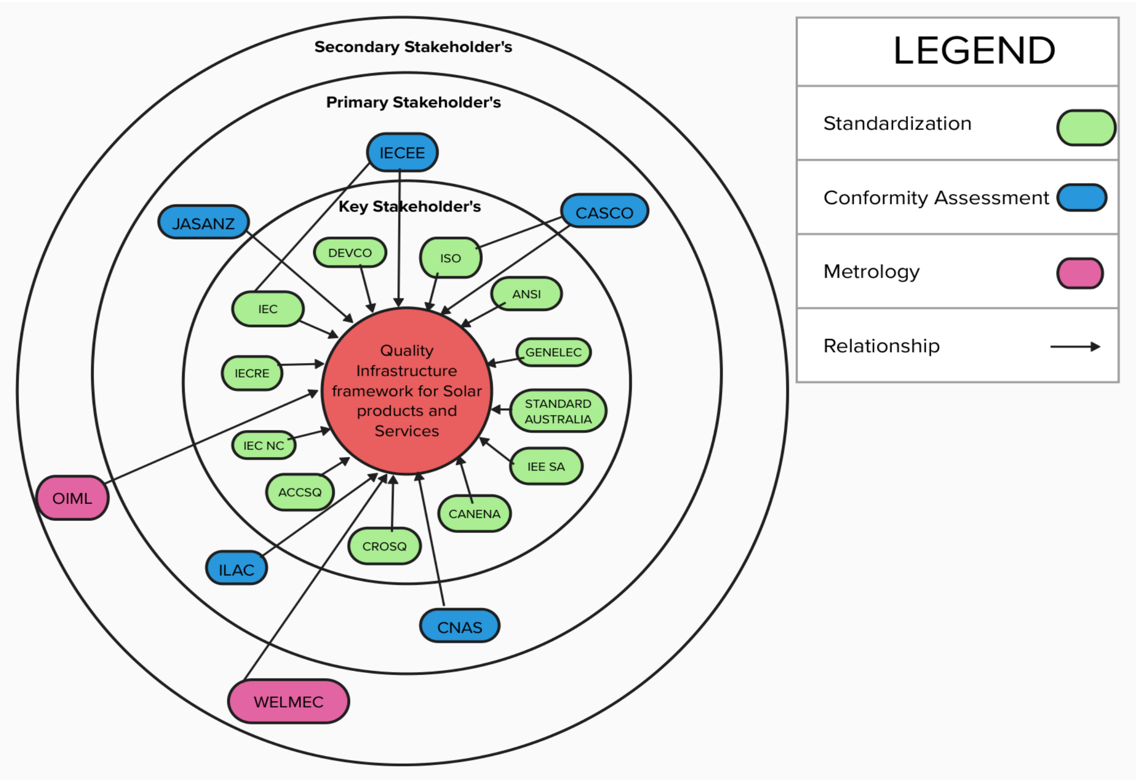

Figure 3-3. QI international stakeholders mapping (Author's representation)

3.2 East African Community (EAC)

The East African Community (EAC), with its central office situated in Arusha, Tanzania, operates as a regional inter-governmental organization comprising the Republics of Burundi, Kenya, Rwanda, Tanzania, Uganda, South Sudan and, since 2022, the Democratic Republic of Congo and Somalia [8]. As a collective, the EAC is home to approximately 301.8 million residents. Within the EAC, proactive initiatives have driven the swift integration and expansion of renewable energy technologies, particularly in off-grid solar photovoltaic applications. Countries such as Kenya, Uganda, Tanzania, and Rwanda have adopted strategies to utilize solar energy. Furthermore, there are established tax incentives aimed at substantially promoting the progress and uptake of solar technology [3].

On a regional scale, the African Electrotechnical Standardization Commission (AESEC) collaborates with GN-SECs on regional standards. While there has been progress in the EAC's solar technology sector, market assessments have only been conducted in Kenya and Tanzania, the region faces challenges in recruiting skilled personnel for the installation, maintenance, and repair of photovoltaic solar systems. Also, limited business skills contribute to insufficient customer information on system usage and basic maintenance tasks. Moreover, poor product quality and non-compliance with installation standards further damage the reputation of photovoltaic solar technology, diminishing user confidence and hindering promised economic benefits [3]. Despite these challenges, within the EAC, standards created or embraced by individual national standards bodies have a longstanding history. In 2006, the EAC Standardization, Quality Assurance, Metrology, and Testing (SQMT) Act (2006) was established, aligning with the EAC Protocol on SQMT. As the region increasingly adopts solar products, it becomes crucial to communicate and enforce well-structured technical standards for both on-grid and off-grid connections, ensuring the prevention of future synchronization and system balancing issues.

This EAC protocol facilitated regional collaboration in the field of standards, metrology, conformity assessment, accreditation, and technical regulations. The aim of the SQMT Act was to promote industrial development and trade while ensuring the safeguarding of health, safety, and the environment within the community [9]. These standards are collaboratively developed by the national standards bodies of the EAC Partner States, following procedures approved and upheld by the East African Standards Committee (EASC).

The legislation of SQMT Act 2006 also outlines specifications and offers direction for [9]:

- Formulating and coordinating procedures for SQMT activities concerning standards harmonization, conformity assessment, and measurement systems.
- Embracing harmonized standards by the partner States.
- Ensuring compliance with mandatory standards.
- Declaring and endorsing certification marks.
- Aligning and adjusting laws and regulations.
- Defining the functions of the National Standards Bodies (NSBs) regarding SQMT activities.
- Creating regulations and frameworks to ease the implementation of SQMT activities.

3.2.1 Regulations

In accordance with Article 81 of the Treaty establishing the East African Community, the EAC Partner States acknowledged the significance of standardization, quality assurance, metrology, and testing in advancing trade and investment, as well as ensuring consumer protection, among other objectives [8]. The solar industries in EAC countries like Kenya, Uganda, and Rwanda adhere to the regulations outlined in Article 5 of the World Trade Organization (WTO) Agreement on Technical Barriers to Trade (TBT) through the Pre-export verification of conformity (PVoC) [10].

Article 81 highlights the need to avoid undue trade restrictions in technical regulations. It encourages aligning regulations with international standards when relevant, advocates for transparency by notifying the WTO of proposed regulations and urges the recognition of equivalent regulations. The primary goal of Article 5 is to find a balance between achieving legitimate objectives and preventing unnecessary obstacles to international trade [11].

Kenya: The effective utilization of Energy for Productive Uses (PUE), referring to the application of off-grid PV electricity to operate electric appliances for business or income-generating purposes, faces key regulatory influences within the energy sector. These regulations primarily include:

- Standards dictating the quality or minimum performance levels for solar equipment and appliances.
- Mandates for certification of solar technicians.

- Guidelines determining tariff-setting procedures for mini-grid systems.
- Taxation policies governing the importation of equipment.

The Energy (Solar Photovoltaic Systems) Regulations, 2020, outlined in the Energy Act of 2019, stipulates the following provisions (refer to the document for additional clauses) [12]:

- An individual is prohibited from designing, installing, testing, commissioning, maintaining, or repairing a solar PV system unless licensed by the Authority.
- To obtain a worker's license from the Authority, an individual must possess the specified educational qualifications, training, and experience.
- Engaging in the importation, manufacture, sale, or installation of solar PV systems or components requires a valid license issued by the Authority.
- The Authority will periodically publish notices indicating the types of solar PV components and systems covered by these regulations.
- Licenses issued under these regulations are valid for three (3) years unless the applicant requests a one-year validity.
- Manufacturers or importers of solar PV systems, components, and consumer devices must ensure product compliance with the relevant Kenya Standard listed in the Seventh Schedule or any subsequent or applicable Kenyan Standards.
- Licensed workers must design PV systems in accordance with the requirements specified in the Kenyan Standard or any subsequent or replacement standard.
- Licensees under these Regulations must ensure that all PV installation work complies with the relevant Kenya Standard and meets other applicable technical, legal, and regulatory requirements in Kenya.

In 2020, the Kenya National Treasury, through the Finance Act, reintroduced a 14% VAT on solar equipment, including batteries. As of 1 July 2021, VAT exemption was reinstated for specialized equipment for the development and generation of solar energy, including photovoltaic modules, DC charge controllers, DC inverters, and deep cycle batteries that use or store solar power. This aligns with the import duty exemption in the EAC Customs Management Act [13].

Rwanda: The solar photovoltaic regulations established by the Rwanda Utilities Regulatory Authority (RURA) board outline the following provisions (refer to the document for additional details) [14]:

- Article 4 emphasizes that any design and specifications of a PV system must consider the electric energy needs and safety of the user, ensuring a suitable match.
- Article 5 dictates that solar modules should be installed at an angle ranging between 10° and 20° from the horizontal plane.
- Article 6 mandates that upon the commissioning of the PV system, the contractor must issue an installation certificate. This certificate must include, at a minimum, the date of installation, the technician's name, address, and permit number, the system owner's name, the location and capacity of the PV system, and the warranty period upon commissioning.
- Article 8 specifies that the owner of a PV system is responsible for using, maintaining, and carrying out necessary repairs to ensure the installation remains in good and efficient working condition.

3.2.2 Standards (incl. IEC/ISO compliance)

EAC is leading in the implementation of standards for standalone solar systems. This is attributed to the region's advanced market for standalone solar, particularly when compared to West and Southern Africa. Kenya and Tanzania have embraced standards for pico-solar products that align with IEC 62257 set by the IEC on Renewable energy and hybrid systems for rural electrification. Ethiopia has mandated standards for pico-solar and voluntary standards for Solar Home System (SHS) kits, both in alignment with IEC 62257 guidelines. Rwanda has also adopted guidelines for SHS kits, conforming to IEC 62257 standards and incorporating additional requirements [10].

Kenya: Kenyan PV systems standards comply to significant international standards (refer to the document for additional Kenya solar PV standards) [12]:

- KS IEC 61215:2005 Crystalline silicon terrestrial PV modules- Design qualification and type approval
- KS IEC 62108: 2007 Concentrator Photovoltaic (CPV) Modules and assemblies- Design
- KS IEC 61730-1: 2004 PV Module Safety Qualification- Part 1: Requirements for construction
- KS IEC 61730-2: 2004 PV Module Safety Qualification- Part 2: Requirements for testing
- KS IEC TS 62257-8-1:2007 Recommendations for small renewable energy and hybrid systems for rural electrification - Part 8-1: Selection of batteries and battery management systems for stand-alone electrification systems - Specific case of automotive flooded lead acid batteries available in developing countries.
- KS IEC 62446:2009 Grid connected PV systems - Minimum requirements for system documentation, commissioning tests and inspection.
- KS IEC/TS 62548 2013: PV arrays – Design requirements

Uganda: Uganda PV systems standards comply to significant international standards (refer to the document for additional Uganda PV standards) [15]:

- US IEC 61215-1-1:2016, Terrestrial PV modules — Design qualification and type approval — Part 11: Special requirements for testing of crystalline silicon PV modules
- US IEC 61215-2:2016, Terrestrial PV modules — Design qualification and type approval — Part 2: Test procedures
- US IEC 61646: 2008, Thin-film terrestrial PV modules Design qualification and type approval
- US IEC TS 62257-9-8:2020, Renewable energy and hybrid systems for rural electrification — Part 1: Integrated systems — Quality standards for stand-alone renewable energy products with power ratings less than or equal to 350 W
- US IEC 60904-2:2015, PV devices – Part 2 Requirements for PV reference devices

Rwanda: The solar energy system standards for Rwanda, as documented by the Rwanda Standards Board (RSB) in 2023, primarily focus on solar water systems [16]. These standards encompass:

- RS 212: 2022, Domestic storage solar water heating systems Requirements
- RS 213: 2014, Domestic solar water heater — Mechanical qualifications tests
- RS 213: 2022, Domestic storage solar water heating systems —Test methods
- RS 214: 2014, The installation, maintenance, repair and replacement of domestic solar water heating systems
- RS 214: 2022, Domestic storage solar water heating systems Requirements for installation, maintenance, repair and replacement

Tanzania: The solar energy system standards for Tanzania outlined by the Tanzania Standards Board (RSB) in 2023 consist of [17]:

- TZS 877-1: 2016/IEC 61215-5:2016(E) Terrestrial PV modules – Design qualification and type approval - PART 1: TEST REQUIREMENTS
- TZS 1911-1:2016/IEC 61427-1:2013(E) Secondary cells and batteries for renewable energy storage - General requirements and methods of test - Part 1: PV off-grid application
- TZS 2407 -1:2020/ IEC 62109 -1:2010(E) Safety of power converters for use in PV systems - Part 1: General requirements. 1065.
- TZS 2407 -2:2020/ IEC 62109 -2:2010(E) Safety of power converters for use in PV systems - Part 2: Specific requirements for inverters.
- TZS 2727:2021/IEC 62727:2012(E) PV systems – Specification for solar trackers 1192. TZS 2729:2021/IEC 62852:2014(E) Connectors for DC – application in PV systems – Safety requirements and tests
- TZS 2916:2021/IEC 62253:2011(E) PV pumping systems - Design qualification and performance measurements 1293.
- TZS 2917-2:2021/IEC 61853- 2:2016(E) PV module performance testing and energy rating - Part 2: Spectral responsivity, incidence angle and module operating temperature measurements.
- TZS 31871:2023/IEC 617301:2016 PV module safety qualification Part 1: Requirements for construction
- TZS 31872:2023/IEC 617302:2016 PV module safety qualification Part 2: Requirements for testing

However, the crucial international standards highlighted in Table 3-2 in section *4.1 International frameworks on solar QI frameworks* are absent from the Tanzania standards catalogue.

3.2.3 Stakeholder mapping and identification of capacities

This mapping is intended to provide a thorough knowledge of the responsibilities and linkages among stakeholders involved in standardising solar products and services at the international, regional, and national levels, thus supporting the potential gaps or overlaps in their efforts and coordinate more effectively. Additionally, this mapping helps identify key decision-makers who can drive the adoption of standardised solar products and services across the EAC region.

The EAC stakeholders were categorized into four groups, aligning with global stakeholders, and encompassing all element stakeholders. This classification was determined by the unique components of QI, which include standardization, conformity assessment, metrology, and all-element considerations.

These groups consist of key stakeholders, primary stakeholders, and secondary stakeholders. A total of 35 stakeholders were identified in the desk research, with 18 key stakeholders involved in standardisation, seven primary stakeholders for conformity assessment, and the rest for quality infrastructure metrology (See Figure 6 below). An extensive list of these stakeholders' full names, mandates, websites, and contact information is included in *Annex II. Identified stakeholders.*
The key stakeholders identified are:

- African Electrotechnical Standardisation Commission (AFSEC)

- African Organisation for Standardisation (ASRO)
- East African Centre of Excellence for Renewable Energy and Efficiency (EACREEE)
- East African Standards Committee (EASC)
- East African Business Council (EABC)
- Uganda National Renewable Energy and Energy Efficiency Alliance (UNREEA)
- Kenya Bureau of Standards (KEBS)
- Rwanda Standards Board (RSB)
- Tanzania Bureau of Standards (TBS)
- Uganda National Bureau of Standards (UNBS)
- South Sudan National Bureau of Standards (SSNBS)
- Rwanda Utilities Regulatory Agency (RURA)
- Directorate of Industrial Training (DIT) Uganda
- National Industrial Training Authority Kenya (NITAK)
- Electricity Regulatory Authority (ERA) Uganda
- Aptech Africa Ltd.-Uganda
- Zuhura Solutions-Kenya
- Nelson Mandela African Institute of Science and Technology (NM-AIST)
- School of Materials, Energy, Water, and Environmental Science (MEWES)

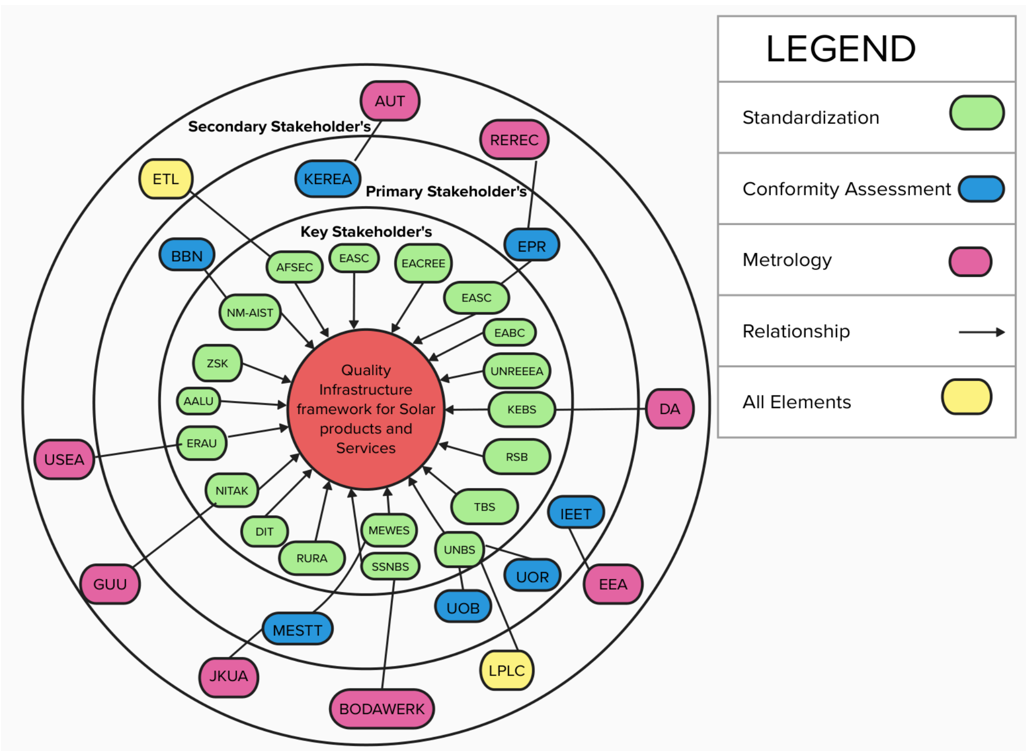

Figure 3-4. Stakeholder mapping in EAC

3.2.4 Gender, digitalisation and climate change adaptation considerations

In the EAC, the gender legal framework outlined in the EAC Gender Policy plays a pivotal role. The treaty acknowledges the significance of achieving Gender Equality and advancing the involvement of women in socio-economic development and business, aligning with the Community's overarching goals [18]. The EAC is dedicated to implementing measures aimed at combating discrimination against women and girls. Additionally, it seeks to promote gender equality and fairness in both elected and appointed positions across public and private sectors, encompassing all domains, including the energy sector, at both regional and national levels [18]. The Tanzania SE4ALL Gender Action Plan has simplified gender considerations within the energy sector, incorporating elements such as the advancement of women's employment, economic empowerment, and the integration of gender perspectives [19].

3.2.5 Stakeholder consultation results, conformity checks and gap analysis

To validate the findings of the desk research and deepen the understanding of the QI framework within the EAC region, eighteen key stakeholders were contacted for interviews. A total of ten interviews were conducted involving 14 participants, comprising 8 males and 6 females, and focused on five main topics specified in Annex I of the interview guides. These topics included the assessment of existing regional QI frameworks for solar products, exploration of challenges and opportunities in the EAC region's solar product domain, examination of cooperation dynamics among stakeholders, and evaluation of intervention needs and support requirements. The upcoming sections provide a detailed overview of the responses obtained during interviews with these stakeholders. For a comprehensive record, the complete interview minutes can be found in the Annex V. Interview minutes.

3.2.5.1 Status Quo – Existing regional QI frameworks for solar products

Standards/technical regulations implemented/under implementation in the region.

- The Transfer of IEC standards to AFSEC standards upon general assembly acceptance, emphasizing local language translation for effective implementation.
- There is adoption of IEC standards in Uganda, recent developments include national standards for PV plug and play SHS and a code of practice by UNBS.
- National-level adoption of IEC and ISO standards for solar products, with regional conformity assessment facilitated through VeraSol and CLASP.
- Kenya's code of practice for PV installers. (Edward Ekuru and Winnie Onziru - UNBS)
- There is a lack of regional standards.
- There has been good progress in adopting standards for solar kits and products like inverters and batteries, but implementation remains a major hurdle.
- In Kenya, a range of standards and technical regulations have been developed and adopted, covering various components of PV systems such as modules, inverters, cables, and batteries, many of which align with IEC standards.
- CREEC operates two specialized testing labs for solar products, certified by UNBS according to ISO 17025:2017.

Testing procedures and facilities for PV products

- Lack of testing facilities for inverters and batteries, particularly in the off-grid sector, prompting suggestions for outsourcing testing.
- Initiatives by CLASP and Kijani contributing to testing and certification efforts exist in the region.
- CLASP's implementation of testing laboratories for IEC conformity testing, focusing on plug and play solar equipment under 350 W with DC applications.
- Testing facilities exist at UNBS, although functionality and capacity are hindered, prompting suggestions to outsource testing to organizations like CREEC for sustainability.

- Some testing labs are listed on the VeraSol website; however, some locations are currently non-functional.
- Existence of UNBS lab for Solar Home Systems (SHS), with a gap in small SHS component standards.
- Existence of testing facilities for batteries, cables, and panels, with some countries possessing current-voltage curves.
- There are privately run labs like CREEC at Makerere University, though their focus is primarily on lighting rather than solar products.
- The existence of a successful EU-funded lab in NREA, which has been operational since 2020 and conducts testing to IEC standards, performing over 500 tests. The lab covers maintenance, calibration, and license renewal, partly funded by testing income.
- Testing procedures for PV products are conducted by both private entities like ABM and academic institutions like the University of Nairobi and Strathmore University.

Regional conformity assessment bodies and PV certification

- There are existing regional testing and accreditation bodies like AFRAC for Africa and particularly in the context of solar water heaters.
- Accreditation for conformity assessment bodies generally inactive with national standard bodies.
- Most solar products are being imported and tested against the international standards through Pre-Export Verification of Conformity (PVoC).
- KEBS implements a mandatory certification scheme and collaborates with other EAC countries for mutual recognition of certifications.

Accreditation Process for Conformity Assessment Bodies:

- Accreditation pending for the entire UNBS lab, with efforts underway to align regional conformity assessment with IEC standards.
- Regional conformity assessment relies on pre-conformity checks, often conducted by international entities like TÜV Rheinland or SGS, although challenges persist with information dissemination and functionality within the EAC's standards office.
- Accreditation processes for conformity assessment bodies vary across countries in the region, with Kenya's Strathmore University potentially being accredited.

3.2.5.2 Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

Human capacities

- Lack of human capacity poses a significant challenge for regional standardization framework. Particularly the lack of personnel dedicated to standardization efforts, with some countries having only one or two individuals working on electrical equipment standardization.
- There is limited awareness and capacity building among stakeholders, insufficient political will for enforcing regulations, and the presence of inferior products in the market.
- Deficiency in governmental attention and funding, with reliance often placed on external sources like international or regional organizations for financial support.
- Deficiency in human capacities, with a limited number of experts and insufficient technical knowledge due to a lack of ongoing training.

Metrology and testing

- Limited testing facilities leading to high fees and delays.
- Inadequate equipment, understaffing, corruption, and weak border protection leading to the influx of low-quality product.
- Only a handful of countries in the region have testing laboratories capable of handling larger-scale testing for MW and grid-connected systems, with most focusing on smaller systems like SHS.
- Testing and metrology units are underfunded, with a focus on more immediate consumer safety concerns rather than PV products.
- There is the lack of clarity in certification processes for electrical professionals.
- Metrology and testing face obstacles due to the scarcity of labs with state-of-the-art equipment.
- There is a lack of commitment from the country to finance a solar lab, with other pressing concerns such as food testing taking precedence.

Accreditation and conformity assessment

- The predominant PVoC method for conformity assessment faces challenges due to porous borders, allowing sub-standard products to enter the market. (Christopher Carlsen - CLASP)
- The prevalence of non-compliant products, such as panels advertised with higher wattage than they deliver and mislabelling of products as AC instead of DC.

