Physikalisch-Technische Bundesanstalt
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INTERNATIONAL COOPERATION

Landscape Study

Service demand and offer in metrology and conformity assessment in the photovoltaic sector in Viet Nam

Hợp tác Đức
DEUTSCHE ZUSAMMENARBEIT

Landscape Study

Service demand and offer in metrology and conformity assessment in the photovoltaic sector in Viet Nam

Authors
Saurabh Kumar, Nguyen Hung Diep (more information on page 67)

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On behalf of

On behalf of the Federal Government of Germany, the Physikalisch-Technische Bundesanstalt promotes the improvement of the framework conditions for economic, social and environmentally friendly action and thus supports the development of quality infrastructure.

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Disclaimer

The views and opinions expressed in this study are those of the authors and do not necessarily reflect the official position of PTB.

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Abbreviations

AB	Accreditation Body
AM	Air Mass
AOSC	Accreditation Office for Standards Conformity Assessment Capacity
APAC	Asia Pacific Accreditation Cooperation
BIPM	International Bureau of Weights and Measures
BoA	Bureau of Accreditation
CA	Conformity Assessment
CAB	Conformity Assessment Body
CB	Certification Body
CMC	Calibration and Measurement Capabilities
CNAS	China National Accreditation Service for Conformity Assessment
DAkkS	Deutsche Akkreditierungsstelle
EVN	Viet Nam Electricity Group
EPC	Engineering, Procurement and Construction
ERAV	Electricity Regulatory Authority of Viet Nam
GQII	Global Quality Infrastructure Index
IECEE	Electrotechnical Equipment and Components
HCMC	Ho Chi Minh City
ILAC	International Laboratory Accreditation Cooperation
ISFH	Institute for Solar Energy Research in Hamelin
ISO	International Organization for Standardization
MOIT	Ministry of Industry
MOST	Ministry of Sience and Technology
MRA	Mutual Recognition Agreement
NIM	National Institute of Metrology of China
NQI	National Quality Infrastructure
PDP8	8th Power Development Plan
PTB	Physikalisch-Technische Bundesanstalt
PV	Photovoltaic
QI	Quality Infrastructure
QUACERT	Quality Assurance and Certification Center of Viet Nam
QUATEST	Quality Assurance and Testing Center of Viet Nam

ABBREVIATIONS

STAMEQ	National Commission for Standards, Metrology and Quality of Viet Nam
STC	Standard Test Conditions
UV	Ultraviolet
VACI	Accreditation Center for Inspection of Viet Nam
VMI	Viet Nam Metrology Institute
VREC	Energy Consulting Joint Stock Company
WPVS	World Photovoltaic Scale

Executive Summary

Context

In recent years, the solar photovoltaic (PV) sector has experienced remarkable growth on a global scale. In 2022, the global installed capacity of solar PV reached 1,053 GW, with major markets including China, India, the United States, and notably, Viet Nam.

In Viet Nam, with the expiration of the feed-in tariff in 2021, the development of the solar energy market has slowed down. The recent Power Development Plan 8 from 15 May 2023 aims to increase the share of renewable energy in the overall energy mix to 30.9 % - 39 % by 2030, in alignment with the ambitious target of 47 % renewable energy set forth in the Political Declaration on the Just Energy Transition Partnership (JETP) between Viet Nam and the G7+ countries and development partners. The plan sets ambitious targets for solar power capacity, aiming for 168-189 GW by 2050, with significant capacity additions planned between 2030 and 2050. It is planned to equip 50 % of residential and commercial buildings with rooftop solar installations by 2030, fostering decentralized energy generation.

Metrology and conformity assessment services are crucial for the development of the PV sector, as they ensure the safety, quality, and sustainability of PV components and installations. According to international standards, such services are required in Viet Nam to achieve the targets set by the Vietnamese government and ensure the sustainable development of the national PV sector.

This study provides an overview of the existing metrology and conformity assessment services for the Vietnamese PV sector, identifies gaps, and defines recommendations for addressing them.

Key findings

Challenges and potential for development:

- **Lack of calibration services for reference modules and sun simulators**: Calibration services for important equipment used in the PV sector are insufficient in Viet Nam. Domestic calibration of reference modules and sun simulators used by module manufacturers is critical for the sector, but not available. In this regard, the Viet Nam Metrology Institute is pursuing the establishment of a sun simulator calibration laboratory, which requires training in sun simulator calibration (IEC 60904-9). VMI also has existent capabilities that can be used to develop several specific calibration services demanded by the PV sector.
- **Lack of calibration of pyranometers** that is highly relevant for the design and performance monitoring of PV power plants. Currently, PV sector actors must purchase such calibration services in other countries, leading to long turnaround times and high costs. Lack of verification scheme for PV power plants: While MOIT's Circular No. 39 and Electricity Regulatory Authority of Viet Nam's (ERAV) Decision No. 25 outline technical requirements for PV power plants, there is currently no verification scheme for power plants. This is especially important for the commissioning of such plants.
- **Lack of third-party testing facilities**: A third-party laboratory for solar products does not exist in Vietnam. Several organizations, including the Viet Nam Electricity Group (EVN) and the Energy Consulting Joint Stock Company (VREC), are interested in developing test facilities for PV components.
- **Lack of awareness and information**: The PV sector stakeholders in Viet Nam, including the authorities regulating and promoting the PV sector, are insufficiently aware of the importance of quality infrastructure, particularly metrology and conformity assessment. For this reason, there is insufficient demand for related services that are crucial for the sector's safety, quality, and sustainability.
- **Lack of market surveillance**: There is no market surveillance for PV components in Viet Nam based on third-party safety and quality tests. According to international good practice, samples of such components should be randomly tested. Currently, quality and safety control of PV products imported into Viet Nam

is limited to checking the completeness of certificates provided by the manufacturers or importers.

- **Lack of training and certification of solar PV installers**: There is a lack of trained staff for installing PV power plants. Professional training and a personnel certification scheme for installers are required to ensure proper installation, safe operation, and better performance of PV power plants.
- **Need for capacity building for quality infrastructure organizations:**
  - PV module testing: As stated above, testing of PV modules is crucial for the further development of the sector in Viet Nam, especially by the standards IEC 61215-1:2021 Terrestrial photovoltaic (PV) modules - Design qualification and type approval and IEC 61730-1:2023 Photovoltaic (PV) module safety qualification. Laboratories intending to establish such services must be advised on how to plan their business, offer appropriate services and obtain the required equipment. Furthermore, laboratory technicians have to be trained for the tests that are planned to be conducted.
  - Accreditation body training: Accreditation bodies in Viet Nam have acknowledged that their assessors lack experience in solar PV module testing. Thus, capacity-building training for technical assessors of accreditation bodies is imperative to enable them to assess laboratories whose scope includes IEC 61215 and IEC 61730.
  - Testing of standard test conditions (STCs): The STC test and maximum power determination are fundamental procedures in solar PV module laboratories. Training in STC testing of PV modules is needed for laboratory technicians and manufacturing plant personnel.
  - PV power plant inspection: Inspection bodies and installer companies require training to inspect PV power plants.

Recommendations

Based on the study results, the authors give the following recommendations for developing metrology and conformity assessment services for the PV sector in Viet Nam.

Increase awareness among relevant stakeholders:

- Organize information and awareness campaigns on the benefits of metrology and conformity assessment in the PV sector.
- Support such campaigns with studies on the status of the safety, quality and sustainability of PV plants in Viet Nam.

Strengthen market surveillance and commissioning:

- Designate a public entity to effectively monitor the market for PV components based on third-party sample tests. The market surveillance system must be based on technical regulations and refer to criteria defined in international standards[1].
- Define a commissioning scheme for PV power plants based on international standards and strengthen the capacities of staff performing the related inspections.