Market surveillance

- Challenges in information dissemination and functionality within the EAC's standards office.
- Issue of insufficient funding and while standardization is crucial, it often takes a backseat due to competing priorities. Additionally, the sector is donor-driven in nature. For instances, the World Bank's plug-and-play standards, which are condition for funding rather than a genuine demand from countries.
- Need for increased awareness among stakeholders regarding the benefits of quality standards.
- There is rampant smuggling of solar products due to limited market surveillance and corruption.
- Market surveillance is hindered by unofficial product routes, but efforts to empower consumers through toll-free platforms and awareness campaigns are underway.

3.2.5.3 Necessary interventions for the promotion of regional frameworks for solar QI

Metrology and testing

- The importance of creating testing facilities in each country to prevent the influx of low-quality products into the market.
- The needs of financing for assessment and testing, knowledge exchange, and supporting research and innovation to foster local advancements in solar technology.

Certification of products and services

- The Importance of IEC certificates for imported PV panels, with incentives such as customs or VAT reductions.
- The need for outsourcing testing to international companies for cost-effectiveness.

- Encouraging market players to leverage existing quality marks while demystifying the certification process.

Accreditation and conformity assessment authorities

- The need to establish a national and international committee for ongoing oversight and adaptation of international standards to regional contexts.

Capacity building

- Need for increased support and funding for organizations like UNBS, advocating for outsourcing testing to create a sustainable business model.

Creation of QI networks

- Efforts needed for regional collaboration through the EAC to streamline standards and testing procedures.
- Need for improved cooperation between national and international organizations, advocating for better communication and integration to align targets with regional needs.
- The need for collaboration among key stakeholders, including governments, energy ministries, standardization bodies, regulators, private sector associations, and civil society organizations.
- The importance of formalized mechanisms to ensure that efforts complement rather than contradict each other, For instance initiatives from organizations like the World Bank (WB) and the German Development Cooperation (GIZ) may not align due to various factors, including politics.

International standards and technical regulations that still require adaptation to the regional context.

- Need for organised effort towards standardization and quality assurance in the solar product sector in the region.
- A need for adopting IEC standards and each country should independently implement them.

Table 3-3. Interview insights summary for key stakeholders in EAC

Category	Findings
Standards/Technical Regulations Implemented	• Transfer of IEC standards to AFSEC standards upon general assembly acceptance, with a focus on local language translation. • Adoption of IEC standards in Uganda, including recent developments such as national standards for PV plug and play SHS and a code of practice by UNBS. • National-level adoption of IEC and ISO standards for solar products, with regional conformity assessment facilitated through VeraSol and CLASP. • - Kenya's implementation of a code of practice for PV installers.
Testing Procedures and Facilities for PV Products	• Presence of specialized testing labs for solar products, such as those operated by CREEC, certified by UNBS according to ISO 17025:2017. • Lack of testing facilities for inverters and batteries, particularly in the off-grid sector. • Initiatives by organizations like CLASP and Kijani contributing to testing and certification efforts in the region. • Challenges with some testing labs listed on the VeraSol website, with some locations currently non-functional.

	• Existence of UNBS labs for Solar Home Systems (SHS), with a gap in small SHS component standards. • - Privately run labs like CREEC at Makerere University focus primarily on lighting rather than solar products.
Accreditation Process for Conformity Assessment Bodies and PV Certification	• Existence of regional testing and accreditation bodies like AFRAC for Africa, particularly in the context of solar water heaters. • Accreditation for conformity assessment bodies generally inactive with national standard bodies. • Implementation of a mandatory certification scheme by KEBS, collaborating with other EAC countries for mutual recognition of certifications. • Accreditation pending for the entire UNBS lab, with efforts underway to align regional conformity assessment with IEC standards. • Challenges with information dissemination and functionality within the EAC's standards office regarding pre-conformity checks. • Accreditation processes for conformity assessment bodies vary across countries in the region.
Challenges and Necessary Interventions	• Lack of human capacity for regional standardization efforts. • Limited awareness and capacity building among stakeholders. • Deficiency in governmental attention and funding. • Challenges in metrology and testing, including limited facilities and lack of clarity in certification processes. • - Market surveillance challenges include information dissemination issues and rampant smuggling of solar products.
Necessary Interventions for the Promotion of Regional Frameworks for Solar QI	• Importance of creating testing facilities in each country to prevent low-quality products from entering the market. • Need for financing for assessment and testing, knowledge exchange, and supporting research and innovation. • Encouraging market players to leverage existing quality marks while demystifying the certification process. • Establishment of national and international committees for ongoing oversight of international standards. • - Increased support for organizations like UNBS and regional collaboration through the EAC.

3.3 Pacific Community (SPC)

The SPC comprises 22 member countries and territories in the Pacific Islands, with a combined population of around 11 million inhabitants [20]. The United Nations Department of Economic and Social Affairs (UNDESA) categorizes 14 of these members as small island developing states (SIDS). While these SPC members exhibit diverse characteristics and cultures, they all grapple with shared challenges—life in remote areas marked by limited human and natural resources, small economies, and distant markets. Their vulnerability extends to the impacts of external geopolitical and economic events, with an even greater susceptibility to the effects of climate change and escalating natural disasters [21]. It is imperative for Pacific Island governments to adopt renewable energy technologies and foster close cooperation with international and regional organisations as well as development partners to ensure sustained and resilient development in the face of these challenges.

The SPC is taking a proactive approach to establishing regulations, standards, and quality infrastructure guidelines within the solar energy sector in the Pacific region. However, The Pacific Islands must carry out the implementation of these regional guidelines, which requires national-level consultations to guarantee acceptance, appropriateness, and sustainability prior to execution. Some of these proactive approaches include the work done by The Sustainable Energy Industry Association of Pacific Islands (SEIAPI) in the development of guidelines, training standards, and workshops for solar PV systems.

The SPC is actively engaged in initiating regulations, standards, and quality infrastructure protocols for the solar energy sector in the Pacific region. However, the implementation of these regional guidelines in the Pacific Islands necessitates national-level consultations to ensure acceptance, suitability, and long-term viability before execution. Remarkable efforts in this regard include the initiatives led by The Sustainable Energy Industry Association of Pacific Islands (SEIAPI), which involves the development of sustainable energy technical guidelines, trainings, and workshops specifically for solar PV systems [21]:

- Grid-Connected PV Systems - Design & Installation guidelines.
- Stand Alone Power Systems (off-grid) - Design & Installation guidelines.
- Grid-Connected PV Systems with Battery Storage - Design & installation guidelines.
- Solar water pumping systems - Design & installation guidelines

The certification/accreditation scheme introduced by the Pacific Power Association (PPA) and SEIAPI in 2012 states that certified designers and installers should adhere to the above guidelines [22]. However, according to SEIAPI, the typical challenges faced in implementing these guidelines include the need to persuade donors and governments to adopt the guidelines for all new systems. It is recognized that achieving national adoption of these guidelines may necessitate legislative and regulatory changes at the national level. Furthermore, there is a demand for additional guidelines and standards for various technologies and their applications [22].

3.3.1 Regulations

Regulations of the electricity industry including solar PV systems differ from country to country in the Pacific Island Countries (PICS). The regulatory oversight is often administered via specific legislation in respective jurisdictions; and supporting regulatory instruments are developed thereof by the respective authorities or government agencies to provide necessary regulatory oversight of the electricity industry. For instance, in Papua New Guinea (PNG), which makes up almost 75% of the PICS population (excluding Australia and New Zealand), the regulatory oversight of the electricity industry is provided by the National Energy Authority (NEA) – a statutory authority established by an Act of Parliament. The NEA, among others, has the mandate to develop or adopt standards and regulatory instruments to administer the electricity industry in PNG. Some of the instruments under consideration include the Feed-in-Tariff policy for grid-connected solar PV systems.

Most PICs have a vertically integrated system where there is only one power utility, mainly a state-owned entity (SOE) that provides electricity services to the people. The regulators in the respective jurisdictions have the mandate to ensure these utilities comply with relevant regulatory requirements and uphold specific service standards.

There are Grid Codes that provide the technical rules and requirements of the respective power systems. And integration of variable renewable energy technologies such as solar PV systems into the main electricity grid follow the technical requirements provisioned in respective grid codes in certain jurisdiction (e.g. PNG).

3.3.2 Standards (incl. IEC/ISO compliance)

Certain Pacific Island nations adhere to standards established by the International Electrotechnical Commission (IEC) and the International Organisation for Standardisation (ISO), as well as standards from the United States (USA), Australia, and New Zealand. These standards include (additional standards are detailed in the referenced documents) [23] [24]:

- IEC 61215: Terrestrial photovoltaic (PV) modules - Design qualification and type approval
- IEC 61730 Photovoltaic (PV) module safety qualification
- UL Standard 1703 Flat Plate Photovoltaic Modules and Panels
- AS/NZS 4509 Stand-alone power systems
- AS/NZS 5033 Installation and safety requirements for PV Arrays.
- UL(IEC) 61646 Thin-film terrestrial photovoltaic (PV) modules—Design qualification and type approval.

3.3.3 Stakeholder mapping and identification of capacities

The stakeholders identified were categorised into three groups: key stakeholders responsible for standardisation, primary stakeholders overseeing the conformity assessment of Quality Infrastructure (QI), and secondary stakeholders involved in metrology and other facets of QI components.

During the desk research, 54 stakeholders were identified. A detailed compilation of mandates, full names, websites, and contact information for these stakeholders is available in *Annex II. Identified stakeholders*. 11 stakeholders actively contribute to the advancement and implementation of quality infrastructure frameworks in the Pacific Region. These stakeholders include:

- Pacific Area Standards Congress (PASC)
- Pacific Energy Regulators Alliance (OPERA)
- Educational Quality and Assessment Programme (EQAP)
- Pacific Regional Infrastructure Facility (PRIF)
- The Pacific Island Forum (PIF)
- The Sustainable Energy Industry Association of Pacific Island (SEIAPI)
- Pacific Power Association (PPA)
- Standards New Zealand (SNZ)
- Pacific Regional Environment Programme (SPREP)
- The Pacific Community (SPC)
- PV Lab Australia

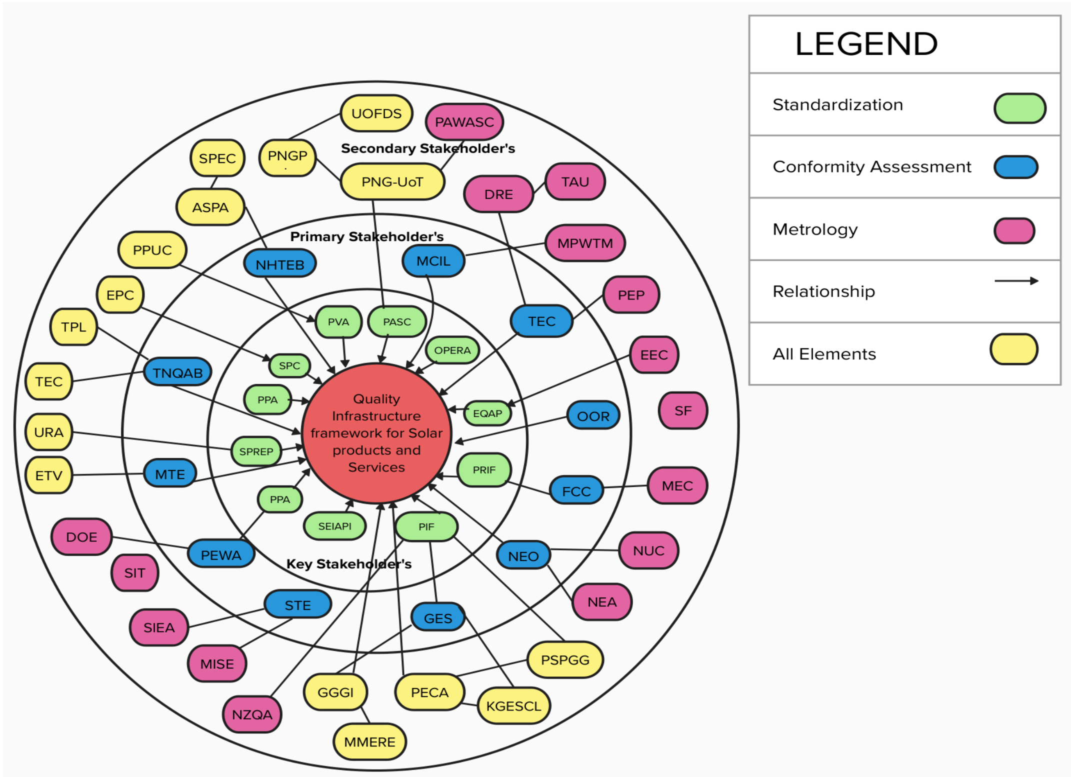

Figure 3-5. Stakeholder mapping in SPC (Author's representation)

3.3.4 Gender, digitalisation and climate change adaptation considerations

SPC is reviving the Pacific Energy and Gender Network and has formulated the Pacific Energy and Gender Network Strategic Action Plan (PEGSAP) 2020–2030 [25]. The strategic action plan adopts a multi-level approach to enhance the participation of women as entrepreneurs and professionals in the clean energy sector. These intervention levels include:

- Institutional Level: Existing and new regional and national energy policies will be tailored to address women's practical and strategic energy requirements. The aim is to encourage women's involvement in various stages of the clean energy value chain.
- Service Provider Level: Efforts will be made to augment employment opportunities for women within the clean energy workforce.
- Community Level: Initiatives will focus on fostering the engagement of women in energy-related decision-making processes within communities and households.
- Individual Level: Emphasis will be placed on enhancing women's knowledge, skills, and access to resources, enabling them to articulate their energy needs and actively participate in the clean energy value chain.

Through the Rural Women Light Up the Pacific Programme by United Nations (UN) Women and United Nations Development Programme (UNDP), women in Kadavu villages are trained as solar engineers. They establish solar workshops, assembling and installing panels for community households, providing maintenance and repairs, and training others. This challenges gender stereotypes, involving grandmothers and semi-literate women as engineers. Women actively participated from the program's inception, collaborating with men to manage community solar electricity. A solar committee, including three women out of five members, selects and trains engineers. Each household contributes to a fund, ensuring joint decision-making on fund usage, panel installation, and lighting decisions [26].

3.3.5 Stakeholder consultation results, conformity checks and gap analysis

To validate the findings of desk research and gain a deeper understanding of the QI framework within the SPC region, twelve key stakeholders were contacted for interviews. Subsequently, a total of Ten interviews were carried out involving 12 participants, comprising 8 males and 4 females to extract valuable insights and perspectives. The interviews included a comprehensive discussion, guided by five key topics, as outlined in the interview guidelines provided in *Annex I. Interview guides.* These key areas of discussion included the examination of existing regional QI frameworks for solar products.

Additionally, the interview delved into the identification of challenges and opportunities prevalent in the solar product domain within the region. It further explored the dynamics of cooperation and involvement among stakeholders, assessment of intervention needs and support requirements as well listing other important stakeholders identified during the interviews. The subsequent subsections present a detailed account of the responses gathered during the stakeholder interviews; the complete interview minutes can be found in *Annex V. Interview minutes.*

3.3.5.1 Status Quo – Existing regional QI frameworks for solar products

Standards/technical regulations implemented/under implementation in the region.

- Existing ineffective regional QI frameworks are based on a regional standard developed by SEIAPI.
- Solar panels must adhere to AS/NZS 5033 standard.
- Inverters must meet AS 4777.1 standards.
- Certificate of Compliance (CoC) are issued for completed solar power.
- Different components of QI have been covered in all the 18 States of the Pacific Region. Work has been done on Standards, metrology, and conformity assessment.
- There is a relevance of IEC 61215 for design qualification and type approval.
- ISO 2859 is used for sampling purposes. It is based on the acceptance quality limit (AQL), which is the maximum percentage of defective items that can be considered acceptable.
- There is a potential to adopt a revised AS/NZS 5033:2021 by New Zealand in the future).
- There is variation in standards application across region, with some countries adopting US-based standards.
- Regulatory measures in Samoa include Energy Efficiency (EE) Acts and Building Code for solar PV installations.
- There is lack of awareness regarding specific solar PV standards development in the region).
- There is ongoing development of solar PV standards within individual Pacific communities).
- The standards for solar controllers are perceived as complex.

Testing procedures and facilities for PV products

- There is scarcity of testing for solar PV system components in the region.
- The only *General Society of Surveillance* (SGS) in Auckland is NATA accredited for testing.
- Testing procedures and facilities for PV products are lacking in the region.
- There are inspections using AS/NZS 3000 from the AC side of the solar system.
- Lack of local testing for parts or components of solar PV systems.

- Lack of awareness regarding testing procedures and facilities for PV products in the Pacific region.

Regional conformity assessment bodies and PV certification

- Absence of regional conformity assessment bodies for solar PV products).
- Certification processes typically handled through the CoC process.
- IEC 61730 certification is required for solar panels in the region.
- Accreditation process for conformity assessment still in the developmental phase.
- Existing certifications for PV products based on internationally recognized frameworks.

Accreditation Process for Conformity Assessment Bodies:

- Accreditation process for conformity assessment bodies align with IEC 61730 and is still in the developmental phase.
- Regional specialization in solar PV accreditation is lacking.
- There is compliance with AS/NZS 3000 for consistency in system designs).

3.3.5.2 Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

Human capacities

- Challenges faced by smaller markets like New Zealand, emphasizes the need for strategic focus on stimulating solar demand and building human capacities.
- Lack of human capacity underscores the need for training to ensure competent operation and maintenance of solar systems.
- Limited human capacities in both government and the private sector are identified as a major challenge, with concerns raised about substandard products entering the market due to capacity constraints.
- Standards development need technical expertise to adopt and/or adapt standards for implementation.

Metrology and testing

- There is reliance on manufacturers' subscribed standards and the lack of resources for independent testing.
- The absence of local metrology and testing facilities, particularly in Fiji, hinders the ability to verify product quality independently.
- Absence of local metrology and testing facilities in most Pacific Island Countries (PICs) requires the reliance on test certificates from accredited organizations.
- PV Lab Australia is the only lab in the Pacific.

Accreditation and conformity assessment

- The absence of accreditation, conformity assessments, and standards, contributing to challenges in ensuring safety and quality.

Market surveillance

- Capacity and resource constraints are identified as hindrances to continuous market surveillance and monitoring.

- Market surveillance faces obstacles due to communication gaps, capacity constraints, and a lack of standards for ensuring product conformity and safety.

Critical challenges

- Limitations in human capacities, small market challenges, absence of test facilities, weak enforcement, and monitoring, lack of awareness, inadequate regulation, lack of accreditation and conformity assessments are critical challenges in regional implementation of QI framework.

3.3.5.3 Necessary interventions for the promotion of regional frameworks for solar QI

Metrology and testing

- Stressed the importance of due diligence to prevent duplication of key programs and activities and optimize resource allocation within the region.
- The prioritization of ensuring the capacity and capability to verify test certificates over mandating test facilities, driven by the considerable setup costs.
- The need for regional training for testing and metrology.

Certification of products and services

- Necessity for interventions, including certification of products and services.
- The necessary for obtaining approval and certification from the Energy Commission for all designs and specifications.

Accreditation and conformity assessment authorities

- Necessity for interventions, including accreditation and conformity assessment authorities.

Market surveillance

- Enforcing regulations for product selling and importing through market surveillance.
- The increased need for support from donors which will encourage competition, which drive both quality and affordability in the solar product market.

Capacity building

- The crucial need for capacity development and infrastructure building, encompassing both human resources and physical structures.
- The need for evaluating cooperation through a sectorial approach to implement sector plans, along with the necessity for mid-term reviews to ensure quality assurance).
- The need for review and evaluation of capacity-building efforts to facilitate the delivery of regional workshops to enhanced awareness in the solar sector.
- The requirement for assistance from donors, fostering competition to propel both the quality and affordability in the market for solar products.
- Local regulators need to be trained and certified to verify solar PV products coming into their respective countries.

Creation of QI networks

- Emphasis on the creation of QI networks through training syllabuses, meetings, workshops, and international cooperation.

- The need for establishing partnerships and collaborations with other countries for the development and integration of renewable energy technologies.
- Critical need of continuous engagement and consultation with all relevant stakeholders since the current awareness levels are not sufficiently effective.
- The necessity for coordinated efforts among relevant stakeholders to harmonize and efficiently manage all initiatives within the QI framework.
- The need for collaboration among key stakeholders for sharing success ideas through meetings, workshops, and training sessions to facilitate QI framework development and enforcement.

International standards and technical regulations that still require adaptation to the regional context.

- There is a need for a review of existing international standards to better align with the specific context of the Pacific region (Jane Romero - PRIF and Solomone Fifita - SPC).
- The need for international cooperation in shaping global best practices for solar Quality Infrastructure in the region.
- Advocacy for a country-specific approach to interventions in QI frameworks for solar products since developing regional frameworks may not effectively serve their intended purpose.

Table 3-4. Interview insights summary for key stakeholders in SPC

Category	Findings
Standards/Technical Regulations Implemented	• Ineffective regional QI frameworks based on a SEIAPI standard. • Certificate of Compliance (CoC) issued for completed solar power installations. • Variation in standards application across the region, with some countries adopting US-based standards. • Regulatory measures in Samoa include Energy Efficiency (EE) Acts and Building Code for solar PV installations. • Lack of awareness regarding specific solar PV standards development in the region. - Ongoing development of solar PV standards within individual Pacific communities. • Perceived complexity of standards for solar controllers.
Testing Procedures and Facilities for PV Products	• Scarcity of testing for solar PV system components in the region. • Lack of local testing for parts or components of solar PV systems. • -Lack of awareness regarding testing procedures and facilities for PV products in the Pacific region.
Accreditation Process for Conformity Assessment Bodies and PV Certification	• Absence of regional conformity assessment bodies for solar PV products. • Certification processes typically handled through the CoC process. • Accreditation process for conformity assessment still in the developmental phase. • Existing certifications for PV products based on internationally recognized frameworks. • Regional specialization in solar PV accreditation is lacking
Challenges and Necessary Interventions	• - Limitations in human capacities, small market challenges, absence of test facilities, weak enforcement and monitoring, lack of awareness, inadequate regulation, lack of accreditation and conformity assessments are critical challenges in regional implementation of QI framework.
Necessary Interventions for the Promotion of	• Importance of due diligence to prevent duplication of key programs and activities and optimize resource allocation within the region.

Regional Frameworks for Solar QI	• Prioritization of ensuring the capacity and capability to verify test certificates over mandating test facilities. • Necessity for interventions, including certification of products and services. - Necessity for obtaining approval and certification from the Energy Commission for all designs and specifications. • Necessity for interventions, including accreditation and conformity assessment authorities. • Enforcing regulations for product selling and importing through market surveillance. • Increased need for support from donors to encourage competition driving both quality and affordability in the solar product market. • Crucial need for capacity development and infrastructure building, encompassing both human resources and physical structures. • Review and evaluation of capacity-building efforts to facilitate the delivery of regional workshops to enhance awareness in the solar sector. • Local regulators need to be trained and certified to verify solar PV products coming into their respective countries. • Creation of QI networks through training syllabuses, meetings, workshops, and international cooperation. • - Establishment of partnerships and collaborations with other countries for the development and integration of renewable energy technologies.

3.4 Regional and trans-regional stakeholder network and cooperation analysis

Drawing insights from the findings of the desk review and stakeholder interviews, the subsequent analysis can be formulated concerning the network and collaboration of stakeholders, both regionally and trans-regionally.

Several vital components seem to be lacking in the partially existing QI framework for solar products and services in the SPC region. Firstly, the establishment of stakeholder networks, including trade associations, alliances, and economic organizations within the region, is absent, and this is essential for fostering local collaboration. Furthermore, there is a deficiency in cooperation mechanisms, such as international treaties, joint research projects, and shared infrastructure, which are crucial for promoting collaboration across different regions. Additionally, the absence of effective information flows across regions is evident. Addressing these gaps is imperative to enhance the overall effectiveness of the QI framework for solar products and services in the SPC region.