Develop quality infrastructure holistically:

- While this study focuses on metrology and conformity assessment, it is important to consider that the national quality infrastructure is an interrelated system in which the components and the regulatory framework complement one another. Consequently, they need to be developed together to be coherent and functional. As described in the study, accreditation and standardization are crucial for developing

[1] "Standards for the photovoltaic sector in Viet Nam", a study developed as part of the same project that also includes the study presented here, describes the role of technical regulations and standardization for effective market surveillance in more detail (PTB 2024).

metrology and conformity assessment for the PV sector[2].

- Moreover, the national quality infrastructure should not be developed in an isolated way but linked to the international system by establishing the respective relations: to ISO and IEC for standardization; to BIPM and OIML for metrology and legal metrology; to IAF and ILAC for accreditation; and the various regional organizations.

Develop metrology and conformity assessment services:

- Support VMI in developing priority calibration services for pyranometers, IV curve tracers, and sun simulators.
- Establish a solar module and solar cell calibration laboratory in Viet Nam. In the first stage, a module calibration laboratory should be established to provide reference modules to solar module laboratories in Viet Nam. Then, after analyzing the demand for reference cells by solar PV manufacturers and testing laboratories, a public secondary reference cell calibration laboratory may be planned.
- Set up a module testing laboratory to offer the services most sought after by manufacturers, installers, importers and end users. In a phased manner, tests based on sun simulators can be offered, followed by electroluminescence testing and wet leakage current tests according to IEC 61215, IEC 61730, IEC 61853-1, 2, 3. Depending on the concrete demand, testing for salt mist could be developed in the following project phase.
- Establish an inverter testing laboratory according to the applicable international standards. These services are required for the PV sector and other renewable energies, such as wind power.

Strengthen capacity building:

- The PV sector in Viet Nam can only be sustainably developed with well-trained staff at all levels and along the entire PV value chain. It is crucial to assign a public entity to implement professional training programs and establish a personnel certification scheme run by a third party.
- The capacity-building requirements in this study's context are described above (see conclusions). Quality infrastructure organizations should be trained and consulted on developing PV sector services by experienced partner organizations from other countries, supported by international cooperation.

[2] "Standards for the photovoltaic sector in Viet Nam" describes the status of standardization for the PV sector in Viet Nam in detail and gives related recommendations (PTB 2024).

1. Introduction

1.1 Objectives of this study

The landscape study titled “Service demand and offers in metrology and conformity assessment in the PV sector in Viet Nam” has been prepared within the scope of a project titled “Promotion of Quality Assurance Services for Sustainable Energy in Viet Nam”, jointly implemented by the Physikalisch-Technische Bundesanstalt (PTB), the German national metrology institute, and the National Commission for Standards, Metrology and Quality of Viet Nam (STAMEQ), which is a governmental agency under the Ministry of Science and Technology (MOST). The Federal Ministry for Economic Cooperation and Development (BMZ) finances the project. It should be noted that a prior study on standardization was conducted, which is why this topic is not incorporated into the current study.

The study has the following objectives:

- Provide an overview of metrology and conformity assessment (CA) as part of Viet Nam's national quality infrastructure (NQI) system.
- Analyse the current situation of metrology and CA services in Viet Nam.
- Describe the calibration services offered in Germany and China that can serve as a reference for Viet Nam.
- Provide recommendations to develop metrology further and CA services relevant to the solar PV sector in the country.

The study consists of the following sections:

- Institutional set-up and legal framework of metrology and CA in Viet Nam
- Status of metrology and CA in the photovoltaic sector in Viet Nam
- Demand for metrology and CA services for PV in Viet Nam
- Recommendations

1.2 Relevance of metrology and conformity assessment for the development of the PV Sector

Metrology and conformity assessment services are crucial for developing the PV sector, as they ensure the safety, quality and sustainability of PV components and installations (Ferdinand et al. 2022).

Safety: Conformity assessment services are needed to ensure that safety criteria are met in the PV sector. Standards, best practices, and technical regulations outline the safety criteria applicable to products and processes, including the installation and operation of PV systems and, when necessary, the handling and processing of hazardous materials. Certification and inspection processes ensure adherence to these safety criteria, protecting workers, nearby communities, and buildings, particularly in rooftop power plants, by mitigating risks such as electric shock and fire.

Quality: Achieving sustainable market growth in the PV industry hinges on maintaining a high level of quality that fosters trust among investors, policymakers, and consumers in the performance of products and services. Metrology and conformity assessment according to international standards and best practices are vital throughout the entire lifecycle of a PV system from design to end-of-life. Exact and traceable measurements and reliable conformity assessments enhance credibility and reduce risks for stakeholders, thereby promoting the development and dissemination of innovative technologies within the industry.

Sustainability: Metrology and conformity assessment can improve the environmental and social impacts of the PV sector and increase energy efficiency. Compliance with relevant standards and market requirements increases the competitiveness of local industries and expands their access to foreign markets, promoting sustainable economic development. Additionally, a quality-driven sector attracts more investments in PV projects and lowers capital costs by increasing investor confidence and stability. Reducing system underperformance risks makes PV systems a safe investment, leading to easy access to funding, reduced capital costs, and stable returns.

1.3 Methodology applied

To prepare this study, the following research methods were utilized:

- Desk research on PV-related policies and regulations.
- Stocktaking of measurement, conformity assessment service providers and other related production/business organizations.
- Onsite visits and interviews with relevant QI institutions and the PV sector stakeholders in July 2023. The list of interviewees is presented in Appendix J.
- Survey of QI service customers and policymakers in August and September 2023.
- Validation workshop with inputs from relevant stakeholders from the private sector and QI institutions in October 2023 in Hanoi and November 2023 in Ho Chi Minh City.

2. The national quality infrastructure of Viet Nam

2.1 Quality infrastructure

Quality infrastructure is a system comprising the organizations (public and private), policies, relevant legal and regulatory framework, and practices needed to support and enhance the quality, safety, and environmental soundness of goods, services, and processes. It relies on several components: metrology, standardization, accreditation, conformity assessment, and market surveillance (INetQI, 2023).

The national quality infrastructure is an interrelated system of complementary components. It should not develop in an isolated way but be linked to the international system by establishing the following relations:

- The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) for standardization
- The International Bureau of Weights and Measures (BIPM) and the International Organization of Legal Metrology (OIML) for metrology and legal metrology
- The International Accreditation Forum (IAF) and the International Laboratory Accreditation Cooperation (ILAC) for accreditation
- The respective regional organizations

Considering this, the study focuses on two of the above-mentioned components: metrology and conformity assessment.

Metrology

Metrology is the science of measurement. Measurement activities must ensure uniformity and accuracy. Common units of measurement, accurate and reliable measurement instruments and techniques are all fundamental components of science and technology and indispensable for a broad variety of human activities. A metrology system comprises scientific, industrial, and legal metrology. Scientific or fundamental metrology is concerned with the establishment of units of measurement. Applied, technical or industrial metrology is the application of measurement to manufacturing and other societal processes. Legal metrology covers the regulation and statutory requirements for measuring instruments and methods of measurement.

To ensure credibility, measurements must be traceable to existing international standards and meet the criteria of international comparability. The global metrological system, administered by the International Bureau of Weights and Measures (BIPM) (scientific and industrial metrology) and the International Organization of Legal Metrology (OIML) (legal metrology), facilitates international coordination and mutual recognition of countries' measurement capabilities.

Conformity assessment

Conformity assessment refers to the processes and procedures used to determine whether products and services, processes, management systems, and personnel meet specific requirements. Conformity assessment services are performed by organizations – conformity assessment bodies (CABs) – that specialize in testing, inspection, and certification.