While in the EAC, there exists a degree of collaboration among certain prominent stakeholders. For example, in Uganda, there is cooperation between UNREEEA and UNBS. However, there is no transnational/regional collaboration.

3.5 Recommendations and roadmap for the inclusion of international standards into regional frameworks/creation of the regional capacity and institutional structure where they currently don't exist.

Based on the comprehensive analysis of the current state of the QI framework in the EAC and SPC regions from desk review, coupled with insights from key stakeholder interviews, the following specific and targeted recommendations, and roadmaps are proposed for the inclusion of international standards into regional frameworks and the creation of regional capacity and institutional structures where they are presently lacking.

3.5.1 East African Community

3.5.1.1 Regional recommendations

1. Institutional framework

Despite the efforts made by key stakeholders such as the AFSEC, AFRAC, and individual national standard bureaus to promote QI in the EAC region, the sustainable implementation of QI across the region necessitates the establishment of a dedicated regional organization for QI in the East African Community Region (QIER). This organization would collaborate closely with entities such as the ISA, EACREEE, UNIDO, National Standard Bureaus, and relevant energy /RE ministries under the framework of the STAR-C project. The QIER mandate will be to supervise the execution, enforcement, and monitoring of QI initiatives throughout the region.

The absence of a comprehensive regional QI framework, despite each member country having its own standards, and the collective lack of capacity to enforce these standards, presents a significant opportunity. This highlights the need to develop a unified framework that can be customized to meet the specific needs of individual countries, rather than attempting to reconcile multiple existing national standards, policies, and guidelines.

- The initial stage in setting up the QIER involves creating a Regional Technical Committee (RTC) dedicated to QI. This committee's composition should encompass members from various entities, including EACREEE, the EAC, representatives from National Standards Bureaus like KEBs, and regional organisations specializing in QI such as AFRAC and AFSEC.
- The QIER is expected to serve multiple functions, including:
    - Coordinate with National Standards Bureaus, regulatory authorities, industry associations, and other stakeholders to promote harmonisation and consistency in the implementation of standards across different countries within the region.
    - Initiate enforcement measures via National Standards Bureaus against products and companies that fail to comply, which may involve issuing warnings, imposing fines, recalling products, and resorting to legal actions as needed to safeguard consumers and uphold market credibility.
    - Conduct regular market surveillance activities to monitor the quality and safety of solar products available in the market, including inspections, product sampling, and testing.
    - Create QI regional guidelines for National Standards Bureaus. These guidelines would serve as a comprehensive resource of best practices aimed at:
        - Simplifying testing and certification processes for solar products and services
        - Strengthening regulatory oversight to ensure that products meet advertised specifications and are correctly labelled.
    - Foster partnerships and collaboration through conferences and working groups involving international organizations, National Standards Bureaus, development agencies, and donor institutions to share experiences and exchange information.
    - Facilitate training, capacity building, and awareness campaigns for stakeholders from private, public, and civil society sectors involved in implementing and enforcing QI at the national level. This involves organizing training sessions, coordinating knowledge dissemination events, and supporting training and research programs financially.

2. Standardization:

- The transfer of IEC standards to regional standards, coupled with local language translation, should be actively promoted, and accelerated across all member states of the EAC. This harmonization would ensure consistency and facilitate smoother integration of regional standards.
- Best practices observed in member states, such as Kenya's code of practice for PV installers and the operation of specialized testing labs by organizations like CREEC, should be shared and promoted across the region. This would encourage knowledge sharing and replication of successful initiatives, further bolstering the regional QI framework.
- Efforts should be directed towards building capacity, providing technical assistance and awareness to relevant stakeholders such as KEBs involved in the implementation and enforcement of standards. This includes training programs for regulators, testing laboratories, and industry professionals to enhance their understanding and proficiency in adhering to and enforcing standards.

3. Certification and conformity assessment bodies:

- Regional conformity assessment mechanisms, such as VeraSol and CLASP, should be further strengthened and streamlined to facilitate the certification process for solar products. This would ensure that products meeting regional standards are readily identifiable and accessible to consumers across the EAC.
- Advocate for mutual recognition of certifications among EAC member states to streamline trade processes and eliminate duplication of conformity assessment requirements. KEBS' mandatory certification scheme can serve as a model for other countries within the EAC, with efforts focused on aligning certification processes and standards to facilitate mutual recognition agreements.
- Support standardizing accreditation processes for conformity assessment bodies across the region, drawing inspiration from internationally recognized standards such as those outlined by the IEC. This standardization will promote consistency, transparency, and reliability in conformity assessment activities within the EAC.

4. Metrology and testing:

- Given the lack of testing facilities, particularly in the off-grid sector, initiatives should focus on establishing or expanding testing laboratories specifically for inverters and batteries. Outsourcing testing to organisation such as CREEC could be a viable short-term solution while local capacities are developed.
- Capacity building programs should be implemented to train local technicians and professionals in testing procedures and standards compliance.
- While existing labs like CREEC primarily focus on lighting products, efforts should be made to support the diversification of their testing capabilities to include a wider range of solar products. Privately-run labs should encourage which can play a significant role in complementing the efforts of government agencies and academic institutions in testing and certification.
- Create joint working group to facilitate the collaboration between private entities and academic institutions like the University of Nairobi and Strathmore University. This collaboration can lead to the development of comprehensive testing procedures and capacity building initiatives.

- Promote the development and strengthening of local testing facilities within the region to reduce dependence on international entities for pre-conformity checks. This can be achieved through investment in infrastructure, technology transfer, and capacity building initiatives aimed at empowering local laboratories to conduct comprehensive testing of solar products in line with international standards.

3.5.1.2 Roadmap for implementation

Focal area	Short term 1 year	Mid term 2- 3 years	Long term 3 – 5 years
1. Institutional Framework	• Establish the Regional Technical Committee (RTC) dedicated to QI • Initiate coordination with National Standards Bureaus and regulatory authorities to promote harmonization. • Conduct market surveillance activities to monitor product quality and safety • Begin drafting QI regional guidelines for National Standards Bureaus.	• Expand the scope of the RTC to include more stakeholders and regional organizations. • Finalize and disseminate QI regional guidelines for National Standards Bureaus	• Consolidate the role of the QIER and RTC in overseeing QI initiatives. • Establish mechanisms for ongoing evaluation and improvement of regional QI frameworks.
2.Standardization	• Promote the transfer and translation of IEC standards to regional standards • Share best practices among member states and provide technical assistance to relevant stakeholders	• Accelerate the transfer and translation of IEC standards to regional standards • Monitor the implementation of best practices and provide ongoing support to stakeholders	• Achieve full integration and adoption of regional standards across all member states. • Promote continuous improvement and innovation in QI standards and practices.
3. Certification and conformity assessment	• Strengthen regional conformity assessment mechanisms • Advocate for mutual recognition of certifications among EAC member states • Support standardizing accreditation processes for conformity assessment bodies	• Enhance the capacity and efficiency of regional conformity assessment mechanisms • Facilitate mutual recognition agreements among EAC member states. • Ensure the standardization of accreditation processes for conformity assessment bodies.	• Ensure the sustainability and effectiveness of regional conformity assessment mechanisms. • Strengthen mutual recognition agreements and harmonization efforts
4. Metrology and testing	• Initiate efforts to establish or expand testing laboratories for inverters and batteries. • Implement capacity-building programs for local technicians and professionals • Support diversification of testing capabilities of existing labs like CREEC • Establish joint working groups to facilitate collaboration between private entities and academic institutions	• Strengthen the capabilities of existing testing laboratories. • Expand training programs for local technicians and professionals. • Encourage further collaboration between private entities and academic institution	• Establish a network of well-equipped and accredited testing laboratories across the region. • Institutionalize capacity-building programs to ensure a skilled workforce in metrology and testing. • Foster a culture of collaboration and knowledge sharing among all stakeholders involved in QI for solar products.

Figure 3-6. Roadmap for the implementation of QI in the East Africa Region

3.5.2 Pacific Community

3.5.2.1 Regional recommendations

1. Institutional framework

- Even though stakeholders such as SPC, PPA and SEIAPI have made significant efforts towards the promotion of QI in the Pacific region, the long-term implementation of QI requires of the establishment of a regional **QI organization for the Pacific Region (QIPR)**, which, working together with ISA and PCREEE within the context of the STAR-C project, will have the mandate of overseeing the implementation, enforcement and monitoring of QI in the region. Considering that there is a lack of a common regional framework for QI and that many countries still lack the capacity to enforce, supposes a **major opportunity to jointly develop a common framework that can be further adapted to country-level needs,** rather than developing a framework that reconciles several already existing national policies and guidelines.
- The first step towards establishing the QIPR is the establishment of a **Regional Technical Committee (RTC) for quality infrastructure**, whose members should include: PCREEE, the SPC, representatives of regional standard bodies and regional organizations with expertise in QI, such as PPI and SEIAPI.
- The QIPR should fulfil several roles including:
    - Harmonising **relevant definitions for QI in solar PV**, particularly regarding solar PV services.
    - Development of **regional guidelines for quality infrastructure**: These guidelines are targeted towards local authorities, including ministries and standardization agencies and should become a **repository of best practices** for:
        - Testing of solar components
        - Conducting certification processes for solar PV products and services
        - Identifying relevant international standards and products and services that comply with them.
        - Identifying accredited conformity assessment bodies.
    - Support the **adaptation of regional guidelines into national standards** via policy advocacy, knowledge dissemination events and technical assistance to national level stakeholders.
    - **Facilitate training and capacity building** initiatives for private, public and civil society stakeholders at the national level active in the implementation and enforcement of QI through hosting trainings, arranging knowledge dissemination events and funding training programmes.
    - Support the creation of **nexus between international standardization experts and organisations, and regional stakeholders** through events, seminars, and networking events.

2. Standardization:

- Develop **regional guidelines for standardization**, which can be based on the guidelines for design and installation of PV systems developed by SEIAPI and the standards implemented in Australia and New Zealand. Furthermore, considering that there is awareness and implementation of the IEC 61730 and IEC 61215, the creation of guidelines for the region should start with an assessment of the following standards:
    - IEC 61646 for PV modules
    - IEC 62109 for inverters
    - IEC 62093 for inverters
    - IEC 62548 for design and installation
    - IEC 60464 for design and installation
    - IEC 61724 for performance monitoring
    - IEC 62257 for off-grid and rural electrification
    - IEC 62738 for utility-scale PV
    - ISO/IEC 17025 for competence of testing laboratories
    - ISO/IEC 17067 for product certification

- Furthermore, national standards can be used as a starting point for the development of the regional guidelines. Including AS 4777.1 standards for inverters, AS/NZS 5033:2021

3. Certification and conformity assessment bodies

- Facilitate knowledge exchange between the QIPR and international experts in certification and conformity assessment to build their capacity on best practices and conduction of certification processes.
- **Integrate local conformity assessment bodies to the RTC and the QIPR.** This process should start via an assessment of the current certification processes that the conformity assessment bodies currently conduct (if there are). In those countries where the conformity assessment bodies have not yet been established, technical assistance should be provided for their establishment.
- Jointly develop **regional guidelines for the certification of PV products and services,** these guidelines should provide overall insights on the basic components of a certification process as well as good practices to both conduct a certification and identify certified products. These guidelines are aimed at the public sector so enforcement authorities can conduct audits and identify QI-compliant solar products and services.
- Starting points for these guidelines can be the existing certificate of compliance (CoC) framework for completed solar installation, the implementation of standards IEC 61730 and the AS/NZS 3000 framework for inspections.

- In the long term, and once sufficient local capacity has been achieved, it is recommended that the **QIPR supports the accreditation of local conformity assessment bodies**, so their certifications become internationally recognised.

4. Metrology and testing

- As a first step and considering the lack of testing facilities in the region, it is recommended that, in the framework of the RTC and the QIPR, **a technical working group of testing and metrology is established**, this group will gather technical experts and researchers from the region to consolidate the existing knowledge on metrology and testing of PV products, and will become a platform to further build local capacities on the topic through the organisation of conferences, events and cooperation with international experts.
- In the mid-term, two processes are recommended in parallel, the development of **regional guidelines for testing** and the mobilisation of funding for the **establishment of a regional testing facility,** this entails establishing specialized training facilities equipped with state-of-the-art technology for testing and certification.
- The technical working group should develop a series of training materials on best practices for testing of PV products, aimed at building the necessary local capacity to perform PV component testing locally.

3.5.2.2 Roadmap for implementation

Component/timeline	Short term 1 year	Mid term 2- 3 years	Long term 3 – 5 years
1. Institutional Framework	• **Establishing Regional Technical Committee (RTC) in QI** • Gathering of relevant QI framework • Draft regional QI guidelines • Promote nexus with international experts and organisations via webinars	• **Establishing Regional QI Organization for the Pacific Region (QIPR)** • Development of training materials in implementation and enforcement of QI for solar PV systems. • Conduction of first Pacific Standardization workshop	
2.Standardization	• Harmonization of categories and definitions for solar PV products and services • Establishment of technical working group on standardization • Assessment of standards currently implemented • Meetings and consultations for the development of regional guidelines	• **Development of regional guidelines for standardization**	• Support the adaptation of regional guidelines into national standards
3. Certification and conformity assessment	• Knowledge exchange between QIPR and international experts via workshops and meetings	• Integration of local conformity assessment bodies to the RTC and QIPR • **Development of regional guidelines for the certification of PV products and services**	• **Supporting the accreditation of local conformity assessment bodies**
4. Metrology and testing	• Establishment of technical working group for testing and metrology • Assessment of possible sources for funding	• **Regional guidelines for testing** • Development of training materials on best practices for testing of PV components	• **Establishment of a regional testing facility**

Figure 3-7. Roadmap for the implementation of QI in the Pacific Region

4 Critical stakeholders for roadmap implementation (e.g., metrological centres, universities, certification bodies)

In establishing a robust roadmap for the implementation of QI within the solar sector in the SPC and EAC, it is essential to engage critical stakeholders. These stakeholders, including metrological centres, universities, certification bodies, and others are instrumental in shaping quality assurance and standardization practices within the industry.

4.1 East Africa Community critical stakeholders for roadmap implementation

Table 4-1. EAC critical stakeholders for roadmap implementation

Stakeholder	Role	Involvement
East African Community (EAC)	Provide overarching governance and coordination for regional QI initiatives	Develop policies, allocate resources, and establish regulatory frameworks to support the implementation of QI standards.
National Standards Bodies (e.g., KEBS, UNBS)	Implement and enforce QI standards at the national level	Develop national standards aligned with regional frameworks, conduct conformity assessments, and oversee market surveillance activities
East African Centre for Renewable Energy and Efficiency (EACREEE)	Facilitate coordination and capacity building for renewable energy initiatives within the EAC region.	Provide technical assistance, organize training programs, and promote collaboration among stakeholders in the renewable energy sector
African Electrotechnical Standardization Commission (AFSEC)	Develop and promote regional QI standards for electrical products, including solar products	Lead standardization efforts, provide technical expertise, and collaborate with national standards bodies within the EAC.
Solar Product Manufacturers and Importers	Ensure compliance with regional QI standards for their products	Participate in conformity assessment processes, adhere to certification requirements, and support capacity building initiatives
Testing Laboratories and Certification Bodies (e.g. CREEC)	Conduct testing and certification of solar products to ensure compliance with QI standards	Expand testing capabilities, provide technical expertise, and collaborate with national standards bodies to streamline certification processes
Universities and Research Institutions	Provide research, training, and technical expertise in QI-related fields	Conduct research on QI best practices, offer training programs for industry professionals, and contribute to the development of testing protocols

Consumer Protection Organizations	Advocate for consumer rights and product safety in the solar energy sector	Monitor market surveillance activities, raise awareness about QI standards among consumers, and provide feedback on product quality.
International Development Partners and Donor Agencies e.g ISA, UNIDO, IRENA, World Bank	Provide funding and technical assistance for QI initiatives in the EAC region	Support capacity building programs, facilitate knowledge sharing, and promote regional collaboration in the implementation of QI frameworks
African Union(AU) and African Development Bank(AfDB)	Support regional integration and development initiatives	Provide funding and technical support for QI projects, align regional QI efforts with broader development objectives.

4.2 The Pacific Community critical stakeholders for roadmap implementation

Table 4-2. SPC critical stakeholders for roadmap implementation

Stakeholder	Roles	Involvement
National government agencies and ministries e.g. Ministry of Transport and Energy - Tokelau	Oversee and regulate the solar energy sector at the national level, ensuring compliance with standards	Collaboration with government agencies for the establishment of national standards bodies for roadmap implementation
NGOs and Donor Organizations e.g. ISA, UNIDO, IRENA, World Bank	Provide support, funding, and expertise for capacity-building programs and infrastructure development	Collaboration with NGOs and donor organizations for financial and technical support in implementing the roadmap
Regional government bodies e.g. PRIF, PIF, SPC and, PCREEE	Work together with national governments to facilitate a coordinated regional initiative, encouraging and backing private sector investments in renewable energy (RE) and energy efficiency across the SPC region.	Active participation in regional collaborations and initiatives to align QI framework across the region
Trade associations and alliances e.g. SEIAPI, PPA, PECA, OPERA, PASC	Facilitate collaboration and information exchange among Pacific Island Countries (PICs) through networks and alliances	Active participation in the establishment of networks, trade associations, and alliances to develop and harmonize regional QI framework
Private sector and consumer advocacy groups e.g. Kiribati Green Energy Solution Company Limited- Kiribati	Represent the interests of consumers in ensuring the quality and safety of solar products	Collaboration with consumer advocacy groups to advocate for and enforce adherence to international standards

National standards bodies e.g. Standards New Zealand	Responsible for overseeing and developing standards for solar products at the national level	Collaboration with national standards bodies to align regional standards with global best practices.
International Standards Organizations e.g. IEC, ISO	Provide guidance on global best practices and standards for the solar energy sector	Collaboration with international standards organizations to align regional standards and ensure compliance with global benchmarks
Metrological Centres e.g. PV lab Australia	Essential for ensuring accurate measurements and adherence to standards in the solar energy sector	Collaboration with metrological centres for the accreditation of testing facilities and enhancement of scientific and industrial metrology
Universities and Educational Institutions e.g. National Higher and Technical Education Boards, EQAP	Responsible for the development and implementation of capacity-building programs for individuals in the solar energy sector.	Collaboration with universities to design and deliver certification opportunities and training sessions.
Conformity assessment bodies e.g. Tonga National Qualifications and Accreditation Board	Responsible for systematically evaluating and certifying solar products against established standards	Active participation in the formation of a conformity assessment body and adherence to international accreditation standards
Certified Testing Laboratories e.g. PV lab Australia	Conduct testing for solar PV system components to ensure compliance with standards	Collaboration with certified testing laboratories for accreditation and adherence to international testing standards

5 Capacity Building and Resource Requirements for the effective adoption and use of the standards

The effective adoption and use of standards in the solar energy sector in both regions require a strategic and sound approach to foster regional and local capacity and set up the required QI infrastructure. These initiatives will ensure that stakeholders are well-equipped with the knowledge, equipment and skills needed to adhere to international standards, ultimately contributing to the development of a robust Quality Infrastructure.

5.1 Capacity building for effective adoption and use of standards

In the rapidly evolving landscape of the solar energy sector, the adoption and adherence to international standards play a pivotal role in ensuring the quality, safety, and sustainability of solar products and services in both regions (SPC and EAC). Capacity building requirements for establishing local QI frameworks revolves around the development and provision of training and awareness raising in the areas of:

- The definition of solar PV products and services
- Quality infrastructure as a framework along with its key components
- Understanding of international standards and certifications and how to identify compliant products and services.
- Guidelines and best practices for testing, conformity assessments and certification of solar PV products and services.

The capacity building aspects include a spectrum of strategic interventions, ranging from targeted training programs to collaborative initiatives with educational institutions and the establishment of certification frameworks (see Table 3 below). The objective is to equip professionals, regulatory bodies, and industry stakeholders with the expertise required to understand, implement, and continually uphold international standards within the dynamic and ever-expanding solar energy domain.

Table 5-1.. Capacity building interventions to strengthen QI.

Capacity building	Objective	Components
Training programs	Develop and implement comprehensive training programs for stakeholders involved in the solar energy sector	● Technical training on standards compliance. ● Capacity building for metrology and testing. ● Educational programs for regulatory bodies. ● Certification courses for industry professionals.
Awareness campaigns	Raise awareness about the importance of adhering to international standards in the solar energy sector	● Public awareness campaigns. ● Industry-focused workshops. ● Educational materials in local languages
Certification initiatives	Establish certification opportunities to enhance the skills of professionals in design, installation, and	● Accredited certification courses. ● Recognition of certified professionals. ● Regular recertification programs.

	maintenance of solar products.	
Collaboration with educational institutions	Foster partnerships with universities and educational institutions for sustained capacity building	● Integration of solar standards in curricula. ● Research collaborations on standards development.
Online Learning Platforms	Provide accessible and flexible learning opportunities for stakeholders	● Development of e-learning modules. ● Webinars and virtual training sessions. ● Online certification programs.
Train-the-Trainer programs	Build a pool of trainers equipped to deliver standardized training programs.	● Master trainer programs. ● Training-of-trainers workshops. ● Continuous professional development for trainers.

- A relevant recommendation in the development of capacities is to promote the participation of female engineers and technicians in quality infrastructure, as training in QI has the potential to create new job openings and increase the participation of women in the sector.

5.2 Resources for effective adoption and use of standards

The effective adoption and application of international standards require a strategic allocation of resources provided in Table 5-2 below.

Table 5-2. Resource requirements for QI implementation

Resource	Requirement	Components
Accreditation and testing facilities	Establish or enhance existing facilities for testing and accreditation.	● Investment in testing equipment. ● Infrastructure development for testing laboratories. ● Recruitment of skilled personnel.
Regulatory oversight	Strengthen regulatory bodies for effective enforcement	● Recruitment and training of regulatory personnel. ● Establishment of monitoring and enforcement mechanisms. ● Collaboration with law enforcement agencies
Technological infrastructure	Implement technology solutions to support standards adoption.	● Development of online platforms for certification processes. ● Database management systems for tracking compliance. ● Technology upgrades for metrology and testing. ● Expertise and investment required to set-up a labelling programme that allows for: ○ A certification for end-users to verify that they are acquiring to a product or service compliant with the QI framework.
Capacity building funds	Allocate funds for ongoing capacity-building initiatives.	● Budget for training programs. ● Financial support for certification initiatives
International collaboration	Allocate resources for collaboration with	● Participation in international forums and conferences. ● Membership fees for global standards organizations.

budget	international bodies.	• Funding for joint research projects.
Certification and recognition budget	Allocate funds for the establishment and maintenance of certification programs	• Certification examination costs. • Marketing and promotion of certified professionals.
Public awareness campaigns	Budget for campaigns to inform the public about the importance of standards	• Advertising and promotional materials. • Community engagement events. • Public relations and media outreach.
Continuous monitoring and evaluation	Establish mechanisms for ongoing monitoring and evaluation	• Evaluation tools and software. • Regular audits and assessments. • Feedback mechanisms for continuous improvement

Table 5-3. Time and cost requirements for PV component certification in the US [2]

	PV modules	Inverters Central	Inverters String/Micro	Combiner Box	Support Structure
Standard	IEC 61215	IEC 62109	IEC 62109	IEC 61439-2	UL 2703
Time	45 - 60 days	5 - 7 months	4 – 6 months	3 – 5 months	5 – 8 months
Cost	USD 50,000 – USD 60,000	USD 80,000 – USD 110,000	USD 40,000 – USD 70,000	USD 40,000 – USD 80,000	USD 50,000 – USD 100,000
	Regionally centred	Regionally centred	Regionally centred	Locally/Manufacturer Centred	Regionally centred

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7 Annexes

7.1 Annex I. Interview guides.

Introduction

- Introduce yourself and the company you represent
- Introduce the purpose of the research
- Introduce purpose of interview

Interview guide.

Topic	Questions
Current Quality Infrastructure Framework	● What are the current standards/technical regulations for solar PV products/services being implemented in the region (EAC/SPC)? ● Could you indicate which international standards are referenced for the development/adaptation of the regional ones? ● Are there any standards/technical regulations for solar PV products/services under development or soon to be published? ● Are there facilities or laboratories where solar products are tested and/or measured? Are these facilities well equipped and follow any standard procedures? ● Which parts or components of solar PV systems are currently tested in the region? ● Are there currently regional conformity assessment bodies that conduct certification processes for solar PV products and services? ● How is the accreditation process that conformity assessment bodies/authorities undergo? ● Are the existing certifications for PV products and services based on internationally recognized frameworks? Which? ● · Are there any regional accreditation bodies specialized in solar PV products and services? Which?
Challenges and Opportunities	● What are the major challenges in the implementation and adherence of technical regulations and standards for solar PV products and services, in general, and particularly in the areas of: ○ Human capacities ○ Metrology and testing ○ Certification of products and services ○ Accreditation and conformity assessment authorities ○ Market surveillance ● Please provide specific instances or examples that highlight these challenges ● In your opinion, out of the challenges identified above, what are the critical challenges that should be addressed as priorities? ● Do you know of any successful initiatives or projects that have supported the improvement of quality infrastructure (QI) frameworks for solar PV in the region (EAC/SPC)? If so, can you name and explain them? ● Can you identify any success factors that can support the further promotion of Quality Infrastructure for solar PC systems in the region?
Stakeholder Involvement and Cooperation	● Who do you consider that be the key stakeholders responsible for promoting and implementing QI frameworks for solar PV products and services in the region? ● How do evaluate cooperation between the different institutions in charge of designing and implementing QI and the solar PV industry and other private sector stakeholders? ● ·How can cooperation among key stakeholders facilitate the development and enforcement of a QI framework?

Interventions and need for support	● What type of interventions do you consider necessary to further promote QI frameworks for solar PV products and services in the region (EAC/SPC), in general, and particularly in the areas of: o Metrology and testing o Certification of products and services o Accreditation and conformity assessment authorities o Market surveillance o Capacity building o Creation of QI networks? ● Which of the following international standards/frameworks still need to be implemented or adapted in the region (EAC/SPC)? o IEC 61730 for PV modules o IEC 61215 for PV modules o IEC 61646 for PV modules o IEC 62109 for inverters o IEC 62093 for inverters o IEC 62548 for design and installation o IEC 60464 for design and installation o IEC 61724 for performance monitoring o IEC 62257 for off-grid and rural electrification o IEC 62738 for utility-scale PV o ISO/IEC 17025 for competence of testing laboratories o ISO/IEC 17067 for product certification o Other, please specify. ● To what extent do you see opportunities for international cooperation in shaping global best practices for solar QI in the region (EAC/SPC)
Stakeholder mapping	● Can you provide us with the contact of other organisations that are relevant to the deployment of Quality Infrastructure for solar PV products and services in the region (EAC/SPC)?

7.2 Annex II. List of identified stakeholders.

7.2.1 A. Pacific Community (SPC)

Key stakeholders

No.	Key Stakeholder	Contact Person	Contact Email	Phone-Number
1	Pacific Area Standards Congress (PASC)	PASC Secretariat	pasc@bsn.go.id	
2	Pacific Energy Regulators Alliance (OPERA)	Col. (Ret'd) Siamelie Latu (Chairperson OPERA)	s.ramadicbd@gmail.com	676) 7717539
3	Educational Quality and Assessment Programme (EQAP)		EQAP@spc.int	(+679) 3315-600 or (+679) 3378-517
4	Pacific Regional Infrastructure Facility (PRIF)	Mr. Luke Smith (Infrastructure Economist Coordination Office)	lsmith@theprif.org	(+614) 01377664
5	The Pacific Islands Forum (PIF)		info@forumsec.org	(+679) 331 2600
6	The Sustainable Energy Industry Association of Pacific Islands (SEIAPI)	Mr Geoffery James Stapleton or the Secretariat	geoff@gses.com.au secretariat@seiapi.com, info@seiapi.com	
7	Pacific Power Association (PPA)	Mr. Gordon Chang	gordonc@ppa.org.fj	(+673) 306-022
8	Standards New Zealand		enquiries@standards.govt.nz,	(+64 3) 943 4259
9	Pacific Regional Environment Programme (SPREP)	Secretariat	sprep@sprep.org	
10	The Pacific Community (SPC)		spc@spc.int	
11	PV lab Australia	Michelle McCann		m.mccann@pv-lab.com.au

Primary stakeholders

No.	Primary Stakeholder	Contact Person	Contact Email	Phone-Number
1	Fijian Competition & Consumer Commission - Fiji		savneel.pratap@fccc.gov.fj	
2	National Energy Office - Marshall Islands	Ms. Angeline Heine-Reimers	gelheine@gmail.com	
3	Green Energy Solutions- Marshall Islands	Denise Reiher (General Manager)	denise@gesmajuro.com	
4	Palau Energy & Water Administration	Eden Uchel	edenu@palaugov.org	

5	Secretary of Transport/Chief Executive- Samoa Officer	Mr. Fui Mau Simanu	mau.simanu@mwti.gov.ws	
6	Office of the Regulator - Samoa	Perelini Lameko	perelini.lameko@regulator.gov.ws	
7	Minister for Transport & Energy - Tokelau	Hon. Esera Tuisano	esera.tuisano@tokelau.org.nz	
8	Tonga National Qualifications and Accreditation Board (TNQAB)	Opeti Pulotu	opeti26@gmail.com	
9	Tonga Electricity Commission (TEC)		s.ramadicbd@gmail.com	
10	National Higher and Technical Education Board - Papua New Guinea		Randall_Manapangkec@education.gov.pg	
11	Ministry of Commerce, Industry and Labour, Samoa		mpal@mcil.gov.ws	(+685) 20441

Secondary stakeholders

No.	Secondary Stakeholder	Contact Person	Contact Email	Phone-Number
1	Te Aonga Uira (TAU)O Tumu-Te-Cook Islands		Lkatoa@electricity.co.ck	(+682) 20054
2	Dept of Renewable Energy – Utility	Mr. Tangi Tereapii (Director)	tangi.tereapii@cookislands.gov.ck	682 25494
3	Ministry of Public Works, Transport & Meteorological Services - Fiji	Hon Filipe Tuisawau	filipe.tuisawau@govnet.gov.fj	
4	Pacific Engineering Projects Ltd - Fiji	Chandar Sen (Managing Director)	csen@pacificprojects.co.nz	(+642)1 467736
5	Environmental &Energy Consultants - Fiji		johnston@unwired.com.fj	
6	Solar Fiji - Fiji		ayshna.solarfiji@gmail.com	
7	Vision Energy Solutions - Fiji		engineering@visionenergy.com.fj	
8	Marshalls Energy Company		jack.chonggum@mecrmi.net	
9	Nauru Utilities Corporation - Nauru		chairman@nuc.com.nr	
10	National Energy Authority - Papua New Guinea	Ronald Meketa	Ronald.Mekete@nea.gov.pg	
11	Ministry of Infrastructure and Sustainable Energy-Kiribati	Hon Willie Tokataake, Ms. Miriam Iakobwa Tikana	ea@mise.gov.ki, m.iakobwa@mise.gov.ki	
12	Solomon Islands Electricity Authority - Solomon Island		Donald.Kiriau@solomonpower.com.sb	

13	Solar Island Technology Tonga		hayden.braddock@mgrouptonga.com	
14	Department of Energy - Tonga	Ofa Sefana (Acting Director of Energy) or Winnie Laumanu	Ofa.sefana@gmail.com or feauini@gmail.com	
15	ProgramCorp.,s accredited through New Zealand Qualifications Authority (NZQA)		dcochrane@education.gov.ck and Birtha.Togahai@mail.gov.nu respectively	
16	Programmes accredited through Western Association of Schools and Colleges of the United States. Marshall Islands		khosia@pss.edu.mh, wayne.mendiola@national.doe.fm and djenkinsmoe@palauschools.org, respectively	

Other stakeholders

No.	Stakeholders	Contact Person	Contact Email
1	Palau Public Utilities Corporation (PPUC)	Mr. Ngiratmetuchel Reagan Belechl	nrbelechl@ppuc.com; nrbelechl@gmail.com
2	Solar Pacific Energy Corp. Palau		contact@solar-pacific.com
3	PNG Power Limited - Papua New Guinea		Obatia@pngpower.com.pg
4	Pacific Solar & Photovoltaics Guam Guam -		info@pacificsolarguam.com
5	Kiribati Green Energy Solution Company Limited- Kiribati		info@kges.com.ki
6	Ministry of Mines, Energy & Rural Electrification (MME&RE)- Solomon Island	Hon Bradley Tovosia, or Mr. John Korinihona, or Mr. Christopher Sagapoa	bradley.tovosia16@gmail.com, or jkorinihona@mmere.gov.sb, or CVehe@mmere.gov.sb
7	Electric Power Corporation - Samoa		toimoanai@epc.ws
8	Tonga Power Limited	Finau Moa	fmoa@tongapower.to
9	Tuvalu Electricity Corporation	Mafalu Lotolua	mafaluloto2@gmail.com
10	Utilities Regulatory Authority (URA) - Vanuatu	Paul Kaun or Antony Garae Antony	ceo@ura.gov.vu, or gantony@vanuatu.gov.vu
11	E Tech - Vanuatu		solarsales@etech.com.vu
12	Global Green Growth Institute (GGGI) - Regional	Katerina Syngellakis	katerina.syngellakis@gggi.org
13	Pacific Electrical Contractors Association (PECA)		Pabo2000@yahoo.com
14	American Samoa Power Authority		wallon@aspower.com
15	University of Fiji, Department of Science		ramendrap@unifiji.ac.fj
16	Papua New Guinea University of Technology (PNG UoT), Department of Applied Physics - Papua New Guinea		seri.2018@pnguot.ac.pg; or dapsy.olatona@pnguot.ac.pg

7.2.2 B. East African Community (EAC)

Key stakeholders

No.	Key Stakeholder	Contact Email-id	Phone Number
1	African Electrotechnical Standardisation Commission (AFSEC)	secretariat@afsec-africa.org or info@afsec-africa.org	(+)202-23429879
2	African Organisation for Standardisation (ARSO)	info@arso-oran.org	(+254) 020 2-22-4561, 3-31-1608
3	East African Centre of Excellence for Renewable Energy and Efficiency (EACREEE)	info@eacreee.org,	Tel: +256 752 738 990
4	East African Standards Committee (EASC)	eac@eachq.org	(+ 255)27 2162100
5	East African Business Council (EABC)	info@eabc-online.com	(+255) 27 2520162
6	Uganda National Renewable Energy and Energy Efficiency Alliance (UNREEEA)	info@unreeea.org,	(+256) 414 699577
7	Kenya Bureau of Standards (KEBS)	info@kebs.org,	(+254) 20 694 8000
8	Rwanda Standards Board (RSB)	info@rsb.gov.rw,	(+250) 0788303492
9	Tanzania Bureau of Standards (TBS)	info@tbs.go.tz	(0)800110827
10	Uganda National Bureau of Standards (UNBS)	info@unbs.go.ug	(0)417333250
11	South Sudan National Bureau of Standards (SSNBS)	info@ssnbs.gov.ss,	(+211) 92 230 112
12	Rwanda Utilities Regulatory Agency (RURA) Rwanda	info@rura.rw	(+250)252584562
13	Directorate of Industrial Training (DIT) Uganda	ochwo.richard@yahoo.com, info@dituganda.org	(+256) 414 259412, or (+256) 414 251256
14	National Industrial Training Authority Kenya	directorgeneral@nita.go.ke	(+254)-20-2695586/9
15	Electricity Regulatory Authority (ERA) Uganda	c.kyohairwe@era.go.ug or info@era.or.ug	(+256) 417 101800, (+256) 393-260166
16	Aptech Africa Ltd - Uganda	laura@aptechafrica.com	
17	Zuhura Solutions - Kenya	info@zuhurasolutions.com	
18	Nelson Mandela African Institute of Science and Technology (NM-AIST), School of Materials, Energy, Water and Environmental Sciences (MEWES	mtaki.maagi@nm-aist.ac.tz thomas.kivevele@nmaist.ac.tz;	

Primary stakeholders

No.	Primary Stakeholder	Contact email-Id	Phone Number
1	Kenya Renewable Energy Association (KEREA)	administrator@kerea.org	(+254) 740 541 896
2	The Energy and Petroleum Regulatory Authority of Kenya (EPRA)	nickson.bukachi@epra.go.ke or info@rerec.co.ke	(+254) 709 193 000
3	Burundi Bureau of Standards and Quality Control (BBN)	info@bbnburundi.org	(+257) 22 221 577 / 22 221 815
4	Ministry of education, science and technology of Tanzania	info@moe.go.tz	
5	Université du Burundi - Burundi	info@ub.edu.bi	(+257) 22 22 20 59
6	University of Rwanda - Rwanda	info@ur.ac.rw	
7	Office Congolais de Controle	delegation.generale_occ@yahoo.fr	

Secondary stakeholders

No.	Secondary Stakeholder	Contact email-id	Phone Number
1	Rural Electrification and Renewable Energy Corporation OF Kenya (REREC)	info@rerec.co.ke	(+254) 709 193 000
2	Uganda Solar Energy Association (USEA)	info@useaug.org, ismail.muyinda@useaug.org	(+256) 200 923 345
3	BODAWERK -Uganda	hornbach@bodawerk.com	
4	Gulu University - Uganda	C.Okello@gu.ac.ug	
5	Jomo Kenyatta University of Agriculture and Technology (JKUAT), Institute of Energy and Environmental Technology (IEET)	xvrfrank@gmail.com	
6	Ardhi University, Tanzania	aru@aru.ac.tz	(+255) 738 357 310
7	Drop Access	norah@dropaccess.org or info@dropaccess.org	(+254)702627384 (+254)724523597
8	ENGIE Energy Access	fredrick.nobala@engie.com	

Other stakeholders

No.	Stakeholders	Contact email-id	Phone Number
1	Lydetco PLC	info@lydetco.com or dwalelign@lydetco.com	(+251) 11 466 7153
2	Ensol (T) Limited	p.magali@ensol.co.tz; magaliprosper@gmail.com	

7.3 Annex III - A. Interview schedule for SPC and Gender inclusion

Stakeholder	Contact person	Email address	Phone number	Interviewee gender	Mode of interview (physical/ telephone/videocall	Date	Time
Pacific Energy Regulators Alliance (OPERA)	Col. (Ret'd) Siamelie Latu (Chairperson OPERA)	s.ramadicbd@gmail.com	676) 7717539	Male	Provided feedback to the questions.	22/01/2024	8:55am (PNG Time)
Pacific Regional Infrastructure Facility (PRIF)	Mr. Luke Smith (Infrastructure Economist, Coordination Office)	lsmith@theprif.org	(+614) 01377664	Female	Virtually via Microsoft Teams	20/1/2023	1pm - 2pm (Manila Time)
The Pacific Islands Forum (PIF)		info@forumsec.org	(+679) 331 2600	Male		08/02/2024	10:30 am- 11:30 am AEDT
The Sustainable Energy Industry Association of Pacific Islands (SEIAPI)	Mr. Geoffrey James Stapleton or the secretariat	geoff@gses.com.au secretariat@seiapi.com, info@seiapi.com		Male	Virtually via Microsoft Teams	8/1/2023	11am - 12pm (PNG Time)
Pacific Power Association (PPA)	Mr. Gordon Chang	gordonc@ppa.org.fj	(+673) 306-022	Male	Virtually via Microsoft Teams	19/1/2023	11am - 12pm (Fiji Time)
Standards New Zealand		enquiries@standards.govt.nz,	(+64 3) 943 4259	Male	Virtually via Microsoft Teams	16/1/2024	1:30pm - 2:30pm (NZ Time)
Pacific Regional Environment Programme (SPREP)	Secretariat	sprep@sprep.org		Two Females	Virtually via Microsoft Teams	20/1/2023	11am - 12pm (Samoa Time)

The Pacific Community (SPC)		spc@spc.int lupet@spc.int		Two males	Virtually via Microsoft Teams	18/1/2023	11am - 12pm (Tonga Time)
	Adrien Moineau	adrienmoineau17@gmail.com		Male	Virtually via Microsoft Teams	17/1/2024	2:00pm - 3:00pm (AEDT)
PV lab Australia	Michelle McCann	m.mccann@pv-lab.com.au		Female		05/02/2024	1pm-2pm AEDT

7.4 Annex III - B. Interview schedule for EAC and Gender inclusion

Stakeholder	Contact person	Email address	Phone number	Interviewee	Interviewee gender	Mode of interview (physical/telephone/videocall	Date	Time
African Electrotechnical Standardisation Commission (AFSEC)		secretariat@afsec-africa.org or info@afsec-africa.org	(+)202-23429879	Omneya Sabry, Kareman Fathy	Two females	online - jitsi	17.01.2024	13:00 EAT
East African Centre of Excellence for Renewable Energy and Efficiency (EACREEE)	Denis Ariho	info@eacreee.org	Tel: +256 752 738 990	Denis Ariho	Male	google meet	19.01.2024	13:30 EAT
Uganda National Renewable Energy and Energy Efficiency Alliance (UNREEEA)	Benard Mbaine	info@unreeea.org; bmbaine@unreeea.org	(+256) 414 699577, (+256)777838002	Benard Mbaine	Male	google meet	20.02.2024	11:30 EAT
Kenya Bureau of Standards (KEBS)	Daniel Kitui	info@kebs.org; kituid@kebs.org	(+254) 20 694 8000	Alex S. Mboa	Male	google meet	28.02.2024	14:30 EAT
Uganda National Bureau of Standards (UNBS)	Winnie Grace Onziru, Edward Ebiru	info@unbs.go.ug; winnie.onziru@unbs.go.ug; edward.ekuru@unbs.go.ug	(0)417333250	First 30 min with Edward Ebiru Ebyau, remaining 60 min with Winnie Grace Onziru	Male and Female	google meet	19.01.2024	15:00 EAT

	Ebyau							
South Sudan National Bureau of Standards (SSNBS)	William Swaka	info@ssnbs.gov.ss; wswaka55@gmail.com	(+211) 92 230 112	William Swaka	Male	google meet	06.02.2024	11:00 EAT
Aptech Africa Ltd - Uganda	Laura Corcoran, Monica Nakyazze, Anna Karugaba	laura@aptechafrica.com monica@aptechafrica.com anna@aptechafrica.com		Anna Karugaba, Monica Nakyazze	Two Females	googe meet	08.02.2024	15:00 EAT
Power Africa - Empower East and Central Africa (EECA)	Mrs. Joyce Nkuyahaga	jnkuyahaga@powerafrica-eeca.org		Mrs. Joyce Nkuyahaga	Female	Online - jitsi	15.01.2024	12:00 EAT
Centre for Research and in Energy and Energy conservation (CREEC)	Moses Kakooza, Mary Suzan Abbo	mkakooza@creec.or.ug, msabbo@creec.or.ug		Paul Asiimwe pasiimwe@creec.or.ug, Patrick Masendi pmasendi@creec.or.ug	Two males	google meet	23.01.2024	11:00 EAT
Collaborative Labeling and Appliance Standards Program (CLASP)	Lisa Kahuthu, Monica Wambui, Angella Wekongo	lkahuthu@clasp.ngo; mwambui@clasp.ngo, awekongo@clasp.ngo		Christopher Carlsen	Male	google meet	26.02.2024	12:00 EAT

7.5 Annex IV. Complete list of existing standards for solar PV documentation [2]

Test	Equipment	Description
General		
Qualification test to IEC 62093	Environmental chambers	Enclosures for controlled testing of temperature, humidity
	Vibration table	Simulator with control of vibration amplitude, frequency, acceleration
	UV chamber	Enclosure for exposing equipment to controlled UV light
	Power supplies	Devices for controlling voltage and current input or output to electrical components
Inverters		
Safety tests to IEC 62109-1 and IEC 62109-2 & UL 1741 (U.S)	PV simulator	Power supply capable of simulating current-voltage characteristics of a PV array
	Grid and load simulator	AC grid connection or simulated grid supply. and load simulators for off-grid tests
	Residual current test circuits	Resistive/capacitive circuits for validating detection of residual currents
	Environmental chambers	Enclosures for controlled testing of temperature, humidity
	Sound and sonic pressure meter	Device for measuring sound intensity (volume) and sonic pressure
	UV chamber	Enclosure for exposing equipment to controlled UV light
	Access probe	Device for determining physical access to live parts
Anti-islanding tests to IEC 62116 and IEEE 1547 (US)	PV simulator	Power supply capable of simulating current-voltage characteristics of a PV array
	Grid and load simulator	AC grid connection or simulated grid supply, and load banks to simulate electrical island
Low-Voltage Ride-Through tests to IEC 62910	PV simulator	Power supply capable of simulating current-voltage characteristics of a PV array
	Grid simulator	AC grid simulator capable of simulating full range of single and three phase voltage (collapse) with programmed durations.
Efficiency tests to IEC 61683 and IEC 62894	PV simulator/DC supply	Power supply capable of simulating current-voltage characteristics of a PV array
	AC Grid connection or simulator	AC grid connection or simulated grid supply
	Complex load banks	Controlled resistive and reactive loads, non-linear loads
	Transducers	High accuracy voltage and current measurement devices, DC and AC
PV charge controller		
Performance to IEC 62509	Environmental chambers	Environmental chamber is required for nearly every test in 62509 so that operational tests can be performed with the charge controller in controlled steady state temperatures.
	PV simulator/DC supply	Power supply capable of simulating current-voltage characteristics of a PV array is preferred. A controlled dc source (voltage and current) in combination with a series resistor is an acceptable alternative.
	Battery simulator/DC supply	Power supply with independent voltage and current control.