Testing: The most common form of conformity assessment involves testing a product, service, or process according to a defined set of criteria, such as performance and safety. Testing also provides support for other types of conformity assessment, such as inspection and product certification.

Inspection: Products, services or processes may be inspected by bodies acting on behalf of governments and businesses. This helps reduce risks to the buyer, owner, user or consumer of the item related to such parameters as quality, fitness for use and operational safety.

Inspection bodies are responsible in the private and public sectors for examining a wide range of domestically produced and imported products, materials, installations, plants, processes, work procedures and services.

Certification: Certification is the formal assurance, provided by an independent third-party

certification body, that a product, service, process, person, organization or management system conforms to specific requirements.

Figure 1 below illustrates the national quality infrastructure system and its connection to the international framework.

agency of the Ministry of Science and Technology (MOST).

The functions of STAMEQ can be summarized as follows:

- Metrology: Serves as the national metrology institute, developing and maintaining the national metrological standards.

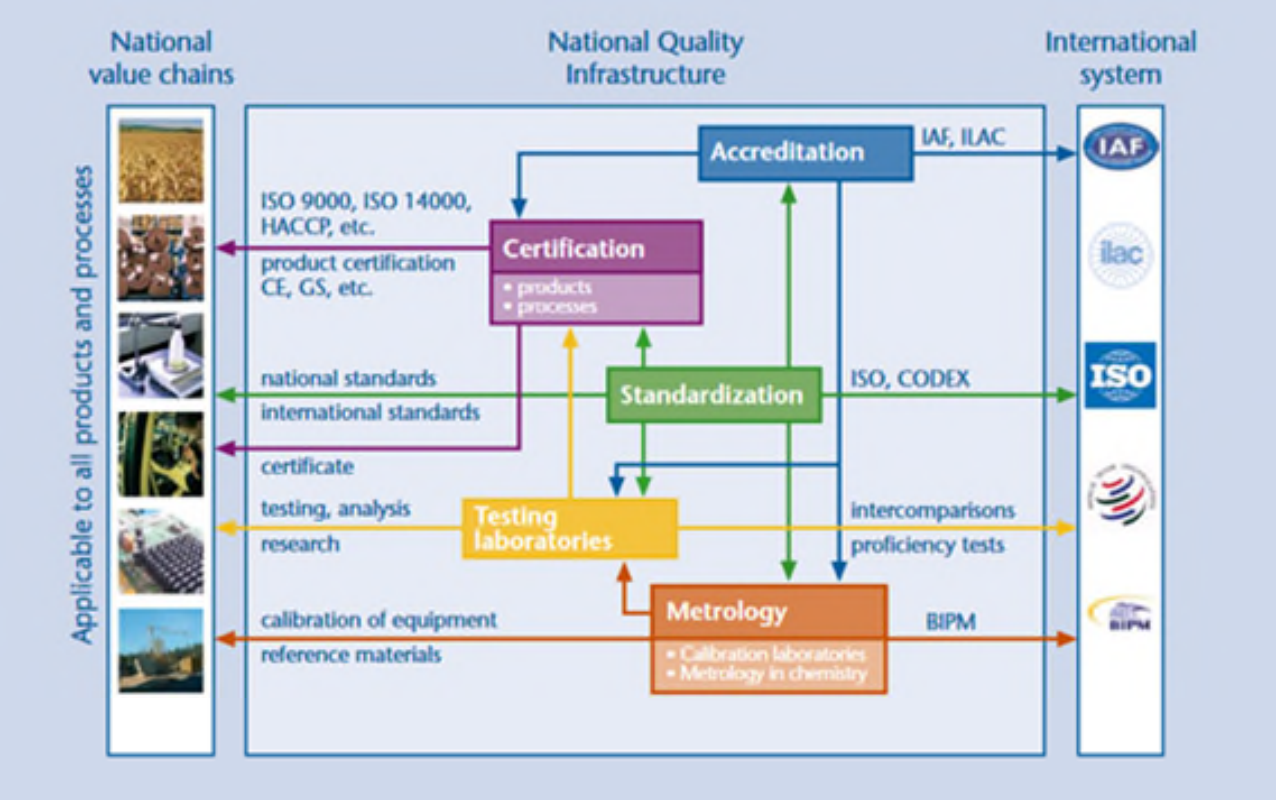

Figure 1: Quality Infrastructure Overview

2.2 Quality infrastructure in Viet Nam

Viet Nam's national quality infrastructure is well-established. The Global Quality Infrastructure Index (GQII), which assesses a country's quality infrastructure (based on its metrology, standardization, and accreditation), ranks Viet Nam 52nd out of 185 economies. Vietnam's ranking in the GQII is closely related to this well-organized national quality infrastructure system.

The National Commission for Standards, Metrology and Quality of Viet Nam (STAMEQ) coordinates the main public organizations comprising the national quality infrastructure. STAMEQ is a governmental

- Standardization: Serves as the national standardization organization, developing standards and providing information on existing standards.
- Certification, inspection and testing: Develops and implements certification, inspection and testing services.
- Advising the government: Provides expert advice on standardization, metrology, and quality management.
- Regulation preparation: Develops regulations related to standardization, metrology, and quality management for government approval.

- Research: Conducts studies on standardization, metrology, and quality management.
- Implementation supervision: Oversees the implementation of standards and regulations.
- Policy and document development: Creates policies, procedures, and guides for conformance activities such as accreditation, certification, testing, and inspection.
- Quality supervision: Conducts state supervision and market surveillance on the quality and safety of goods and services.

Figure 2 below illustrates the organizational structure of STAMEQ, showcasing various quality infrastructure (QI) institutions operating under its umbrella.

Figure 2: Organizational Structure of STAMEQ. Source: Directorate for Standards, Metrology and Quality

In addition to STAMEQ, several other public entities are part of the national quality infrastructure. These include the departments of science and technology under fourteen line ministries, as mandated by Decree No. 132/2008/NĐ-CP, and 63 local departments dedicated to standards, metrology, and quality under the science and technology departments of the provinces, which fall under the jurisdiction of 63 provincial people's committees.

Three accreditation bodies are registered in Viet Nam: The Bureau of Accreditation (BoA), the Accreditation Office for Conformity Assessment Bodies (AOSC) and the Viet Nam Accreditation Center for Inspection (VACI).

The General Department of Market Surveillance (GDMS) manages Vietnam's market surveillance under the Ministry of Industry and Trade (MOIT). Established by Decision 34/2018, the GDMS oversees 63 provincial-level departments to enforce laws on combating smuggling, counterfeit goods, intellectual property violations, and ensuring product quality and consumer protection. The agency is led by a General Director and operates through specialized departments, providing centralized direction to local market surveillance offices.

Furthermore, a great number of private organizations offer quality infrastructure services in areas such as certification and inspection as well as calibration and testing.

The legal basis for the national quality infrastructure system is relatively well developed. A list of legal documents in metrology is included in Appendix A, a list of legal documents in product and goods quality in Appendix B and a list of legal documents in standards and technical regulation in Appendix C.

3. Metrology and conformity assessment in Viet Nam

3.1 Metrology

The National Metrology Institute (NMI) of Viet Nam is VMI, which operates under STAMEQ. Its primary functions include developing, maintaining, and being the custodian of the national measurement standards system. Additionally, VMI conducts scientific, technical, and professional research in metrology. VMI has 12 laboratories, all of which are accredited in accordance with ISO/IEC 17025:2005 by the Viet Nam Laboratory Accreditation Scheme (VILAS) of the Bureau of Accreditation (BoA).

Viet Nam's 32 national measurement standards have been administratively approved under the national Law on Measurement (see Appendix E), establishing the legal and technical basis to ensure consistency and accuracy in measurement activities.