	Resistive load bank	Variable resistive load to provide controlled loads to the simulated battery and charge controller.
Combiner Boxes		
Safety and design verification to UL 1741 and IEC 614392	Environmental chamber	Enclosures for controlled testing of temperature, humidity.
	DC power supplies and DC voltage hi-pot tester	Controlled dc voltage and current supply for steady state testing as well as dc high pot voltage tests for validating insulating properties of components.
	DC power supply with high current capability	Supply for performing short-circuit current withstand capability tests on power components (busbars, switches, etc.)
	Radiant heat lamps	Radiant lamps are used to simulate the effects of solar radiation on various sides of the enclosure during the assembly heat-rise tests. (This test is new and will be included in the next edition of the standard).
	Salt-mister	Salt-mist spray device used for corrosion testing of metallic parts and assemblies
	Miscellaneous environmental related test equipment	Test equipment used for mechanical impact tests (e.g. controlled hammer). controlled water and particulate sources for water and solid body ingress tests (IP ratings). etc.
	EMC test equipment	Appendix C
	Transducers	High accuracy voltage and current measurement devices, DC and AC
PV disconnect switches		
Safety to IEC 60947-3 or UL 98B	Environmental chamber	Enclosures for controlled testing of temperature, humidity.
	DC power supplies and DC voltage hi-pot tester	Controlled dc voltage and current supply for steady state testing as well as dc high pot voltage tests for validating insulating properties of components.
	Miscellaneous endurance related test equipment	Test equipment used for mechanical operations of switch (on/off), contact opening, mold stress relief, IP ratings, etc

Equipment	Test	Description
Ambient temperature measurement	**IEC 61215 10.3** Insulation test; 10.5 Measurement of nominal operating cell temperature (NOCT); 10.9 Hotspot endurance test **UL1703 19** Temperature test	An ambient temperature sensor with a time constant equal to or less than that of the module(s) installed in a shaded enclosure with good ventilation near the wind sensors
Balance	**IEC 61215 10.17** Hail test	A balance for determining the mass of an ice ball to an accuracy of ± 2%.
Irradiance meter	**IEC 61215 10.8** Outdoor exposure test; 4.10 ultraviolet (UV) preconditioning test IEC 61215-2:2016);4.19.3 Hotspot endurance test (IEC 61215-2:2016)	A device capable of measuring solar irradiation, with an uncertainty of less than ± 5%.
Pyranometer	**IEC 61215** 10.5 Measurement of NOCT **UL1703** 19 Temperature test	A pyranometer, mounted in the plane of the module(s) and within 0,3 m of the test array.
Reference cell for measuring the light source	**IEC 61215** 10.2 Maximum power determination; 10.4 Measurement of temperature coefficients; 10.6 Performance at standard test conditions (STC) and NOCT; 10.7 Performance at low irradiance **UL1703** 20 Voltage and current measurements test	A photovoltaic reference device having a known short-circuit current versus irradiance characteristic, determined by calibrating against an absolute radiometer in accordance with IEC 60904-2 or IEC 60904-6.
UV light sensor	**IEC 61215** 10.10 UV preconditioning test	Instrumentation capable of measuring the irradiation of UV light produced by the UV light source at the test plane of the module(s), within wavelength ranges of 280-320 nanometres and 320-385 nanometres with an uncertainty of ±15%.
Velocity meter	**IEC 61215** 10.17 Hail test	An instrument for measuring the velocity of the ice ball to an accuracy of ± 2%. The velocity sensor shall be no more than 1 meter from the surface of the test module.
Continuity tester	**IEC 61215** 10.12 Humidity-freeze test; 10.16 Mechanical load test UL1703 41 Mechanical loading test	Instrumentation to monitor the electrical continuity of the module during the test.
Resistance measurement	**IEC 61215** 10.15 Wet leakage current test UL1703 27 Wet insulation-resistance test	Instrument to measure insulation resistance.
Steady-state light source	**IEC 61215** 10.9 Hot-spot endurance test	Radiant source 1: Steady-state solar simulator or natural sunlight capable of an irradiance of not less than 700 watts per square meter (W/m2) with a non-uniformity of not more than ±2% and a temporal stability within ±5%; or: radiant source 2: Class C steady-state solar simulator (or better) or natural sunlight with an irradiance of 1 000 ± 10% W/m2.
UV light source	**IEC 61215** 10.10 UV preconditioning test	A UV light source capable of producing UV irradiation with an irradiance uniformity of ±15 %

		over the test plane of the module(s), with no appreciable irradiance at wavelengths below 280 nanometres, and capable of providing the necessary irradiation in the different spectral regions of interest as defined in 10.10.3.
Thermal test chamber	**IEC 61215** 10.11 Thermal cycling test **UL1703** 35 Temperature cycling test	A climatic chamber with automatic temperature control, a means for circulating the air inside and minimising condensation on the module during the test; capable of subjecting one or more modules to the thermal cycle.
Test fixture	**IEC 61215** 10.16 Mechanical load test **UL1703** 41 Mechanical loading test	A rigid test base which enables the modules to be mounted front-side up or front-side down. The test base shall enable the module to deflect freely during the load application.
Power supply	**IEC 61215** 10.15 Wet leakage current test **UL1703** 21 Leakage current test; 27 Wet insulation-resistance test; 40 Arcing test	Direct current voltage source with, with current limitation, capable of applying 500 Volts or the maximum rated system voltage of the module, whichever is more
Light filters	**IEC 61215** 10.7 Performance at low irradiance	Equipment is necessary to change the irradiance in 200 W/m2 without affecting the relative spectral irradiance distribution and the spatial uniformity in accordance with IEC 60904-10
Chemical fume hood	**UL1703** 38 Metallic coating thickness test	The metallic coating thickness test requires the chemical etching of metal samples using concentrated sulphuric acid (H2S04).

7.6 Annex V. Interview minutes.

7.6.1 A. East African Community

Development of regional quality infrastructure frameworks for solar photovoltaics products and services in the East African Community and the Pacific Community – Interview minutes

Interviewer: Josef Hermann	**Interviewee:** Joyce Nkuyahaga
Interview date: 15.1.2024	**Organization: USAID, Power Africa EECA**
Interview time and time zone: 12 EAT	**Position: Uganda country coordinator**

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products

1.1. Standards/technical regulations implemented/under implementation.

- In Uganda, each East African Community (EAC) country operates independently, with its own national standard agency such as the Ugandan National Bureau of Standards (UNBS). These agencies often adapt standards from the International Electrotechnical Commission (IEC), of which Uganda is a member.
- Initially, Lighting Global led the standardization efforts in the region about a decade ago. However, this approach favored certain companies, disadvantaging importers from countries like China. Consequently, there arose a need for the development of indigenous standards.
- Standards for solar batteries, panels, etc., are typically aligned with the IEC framework.
- In 2021, UNBS released a national standard for Plug and Play Solar Home Systems (SHS).
- Subsequently, a code of practice was also introduced.
- Jeff XXX, an Australian consultant involved in a standardization project, is progressing slowly as part of the World Bank's Energy for Rural Transformation (ERT) project.
- Gazette was printed in 2020, reflecting updates in standards.
- Many of the standards in Uganda are derived from European (particularly British) and IEC standards, owing to historical influences like colonial ties and infrastructure similarities.
- UNBS is currently developing a Solar Code of Practice for both installation and equipment.

1.2. Testing procedures and facilities for PV products

- UNBS possesses testing facilities; however, the functionality of equipment received in 2019 for testing panels and batteries is limited due to issues with human capacity and equipment limitations.
- CREEC (Centre for Research and in Energy and Energy Conservation), a non-profit organization affiliated with a university's engineering department, lacks recalibration of equipment necessary for testing PV panels and batteries. Additionally, there is no sustainable business model or income through testing.
- Joyce suggests outsourcing testing from UNBS to organizations like CREEC to establish a sustainable income and create a business case. However, testing of components such as PV panels and batteries faces limitations in practice.
- CLASP, an NGO overseeing VeraSol activities, tests appliances and released the first standards in productive energy use in the region. They collaborate with companies in China and are considered the most advanced testing facility in Uganda, primarily focusing on plug-and-play SHS. (Later interviews question the presence of a CLASP lab in Uganda.)
- CREEP tests clean cookstoves, PV panels, and batteries.
- Kijani, a Kenyan private company, offers testing services for various product.

1.3. Regional conformity assessment bodies and PV certification

1.4. Accreditation process for conformity assessment bodies

- In the region, most standard bodies implement a pre-conformity check process before product delivery from abroad.

- The pre-conformity check involves hiring external organizations such as TÜV Rheinland or SGS to perform pre-verification at the producing companies in the exporting country.
- Only products that receive certification through this process are allowed to be imported into countries like Uganda.
- Sometimes, the Uganda National Bureau of Standards (UNBS) takes samples from shipments and tests them internally, but there are issues with delays and lack of transparency in sharing testing results.
- The East African Community (EAC) has made attempts to address standards issues but lacks consumer protection measures similar to CE in Europe.
- Efforts to strengthen the standards office within the EAC have faced challenges in functionality.
- The EAC maintains its own standards catalogue, which includes specifications for PV products.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

- Lack of funding remains the most prominent issue, as addressing most challenges requires adequate resources and goodwill.
- Standardization often takes a backseat due to competing priorities, despite its potential to mitigate challenges.
- The sector's reliance on donor funding is evident, leading to initiatives like the World Bank's plug and play standards being driven by donor requirements rather than genuine demand from countries.
- Organizations like the Uganda National Bureau of Standards (UNBS) rely on external donors for standardization processes instead of taking proactive measures themselves.
- Consumer protection regulations are lacking, particularly evident in Kenya and Uganda, where minimal to no consumer protection measures are in place. Tanzania shows some improvement in this regard.

2.1. Human capacities

- Insufficient staffing dedicated to standardization efforts; for instance, in Uganda, only one or two individuals are responsible for standardizing electrical equipment.

2.2. Metrology and testing

- Lack of equipment

2.3. Certification

2.4. Accreditation and conformity assessment

2.5. Market surveillance

- Understaffing at UNBS is widespread, with surveillance officers present but insufficient to prevent smuggling of products into the country, notably from Sudan.
- UNBS lacks adequate funding for surveillance operations, receiving only around 10% of the required budget.
- Corruption is prevalent, with UNBS officers and traders soliciting bribes, contributing to ongoing issues of corruption within the organization.
- Border protection measures are weak, resulting in a flood of products into the market, many of which fail quickly.
- These low-quality products are readily available even on online platforms where certification is not required, further exacerbating the problem.
- The prevalence of low-quality products has negatively impacted the perception of PV products. While these products used to comply with regulations due to the lack of standards, the implementation of standards and awareness campaigns have significantly improved the situation.

2.6. Critical challenges

- UNBS requires additional support and funding to enhance its operations.
- Collaboration with external contractors could further strengthen UNBS's capabilities.
- Emphasis should be placed on building sustainability within UNBS.
- Outsourcing testing services could alleviate financial burdens on UNBS and potentially create a viable business opportunity.

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
   - CLASP is performing well.
   - CREEK is also excelling.
   - Emphasis on continuous skills development.
   - Ensuring sustainability of the process.
   - Striving for independence from donors.
4. Key stakeholders and assessment of regional cooperation frameworks
   - The standards body in the EAC exists but lacks adequate facilitation and seeks revitalization, lacking convening power.
   - There's a call for enhanced collaboration among national standards bureaus.
   - Suggested idea: Establishing testing labs in various countries specialized in different areas (e.g., PV lab in Uganda, battery lab in Tanzania, Agromechanical equipment lab in another country).
   - Collaboration currently exists at a high level, but further details can be obtained by contacting UNBS and sharing contacts.

5. Necessary interventions for the promotion of regional frameworks for solar QI

5.1. Metrology and testing
5.2. Certification of products and services
5.3. Accreditation and conformity assessment authorities
5.4. Market surveillance
5.5. Capacity building
5.6. Creation of QI networks
5.7. International standards and technical regulations that still require adaptation to the regional context.

6. Other key stakeholders
   - CREEC, represented by Moses Kakooza mkakooza@creec.or.ug and Mary Suzan Abbo msabbo@creec.or.ug, demonstrates responsiveness.
   - CLASP, with contact information at info@clasp.ngo or Lisa Kahuthu at lkahuthu@clasp.ngo, is also responsive.
   - UNBS, reachable via winnie.onziru@unbs.go.ug, is another responsive entity.

Interviewer: Josef Hermann	Interviewee: Benard Mbaine
Interview date: 20.02.2024	Organization: UNREEEA
Interview time and time zone: 11:30 EAT	Position: CEO of UNREEEA

UNREEEA - Uganda National Renewable Energy and Energy Efficiency Alliance

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products

1.1. Standards/technical regulations implemented/under implementation

- Derived from IEC standards for adaptation.
- Almost all solar products are imported, hence tested against international standards.
- Pre-Export Verification of Conformity (PVoC) is enforced, involving testing before importation.
- UNBS conducts sampling; products lacking PVOC documents undergo costly testing at UNBS.
- Standards for refrigeration, cooling, biogas, and cookstove are in progress.
- Market demand drives development; new quality standards are developed based on market needs. Example: solar fishing equipment.

1.2. Testing procedures and facilities for PV products

- Testing procedures at UNBS are time-consuming due to limited resources, including equipment and personnel.
- Limited testing facilities exist in Uganda, with only one lab operated by UNBS in Kampala, albeit with very restricted capacity.
- The high testing fees at UNBS pose challenges for private companies due to the limited capacity and increased costs.
- Privately run labs, such as CREEC at Makerere University, are available but are primarily recognized for testing lights rather than solar products.
- Another emerging private lab, Sakodu, focuses more on testing cooking-related components rather than solar products.
- Components typically tested include inverters, lights, panels, and batteries.

1.3. Regional conformity assessment bodies and PV certification

1.4. Accreditation process for conformity assessment bodies

- UNBS operates under the Ministry of Trade (verification needed) and is established by an act of parliament with government authorization.
- Private testing companies must obtain accreditation from UNBS.
- Each country in the region conducts its own testing, but there are efforts towards regional collaboration through the EAC, facilitated by an entity within the EAC.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

- Further awareness-raising efforts are required for UNREEEA members.
- Some members do not recognize the advantages of adhering to quality standards.
- Additional sensitization is necessary.

2.1. Human capacities

- UNBS has not enough staff to cover the whole country.

2.2. Metrology and testing

- Testing capacity constraints lead to prolonged and costly procedures.
- The exorbitant testing expenses prompt some members to seek alternatives.

2.3. Certification

2.4. Accreditation and conformity assessment

2.5. Market surveillance

- UNBS does not survey all borders, leading to widespread product smuggling.
- Corruption and political interference are prevalent issues.
- The regulation landscape lacks clarity and enforcement.
- Efforts are underway to pass the "energy efficiency and energy conservation bill" to mandate compliance with energy efficiency standards.
- Currently, energy efficiency standards are voluntary.
- Minimum energy performance standards are absent from the law.
- Implementation of laws by non-technical parliament members may require increased awareness.
- Some market players may interfere with law implementation to avoid higher product costs.
- Lack of legislation allows individuals to use high-energy-consuming products without consequence.
- Companies often avoid certification and testing due to time constraints and financial losses.
- Uncontrolled and unregulated entry points facilitate smuggling, with UNBS facing limited capacities to address these issues.

2.6. Critical challenges

- The testing capacities at UNBS play a vital role: both in terms of human resources and testing capabilities. Increasing testing capacity can lead to more efficient processes and lower costs.
- Corruption is acknowledged as a significant challenge, yet addressing it proves to be complex and unrealistic within this context, hence not included in the list of insights.
- The absence of a conservation bill in the law, which is currently being prepared.
- Awareness efforts are directed towards achieving self-regulation, including the potential introduction of mandatory registration for companies/UNREEEA members. This registration could enable participation in governmental tenders, among other benefits.
- Industry regulations are proposed to be established through the association to ensure compliance and standardization.

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level

- The World Bank (WB) provided testing equipment to UNBS for their laboratory.
- The WB-funded "Scale up project" is also enhancing testing facilities at CREEC and UNBS.
- GIZ has previously supported various standards initiatives.
- GIZ's endev project contributed significantly to raising awareness and developing standards in collaboration with UNBS.
- Currently, GOOGLA is involved in the solar fishing project, as mentioned earlier in Question 3.
- It's advisable to direct questions about these initiatives to UNBS staff for accurate information.
- It's crucial to prioritize understanding the sector before developing or implementing standards.
- Consumer awareness and empowerment are essential; neglecting consumers has contributed to the persistence of low-quality products in the market.
- Measures such as labeling goods and consumer education can lead to self-regulation.
- Legal frameworks play a vital role in ensuring quality standards are upheld.

4. Key stakeholders and assessment of regional cooperation frameworks

- Ministry of Energy
- UNBS
- Private sector through the UNREEEA
- Consumer
- There has been significant support from development partners.
- UNREEEA collaborates well with UNBS.
- Capacity at UNBS appears limited, with overloaded staff, particularly Winnie.

- Cooperation with UNBS is hindered by the small team size.
- Reports suggest some UNBS staff may misuse their authority.
- UNBS faces limited funding, as development partners prefer funding private consultants rather than government entities directly.
- UNBS struggles to handle consultants efficiently.
- UNBS functions primarily as a secretariat, with technical committees comprising industry experts.
- Overall, cooperation between UNBS and UNREEEA is positive.

5. Necessary interventions for the promotion of regional frameworks for solar QI

5.1. Metrology and testing
5.2. Certification of products and services
5.3. Accreditation and conformity assessment authorities
5.4. Market surveillance
5.5. Capacity building
5.6. Creation of QI networks
5.7. International standards and technical regulations that still require adaptation to the regional context

- Most solar technologies are imported, indicating a lag in quality regulations and standards compared to the global market.
- There's an opportunity for benchmarking and learning from international best practices, although adaptation to local conditions in Uganda is necessary.
- Financing is essential for activities such as assessment, testing, and knowledge exchange.
- Knowledge exchange is crucial for improving understanding and implementation of quality standards.
- Support for research and innovation is needed to foster local innovation and activity within Uganda.
- UNREEEA aims to assess the current market status and quality of solar products, seeking support for this initiative. Sharing this information with UNIDO would be beneficial for collaborative efforts.

6. Other key stakeholders

Interviewer: Josef Hermann	**Interviewee:** Denis Ariho
Interview date: 19.01.2024	**Organization:** EACREEE
Interview time and time zone: 13:30 EAT	**Position:** Lead technical Expert for the EAC region

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products

1.1. Standards/technical regulations implemented/under implementation.

- At the national level, standards exist for various products such as panels and batteries, with adoption of IEC or ISO standards.
- For instance, Uganda is developing standards for human capacity and protection.
- For access to national standards, IEC and ISO recommend checking resource centers, websites, or web stores of national standard bodies.
- In the East African Community (EAC), standards for green cooling (refrigerators, AC, etc.) are forthcoming, but standards for photovoltaic (PV) products are not yet in place.

1.2. Testing procedures and facilities for PV products

- Laboratories for solar testing, particularly for batteries and cables, exist in Kenya, Rwanda, Uganda, and Tanzania as part of their national standard bodies.
- However, these testing facilities are often inadequately equipped.
- Testing covers batteries, cables, and panels, although some countries may have Current-Voltage curves available.
- Verification with the respective countries is recommended to confirm the availability of specific testing capabilities.

1.3. Regional conformity assessment bodies and PV certification

- VeraSol through CLASP.

1.4. Accreditation process for conformity assessment bodies

- Accredited standard bodies are responsible for conducting conformity assessments, although in certain countries, other organizations may also perform this function, such as RECA in Rwanda or the Kenya Energy and Petroleum Regulatory Authority.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

- Insufficient awareness and capacity-building regarding standards and their implementation, affecting all stakeholders.
- Inadequate political commitment, particularly in enforcing standards and regulations, despite having well-drafted policies.
- Presence of substandard and low-quality products in the market, indicating a need for increased awareness, capacity-building, and interest from decision-makers to address this issue.

2.1. Human capacities

2.2. Metrology and testing

- Limited testing facilities

2.3. Certification

- Lack of testing lack of certification

2.4. Accreditation and conformity assessment

2.5. Market surveillance

2.6. Critical challenges

- Prioritization: Enhancing awareness and capacity building, improving testing infrastructure, and implementing compliance frameworks, in order of significance.

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level

4. Key stakeholders and assessment of regional cooperation frameworks

5. Necessary interventions for the promotion of regional frameworks for solar QI

5.1. Metrology and testing
5.2. Certification of products and services
5.3. Accreditation and conformity assessment authorities
5.4. Market surveillance
5.5. Capacity building
5.6. Creation of QI networks

- Stakeholder collaboration occurs across various thematic areas, fostering frequent interaction.
- Workshops, conferences, and training sessions serve as platforms for stakeholder engagement and interaction.
- Joint projects spanning multiple areas strengthen collaboration among stakeholders.
- EAC recognizes the importance of collaborating with international organizations to benchmark their work and implement best practices gleaned from successful international initiatives.

5.7. International standards and technical regulations that still require adaptation to the regional context

6. Other key stakeholders

Interviewer: Josef Hermann	**Interviewee:** Edward Ekuru / Winnie Onziru
Interview date: 19.01.2024	**Organization:** UNBS
Interview time and time zone: 13:30 EAT	**Position:** Head of Electric testing / Senior Standards Officer

1. Status Quo – Existing regional QI frameworks for solar products

1.1. Standards/technical regulations implemented/under implementation

- The East African Community (EAC) suggests the adoption of IEC standards, although each country must independently acknowledge and implement this recommendation.

- IEC standards are currently being developed, including a Code of Practice for PV installers, addressing concerns about the quality of installations due to poor craftsmanship.
- Kenya has already implemented a code of practice, indicating proactive measures in ensuring quality installations.

1.2. Testing procedures and facilities for PV products

UNBS Lab:

- Testing available for Solar Home Systems (SHS) or solar kits.
- Existing standards do not cover the smaller components of SHS, prompting UNBS to develop a standard protocol.
- Limited to basic testing equipment, primarily connecting small loads to assess performance.
- Recognizes the need for standard measurements.
- Conducts basic testing on various equipment including batteries, panels, charge controllers, and inverters.
- The UNBS Lab is currently not accredited but is in the process of accreditation, expected to be completed this year, pending the arrival of creditors.

1.3. Regional conformity assessment bodies and PV certification

- No known insights on this matter.
- We aim to employ the IEC conformity assessment.
- Kenya is ahead of us in utilizing the IEC conformity assessment, with the team at Strathmore University leading the initiative, although not specifically in the context of photovoltaics.

1.4. Accreditation process for conformity assessment bodies

- No accreditation on a regional level, but Strathmore University in Kenya might have accreditation.
- Uncertain about the accreditation status of CREEC.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

2.1. Human capacities

- Implementation of a code of practice to address deficiencies in human capacities.
- Observation that many technical experts mistakenly consider themselves proficient in photovoltaics (PV).
- Issuance of certificates for "wire humans" (electricians) by the electrical authority, although the certification process lacks clarity and assurance.
- Contact with the electricity regulator authority, particularly Eng. Yudith, for clarification on the certification process handling.

2.2. Metrology and testing

- There are upcoming developments regarding solar Mini grids.
- Net metering poses a concern (it's advisable to consult Eng. Yudith).
- The feed-in tariff is currently under development.

2.3. Certification

2.4. Accreditation and conformity assessment

2.5. Market surveillance

- Market surveillance poses significant challenges due to limited team size, with a focus primarily on testing.
- Effective market surveillance relies heavily on the expertise and knowledge of officers, particularly in the solar energy field.
- Businesses often show reluctance to engage with officers, sometimes resulting in confrontations and violence due to perceived disadvantages.
- Empowering consumers with knowledge about product quality and benefits is crucial, especially in the country context, to drive better purchasing decisions.
- Efforts by organizations like UNBS to empower consumers face financial constraints, highlighting the need for increased funding.
- Initiatives like Energy for Rural Transformation 2 and 3 in Uganda have raised awareness about PV products, but significant gaps remain in achieving comprehensive quality awareness and uptake.

2.6. Critical challenges

- Utilizing radio for sensitization and awareness campaigns can effectively reach grassroots levels, especially with announcements made one or two weeks before the show, which surpasses the reach of workshops.
- Enhancing testing capabilities, providing necessary equipment for laboratories, and ensuring staff are adequately trained.
- Acknowledging the significant assistance provided by ERT 2 and 3 (WB) and suggesting continuation from their efforts.

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level

4. Key stakeholders and assessment of regional cooperation frameworks
   - Addition to the national bureaus of standards, which handle development, certification, surveillance, import inspection, and testing, other key stakeholders include:
     - Ministry of Energy
     - Ministry of Trade
     - Trading associations
     - Uganda Solar Energy Association (USEA), ensuring member compliance with quality standards through contracts
     - Uganda Renewable Energy Association (UNREEEA), overseeing USEA's activities
   - Collaboration between national bodies is evident, with effective communication and coordination to inform the Uganda National Bureau of Standards (UNBS).
   - Despite occasional lapses in commitment, there is a concerted effort to collaborate among stakeholders, particularly at the regional level, where renewable energy associations from Kenya (KEREA), Tanzania (TAREA), and Uganda work closely together, representing the original three East African countries.

5. Necessary interventions for the promotion of regional frameworks for solar QI

5.1. Metrology and testing

5.2. Certification of products and services

- The standards listed are enforced as Ugandan standards, with notable difficulties particularly concerning testing procedures.
- The Pre-Export Verification of Conformity (PVOC) program facilitates product testing in the country of origin.
- If products fail to meet the required quality standards, importers are responsible for either covering the expenses of destruction or arranging for their return under the supervision of the Uganda National Bureau of Standards (UNBS).

5.3. Accreditation and conformity assessment authorities

5.4. Market surveillance
5.5. Capacity building
5.6. Creation of QI networks

- Engage with KEREA and TAREA to understand their additional requirements.
- UNBS is eager to collaborate with associations due to their proximity to consumers and the market.
- Consider making association membership mandatory to streamline sector involvement.
- Internationally, Uganda faces challenges as a net importer in the solar sector, often receiving lower quality products due to perceived affordability issues.
- Clean intentions in international cooperation are crucial for sector improvement, but current motives may not be helpful.
- Climate change is undeniable, with its effects visible worldwide, yet some continue to prioritize personal agendas.
- Recognize the interconnectedness of human actions and their impact globally, fostering a mindset of cleaner intentions for better outcomes.

5.7. International standards and technical regulations that still require adaptation to the regional context
6. Other key stakeholders

Interviewer: Josef Hermann	Interviewee: Omneya Sabry / Kareman Fathy
Interview date: 17.01.2024	**Organization:** AFSEC
Interview time and time zone:	**Position:** Secretary of AFSEC / Engineer

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products

1.1. Standards/technical regulations implemented/under implementation

- IEC standards are adopted by AFSEC, receiving an AFSEC number after approval by the general assembly.
- In Egypt, the Egyptian Organization for Standardization adopts IEC/ISO standards.
- Egypt has two testing facilities for conducting tests.
- AFSEC, a regional organization, includes Egypt as a member of its council, contributing to its operations.
- National Electrotechnical Committees (NECs) act as focal points for AFSEC's work.
- AFSEC's standards are integrated into national standards, with translation into local languages being prioritized.

1.2. Testing procedures and facilities for PV products

- In Egypt: no inverter testing, batteries are only 2 or 3 little tests (voltage test) no proper testing facilities for batteries.
- Two testing facilities are available to test PV modules, meeting the 2021 IEC standards and accredited by the Egyptian Accreditation Council.
- AFSEC serves as a coordinating unit and provides adapted standards but does not conduct testing.
- An AFSEC database of testing facilities is currently being prepared but is not yet operational.
- In Egypt, there is a lack of inverter testing facilities, and batteries undergo only minimal testing, such as voltage tests, with no proper testing facilities dedicated to batteries.

1.3. Regional conformity assessment bodies and PV certification

1.4. Accreditation process for conformity assessment bodies

- In Egypt, certification involves submitting cases to the Accreditation Council for review under ISO standards.
- Imported PV panels undergo inspection by authorities, who verify IEC certificates; panels without certificates are tested in national labs like NREA.
- A national certification scheme exists for on-grid systems, but off-grid sector lacks control measures.
- TÜV serves as a testing lab
- Incentives for reduction require imported equipment to be certified, enabling benefits such as customs or VAT reductions and support for renewable energies.
- Egyptian Accreditation Council (EGAC) accredits various equipment, not solely PV panels.
- AFRAC, the African accreditation body, facilitates regional testing and accreditation, with contacts provided.
- Egyptian lab under EACREE serves as a regional facility for water solar heaters in Arab countries.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

2.1. Human capacities

2.2. Metrology and testing

- Testing laboratories for larger-scale testing, such as MW and grid-connected systems, are only available in a handful of countries (e.g., Egypt, Tunisia, South Africa). Limited testing facilities may primarily focus on smaller-scale systems like SHS.
- Implementation challenges exist regarding technical regulation.

2.3. Certification
2.4. Accreditation and conformity assessment
2.5. Market surveillance
2.6. Critical challenges

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
    - The NREA laboratory, funded by an EU grant, has achieved significant success.
    - It conducts testing according to IEC standards and has been certified as an accredited lab since 2020.
    - The lab conducts over 500 tests and is responsible for maintenance, calibration, and license renewal, all managed by NREA.
    - While testing expenses are minimal, they generate some income for the laboratory, contributing to its sustainability.
4. Key stakeholders and assessment of regional cooperation frameworks
    - African committees such as AFSEC, UNIDO, and AU should establish regional short- and long-term goals and allocate funding accordingly.
    - Collaboration between national and international organizations is currently lacking, leading to isolated efforts and a lack of coordination.
    - Improved communication and coordination are essential to align targets with actual needs and promote more effective collaboration.
    - There's a tendency for organizations to focus solely on their individual objectives, highlighting the need for greater integration with regional and international entities.
5. Necessary interventions for the promotion of regional frameworks for solar QI
    - Increased budget allocation and prioritization for quality-related initiatives, including awareness campaigns and human capacity building.
    - Example: Funding for the testing lab was provided by the EU rather than the Egyptian government.
    - Limited attention to quality-related issues at the government level.
    - Funding for such initiatives should ideally come from international or regional organizations.
    - Greater emphasis on enhancing technical expertise among higher-level ministries.
    - Human capacity building emerges as a significant challenge in East African countries and Egypt.
    - Urgent need for awareness campaigns to promote understanding of quality-related benefits.
    - Capacity-building efforts required in both the private sector and government institutions.
    - Advocacy for the advantages of higher quality products through various communication channels.

5.1. Metrology and testing
5.2. Certification of products and services
5.3. Accreditation and conformity assessment authorities
5.4. Market surveillance
5.5. Capacity building
5.6. Creation of QI networks
    - A national and international committee is necessary.
    - The committee should be permanent rather than project-based.

5.7. International standards and technical regulations that still require adaptation to the regional context

6. Other key stakeholders

Interviewer: Josef Hermann	Interviewee: Christopher Carlsen
Interview date: 26.02.2024	**Organization:** CLASP
Interview time and time zone: 12:00 EAT	**Position: Program Consultant**

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products
1.1. Standards/technical regulations implemented/under implementation
1.2. Testing procedures and facilities for PV products
- CLASP established testing laboratories for IEC conformity testing (IECTS 62257-9-5 testing method, …/9/8 for quality standard) of plug and play solar equipment (under 350 W and with DC applications only).
- The plug and play solar testing labs are listed on the VeraSol website (https://verasol.org/).
- Countries hosting these labs include:
    - Ethiopia
    - Nairobi, Kenya
    - Dakar, Senegal (currently not operational)
    - Lagos, Nigeria
    - Zambia
    - Tanzania (currently not operational)

1.3. Regional conformity assessment bodies and PV certification
1.4. Accreditation process for conformity assessment bodies
2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level
- The EAC has made notable progress in adopting standards for solar kits and implementing IEC standards, particularly for products like inverters, batteries, and charge controllers.
- However, the main challenge lies in effectively implementing these standards, which is a common issue across regions.
- Many EAC countries utilize the Pre-Shipment Verification of Conformity (PVoC) method for conformity assessment, where multinational companies like TÜV, SGS, and Intertec are hired by the government to ensure quality standards are met before products are shipped.
- Generally, the PVoC approach works well in the EAC, but porous borders in Africa pose challenges, allowing private companies to bypass standards through smuggling and falsified testing certificates, resulting in a dominance of sub-standard solar products in the market.
- A comprehensive study conducted in Kenya highlighted that despite legal procedures, low-quality products still enter the market.
- Improving the knowledge and capacity of PVoC companies in testing solar kits could be beneficial to address these issues.

2.1. Human capacities
- Challenges in the EAC include limited funding for standard bureaus, resulting in inadequate staffing and institutional memory, with high staff turnover rates aimed at combating corruption, making it difficult to retain knowledge and experience.

2.2. Metrology and testing
- Testing and metrology units in Sub-Saharan Africa, particularly for solar, suffer from underfunding, with a focus on more critical issues like powdered milk and water safety rather than photovoltaics due to perceived lower consumer harm.
- Government prioritization of test labs is often misconceived, with limited funding posing sustainability challenges for operating labs efficiently, as noted by CLASP.

- It is more effective to outsource testing to international quality infrastructure rather than conducting tests solely in national labs, especially for countries with limited funding.
- In Ethiopia, the attempt by ECAE to independently test all imported solar products, despite international labels, resulted in significant market repercussions.
- For markets dominated by imported goods, utilizing labs near production sites (PVoC) rather than establishing local labs and certification schemes is more efficient.
- Outsourcing testing is preferred, although having a national lab would be ideal; however, limited funding makes it more effective to rely on international companies for such work.

2.3. Certification

- CLASP is collaborating with Zimbabwe to enhance the implementation of a solar quality infrastructure.
- Zimbabwe is in the process of establishing a product registration database as part of this effort.
- The database serves as a compliance mechanism, requiring imported and domestically manufactured products to be registered with specifications, manufacturer details, and standards compliance information.
- This database strengthens the quality assurance framework within Zimbabwe.
- Products not listed in the database should not be permitted for sale in the market.

2.4. Accreditation and conformity assessment

- Implementation of a strong solar professional certification/accreditation program could serve as an effective method to increase awareness about the significance of quality among experts.
- Professionals accredited through such a program would be more inclined to prioritize quality products, addressing the issue from the demand side.

2.5. Market surveillance

- Despite significant efforts by organizations like CLASP in some EAC countries, progress in solar product market surveillance remains limited.
- Market surveillance for solar products is underfunded and lacks priority compared to other areas due to limited budgets.
- There is little interest in investing in market surveillance of solar products, with higher priority given to potentially harmful and dangerous goods like fuel and powdered milk.
- This lack of focus and funding has led CLASP to shift its attention to other topics where outcomes are more achievable.

2.6. Critical challenges

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level

- Introduction of innovative financing models like Pay as you go, addressing consumer financing challenges for quality products.
- Strategies can either enforce changes or attract the market towards change.
- Mandatory standards and rule enforcement may not be as effective in most markets.
- Voluntary measures, such as Result Based Financing (RFB), appear to yield better results.
- RFB can significantly enhance product quality in markets if subsidies benefit consumers and lower prices.
- Properly designed and executed RBF initiatives have the potential to elevate product quality, with several projects implemented in Africa.

4. Key stakeholders and assessment of regional cooperation frameworks
5. Necessary interventions for the promotion of regional frameworks for solar QI

5.1. Metrology and testing
5.2. Certification of products and services
5.3. Accreditation and conformity assessment authorities
5.4. Market surveillance
5.5. Capacity building
5.6. Creation of QI networks

- Enhancement is needed in aligning the efforts of development partners, as there are instances of overlapping initiatives within the same country or region, such as those between WB and GIZ, which may not leverage each other's efforts and could even conflict with one another.
- Improved formal mechanisms for aligning development actions could mitigate these issues, possibly addressing underlying political factors.
- When engaging with national governments, the promotion of establishing multi-stakeholder working groups focused on energy access is advocated. Such collaborative efforts involving all key stakeholders tend to facilitate smoother project implementation processes.

5.7. International standards and technical regulations that still require adaptation to the regional context

6. Other key stakeholders

Interviewer: Josef Hermann	Interviewee: Paul Asiimwe / Patrick Masendi
Interview date: 23.01.2024	**Organization:** CREEC
Interview time and time zone: 13:30 EAT	**Position:** Project engineer for the solar department / Project coordinator in the solar department

- The Centre for Research in Energy and Energy Conservation (CREEC) at Makerere University in Kampala, Uganda, specializes in renewable energy and related areas such as rural electrification, energy efficiency, productive use for energy, energy entrepreneurship, and energy testing.
- CREEC operates two testing labs, as mentioned in question 1.2.
- CREEC runs the CREEC academy, providing training for technicians. Over 1500 technicians have been trained so far.
- The institution has developed training manuals and focuses on building local capacity in the field of renewable energy and energy conservation.

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products

1.1. Standards/technical regulations implemented/under implementation

- CREEC applies both Ugandan standards and IEC standards for testing.
- Ugandan standards are derived from IEC standards, indicating a close alignment.
- UNBS is in the process of developing a new guideline for off-grid solar system installations.
- Initially, CREEC utilized GOGLA standards, but due to their focus on the off-grid sector, they have shifted towards IEC standards.
- Additionally, CREEC considers ISO standards and national standards, which are adapted from ISO and IEC.

1.2. Testing procedures and facilities for PV products

- The UNBS lab serves as a general testing facility.
- CREEC operates two specialized testing labs:
    - One focuses on bioenergy products like stoves, biofuels (such as bioethanol and briquettes), and electric pressure cookers.
    - The other specializes in testing solar products, including panels, batteries, charge controllers, solar home systems (SHS), cables, LED lights, and other small components.
    - Testing at CREEC labs adheres to IEC 622579-5 standards, incorporating both indoor (lab) and outdoor (practical) tests.
    - CREEC labs are certified by UNBS according to ISO 17025:2017 and undergo annual inspections by UNBS.
    - However, they face limitations such as inadequate equipment, preventing testing of inverters, lithium-ion batteries, or larger batteries. Calibration poses challenges, with options being either shipping equipment to manufacturers or bringing experts to Kampala, both of which are costly and make quality control difficult.
- Outside Uganda, solar labs include:
- University of Nairobi, Kenya.
- Lab at University of Strathmore, Nairobi, Kenya. Certification status is uncertain.
- University of Dar es Salaam, Tanzania, which is IEC certified.

1.3. Regional conformity assessment bodies and PV certification

- Regionally:

- Kenya National Accreditation Service (KENAS) is responsible for accreditation services in Kenya.
- Nationally:
    - Uganda National Bureau of Standards (UNBS) oversees standards and policies in Uganda.
    - Tanzania National Bureau of Standards (TNBS) plays a similar role in Tanzania.
- Uganda:
    - UNBS is mandated to endorse and enforce standards and policies, which are approved by parliament and then ratified by the executives to become mandatory.
    - The Ministry of Energy and Mineral Development identifies gaps in standardization and presents them as policies to be passed and enforced by UNBS, indicating the ministry's crucial role in the process.

1.4. Accreditation process for conformity assessment bodies

- UNBS provide the application process
- Provision of a checklist for developing internal processes in line with protocols
- On-site inspection to ensure implementation of the checklist
- Issuance of recognition certificate enabling work
- Occasional due diligence checks
- Support services such as training offered intermittently

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

2.1. Human capacities

- Limited number of experts with restricted technical knowledge available.
- Challenges in keeping up with continuous technological advancements due to inadequate training opportunities, resulting in limited awareness of new technologies.

2.2. Metrology and testing

- Limited number of laboratories available.
- The existing laboratories lack modern equipment necessary for thorough testing.

2.3. Certification

- The procedure incurs significant costs.
- Establishing a reputable testing facility requires substantial investment.
- Ongoing training also comes with a high price tag.

2.4. Accreditation and conformity assessment

2.5 Market surveillance

- The off-grid sector faces significant challenges, primarily due to the prevalence of substandard products in the market despite existing regulations, indicating poor implementation and enforcement.
- The issue of substandard products underscores the failure of regulatory bodies such as the Uganda Revenue Authority and the Uganda National Bureau of Standards (UNBS) to ensure product quality, with some avoiding taxes altogether.
- Ineffective border control allows substandard products to enter from neighboring countries like Rwanda, Kenya, and South Sudan, particularly impacting the off-grid sector.
- Limited resources and manpower hinder efforts to secure borders effectively, exacerbating the problem of substandard products.
- The on-grid sector benefits from more robust regulation under the Electricity Act by the national electricity regulatory body (ERA), which requires registration for larger systems serving community needs.
- Despite efforts to address substandard products, such as market surveillance and testing, corruption and lack of consequences undermine enforcement, allowing inferior products to remain in circulation.

- Consumer protection measures, including the Consumer Protection Act of 2019, are poorly implemented, with no functional warranty schemes and inadequate awareness among consumers, leaving them vulnerable to exploitation by unscrupulous businesses.

2.6. Critical challenges

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
   - The World Bank provided support to UNBS by equipping their test lab.
   - UNCDF conducted trainings and provided equipment for UNBS and CREEC.
   - The Lighting Global project, supported by GOGLA and funded by the World Bank, executed a successful project focusing on pico solar (below 20W), resulting in significant quality improvement.
   - CREEC conducted capacity building with UNBS and the private sector, yielding successful outcomes.
   - Regional bodies such as EAC and SADC are implementing energy efficiency solutions funded by UNIDO through the EELA project.
   - The EELA project involves close collaboration with the Swedish Energy Agency, emphasizing capacity building and sectorial collaboration as key success factors. Roles definition and harmonization of different stakeholders, along with collaboration on the national level (NGOs, government, private sector, international organizations), are highlighted.
4. Key stakeholders and assessment of regional cooperation frameworks
   - Government agencies, particularly the Ministry of Energy, play a crucial role in harmonizing entities responsible for implementing various quality frameworks in the energy sector.
   - Inter-collaboration among government institutions is essential for effective coordination and implementation of standards.
   - Cooperation, led by the Ministry of Energy, is improving steadily, with efforts such as stakeholder mapping and intervention realization.
   - Implementation of umbrella bodies allows for unified representation and communication with the government.
   - The Ministry of Energy spearheaded a renewable energy conference last year, which will now become an annual event featuring talk shows, expos, and panel discussions.
   - Market surveillance and gap analysis are vital for ensuring accountability and avoiding duplication of efforts among agencies.

5. Necessary interventions for the promotion of regional frameworks for solar QI

5.1. Metrology and testing
   - Establishing additional laboratories, particularly at border entry points, to accommodate the expanding market.
   - Increasing the number of experts to meet the growing demands of the market.
   - Implementing a mechanism to support the market surveillance team, such as introducing a Code of Conduct (e.g., requiring the use of cameras).

5.2. Certification of products and services
   - Lack of a universally recognized mark for quality assurance.
   - In Kenya, products are marked by KEBS, facilitating consumer recognition of quality.
   - UNBS lacks a similar mark for PV products, hindering consumer awareness of quality standards.
   -

5.3. Accreditation and conformity assessment authorities

5.4. Market surveillance

5.5. Capacity building

5.6. Creation of QI networks

5.7. International standards and technical regulations that still require adaptation to the regional context
   - In East African countries like Uganda, Kenya, Tanzania, Rwanda, and Burundi, there is a strong inclination towards international cooperation and open markets.

- Significant potential for international collaboration exists, including sharing knowledge, best practices, financial support, and technology transfer. This is especially important as technological advancements often reach developing countries later.
- Aligning policies to facilitate trade would enhance collaboration and market growth.
- Opportunities for research and development (R&D) innovation are abundant.
- International collaboration has the potential to create jobs and improve the local market through exposure to international experience

6. Other key stakeholders
   - Kenya Accreditation Service (KENAS) website: https://www.kenas.go.ke/
   - Kenya Bureau of Standards (KEBS) website: https://www.kebs.org/
   - Lighting Global Quality Standards resource: https://www.lightingglobal.org/resource/lighting-global-quality-standards/
   - Contact for Winnie Onziru at Uganda National Bureau of Standards (UNBS): winnie.onziru@unbs.go.ug
   - Contact for Peter Wangara at Kenya Bureau of Standards (KEBS): wangara@kebs.org
   - Contact for Gacheru at Kenya Bureau of Standards (KEBS): gacherus@kebs.org / Gacherus@kebs.org
   - Contact for Kenya Accreditation Service (KENAS): info@kenas.go.ke
   - Contact for Thomas Bundi at Strathmore Energy Research Center, Kenya: tbundi@strathmore.edu
   - Contact for Ignatius Maranga at Strathmore Energy Research Center, Kenya: imaranga@strathmore.edu

Interviewer: Josef Hermann	**Interviewee:** Alex S. Mboa
Interview date: 28.02.2024	**Organization:** KEBS
Interview time and time zone: 14:30 EAT	**Position: Manging Director**

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products

1.1. Standards/technical regulations implemented/under implementation

- Kenya has developed and adopted various standards associated with photovoltaic (PV) systems, including PV modules, inverters, solar PV cables, converters, charge controllers, batteries, and connectors.
- Some of these standards are adopted from International Electrotechnical Commission (IEC) standards.
- Kenya serves as the secretariat for the East African technical committee for renewable energy, contributing to the development of regional standards, many of which are also based on IEC standards.
- Currently, Kenya is reviewing a code of practice for the design and installation of PV products, applicable to both standalone and grid-connected PV systems.
- Efforts are underway to establish a net metering tariff system for households, which is still in progress.
- Additionally, Kenya is in the process of developing standards for solar illumination systems.

1.2. Testing procedures and facilities for PV products

- Solar batteries in Kenya undergo testing by ABM, a private company, adhering to ISO 17025 standards.
- KEBS operates a lab primarily focusing on safety-related tests, lacking full capacity testing capabilities.
- The University of Nairobi lab specializes in testing plug and play solar systems.
- The accreditation status of the Strathmore University lab is uncertain.

1.3. Regional conformity assessment bodies and PV certification

- KEBS mandatory certification scheme:
    - Mutual recognition within the EAC: Products certified by one EAC country's national bureau of standards are accepted throughout the EAC, including locally produced items.
    - For imported equipment: PVoC (Pre-Export Verification of Conformity) or the international standardization mark is required.
- KEBS implements the PVOC approach.
- One-stop shop for importation: Collaboration with customs authorities for clearance, customs, PVoC, etc.
- Energy regulator: EPRA (Energy and Petroleum Regulatory Authority).
- Voluntary certification scheme for plug and play systems: VeraSol approach.

1.4. Accreditation process for conformity assessment bodies

- Our accreditation aligns with the ISO IEC 17020 standard.
- Kenya's national accreditation body is KENAS (https://www.kenas.go.ke/).
- Kenya is a member of the IECEE scheme (https://www.iecee.org/who-we-are/about-us), where product certifications can be verified.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

2.1. Human capacities

2.2. Metrology and testing

- Testing capabilities: Numerous tests cannot be conducted locally, necessitating shipment abroad, resulting in delays and increased expenses.

2.3. Certification

2.4. Accreditation and conformity assessment

2.5. Market surveillance

- Our Market Surveillance department is in operation.
- Various products are entering through unofficial channels.
- Efforts are made to empower consumers, including checking product marks.
- A toll-free platform has been established for producers to verify product validity and inquire about product marks.

2.6. Critical challenges

- KEBS or any private company ought to establish a comprehensive PV solar test laboratory.
- Increase consumer awareness to designate market surveillance officers from within the consumer community, alleviating the workload of official officers.

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level

- KEBS has established an online platform for consumers to verify the authenticity of product marks, enhancing transparency.
- The Kenya Renewable Energy Association has developed a platform for users to verify technicians' qualifications for PV installation, although it is currently undergoing maintenance.
- Regional activities by Lighting Global (now VeraSol) for plug-and-play products have been successful, with a baseline market research study showing sector improvements such as enhanced business environment and increased involvement of key actors.
- Recognizing the need for a mandatory national standard, Lighting Global shifted from voluntary quality assurance to a more inclusive approach.
- Emphasizing collaboration over working in isolation, there is a call to think beyond individual nations to promote broader regional cooperation.

4. Key stakeholders and assessment of regional cooperation frameworks

- The Regulatory framework mandates involvement from national standards bureau (KEBS) and national accreditation bodies (KENAS).
- Private companies, including Multinational Inspection bodies, play a role in Pre-Export Verification of Conformity (PVoC).
- Testing labs such as ABM, University of Nairobi, and Strathmore University contribute to quality assessment.
- Calibration labs ensure accuracy and reliability of measurement instruments.
- Voluntary verification schemes like Vera Sol offer additional assurance of quality.
- Regulatory bodies in the energy sector, such as the Energy and Petroleum Regulatory Authority (EPRA), hold significance in ensuring compliance.
- The government's endorsement of quality infrastructure through a QI policy is essential for support.
- Enhanced cooperation among stakeholders is necessary; working in silos has been observed, indicating the need for increased collaborative efforts.

5. Necessary interventions for the promotion of regional frameworks for solar QI

5.1. Metrology and testing

5.2. Certification of products and services

- Encourage all market participants to utilize existing quality marks and enhance their effectiveness.
- Improve accessibility to information about product certification processes for consumers and manufacturers alike.
- Simplify the process of product certification to increase participation and understanding.
- Implement incentives to demonstrate the benefits of product certification to stakeholders.

5.3. Accreditation and conformity assessment authorities

5.4. Market surveillance

5.5. Capacity building

- Capacity development is most urgently required in testing, market surveillance, and product certification.
- Testing, market surveillance, and product certification are the areas with the greatest need for capacity enhancement.
- The primary focus for capacity development lies in testing, market surveillance, and product certification.

5.6. Creation of QI networks

5.7. International standards and technical regulations that still require adaptation to the regional context

6. Other key stakeholders

- KENAS, contact info@kenas.go.ke

Interviewer: Josef Hermann	**Interviewee:** Anna Karugaba / Monica Nakyazze
Interview date: 08.02.2024	**Organization:** APTech Africa
Interview time and time zone: 15:00 EAT	**Position:** CTO of APTech Africa / Electrical Engineer

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products

1.1. Standards/technical regulations implemented/under implementation.

- The majority of standards in Uganda are derived from IEC standards, with some being mandatory for equipment importation.
- Standards for system installation are not consistently enforced, except for large-scale installations and minigrids regulated by the Energy Regulatory Authority (ERA).
- Compliance with standards for imported equipment is monitored by the Uganda National Bureau of Standards (UNBS), yet substandard products persist in the market.
- Larger plants are subject to regulation and registration, while smaller plants often go unregistered.
- Commonly adopted standards include IEC 61215, IEC 61646, IEC 62109, and IEC 62257 for rural electrification, among others, alongside regular electrical standards.
- Uganda is currently developing a feed-in tariff system, though it is not yet implemented.