VMI is a signatory to the CIPM Mutual Recognition Arrangement (CIPM MRA) of the International Bureau of Weights and Measures (French: Bureau international des poids et mesures, BIPM), which demonstrates the international equivalence of its measurement standards and the calibration and measurement certificates it issues. It has 31 calibration and measurement capabilities registered under the arrangement in the areas of length, mass, pressure, fluid flow, time and frequency, and thermometry.[3]

Decree No 105/2016/NĐ-CP issued by the Vietnamese Government and Circular No 24/2013/TT- BKHCN issued by the Ministry of Science and Technology (MOST) have established a system of registration and notification, outlining operating conditions for organizations in charge of verification, calibration, testing of measuring instruments and maintaining measurement standards. Under this system, around 564 public and private entities are registered, and 385 are notified for offering metrology services.

3.2 Conformity assessment

Various organizations in Viet Nam are encouraged to conduct conformity assessment activities in compliance with relevant laws and regulations, including the Law on Product and Goods Quality and the Law on Standards and Technical Regulations, as well as associated decrees (Decree No. 107/2016/NĐ-CP, Decree No. 154/2018/ND-CP). These activities are open to all organizations that meet the operational requirements outlined in these decrees, irrespective of their nature (public, private, domestic, foreign, etc.), as long as they adhere to the laws of Viet Nam.

As of December 30, 2022, 1,582 conformity assessment organizations were registered according to the systems of the line ministries and STAMEQ, including 1,075 testing organizations, 240 product and management system certification organizations, 106 product and goods quality inspection organizations and 161 product and goods quality verification organizations (STAMEQ, 2023).

In addition, line ministries have also appointed more than 370 conformity assessment organizations to serve state management requirements for Group 2 products and goods under their management responsibility[4].

[3] The source of this data, which was accessed in October 2023, is https://www.bipm.org/kcdb/cmc/statistics/public. This differs from the latest BIPM statistics (https://www.bipm.org/kcdb/cmc/quick-search?includedFilters=&excludedFilters=&page=1&keywords=%22Viet+Nam%22), as accessed in July 2024. VMI has informed the consultants that it is in contact with BIPM for the data update.

[4] Government in Degree no 132/2008/NĐ-CP defines products and goods falling under the state management responsibility of the Ministry of Labor, War Invalids and Social Affairs, including machinery and equipment subject to strict labor safety requirements, and public recreation facilities and personal protection equipment likely to become unsafe in the use process.

3.3 Accreditation of metrology and conformity assessment services

Accreditation is the process via which a body gives formal recognition that an organization, institution, or program meets certain predefined standards and is competent to carry out specific tasks (ISO/IEC 17011:2017).

Conformity assessment service providers need to demonstrate that they operate impartially and possess the competence to determine whether or not the various requirements are being met. These requirements can be specified by laws and regulations or be set by standards developed by industry or other stakeholders.

The accreditation of metrology laboratories ensures international recognition of their measurement accuracy and reliability. The alignment with international standards promotes confidence in the laboratories' data and services among stakeholders, including regulatory bodies, industry, and consumers.

All three accreditation bodies registered in Viet Nam (BoA, AOSC and VACI, see above) are signatories of Mutual Recognition Agreements (MRAs) with the Asia Pacific Accreditation Cooperation (APAC) and ILAC for the accreditation of laboratories according to ISO/IEC 17025. BoA and AOSC are also signatories to the APAC and ILAC MRA for Medical Laboratories according to ISO 15189.

4. Solar PV sector

4.1 Global solar PV market

The global solar PV market is rapidly growing due to the drop in the cost of PV-generated electricity and the global demand for solar PV power plants. This development is supported by advances in solar technology and manufacturing, with diffusion on a worldwide basis directly linked to the technology's advantages as a power generation source in terms of its modularity, distributed nature, and reliability of its output.

However, the global solar PV market faces significant challenges due to underperforming, unreliable, and substandard products, hindering the advancement of this renewable technology. This issue is particularly critical as the number of households depending on solar PV is projected to surge from 25 million to over 100 million by 2030 under the Net Zero Emissions by 2050 Scenario. With an estimated annual installation of at least 190 GW from 2022 onwards, driven by the increasing competitiveness of PV and rising demand for clean energy sources, addressing these challenges is imperative for sustainable growth in the solar industry. (IEA, 2022)

4.2 Solar PV market in Viet Nam

In 2019, Viet Nam experienced a historic surge in the expansion of PV installations, primarily driven by high feed-in tariffs. From 2010 to 2021, Viet Nam ascended from 196th to 9th place globally in terms of available solar energy capacity[5]. Despite this growth, there is a current lack of safety, quality, and sustainability assurance along the PV value chain.

For instance, a lack of market surveillance leads to using sub-standard PV components, which is especially problematic for imported PV modules. In this context, there is a lack of testing facilities for PV components, which leads to inconsistent module quality, among other things. For PV plant construction, while certain engineering, procurement and construction (EPC) companies generally have good practices, there is no scheme to control the fulfilment of safety and quality requirements effectively, for example, an inspection required as part of the commissioning.

There is also a need to develop commissioning/final acceptance criteria for solar PV plants.

4.3 Photovoltaic sector stakeholders in Viet Nam

STAMEQ serves as the national authority responsible for implementing and supporting the development of QI across all industries, including the electricity sector. Meanwhile, the Electricity and Renewable Energy Authority (EREA) and the Electricity Regulatory Authority of Viet Nam (ERAV) under the Ministry of Industry and Trade (MOIT) oversee conformity assessment activities within the electricity industry.

The Police Department of Fire Prevention, Fighting, and Rescue, operating under the Ministry of Public Security (MPS), manages conformity assessment activities related to fire prevention, including those relevant to the electricity industry. Furthermore, the Ministry of Agriculture and Rural Development (MARD) and the Ministry of Construction (MOC) issue regulations on farming and construction, which also cover regulations concerning ground-mounted and rooftop PV systems.

The 63 standards, metrology, and quality departments that are part of the science and technology departments of the provinces cover local quality infrastructure functions, including those in the electricity sector. Additionally, the Institute of Energy (IE), the Hanoi University of Science and Technology (HUST), and Ton Duc Thang University (TDTU) contribute to scientific research activities in solar power and provide input for related policies.

Various associations, including the Viet Nam Metrology Association, Viet Nam Standards and Quality

[5] Data taken from https://rapidtransition.org/stories/viet-nams-rapid-rise-to-becoming-a-solar-powered-state/ accessed in May 2024

Association, Viet Nam Association of Testing Laboratories, and Viet Nam Electricity Association, coordinate functions and offer insights and recommendations on metrology and conformity assessment policies within the PV sector.

Beyond governmental and institutional entities, key stakeholders in the photovoltaic sector in Viet Nam include solar cell, panel, and inverter manufacturers (approx. 20), solar panel importers and re-sellers (approx. 22), solar power system installers (approx. 35), and financing bodies (besides owners of PV plants, around 10 financing bodies are active in the PV sector). The detailed lists can be found in appendices F-I.

4.4 Metrology and conformity assessment services required along the PV value chain

The following table provides a non-exhaustive overview of the conformity assessment services required to ensure safety, quality and sustainability along the photovoltaic value chain (Table 1, Ferdinand et al. 2022)

Table 1: Overview of metrology and conformity assessment services required to ensure safety, quality and sustainability along the photovoltaic value chain (Source: Ferdinand, N.; Telfser, K; Heider, C.; Balbín, N (2022). Quality Infrastructure for Photovoltaic Systems. Assuring safety, quality and sustainability in emerging and developing economies).

QI	Manufacturing	System design and equipment selection	Transport, installation and commissioning	Operation and maintenance	Grid integration and storage	End of life, reuse and recycling
Metrology	Calibration and traceability for testing equipment used for PV components. For modules and inverters mainly: - irradiance level and spectral irradiance of the light source - electrical characteristics: current and voltage - temperature Calibration of reference cells and PV modules	Calibration and traceability for testing equipment and monitoring devices for meteorological parameters e.g., irradiance, wind speed, temperature, humidity, conductivity	Calibration and traceability for testing equipment, e.g., force, electric insulation	Calibration and traceability for testing equipment as well as plant and weather monitoring devices required for the monitoring of PV power plants, e.g., current and voltage, irradiance, wind speed and temperature	Calibration and traceability for testing equipment used in quality assurance of storage infrastructure and applied in grid management, e.g., electrical characteristics (current and voltage) for electricity meters and batteries; advanced measurement frameworks for SCADA systems, phasor measurement units, battery characterization	Calibration and traceability for testing equipment used for reuse and recycling
Testing	Testing for R&D, quality assurance during production process, and final products Testing of component samples for market surveillance	Random sample testing of PV modules (for large projects)	Testing for transport damage of modules upon arrival Field tests (e.g., performance, infrared and EL imaging)	Field testing on component, string and system level (e.g., performance, infrared and EL imaging)	Batteries	Leaching of hazardous materials from PV waste Purity of recovered material in recycling
Certification	Certification of QMS Product certification	Product and QMS certification for equipment selection Personnel certification	Personnel certification Certification of compliance with requirements for transportation Certification of PV power plants after installation	Personnel certification Certification of operation and maintenance contractors	Battery certification Commissioning surveillance as part of the project certification	Certification of sustainability aspects of components (e.g., carbon footprint of modules)
Inspection	-	-	Plant inspection during construction and commissioning	Plant inspection (e.g., to investigate underperformance for warranty claims)	Plant inspection based on grid codes before grid integration	-

4.5 Legal documents for the photovoltaic sector in Viet Nam

The legal framework relevant to the PV sector in Viet Nam is outlined in various legislative documents, including the Electricity Law of 2004 and amendments to this law in 2012 and 2022, as well as the Law on the Economical and Efficient Use of Energy. These legal documents cover a wide range of aspects, including electricity development planning, investment regulations, energy conservation, electricity markets, and the rights and obligations of entities involved in electricity activities. They also address the protection of electric equipment and facilities, electricity works, and electrical safety.

Some legal documents include quality requirements for the PV sector. Decision No. 25/QD-DTDL, issued by ERAV, outlines testing procedures of PV modules in the field, Circular 39/2015/TT-BCT defines quality and safety criteria in the distribution system, and the national electricity development plan, approved by Decision 50/QD-TTg of 2023, includes quality aspects.

Additionally, decrees, circulars, and guidelines provide further details on implementing these laws. Moreover, strategies, policies, and plans related to power development in Viet Nam contribute to shaping the regulatory landscape for the PV sector.

Please refer to Appendix D for a comprehensive overview of legal documents pertaining to the electricity branch and the PV sector in Viet Nam.

5. Status and demand for metrology and conformity assessment services for the PV sector in Viet Nam

This chapter outlines the status of metrology and conformity assessment services for the PV sector in Viet Nam, summarizes demand and gives examples of existing services in Germany and China.

5.1 Existing capacities in calibration

Currently, no laboratory in Viet Nam provides calibrating services for solar PV modules, cells, pyranometers, or inverters. For this reason, solar module manufacturers (among others) must seek reference modules from calibration laboratories in other countries.

Several VMI laboratories have equipment and capabilities that could be used for the PV sector:

- Temperature measurement laboratory: This laboratory could offer calibration services for temperature and moisture. Equipped with four CMCs, the lab covers a temperature range of -40°C to 1100°C. Using standard platinum resistance thermometers and high-temperature standard platinum resistance thermometers, it achieves an uncertainty of 2 mK within the range of -40°C to 420°C and 10 mK within the range of 0°C to 962°C. Given that solar PV module and inverter test laboratories commonly utilize environmental chambers for accelerated testing that simulate temperature and humidity conditions, this laboratory could be instrumental in calibrating such chambers' humidity and temperature measurement devices. Furthermore, the calibration of temperature measurement equipment used in solar PV plants and sun simulators could be offered.
- Optical measurement laboratory: This laboratory is equipped with a spectroradiometer with a range of 200 – 900 nm, an interferometer, and an integrating sphere. The spectroradiometer can be calibrated with a standard lamp (LMT MS 202) with international traceability. This spectroradiometer, along with an additional spectroradiometer covering the range up to 1200 nm, could be used for calibrating sun simulators against the standard IEC 60904-9.
- Ultraviolet calibration facility: VMI has an ultraviolet (UV) calibration facility with a range of 0 ÷ 10000 mW/cm² and a calibration and measurement capability of 0.6 %. It could calibrate the UV sensors of UV chambers used in solar PV testing laboratories.
- Photometry laboratory (Figure 3): VMI has an advanced photometric setup but does not offer pyranometer calibration. To offer this service, which is highly relevant for the reliable measurement of solar irradiance, additional equipment, processes, and capacity building are required.

Figure 3: Photometry laboratory of VMI

- Electricity laboratory: VMI has a metrological laboratory for electricity that is traceable to Australia and South Korea. The laboratory offers metrological services for DC voltage from 0.22 V to 180 kV and DC current from 0.22 mA to 120. The smallest uncertainty is 2.8 ppm for a DC voltage range of 0.22 V ÷ 1100V and 10 ppm for a DC current range of 0.22 ÷ 10A (Figure 4).

Additional procedures and capacity building are required to offer services for the PV sector from this laboratory (e.g., the calibration solar PV array testers

and IV curve tracers required for on-site inspection/testing of PV power plants).

Figure 4: Part of the equipment used in the electricity laboratory of VMI

5.2 Local demand for calibration services

- Sun simulator calibration services: In Viet Nam, the annual solar PV module manufacturing capacity exceeds 40 GW. Despite this high capacity, there is a notable gap in sun simulator calibration services specifically tailored to meet the criteria outlined in the standard IEC 60904-9 for solar PV module manufacturers and test laboratories.
- Other calibration services: Currently, testing laboratories and inspection bodies must send IV curve tracers abroad for calibration, adding logistical complexity and delays. Additionally, requests to calibrate solar array simulators/IV curve tracers (up to 1500V, 20A I - V range) from installers, test laboratories, and inspection bodies cannot be met domestically.
- Reference modules and cells: In Viet Nam, the solar cell manufacturing capacity exceeds 20 GW, with industry leaders such as Toyo Trina and JA Solar. For critical tests such as maximum power determination and IV curve characterization, reference modules and cells are required. Manufacturers in Viet Nam face challenges as they must import these reference modules and cells from other countries, risking damage during shipment (especially for reference modules) and increasing costs and shipment time.
- Pyranometer calibration: Pyranometer calibration is in high demand. Currently, pyranometers used to measure the solar irradiance in PV power plants must be uninstalled and sent abroad for calibration, which takes approximately 3 to 4 weeks. For example, Solar BK, an EPC and project developer, requires calibration for over 1,000 pyranometers annually across its 122 PV projects, highlighting the scale of the issue.

5.3 Calibration services offered in other countries

The following section describes the calibration services offered in Germany and China. These countries were selected as examples because they both have an advanced PV sector and a robust quality infrastructure system. They can serve as references for Vietnam regarding the necessary structures to support the PV sector in an advanced state. Additionally, the potential for cooperation with the institutions described can be evaluated for Vietnamese quality infrastructure organisations.