1.2. Testing procedures and facilities for PV products

1.3. Regional conformity assessment bodies and PV certification

- Kenya imposes stricter PV standards compared to other countries in the region.
- South Sudan has minimal regulations or standards regarding photovoltaic (PV) products.
- The East African Community (EAC) Taxation handbook, developed by solar associations, aims to standardize import processes within the EAC to address disparities between member countries.
- The Uganda National Bureau of Standards (UNBS), operating under the Energy Regulatory Authority (ERA), is responsible for enforcing regulations, including licensing and approving mini-grid tariffs.

1.4 Accreditation process for conformity assessment bodies

- Due to being a private company, their responses focused primarily on their ongoing processes.
- Importation: UNBS requests a Certificate of Conformity (COC) from the producing country (PVoC).
- Samples are occasionally taken, although they may be returned after several months.
- Clearance typically takes around a week, occasionally extending to two weeks, but certainty regarding timelines is not guaranteed.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

2.1. Human capacities

- Installers lack expertise, often at lower skill levels.
- Technicians are unfamiliar with standards or may not even possess technical qualifications.
- Distributors or sellers lack proficiency in solar technology.

2.2. Metrology and testing

2.3. Certification

2.4. Accreditation and conformity assessment

2.5. Market surveillance

- Numerous products fail to meet standards (e.g., advertised as 350W but actually 320W).
- Unclear entry into the market for non-compliant products.
- Incorrect labeling, such as AC products labeled as DC.
- Limited number of authorized resellers.
- Bribery poses challenges during importation.

- Inconsistent application of taxes/customs, with some companies exempt.

2.6. Critical challenges

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
    - Solar energy associations are effectively training individuals, conducting workshops such as mini-grid sessions that attract participants from various countries.
    - GIZ and UN initiatives are focused on capacity building and raising awareness.
    - International organizations like GIZ demonstrate high-quality installations, although local replication often uses inferior equipment and installation standards.
    - Notable success stories are observed in refugee camps where high-quality equipment installations are evident.
    - Uganda requires enhanced regulations and market surveillance for maintaining quality standards, especially in smaller installations.
    - APTech Africa adheres to international standards, despite consumer preference for cheaper products due to budget constraints.
    - Implementing regulations is as crucial as establishing them; market surveillance should ensure solar products are sold and installed by certified professionals.
    - Capacity training for existing companies is essential for disseminating knowledge and maintaining quality standards.
    - Government involvement is necessary to prioritize quality infrastructure (QI), including the registration of installed systems to incentivize proper installations by traceable professionals.
4. Key stakeholders and assessment of regional cooperation frameworks
5. Necessary interventions for the promotion of regional frameworks for solar QI

5.1. Metrology and testing

5.2. Certification of products and services

5.3. Accreditation and conformity assessment authorities

5.4. Market surveillance

5.5. Capacity building

5.6. Creation of QI networks

- Collaboration between the solar association and UNBS regarding standards primarily involves larger companies.
    - Enhanced cooperation is necessary and remains an ongoing process to ensure effective dissemination of information.
    - Increased information sharing enables better responsiveness to new developments, benefiting both industry players and government agencies seeking to stay abreast of the latest technological advancements.
- International cooperation:
    - Collaboration on regulations, such as feed-in tariffs, and technical aspects, including emerging technologies like Mini-grids and large-scale grid-connected PV systems, offers valuable learning opportunities.
    - Research findings from organizations like IEEE regarding the integration of various power producers contribute to knowledge exchange.
    - International organizations like GIZ bring significant expertise to the country, presenting favorable prospects for cooperation.
    - Some international organizations may introduce standards not yet implemented in Uganda, offering opportunities for learning and knowledge transfer from these installations.

5.7. International standards and technical regulations that still require adaptation to the regional context

6. Other key stakeholders

Interviewer: Josef Hermann	**Interviewee:** Wiliam Swaka
Interview date: 06.02.2024	**Organization:** South Sudan National Bureau of Standards
Interview time and time zone: 11:00 EAT	**Position:** Senior inspector

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products

1.1. Standards/technical regulations implemented/under implementation.

- South Sudan lacks established standards for solar products and currently has no funding allocated for their development.
- Despite the presence of a laboratory for over 12 years, there has been no testing of photovoltaic (PV) products.
- Solar energy is widely utilized in South Sudan, yet there are no mechanisms in place to ensure the quality of solar products.
- Even in personal usage scenarios, such as in the speaker's own home, solar energy is utilized without assurance of quality.
- The understanding of the importance of quality infrastructure is still nascent in South Sudan, compounded by numerous challenges facing the country.
- There is a pressing need for support in various areas, including establishing a solar testing laboratory and implementing quality infrastructure for solar products.
- South Sudan lacks national standards for solar energy and is not a member of the International Electrotechnical Commission (IEC) board, relying instead on harmonizing standards through the East African Community (EAC).

1.2. Testing procedures and facilities for PV products

1.3. Regional conformity assessment bodies and PV certification

1.4. Accreditation process for conformity assessment bodies

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

- The country lacks commitment to finance a solar lab.
- Solar energy is not currently a priority in the country due to more urgent challenges such as food testing, resulting in insufficient funding for quality infrastructure (QI) of solar equipment.
- There is also a lack of awareness at the governmental level.

2.1. Human capacities

- Trained personnel are necessary.
- There is no solar association in the country to represent the solar sector.

2.2. Metrology and testing

2.3. Certification

2.4. Accreditation and conformity assessment

2.5. Market surveillance

2.6. Critical challenges

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level

- There could be some solar-powered pumps in the country, but the exact number is unknown.
- EACREEE visited last year and engaged with the Ministry of Energy and Dams.
- There was a knowledge exchange visit to Lusaka, Zambia, funded by UNIDO.

4. Key stakeholders and assessment of regional cooperation frameworks

5. Necessary interventions for the promotion of regional frameworks for solar QI

- There is a necessity for heightened awareness, particularly among ministers such as those from the Ministry of Thermal Energy.

5.1. Metrology and testing
5.2. Certification of products and services
5.3. Accreditation and conformity assessment authorities
5.4. Market surveillance
5.5. Capacity building
5.6. Creation of QI networks

- International organizations' involvement in South Sudan is crucial.
- Assistance is sought to establish a solar quality infrastructure (QI) framework.
- Specific funding is needed to gradually meet requirements in metrology, testing, human capacity, and standard adaptation.

5.7. International standards and technical regulations that still require adaptation to the regional context.
Other key stakeholders

Development of regional quality infrastructure frameworks for solar photovoltaics products and services in the East African Community and the Pacific Community – Interview minutes

Interviewer: Francis Sakato	Interviewee: Brian Fitzgerald
Interview date: 16th January, 2024	**Organization: Energy Efficiency and Conservation Authority**
Interview time and time zone:	1:30pm New Zealand Time

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products
   1.1. Standards/technical regulations implemented/under implementation.
      - Solar panels must meet the AS/NZS 5033 standard and must have IEC 61730 certification. The inverter of the solar power system must meet AS 4777.1 standards. Once the solar power installation is complete, the electrician for the job is obligated to issue a Certificate of Compliance (CoC).
      - IEC 61215 lays down requirements for the design qualification and type approval in general open-air climates defined in IEC 60721-2-1.
      - Standards Australia has recently published revised standard AS/NZS 5033:2021, Installation and safety requirements for photovoltaic (PV) arrays. NZ may adopt this in the future. AS/NZS5033 is referenced in AS/NZS 3000, commonly known as the Wiring Rules, which is called upon in the Electricity Safety (General) Regulations 2019.

   1.2. Testing procedures and facilities for PV products
      - Only SGS in Auckland – NATA accredited to all NZ standard requirements. Broad spectrum test laboratory
      - Very few parts or components of solar PV systems are currently tested in the region.

   1.3. Regional conformity assessment bodies and PV certification
      - No regional conformity assessment bodies that conduct certification processes for solar PV products and services

   1.4. Accreditation process for conformity assessment bodies
      - No – handled via the Certificate of Conformity (CoC) process.
      - The accreditation process that conformity assessment bodies/authorities undergo are as per IEC 61730
      - The existing certifications for PV products and services are based on internationally recognized frameworks as explained above.
      - However, there are no regional accreditation bodies specialized in solar PV products and service.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level
   2.1. Human capacities
   2.2. Metrology and testing
   2.3. Certification
   2.4. Accreditation and conformity assessment
   2.5. Market surveillance
      - Very few challenges in a market as small as NZ with (currently) low solar uptake. Local industry is just starting to get going.

   2.6. Critical challenges
      - Critical challenges that should be addressed as priorities are demand for solar and when available human capacities

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
    - New Zealand is very aligned with Australia on most electrical technology regulation. We would look to maintain alignment with Australia
4. Key stakeholders and assessment of regional cooperation frameworks
    - EECA does not regulate solar but is a member of EL-042 the trans-Tasman standards committee that looks after renewable technologies
5. Necessary interventions for the promotion of regional frameworks for solar QI
    5.1. Metrology and testing
    5.2. Certification of products and services
    - Yes, intervention needed
    5.3. Accreditation and conformity assessment authorities
    - Yes, intervention needed
    5.4. Market surveillance
    5.5. Capacity building
    - Yes, intervention needed
    5.6. Creation of QI networks
    5.7. International standards and technical regulations that still require adaptation to the regional context
    - International cooperation in shaping global best practices for solar QI in the region is needed as a matter of high important.
    - o IEC 61730 for PV modules
    - o IEC 61215 for PV modules
    - o IEC 61646 for PV modules – Not yet
    - o IEC 62109 for inverters – Use AS/NZS 4777.1
    - o IEC 62093 for inverters
    - o IEC 62548 for design and installation – Use AS/NZS 5033
    - o IEC 60464 for design and installation
    - o IEC 61724 for performance monitoring
    - o IEC 62257 for off-grid and rural electrification
    - o IEC 62738 for utility-scale PV
    - o ISO/IEC 17025 for competence of testing laboratories – used now
    - o ISO/IEC 17067 for product certification
6. Other key stakeholders

Comments

- Standards New Zealands was reached as one of the key stakeholders for the interview, however, they referred the team to Katrina Murison, Lead Adviser Infrastructure of New Zealand Ministry of Foreign Affairs & Trade and Brian Fitzgerald, Technical Lead, Standards and Regulation of Energy Efficiency & Conservation Authority. Mr. Brian Fitzgerald responded to our request for the interview.
- Most of the feedback is from New Zealand perspective where the respondent is based at.

Interviewer: Francis Sakato	**Interviewee:** **Col. (Ret'd) Siamelie Latu**
Interview date: 22nd January, 2024	**Organization: OPERA**
Interview time and time zone:	Responding to Questionnaire

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products
   1.1. Standards/technical regulations implemented/under implementation
      - There is a Regional Standard developed by SEIAPI adopted by Ministry of Energy. The Energy Commission used the AS/NZS 3000 for inspections started from AC side of the solar system.
      - Mostly the Pacific Region follows AS/ NZS (Combine Australia and New Zealand Standard.
      - There are solar PV standards under development in respective Pacific communities.

   1.2. Testing procedures and facilities for PV products
      - No testing procedures and facilities for PV products available.
      - No parts or components of solar PV systems are tested in the region.

   1.3. Regional conformity assessment bodies and PV certification
      - No regional conformity assessment bodies that conduct certification processes for solar PV products and services

   1.4. Accreditation process for conformity assessment bodies
      - Accreditation process for conformity assessment is still under development.
      - The AS/NZS 3000 is widely used to ensure systems and design are consistent with.
      - There are no regional accreditation bodies specialized in solar PV products and services.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level
   2.1. Human capacities
      - Small market, lack of interest and Finance

   2.2. Metrology and testing
      - Testing of earthling, polarity, connection and follow up the testing format recommended on AS/NZS WIRING RULES.

   2.3. Certification
      - No test facilities and lack of regulation

   2.4. Accreditation and conformity assessment
      - No accreditation and conformity assessments are done

   2.5. Market surveillance
      - Lack of information and regulation.

   2.6. Critical challenges
      - For Tonga, there is no specific LAW AND Regulation to direct which ministry is responsible for the whole system of Solar.
      - No standards are in place to ensure conformity for safety and quality reasons
      - No proper waste management (recycling, disposal, etc.) in place for PICs when solar PV products are past their useful life

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
   - The Vaini Solar Farm in Tonga is a success initiative which although has few maintenances but is still working properly
   - More support is required from donor.
   - Competition must be facilitated to drive quality and enable affordability.

4. Key stakeholders and assessment of regional cooperation frameworks
    - Energy Regulators are the key stakeholders responsible for promoting and implementing QI frameworks for solar PV products and services in the region.
5. Necessary interventions for the promotion of regional frameworks for solar QI
    - All designs and specifications must be approved and certified by the Energy Commission (Regulator).
    - Key stakeholders need to share success ideas in meeting, workshop, trainings etc. to facilitate the development and enforcement of a QI framework.

    5.1. Metrology and testing
    - A regional training is required.

    5.2. Certification of products and services
    - Adopt a standard to guide the standard of productions.

    5.3. Accreditation and conformity assessment authorities
    - Need a testing Laboratory and testing facility

    5.4. Market surveillance
    - Enforce regulation for selling and importing of products.

    5.5. Capacity building
    - Establishment of a training and testing facility

    5.6. Creation of QI networks
    - Training Syllabus to start at institutes, meeting, workshop, training.

    5.7. International standards and technical regulations that still require adaptation to the regional context
    - International cooperation in shaping global best practices for solar QI in the region is needed as a matter of high important.
    - In terms of standards, all the listed standards are relevant and should be adopted as and when necessary.
        - IEC 61730 for PV modules
        - IEC 61215 for PV modules
        - IEC 61646 for PV modules
        - IEC 62109 for inverters
        - IEC 62093 for inverters
        - IEC 62548 for design and installation
        - IEC 60464 for design and installation
        - IEC 61724 for performance monitoring
        - IEC 62257 for off-grid and rural electrification
        - IEC 62738 for utility-scale PV
        - ISO/IEC 17025 for competence of testing laboratories
        - ISO/IEC 17067 for product certification
6. Other key stakeholders (Tonga based)
    - Energy Commission
    - MEIDECC Department of Energy
    - Ministry of Infrastructure.

Comments:

- Interview not conducted due to busy schedules and difficulty faced in setting up an interview. Nevertheless, the questions were answered and provided via email at 8:55am, PNG Time.
- Some of the responses are from Tonga perspective where the respondent is based at.

Interviewer: Francis Sakato	Interviewee: Jane Romero
Interview date: 20th December, 2023	**Organization: PRIF**
Interview time and time zone:	1pm Manila Time

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products
   1.1. Standards/technical regulations implemented/under implementation
      - QI framework principles recently introduced in the Pacific region (November 2023).
      - PRIF is not aware of any solar PV standards development in the region;
      - Donor led projects subscribe to international standards such as IEC during the procurement process, that is, proposed projects to be implemented are required to comply with certain minimum standards;
      - Standards the donors subscribe to are often those that are more appropriate for the Pacific context, however, there is the risk of mismatch in standards during project development stage;
      - There is a need for review of existing international standards to align within the context of the Pacific region.

   1.2. Testing procedures and facilities for PV products
      - Not aware of any testing procedures and facilities for PV products available

   1.3. Regional conformity assessment bodies and PV certification
      - No comments

   1.4. Accreditation process for conformity assessment bodies
      - No comments

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level
   2.1. Human capacities
      - There is a lean workforce in both government and private sector to drive solar PV industry forward;
      - Capacity constraints is one of the biggest challenges, there appears to be very little to nil internal capacity in key government agencies to develop the solar PV industry;
      - Standards relied on are often the ones the manufacturers subscribe to on their products, and with limited to nil resources to independently test and verify these products.

   2.2. Metrology and testing
      - No metrology and testing facilities available locally. For instance, in Fiji the Department of Trade and Industry looks into standards but limited capacity and resources such labs to test and verify and originality and quality of the products independently.
      - There was no issue before but now with the influx of substandard products entering the markets, the importance of ensuring the products are compliant to relevant accredited standards and codes becomes increasingly imperative.

   2.3. Certification
      - Fear of substandard equipment entering the markets with possibility dubious certification are likelihood;

   2.4. Accreditation and conformity assessment
      - No accreditation and conformity assessments are done to their knowledge.

   2.5. Market surveillance
      - The challenges in the market and entire supply chain needs to be addressed holistically. For example, in the development of any renewable energy solution, say solar PV, one must

understand that for the project to get off the ground involves an entire spectrum of stakeholders from the government sector to the private sector in the supply chain. Therefore, communication is key to success as lack of active engagement of all relevant stakeholders thereof can result in significant challenges while implementing.

- Capacity and resource constraints often limit continuous market surveillance and monitoring to ensure quality assured products are imported into the region.

2.6. Critical challenges

- No standards are in place to ensure conformity for safety and quality reasons, hence it is important to scrutinise the projects.
- No proper waste management (recycling, disposal, etc.) in place for PICs when solar PV products are past their useful life
- Child labour in the solar PV industry is a critical area that requires attention in the entire supply chain.
- Enforcement gap in terms of implementing existing guidelines and standards is a critical challenge for a lot of PICs.

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
    - Capacity development and building, both in terms of human capacity and infrastructures;
    - Awareness at the moment is not very effective, there needs to greater emphasis and cooperation to deliver regional workshops
    - SPC has influence in the Pacific communities, utilise its networks to involve relevant stakeholders in meaningful engagements;
    - The extent of capacity building needs to be reviewed and evaluated to determine whether desire outcomes are achieved;
4. Key stakeholders and assessment of regional cooperation frameworks
    - QI needs enhancement, hence need to coordinate with every relevant stakeholders so that all initiatives are harmonised and coordinated efficiently.
5. Necessary interventions for the promotion of regional frameworks for solar QI

    No sure of the QI framework, hence little contributions made in the area. Some of the comments made are:
    - Continuous engagement and consultation with all relevant stakeholders, awareness at the moment is not very effective.
    - Information for sola PV materials and guidelines need to be translated into local languages.

    5.1. Metrology and testing
    5.2. Certification of products and services
    5.3. Accreditation and conformity assessment authorities
    5.4. Market surveillance
    5.5. Capacity building
    5.6. Creation of QI networks
    5.7. International standards and technical regulations that still require adaptation to the regional context
6. Other key stakeholders
    - SEIAPI, Donor partners
    - Government agencies
    - Trade and Industry (or Commerce), Energy, Customs, etc.
    - Private sector involved in solar PV projects

Comments

- It is noted from the interview that there appears to be no awareness of existing regional standards, guidelines, codes, etc., if any in existence.
- Active involvement of relevant stakeholders in meaningful engagements is key to achieving greater outcomes to drive the QI framework initiative the Pacific communities.

- There are no test facilities available to independently verify information given on the solar PV products.

Interviewer: Francis Sakato	Interviewee: Solomone Fifita & Sosefo Tofu
Interview date: 18th January, 2024	**Organization: SPC**
Interview time and time zone:	11am – 12pm Tonga Time

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products
   1.1. Standards/technical regulations implemented/under implementation
      - The Guidelines developed by SEIAPI recommends relevant international standards and codes for design and installation of solar PV systems – both on-grid and off-grid;

   1.2. Testing procedures and facilities for PV products
      - No testing procedures and facilities for PV products available in the region.
      - Before installations, basic tests are done such as testing the open circuit voltage. And after installation, basic tests are done again before commissioning. However, no detailed tests are undertaken to verify the ratings prescribed by manufacturers on the products.

   1.3. Regional conformity assessment bodies and PV certification
      - There are no regional conformity assessment bodies, however, it is anticipated that technical requirements must be met by the suppliers/manufacturers;

   1.4. Accreditation process for conformity assessment bodies
      - There are no accreditation bodies at the moment in the region.
      - There are no testing facilities because of lack of funding and lack of technical capacity to operate the facilities.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level
   2.1. Human capacities
      - Technical capacity constraints, skills gap in terms of appropriate knowledge and expertise is significant in the region;

   2.2. Metrology and testing
      - No metrology and testing facilities available locally in the PICs

   2.3. Certification
      - Local regulators need to be equipped and well resourced to ensure quality assurance and certified products are imported into the country

   2.4. Accreditation and conformity assessment
      - No accreditation and conformity assessments are done in the region

   2.5. Market surveillance
      - Capacity and resource constraints often limit continuous market surveillance and monitoring to ensure quality assured products are imported into the region.
      - Lack of coordination among inter-agencies to counter importation of counterfeit and low-quality products.

   2.6. Critical challenges
      - No standards are in place to ensure conformity for safety and quality reasons; hence it is imperative that standards for solar equipment are in place to guarantee safety and sustainability of solar PV products and services;
      - Importers must ensure standards are complied with.
      - Coordination and monitoring among relevant stakeholders such as Customs and Standards bodies with appropriate knowledge and skills level are crucial to detect counterfeit and low-quality products.

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
    - Build capacity in terms of human and infrastructure development;
    - There is a high-level support required from the Pacific Islands Forum (PIF) Leaders.
4. Key stakeholders and assessment of regional cooperation frameworks
    - Identify leading agency to coordinate this framework.
    - Key stakeholders include PIF Leaders, SPC, SEIAPI, PPA
5. Necessary interventions for the promotion of regional frameworks for solar QI
    - Enforcement of QI framework once adopted;
    - Train and build local capacity;
    - Customs Officers need to be trained to ensure appliances are compliant with relevant standards.
    - Awareness program to push the QI framework

    5.1. Metrology and testing
    5.2. Certification of products and services
    5.3. Accreditation and conformity assessment authorities
    5.4. Market surveillance
    5.5. Capacity building
    5.6. Creation of QI networks
    5.7. International standards and technical regulations that still require adaptation to the regional context
    - Adopt all standards that need to be adopted,
6. Other key stakeholders
    - University of South Pacific
    - PPA
    - SEIAPI
    - SPC

Interviewer: Francis Sakato	Interviewee: Vanda Faasoa-Chan Ting and Vainalepa Toiata Uili
Interview date: 20th December, 2023	**Organization: SPREP and Samoan Ministry of Natural Resources and Environment**
Interview time and time zone:	11am Samoa Time

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products
   1.1. Standards/technical regulations implemented/under implementation
   - Not aware of any regional QI frameworks available for the region.
   - Samoa has Energy Efficiency (EE) Acts to regulate certain electrical appliances imported into the country.
   - Samoa has a Building Code that provides a technical regulatory oversight of solar PV installations on rooftops.
   - There are Grid Codes available in certain PICs that provide the technical requirements for integration of solar PV to the main utility grids.
   - Relevant standards to be complied with are often captured in the specific projects, however, most of these standards are international standards such as AS/NZS or IEC, etc.

   1.2. Testing procedures and facilities for PV products
   - No testing procedures and facilities for PV products available

   1.3. Regional conformity assessment bodies and PV certification
   - Not aware of any, hence no comment

   1.4. Accreditation process for conformity assessment bodies
   - No aware of any, hence no comment
2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level
   2.1. Human capacities
   - Local regulators need to be trained and certified to verify solar PV products coming into their respective countries
   - Prioritise national and regional capacity development

   2.2. Metrology and testing
   - No metrology and testing facilities available locally

   2.3. Certification
   - Local regulators need to be equipped and well resourced to ensure quality assurance and certified products are imported into the country

   2.4. Accreditation and conformity assessment
   - No accreditation and conformity assessments are done

   2.5. Market surveillance
   - Capacity and resource constraints often limit continuous market surveillance and monitoring to ensure quality assured products are imported into the region

   2.6. Critical challenges
   - No standards are in place to ensure conformity for safety and quality reasons
   - No proper waste management (recycling, disposal, etc.) in place for PICs when solar PV products are past their useful life
3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
   - Capacity development and building, both in terms of human capacity and infrastructures

- Evaluate cooperation in terms of achievement by applying a sectorial approach to implement sector plans.
- Undertake mid-terms reviews quality assurance
- Create partnerships and collaboration with other countries on the development and integration of renewable energy technologies.
- Commitment from relevant stakeholders is important to enforce the quality assurance framework for any solar PV projects; and ensure proponents abide by regulations.