Germany

- As Germany's national metrology institute, PTB offers metrology services, including primary reference cell and module calibration. PTB is one of four designated world photovoltaic scale (WPVS) laboratories and the only European facility involved in maintaining the WPVS, a reference for calibrating primary reference solar cells and PV performance measurements worldwide. PTB also provides secondary and primary solar PV module calibration services with advanced facilities such as an LED-based sun simulator and outdoor calibration setups.
- Other calibration laboratories, including Fraunhofer Institute for Solar Energy (ISE) and Institute for Solar Energy Research GmbH

(ISFH), offer secondary reference cell and module calibration. Both laboratories are accredited according to ISO 17025 by the German Accreditation Body (DAkkS). The German Meteorological Service (DWD) calibrates pyranometers outdoors according to ISO 9846 or ISO 9847 standards using a reference pyrheliometer or pyranometer.

China

- The National Institute of Metrology (NIM) in China offers primary cell calibration based on the differential spectral responsivity method. NIM also provides solar PV module calibration and sun simulator calibration services to the solar PV industry.
- Other calibration laboratories in China include the Fujian Metrology Institute, a public institute offering calibration services to the PV industry. Its National PV Measurement & Testing Centre provides solar PV module and sun simulator calibration and is ISO 17025 accredited by the China National Accreditation Service for Conformity Assessment (CNAS). In addition, the World Meteorological Organization's (WMO) Regional Instrument Centre located in the Meteorological Observation Centre of the China Meteorological Administration in Beijing offers the service of pyranometer calibration.

5.4 Existing capacities in testing

There are no third-party testing laboratories for PV modules and PV inverters in Viet Nam. A few companies like Boviet, Vina Solar and JA Solar have in-house testing laboratories to control the safety, reliability and performance of PV modules manufactured in their factories. JA Solar and Vina Solar are the only laboratories in Viet Nam that are accredited according to ISO/IEC 17025 by BOA.

The SELTEC Electric Testing company and Viet Nam Electricity Group (EVN) are accredited by BOA according to ISO/IEC 17025 for tests in PV power plants. SELTEC has the testing of insulation resistance, open circuit voltage, short circuit currents, and I-V curves of PV arrays/modules in its accredited scope.

The Electrical, Electronic and Energy Efficiency Testing Laboratory of QUATEST 1 is accredited by BOA according to ISO/IEC 17025. QUATEST has portable equipment to perform on-site measurements of current-voltage characteristics of PV modules. QUATEST 1 will apply for accreditation extension for this test in the future.

During the interviews conducted as part of this study, VREC expressed interest in establishing a laboratory for solar PV modules for basic tests such as performance under standard test conditions, wet leakage and electroluminescence. EVN HCMC has expressed interest in establishing a solar inverter laboratory with a capacity of 100 kW.

5.5 Local demand for testing services

- Module testing: Currently, around 15 large-scale solar PV module manufacturers, such as Boviet, IREX, Vina Solar, Trina, and Viet Nam Green Energy, operate in Viet Nam. All of them need to send their modules to other countries for third-party testing. Many stakeholders have emphasized the urgent need for a local module test facility to cover component-specific tests (e.g., IEC 61215, 61730, and 61853).

Export of PV modules from Viet Nam is hindered by the non-existence of suitable external testing laboratories. To meet the criteria of customers from other countries and field insurance claims for issues during transportation, local module manufacturers are required to provide certificates based on tests performed in external testing laboratories (i.e., performance at standard test conditions, electroluminescence, wet leakage) before exporting from Viet Nam.

- Inverter testing: Two companies, Growatt and Goodwe, have started to produce solar inverters in Viet Nam, but no third-party laboratory is available to test them. Heavy equipment must, therefore, be sent to other countries for third-party testing for quality and safety control and market surveillance. For this reason, the inverters used in Viet Nam are often not tested at all after leaving the production plant.

5.6 Testing services in other countries

Germany

- Germany hosts numerous solar PV testing laboratories accredited by DAkkS according to ISO/IEC 17025.
- For example, TÜV Rheinland offers PV module testing services compliant with standards such as IEC 61215 and 61730. They also conduct sun simulator testing according to IEC 60904-9, with onsite testing services available. Other organizations offering PV module testing are PI Berlin and Fraunhofer ISE.
- The Fraunhofer Institute for Energy Economics and Energy System Technology (IEE) and Fraunhofer ISE, among others, offer solar inverter testing.

China

- In China, many laboratories test solar PV modules and inverters. Most of them are accredited by the Chinese accreditation body CNAS.
- Domestic laboratories such as Beijing CGC Certification Center, Yangzhou Opto-Electrical Products Testing Institute, and China Electric Power Research Institute are recognized as CBTLs under the Electrotechnical Equipment and Components (IECEE) scheme, which offers testing services for solar modules and inverters.

5.7 Existing capacities in certification and inspection

Currently, there are no third-party certification bodies offering services to the PV sector in Viet Nam. All manufacturers with operations in Viet Nam receive certificates for their products from abroad, mainly from China. PV power plants must be certified by foreign certification bodies, leading to high costs and the fact that the plants are normally not certified in Viet Nam.

VREC, a private entity, and QUATEST 3, a public entity, both located in Ho Chi Minh City, offer inspection of PV power plants according to TCVN 11855 / IEC 62446. VREC is equipped with advanced instruments for onsite IV characterization of PV panels. It has an accredited testing laboratory but is not accredited as an inspection body according to ISO 17020. QUATEST 3 is accredited according to ISO/IEC 17025, 17020, 17065, 17021 and 17043. It inspects solar PV plants according to MOIT Circular 39/2015/TT-BCT, which regulates the electricity distribution system.

In this context, it must be noted that there is no market surveillance for PV components in Viet Nam based on third party safety and quality tests. Currently, quality and safety control of PV products imported into Viet Nam is limited to checking the completeness of certificates provided by the manufacturers or importers.

Figure 5: IV Curve Tracer used in onsite inspections of PV plants.

Source: Ht-instruments.com

5.8 Local demand for certification and inspection

- Certification of personnel: Skilled manpower is indispensable to ensure optimal performance of PV power plants, especially for their proper installation. Certification bodies, installer companies, and power distribution firms have emphasised the need for certified personnel.
- Certification of PV components: PV components must be certified according to the applicable IEC standards for export, which cannot currently be fulfilled in this country. National certification of such components would require testing according to IEC standards, which is also currently unavailable.
- Inspection and certification of PV power plants: There is growing demand for inspection and

certification of PV power plants to ensure good performance and personnel safety, following standards such as TCVN11855 / IEC 62446. The existing inspection agencies are unable to respond to all inspection requests due to the large number of installed rooftop plants.
- Market surveillance: To ensure the quality and especially the safety of PV components, samples should be randomly tested. This requires a designated public entity for effective market surveillance of PV components based on third-party sample tests. The market surveillance system must be based on technical regulations, referring to criteria defined in international standards.

5.9 Certification of solar PV products in other countries

Germany

- Five organizations operate as Certification Bodies (CBs) under IECEE, the IEC System of Conformity Assessment Schemes for Electrotechnical Equipment. These bodies are Intertek, TÜV NORD, TÜV Rheinland, TÜV SÜD, and VDE. They issue product certificates for various solar PV products such as modules, power converters, and sun simulators. The certificates are granted based on test reports provided by recognized IEC CB testing laboratories.
- Organizations such as PI Berlin, Fraunhofer ISE, and TÜV Rheinland provide PV power plant inspection, which includes the PV plant performance, thermography, electroluminescence imaging, defects in components, and the quality and safety of the installation.

China

- China General Certification Center is acknowledged as a national certification body (CB) under the IECEE scheme. Its scope includes solar PV module standards such as IEC 61215 and IEC 61730. Similarly, the China Quality Certification Center (CQC) is another national CB under the IECEE scheme and covers solar modules (IEC 61215 and IEC 61730) and solar inverters (IEC 62109).
- Given China's role as a major manufacturing hub for solar PV products, there is significant demand for factory inspection services. Companies such as PI China, UL, and TÜV Rheinland offer production witness and pre-dispatch inspection services to importers worldwide.

6. Recommendations

Considering the current conditions of quality assurance services for the photovoltaic sector in Viet Nam, the consultants give the following recommendations to relevant QI institutions in the country. Recommendations directed at PTB are presented in Appendix K.

Increase awareness among relevant stakeholders:

- Organize information and awareness campaigns on the benefits of metrology and conformity assessment in the PV sector.
- Support such campaigns with studies on the status of the safety, quality and sustainability of PV plants in Viet Nam.

Strengthen market surveillance and commissioning:

- Designate a public entity to effectively monitor the market for PV components based on third-party sample tests. The market surveillance system must be based on technical regulations, referring to criteria defined in international standards[6].
- Define a commissioning scheme for PV power plants based on international standards and build the capacity of staff to perform the related inspections.

Develop quality infrastructure holistically:

- While this study focuses on metrology and conformity assessment, it is crucial to consider that a national quality infrastructure is an interrelated system in which the components and the regulatory framework complement one another. Consequently, they need to be developed together to be coherent and functional. As described in the study, accreditation and standardization are crucial for developing metrology and conformity assessment for the PV sector[7].
- Moreover, national quality infrastructure should not be developed in an isolated way but instead linked to the international system by establishing the respective relations: to ISO and IEC for standardization; to BIPM and OIML for metrology and legal metrology; to IAF and ILAC for accreditation; and to the various regional organizations.

Develop metrology and conformity assessment services:

- Support VMI in developing priority calibration services for pyranometers, IV curve tracers and sun simulators.
- Establish a solar module and solar cell calibration laboratory in Viet Nam. In the first stage, a module calibration laboratory should be established to provide reference modules to solar module laboratories in Viet Nam. Then, after analyzing the demand for reference cells by solar PV manufacturers and testing laboratories, a public secondary reference cell calibration laboratory may be planned.
- Set up a module testing laboratory to offer the services most frequently requested by manufacturers, installers, importers and end users. In a phased manner, tests based on sun simulators can be offered, followed by electroluminescence testing, and wet leakage current tests according to IEC 61215, IEC 61730, IEC 61853-1, 2, 3. Depending on the concrete demand, testing for salt mist could be developed in the following project phase.
- Establish an inverter testing laboratory according to the applicable international standards. These services are required not only for the PV sector but also for other renewable energies such as wind power.

Strengthen capacity building

[6] "Standards for the photovoltaic sector in Viet Nam", a study elaborated as part of the same project as this study, describes the role of technical regulations and standardization for effective market surveillance in more detail (PTB 2024).

[7] "Standards for the photovoltaic sector in Viet Nam" describes the status of standardization for the PV sector in Viet Nam in detail and gives related recommendations (PTB 2024).

- The PV sector in Viet Nam can only be sustainably developed with well-trained staff at all levels and along the entire PV value chain. It is crucial to assign a public entity the task of implementing professional training programs and to establish a personnel certification scheme that should be run by a third party.
- The capacity-building requirements in this study's context are described above (see conclusions). Quality infrastructure organizations should be trained and consulted on the development of PV sector services by experienced partner organizations from other countries that have been supported by international cooperation.

7. Appendix A. List of Legal Documents on Metrology

No	Name	Issued Date
04/2011/QH13	Law on Metrology	25/11/2011
86/2012/NĐ-CP	Decree detailing and guiding the implementation of a number of articles of the Law on Metrology	19/10/2012
105/2016/NĐ-CP	Regulations on operating conditions of organizations inspecting calibrating and testing measuring instruments and measurement standards	01/07/2016
154/2018/NĐ-CP	Decree amending, supplementing and abolishing a number of regulations on business investment conditions in the field of state management of the Ministry of Science and Technology	09/11/2018
1361/QĐ-TTg	Decision of the Prime Minister approving the master plan on development of national metrological standards until 2020	08/08/2013
996/QĐ-TTg	Decision of the Prime Minister approving the project "Strengthening and renovating measurement activities to support Vietnamese enterprises to improve their competitiveness and international integration in the period to 2025, with orientation to the year 2030"	10/8/2018
07/2019/TT-BKHCN	Circular amending and supplementing a number of articles of Circular No. 23/2013/TT-BKHCN dated September 26, 2013, of the Minister of Science and Technology providing for measurement for group 2 measuring instruments	26/7/2019
2284/QĐ-BKHCN	The decision to announce the HS code table for group 2 measuring instruments subject to approval of samples subject to state inspection on metrology upon import	15/08/2018
11/2018/TT-BKHCN	Circular on regulations on economic and technical norms for inspection and calibration of measuring instruments for automatic and continuous air environment monitoring stations	6/8/2018
08/2018/TT-BKHCN	Circular amending a number of articles of Circular 15/2015/TT-BKHCN dated August 25, 2015, regulating measurement and quality in petroleum business	15/6/2018
14/2013/TT-BKHCN	Circular on metrology for national standards	12/07/2013

APPENDIX A. LIST OF LEGAL DOCUMENTS ON METROLOGY

No	Name	Issued Date
23/2013/TT-BKHCN	Circular on measurement of measuring instruments of group 2	26/09/2013
22/2013/TT-BKHCN	Circular on management of measurement in gold business and quality control of gold jewellery and fine art circulated on the market	26/09/2013
24/2013/TT-BKHCN	Circular on verification, calibration and testing of measuring instruments and measurement standards	30/09/2013
28/2013/TT-BKHCN	Circular on state examination of metrology	17/12/2013
21/2014/TT-BKHCN	Circular on quantity of prepackaged goods	15/07/2014
15/2015/TT-BKHCN	Circular on regulations on measurement and quality in petroleum business	25/08/2015
09/2017/TT-BKHCN	Circular on metrology for volume measurement in retail trade	27/06/2017
06/2017/TT-BKHCN	Circular stipulating economic - technical norms for activities of verification and calibration of measuring instruments of automatic and continuous water monitoring stations	25/05/2017
20/2019/TT-BKHCN	Circular provides for measurement and quality in gas trading	10/12/2019
10/2022/TT-BKHCN	Circular amending and supplementing a number of articles of Circular No. 28/2013/TT-BKHCN dated December 17, 2013, of the Minister of Science and Technology regulating state examination of metrology	12/9/2022

8. Appendix B. List of Legal Documents on Product and Goods Quality

No	Name	Issued Date
05/2007/QH12	Law on product and goods quality	21/11/2007
132/2008/NĐ-CP	Decree detailing the implementation of a number of articles of the Law on Product and Goods Quality	31/12/2008
67/2009/NĐ-CP	Decree Amending a number of articles of the Government's Decree No. 127/2007/ND-CP dated August 1, 2007, detailing the implementation of a number of articles of the Law on Standards and Technical Regulations and Decree No. 132 /2008/ND-CP dated December 31, 2008, of the Government detailing the implementation of an article of the Law on Product and Goods Quality.	03/08/2009
107/2016/NĐ-CP	Decree stipulating conditions for conducting business in conformity assessment services	01/7/2016
154/2018/NĐ-CP	Decree amending, supplementing and abolishing a number of regulations on business investment conditions in the field of state management of the Ministry of Science and Technology	09/11/2018
74/2018/NĐ-CP	Decree amending and supplementing a number of articles of the Government's Decree No. 132/2008/ND-CP dated December 31, 2008 detailing the implementation of a number of articles of the law on product and goods quality.	15-5-2018
119/2017/NĐ-CP	Decree on handling of administrative violations in the field of standards, measurement and quality of products and goods	1/11/2017
36/2010/QĐ-TTg	Decision of Prime Minister promulgating "Regulation on coordination in product and goods quality inspection"	15/04/2010