4. Key stakeholders and assessment of regional cooperation frameworks
    - Cooperation among key stakeholders to align and streamline work programs for optimal output
5. Necessary interventions for the promotion of regional frameworks for solar QI

    No sure of the QI framework, hence little contributions made in the area. Some of the comments made are:
    - Continuous engagement and consultation with all relevant stakeholders
    - Systems and mechanisms need to be in place to test and verify solar PV products
    - Legislations need to be enacted to ensure relevant standards are adopted and complied with
    - Some products manufactured in conformance of Chinese standards which need to be converted to relevant regional standards;
    - Build good working relationships with suppliers and solar PV products

    5.1. Metrology and testing
    5.2. Certification of products and services
    5.3. Accreditation and conformity assessment authorities
    5.4. Market surveillance
    5.5. Capacity building
    5.6. Creation of QI networks
    5.7. International standards and technical regulations that still require adaptation to the regional context
6. Other key stakeholders
    - Ministries
    - Utilities
    - Private sector involved in solar PV projects

Interviewer: Francis Sakato	**Interviewee:** **Dr. Michelle McCann**
Interview date: 05th February, 2024	**PV Lab Australia**
Interview time and time zone:	1pm-2pm AEDT

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products
   1.1. Standards/technical regulations implemented/under implementation
   - IEC 61215 is used in Australia and covers a lot on solar PV systems;
   - ISO 2859 is used for sampling purposes. It is based on the acceptance quality limit (AQL), which is the maximum percentage of defective items that can be considered acceptable.
   - Standards are not mandated by Government in some jurisdiction, but are used mostly for commercial reasons;

   1.2. Testing procedures and facilities for PV products
   - IEC Guidelines are followed for testing. Plans are in place to expand testing of solar PV systems.
   - Modules are sent for testing at the Lab.

   1.3. Regional conformity assessment bodies and PV certification
   - Certificates are checked to ensure the products are tested and validated from an accredited testing facility, PV Lab Australia being one of these.

   1.4. Accreditation process for conformity assessment bodies
   - There are accreditation procedures in place, and handful of solar PV components are testing using IEC 61215.
   - PV Lab Australia is the only lab in the Pacific.
2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level
   2.1. Human capacities
   2.2. Metrology and testing
   2.3. Certification
   2.4. Accreditation and conformity assessment
   2.5. Market surveillance
   2.6. Critical challenges
   - End users not engaging the testing organisations to ensure quality and conformity to standards;
   - Specifications ought to be clearly spelt out in the contract so quality is maintained during installations.
3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
   - Do what needs to be done early to minimise low quality and sub-standard installations and systems.
4. Key stakeholders and assessment of regional cooperation frameworks
   - Cooperation among key stakeholders is key for the successful implementation of regional frameworks to achieve tangible output.
5. Necessary interventions for the promotion of regional frameworks for solar QI

No sure of the QI framework, hence little contributions made in the area. Some of the comments made are:

- Build capacity and testing facilities;
- Close cooperation and stakeholder engage because it is very important;
- Quality control is necessary to minimise risks;

5.1. Metrology and testing
5.2. Certification of products and services
5.3. Accreditation and conformity assessment authorities
5.4. Market surveillance
5.5. Capacity building
5.6. Creation of QI networks
5.7. International standards and technical regulations that still require adaptation to the regional context

6. Other key stakeholders
   - National University of Singapore
   - University of New South Wales
   - Energy Fiji Limited

Note:

- The feedback provided were from the PV Lab Australia perspective in terms of what they are doing at the moment;
- This work is very important and PV Lab Australia is willing to engage further if the need arises to do so;
- Permission granted to acknowledge the interviewee as a participation in this consultation.

Interviewer: Francis Sakato	Interviewee: Dr. Ulrich Diekmann
Interview date: 08th February, 2024	**The Pacific Island Furum**
Interview time and time zone:	10:30 am- 11:30 am AEDT

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products
   1.1. Standards/technical regulations implemented/under implementation
      - Quality Infrastructure in general started by PIF Secretariat with funding support from donors;
      - Different components of QI have been covered in all the 18 States of the Pacific Region. Work has been done on:
         - Standards
         - Metrology
         - Conformity Assessment
      - Standards development need technical expertise to adopt and/or adapt standards for implementation.

   1.2. Testing procedures and facilities for PV products
      - Not aware of any at the moment but testing of solar PV panels can be looked into.
      - Currently testing is done mostly on food and agriculture products and systems.

   1.3. Regional conformity assessment bodies and PV certification
      - Pacific Islands Standards Committee does assessment of QI frameworks and related projects to ensure quality and sustainability of systems and processes.

   1.4. Accreditation process for conformity assessment bodies
      - No info provided
2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level
   2.1. Human capacities
      - Technical experts need to be mobilised to adopt and/or adapt standards;
      - Countries need to guided on what is fit-for-purpose in terms of their specific QI frameworks and related systems and/or process.
      - Work is currently being done to establish a coordination mechanism;

   2.2. Metrology and testing
      - Establishment of labs is important and should be supported by respective Governments;
      - There needs to be one stop mechanism for standards development;
      - UNIDO has provided support to the PIF Secretariat to look into QI for various systems;

   2.3. Certification
      - No comments provided

   2.4. Accreditation and conformity assessment
      - No comments provided

   2.5. Market surveillance
      - No comments provided

   2.6. Critical challenges
      - Commitment from the countries is required to:
         - Develop fit-for-purpose standards and frameworks;
         - Countries want to develop their own standards; however, small systems may seem futile to delve into;

- For standards development, it is very challenging to convince tech experts to sit in standards committee because most of these engagements are voluntary based;
- Lack of awareness is one of the major hinderance for successful implementation of existing standards and frameworks;
- It takes time to develop, adopt and/or adapt to new standards;
- Standards may not be mandatory in some jurisdictions, hence may not be stringently followed and/or enforced;
- Enforcement is weak;
- Quality can be compromised if not monitored and enforced;
- Lack of appropriate knowledge and skills can be a major hinderance;
- Lack of active engagement and participation from key stakeholders.

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
    - Quality is an important aspect of solar PV that must be upheld;
4. Key stakeholders and assessment of regional cooperation frameworks
    - Needs assessment work ought to be shared among key stakeholders to optimise output both in terms of time and resources;
    - There could be a potential overlap that can be overcome through communication and open consultation with all relevant stakeholders.
5. Necessary interventions for the promotion of regional frameworks for solar QI
   No sure of the QI framework, hence little contributions made in the area. Some of the comments made are:
    - Training on the fundamentals, Build capacity for countries
    - Provide guidance and facilitate activities, but respective countries need to take ownership of such programs and interventions;
    - Commitment from relevant stakeholders is needed.

   5.1. Metrology and testing
   5.2. Certification of products and services
   5.3. Accreditation and conformity assessment authorities
   5.4. Market surveillance
   5.5. Capacity building
   5.6. Creation of QI networks
   5.7. International standards and technical regulations that still require adaptation to the regional context
6. Other key stakeholders

Note:

- PIF Secretariat has done some QI work in the Pacific with funding support from donor partners such as UNIDO, ADB, MFAT, etc.;
- Most of QI work done are on food and agriculture products and systems, with few done for solar PV. Plans are however, underway to expand on the work done for solar PV systems in the region.
- Permission granted to acknowledge the interviewee as a participation in this consultation.

Interviewer: Francis Sakato	Interviewee: Andrien Moineau
Interview date: 17th January, 2024	**Organization: Individual Consultant (Freelance)**
Interview time and time zone:	2pm – 3pm (AEDT)

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products
   1.1. Standards/technical regulations implemented/under implementation
      - No current standard for the region;
      - SEIAPI Guidelines developed based on applicable international standards and code and/or recommendations from national standards bodies that approved or adopted these standards (such as AS/NZS 3000, IEC 61215, etc.).

   1.2. Testing procedures and facilities for PV products
      - The Regional Training and Accredited Centre in Nadi, Fiji accredited the Grid-Connected Solar PV System guideline

   1.3. Regional conformity assessment bodies and PV certification
      - The Regional Training and Accredited Centre in Nadi, Fiji;

   1.4. Accreditation process for conformity assessment bodies
      - No information on the accreditation process for the Regional Training and Accredited Centre in Nadi, Fiji.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level
   2.1. Human capacities
      - Capacity constraints in a significant challenge. Capacity building is critical to the success for QI framework implementation;
   2.2. Metrology and testing
   2.3. Certification
   2.4. Accreditation and conformity assessment
   2.5. Market surveillance
   2.6. Critical challenges
   - Capacity constraints is the biggest challenge which needs to be addressed through proactive engagement and training;

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
   - Capacity building and awareness
4. Key stakeholders and assessment of regional cooperation frameworks
   - No comments
5. Necessary interventions for the promotion of regional frameworks for solar QI
   - Capacity building
   5.1. Metrology and testing
   5.2. Certification of products and services
   5.3. Accreditation and conformity assessment authorities

5.4. Market surveillance
5.5. Capacity building
5.6. Creation of QI networks
5.7. International standards and technical regulations that still require adaptation to the regional context
- Adopt all standards

6. Other key stakeholders
    - SPC
    - PPA
    - SEIAPI

Interviewer: Francis Sakato	Interviewee: Geoff Stapleton
Interview date: 08th January, 2024	**Organization: SEIAPI**
Interview time and time zone:	11am PNG Time

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products

   1.1. Standards/technical regulations implemented/under implementation

   - SEIAPI developed several guidelines to design and install renewable energy solutions in the Pacific region. These guidelines are for both grid-connected and off-grid connected systems. Some of the standards the Grid-Connected PV Systems and Off-Grid Solar PV Design Guidelines subscribe to are:

Standard	Description of Standard
AS/NZS 3000	Wiring Rules.
AS/NZS 3008	Electrical Installations - Selection of Cables.
AS 4086	Secondary Batteries for use with stand-alone power systems (Note this will soon be superseded by AS/NZS 5139 Electrical installations — Safety of battery systems for use with power conversion equipment).
AS 3011	Electrical Installations- Secondary batteries installed in buildings.
AS 2676	Guide to the installation, maintenance, testing and replacement of secondary batteries in building.
AS/NZS 5033	Installation and safety requirements for PV Arrays.
AS/NZS 4509	Stand-alone power systems.
AS 3598	Energy audits.
AS 1768	Lightning Protection.
AS/NZS 1170	Structural Design Action Set.
IEC 61215	Terrestrial photovoltaic (PV) modules - Design qualification and type approval.
• IEC 61215-1	Part 1: Test requirements.
• IEC 61215-1-1	Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules.
• IEC 61215-1-2	Part 1-2: Special requirements for testing of thin-film Cadmium Telluride (CdTe) based photovoltaic (PV) modules.
• IEC 61215-1-3	Part 1-3: Special requirements for testing of thin-film amorphous silicon based photovoltaic (PV) modules.
• IEC 61215-1-4	Part 1-4: Special requirements for testing of thin-film Cu (In,GA (S,Se)2 based photovoltaic (PV) modules.
• IEC 61215-2	Part 2: Test Procedures.
IEC 61730	Photovoltaic (PV) module safety qualification.
IEC 61730-1	Part 1: Requirements for construction.
IEC 61730-2	Part 2: Requirements for testing.
IEC 62109	Safety of power converter for use in photovoltaic power systems.
• IEC 62109-1	Part 1: General requirements.

● IEC 62109-2	Part 2: Particular requirements for inverters.
In USA the relevant codes and standards include:	
Electrical Codes-National Electrical Code and NFPA 70:	
● Article 690	Solar Photovoltaic Systems.
● Article 706	Energy storage Systems.
● Article 710	Stand-alone systems.
Building Codes	ICC, ASCE 7.
UL Standard 1703	Flat-Plate Photovoltaic Modules and Panels.
IEEE 1547	Standard for Interconnecting Distributed Resources with Electric Power Systems.
UL Standard 1741	Standard for Inverters, converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources.
UL 62109	Standard for Safety of Power Converters for Use in Photovoltaic Power Systems.
UL 2703	Standard for Mounting Systems, Mounting Devices, Clamping Retention Devices, and Photovoltaic Modules and Panels. Ground Lugs for Use with Flat-Plate
UL(IEC) 61215	Crystalline silicon terrestrial photovoltaic (PV) modules—Design qualification and type approval.
UL(IEC) 61646	Thin-film terrestrial photovoltaic (PV) modules— Design qualification and type approval.

- Previous work has been done on QI frameworks which need to be looked at to evaluate the progress of these frameworks.
- Modules and inverters follow the IEC standards.
- Some countries in the Micronesia apply US based standards.
- Standards for solar controllers is a bit challenging at the moment.

1.2. Testing procedures and facilities for PV products

- A lab in Australia verify solar PV products. It is important though to ensure the labs are accredited with the right equipment and resources to test.
- Test labs are not necessary, the most important thing is to verify the test certificates to ensure these certificates are from an accredited lab and indeed these certificates come from them.

1.3. Regional conformity assessment bodies and PV certification

- At this stage, the test certificates from manufactures are verified to ensure these come from an accredited lab.

1.4. Accreditation process for conformity assessment bodies

- No comments.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

2.1. Human capacities
- Training of people to an adequate level to competently operate and maintain systems remain a persistent challenge;
- People quality control and product quality control are very important components to ensure systems are optimised as per the intended design specifications.
- Capacity building is important, also teaching people how to verify solar PV products.
- SEIAPI working with countries to put in place solar licensing process.

2.2. Metrology and testing
- Most PICs do not have metrology and testing facilities available locally to verify solar PV products. The facilities are not necessary as the test certificates can be verified with the supplier of these test certificates. These test certificates are released by accredited organisations after ensure the products tested go through the rigorous testing process.

2.3. Certification
- Test certificates are provided by accredited organisations, however local users may not have the resources nor the capacity to verify these test certificates to ensure the products they procure are indeed compliant to the relevant standards and codes they say they are compliant with;

2.4. Accreditation and conformity assessment
- No comments.

2.5. Market surveillance
- Capacity and resource constraints often limit continuous market surveillance and monitoring to ensure quality assured products are imported into the region.

2.6. Critical challenges
- Implementation of the SEIAPI Guidelines has been a significant challenge. Most stakeholders are either not aware of these guidelines or are coming up with their own specific guidelines that they do not utilise what is already being developed.
- SEIAPI is working country to country to design modules and programs that are country specific. 13 Pacific countries have been covered with over 650 participants, however, the momentum was disrupted by the Covid-19 pandemic.
- Most products come from China and they are coming up with the own standards which would pose significant challenge to the Pacific communities.

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
   - Develop standards, codes and guidelines to suit country context, experience indicates that regional guidelines may not work well in respective Pacific communities.

4. Key stakeholders and assessment of regional cooperation frameworks
   - Due diligence is required to avoid any duplication of activities to align and optimise the pool of resources and support provided to achieve maximum output.

5. Necessary interventions for the promotion of regional frameworks for solar QI
   - Country by country intervention seems more feasible than developing regional frameworks which most likely would not be effectively serve its maximum purpose.

5.1. Metrology and testing

5.2. Certification of products and services

5.3. Accreditation and conformity assessment authorities

5.4. Market surveillance
5.5. Capacity building
5.6. Creation of QI networks
5.7. International standards and technical regulations that still require adaptation to the regional context

6. Other key stakeholders
    - PCREEE
    - SPC

Comments

- SEAPI has developed guidelines that subscribed to relevant international standards, particularly AS/NZS and IEC standards. Also, US standards such as UL and National Electrical Code are also used to satisfy requirements of different Pacific communities whose power systems subscribe to that of the Australia and New Zealand system of 50Hz frequency or US system of 60Hz frequency.
- Due diligence is very paramount to key programs and activities are not duplicated to optimise on the pool of resources and support provided to the region.
- Test facilities are not required, especially with the cost of setting it up. The most important thing is to have the capacity and capability to verify test certificates being provided and ensure these certificates are indeed from an accredited organisation that did the test and release the certificate.

Interviewer: Francis Sakato	Interviewee: Geoff Stapleton (SEIAPI) through PPA (Written feedback)
Interview date: 19th January, 2024	**Organization: Pacific Power Association**
Interview time and time zone:	11am - 12pm (Fiji Time)

Please write down the main points resulting from the interview along the following topics:

1. Status Quo – Existing regional QI frameworks for solar products
   1.1. Standards/technical regulations implemented/under implementation

- Technical Guidelines on RE/EE were developed through SEIDP (funded by the World Bank), available from: https://www.seiapi.com/guidelines/. Currently, these technical guidelines are voluntarily available and SEIAPI/PPA have plans to liaise with the various energy departments and have the guidelines adopted into the in-country framework.
- Australia/New Zealand Standards
  - A few Southern Pacific countries like Fiji, Tonga, Samoa, PNG, etc are complying with Australian/New Zealand standards such as AS/NZS 3000, AS/NZS 5033, AS/NZS 4777, AS/NZS 3008, AS/NZS 1170, etc.
- NEC Article 690
  - The North Pacific countries (FSM, RMI, Guam, etc) mostly comply with NEC article 690 and industry best practices (US territories)
- The IEC standards are being referenced for proposed and planned equipment standards to be implemented for PICs.
- PV Inverter
  - IEC 62109 Safety of power converters for use in photovoltaic power systems
  - IEC 62109-1 Part 1: General requirements
  - IEC 62109-2 Part 2: Particular requirements for inverters
- Solar Controller
  - IEC 62109 Safety of power converters for use in photovoltaic power systems
  - IEC 62109-1 Part 1: General requirements
  - IEC 62509:2010 Battery charge controllers for photovoltaic systems - Performance and functioning
- PPA is aware of the following standard but still investigating whether it is relevant for the Pacific. It is not required in Australia at this point of time for Inverters or controllers.
  - IEC 62093 Balance-of-system components for photovoltaic systems - Design qualification natural environments
- PV module
  - IEC 61215 Terrestrial photovoltaic (PV) modules – Design qualification and type approval
    - IEC 61215-1 Part 1: Test Requirements (see below for more details)
    - IEC 61215-2 Part 2: Test Procedures
  - IEC 61730 Photovoltaic (PV) module safety qualification
    - IEC 61730-1 Part 1: Requirements for construction
    - IEC 61730-2 Part 2: Requirements for testing
  - IEC 61701 Photovoltaic (PV) modules - Salt mist corrosion testing
  - IEC 62804 – (2020) Photovoltaic (PV) modules - Test methods for the detection of potential induced degradation (PID) - Part 1-1: Crystalline silicon – Delamination

- Batteries
  - IEC 60896 Stationary lead-acid batteries (series)
  - IEC 62619 Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications.
  - AS IEC 60622 Secondary cells and batteries containing alkaline and other non-acid electrolytes - Sealed nickel-cadmium prismatic rechargeable single cells
- Solar Cables
  - IEC 62930: Electric cables for photovoltaic systems with a voltage rating of 1.5 kV d.c.
- Connectors
  - IEC 62852 Connectors for DC-application in photovoltaic systems - Safety requirements and tests

1.2. Testing procedures and facilities for PV products
- The current avenue that most south pacific countries are using is the CEC accredited products list
- Approved inverter https://www.cleanenergycouncil.org.au/industry/products/inverters/approved-inverters
- Approved Modules https://www.cleanenergycouncil.org.au/industry/products/modules/approved-modules
- Currently, according to PPA's knowledge, there are no testing facility in the region.

1.3. Regional conformity assessment bodies and PV certification
- None at the moment

1.4. Accreditation process for conformity assessment bodies
- Not aware of any.
- SEIAPI has an accreditation scheme for solar designers and installers but not for solar products specifically.

2. Challenges in the implementation of technical regulation and standards for PV products and services at the regional level

2.1. Human capacities
- Lack of capacity

2.2. Metrology and testing
- Lack of testing facility, however, CEC accreditation is one possible option for now

2.3. Certification
- Lack of regulation, testing facility, etc

2.4. Accreditation and conformity assessment
- Needs adoption of product certification schemes in consultation with various stakeholders.

2.5. Market surveillance
- Authorities lack regulation to prosecute for non-compliance

2.6. Critical challenges
- In-country training and capacity building on solar
- Adoption of standards and guidelines
- Product standards regulation
- Accreditation of designers and installers

- Specific instances or examples that highlight these challenges:
    - Though voluntary SEIAPI Technical guidelines are available but still there is slow adoption. Only a few energy departments are emphasising on following these guidelines e.g. Vanuatu DOE requires compliance to SEIAPI Guidelines for their off-grid systems
    - The Fiji DOE conveyed that though they want to adopt, they need enforcement of the product standards/Guidelines/standards so that those not complying could be penalised/prosecuted for non-compliance. The product standards regulation authority usually lies with the Ministry of Trade or relevant government department and hence they need to approach this collectively to get product standards implemented.

3. Success factors and initiatives for the implementation of technical regulation and standards for PV products and services at the regional level
    - More funding for consultation with various stakeholders, continuous liaising and follow up, country by country approach
    - A successful initiative that have supported the improvement of quality infrastructure (QI) frameworks for solar PV in the region is SEIDP – Sustainable Energy Industry Development Project (SEIDP) funded by the World Bank.
4. Key stakeholders and assessment of regional cooperation frameworks
    - The key stakeholders responsible for promoting and implementing QI frameworks for solar PV products and services in the region are the Energy and trade departments, Electrical Utilities, Industry Associations, Contractor Associations, Donor agencies, CROP agencies (PPA, SPC, etc),
    - To evaluate cooperation between the different institutions in charge of designing and implementing QI and the solar PV industry and other private sector stakeholders needs a Project Manager to liaise collectively with various organisations, assign roles and responsibilities, etc.
    - Cooperation among key stakeholders facilitate the development and enforcement of a QI framework by getting various stakeholders involved. The solar industry does not stand on its own; hence enforcement will come in every stage e.g. Governments to adopt standards/guidelines/product standards, Solar industry (association and companies) to comply and implement use of standards/guidelines. A body to monitor and take action on non-compliance, Utilities to ensure compliance simultaneously, Donor agencies to focus on the same.
5. Necessary interventions for the promotion of regional frameworks for solar QI

    5.1. Metrology and testing
    - Explore current avenues available

    5.2. Certification of products and services
    - Explore and develop on current avenues available

    5.3. Accreditation and conformity assessment authorities
    - Explore and develop on current avenues available

    5.4. Market surveillance
    - Empower authorities to enforce

    5.5. Capacity building
    - More practical training centres required

    5.6. Creation of QI networks
    - Explore and develop on current avenues available

    5.7. International standards and technical regulations that still require adaptation to the regional context
    - IEC 61730 for PV modules

- IEC 61215 for PV modules
- IEC 61646 for PV modules
- IEC 62109 for inverters
- IEC 62093 for inverters
- IEC 62548 for design and installation
- IEC 60464 for design and installation
- IEC 61724 for performance monitoring
- IEC 62257 for off-grid and rural electrification
- IEC 62738 for utility-scale PV
- ISO/IEC 17025 for competence of testing laboratories
- ISO/IEC 17067 for product certification
- Those following Australian standards are adapting most of them.
- Little emphasis and fewer opportunities at this stage of the opportunities for international cooperation in shaping global best practices for solar QI in the region.

6. Other key stakeholders
   - Energy and Trade Departments
   - SPC
   - Pacific Utilities
   - Donor agencies
   - Other CROP agencies

Comments

- Pacific Power Industries (PPA) advised that they are only a Secretariat and therefore, would not be able to provide feedback on the questions. Therefore, they escalated the questions to their key stakeholders in which Geoff Stapleton (from SEIAPI) provided this response.