No	Name	Issued Date
3482/2017/QĐ-BKHCN	The decision on the announcement of group 2 products and goods is under the management responsibility of the Ministry of Science and Technology	08/12/2017
01/2009/TT-BKHCN	Circular stipulating the list of potentially unsafe products and goods under the management responsibility of the Ministry of Science and Technology	20/03/2009
09/2018/TT-BKHCN	Circular amending and supplementing a number of articles of Circular No. 09/2016/TT-BKHCN dated June 9, 2016, of the Minister of Science and Technology stipulating the order and procedures for granting permits to transport dangerous goods are oxidizing agents, organic oxide compounds (of category 5) and corrosives (of category 8) by road, rail and inland waterway motor vehicles under the responsibility of Science and technology.	01/07/2018
12/2017/TT-BKHCN	Circular amending and supplementing a number of articles of Circular No. 26/2012/TT-BKHCN dated December 12, 2012, of the Minister of Science and Technology regulating the state inspection of the quality of goods in circulation on the market.	28/9/2017
07/2017/TT-BKHCN	Circular amending and supplementing a number of articles of Circular No. 27/2012/TT-BKHCN dated December 12, 2012, of the Minister of Science and Technology regulating the state inspection of the quality of imported goods under the management responsibility of the Ministry of Science and Technology.	16/06/2017
02/2017/TT-BKHCN	Circular amending and supplementing a number of articles of Circular No. 28/2012/TT-BKHCN dated December 12, 2012, of the Minister of Science and Technology providing regulations on standard conformity announcement, regulation conformity announcement and methods form of assessment of conformity with standards and technical regulations	31/3/2017
110/2016/TTLT-BTC-BKHCN	Joint Circular guiding the coordination of quality inspection and customs clearance of imported goods	30/6/2016

No	Name	Issued Date
11/2016/TT-BKHCN	Circular guiding the registration of gas processing facilities	28/6/2016
09/2016/TT-BKHCN	Circular stipulating the order and procedures for granting permits to transport dangerous goods which are oxidizing substances, organic oxide compounds and corrosive substances by road, rail and waterway motorized vehicles. inland	09/6/2016
77/2016/TTLT-BTC-BKHCN	Joint Circular guiding the implementation of the national single window for state inspection procedures for quality of goods imported into Viet Nam under the management responsibility of the Ministry of Science and Technology	30/6/2016
36/2014/TT-BKHCN	Circular stipulating training activities of management system assessors and product certification experts of conformity assessment organizations	12/12/2014
02/2014/TT-BKHCN	Circular amending Article 2 of Decision No. 04/2008/QD-BKHCN dated April 28, 2008, of the Minister of Science and Technology on the promulgation of national technical regulations on helmets for motorcyclists, motorcycle	31/3/2014
26/2013/TT-BKHCN	Circular stipulates requirements, order and procedures for appointing foreign conformity assessment organizations to conduct conformity assessment of products and goods according to national technical regulations promulgated by the Ministry of Science and Technology.	15/11/2013
13/2013/TT-BKHCN	Circular amending and supplementing a number of articles of Circular No. 21/2011/TT-BKHCN, Circular No. 10/2012/TT-BKHCN and Circular No. 11/2012/TT-BKHCN of the Minister of Science and Technology	12/4/2013
28/2012/TT-BKHCN	Circular stipulating standard conformity announcement, regulation conformity announcement and methods of assessing conformity with standards and technical regulations	12/12/2012

APPENDIX B. LIST OF LEGAL DOCUMENTS ON PRODUCT AND GOODS QUALITY

No	Name	Issued Date
26/2012/TT-BKHCN	Circular stipulating the inspection of the quality of goods circulating on the market	12/12/2012
16/2012/TT-BKHCN	Circular stipulating the state inspection of product quality in production under the management responsibility of the Ministry of Science and Technology	27/08/2012
05/2012/TT-BKHCN	Circular amending and supplementing Article 1 of Decision No. 05/2005/QD-BKHCN dated May 11, 2005, of the Minister of Science and Technology on amending and supplementing Decision No. 28/2004/QD- BKHCN dated October 1, 2004, on the method of determining the localization rate for automobiles	12/03/2012
01/2011TTLT-BNV-BKHCN	Joint Circular guiding the transfer of rank and salary ranking for specialized officials and employees of product and goods quality controllers	07/4/2011
22/2010/TT-BKHCN	Circular stipulating the issuance and inspection of the Certificate of free sale for exported and imported products and goods under the management responsibility of the Ministry of Science and Technology	29/12/2010
06/2009/TT-BKHCN	Circular guiding the conditions and procedures for considering and giving awards for product and goods quality of organizations and individuals	03/04/2009
3482/2017/QĐ-BKHCN	The decision on the announcement of group 2 products and goods is under the management responsibility of the Ministry of Science and Technology	08/12/2017
27/2012/TT-BKHCN	Circular stipulating the state inspection of the quality of imported goods under the management responsibility of the Ministry of Science and Technology	27/01/2013
26/2006/QĐ-BKHCN	Decision promulgating regulations on responsibilities for organizing and inspecting the quality of products and goods circulating on the domestic market and for export and import:	18/12/2006
22/2009/TT-BKHCN	Circular guiding the order and procedures for registration of new potentially unsafe products under the	30/09/2009

No	Name	Issued Date
	management responsibility of the Ministry of Science and Technology	
19/2010/TT-BCT	Circular promulgating the list of products and goods capable of causing unsafety under the management responsibility of the Ministry of Industry and Trade	17/05/2010
19/2009/TT-BKHCN	Circular on quality control measures for products and goods that need to be strengthened before being circulated on the market issued by the Ministry of Science and Technology	14/08/2009
17/2009/TT-BKHCN	Circular guiding the state inspection of the quality of imported goods under the management responsibility of the Ministry of Science and Technology	02/08/2009
16/2009/TT-BKHCN	Circular guiding the state inspection of the quality of goods circulating on the market	02/06/2009
15/2015/TT-BKHCN	Circular on Regulations on measurement and quality in petroleum business	25/08/2015
15/2009/TT-BKHCN	Circular guiding the order and procedures for registration of the use of uncommon additives for the production, processing and preparation of gasoline and diesel fuel	02/06/2009
1171/QĐ-BKHCN	The decision on publication of the list of imported goods subject to quality inspection according to national technical regulations before customs clearance falls under the management responsibility of the Ministry of Science and Technology.	27/05/2015
11/2009/TT-BKHCN	Circular on Regulations on National Quality Award	06/05/2009
09/2009/TT-BKHCN	Guidance on requirements, order and procedures for appointing conformity assessment organizations	08/04/2009
08/2009/TT-BKHCN	Circular Guiding requirements, order and procedures for registration of the field of conformity assessment activities	08/04/2009

APPENDIX B. LIST OF LEGAL DOCUMENTS ON PRODUCT AND GOODS QUALITY

No	Name	Issued Date
22/2013/TT-BKHCN	Circular on management of measurement in gold business and quality control of gold jewelry and fine art circulated on the market	26/09/2013

9. Appendix C. List of Legal Documents on Standards and Technical Regulations

No	Name	Issued Date
68/2006/QH11	Law on Standards and Technical Regulations	29/06/2006
127/2007/NĐ-CP	Decree detailing the implementation of a number of articles of the Law on Standards and Technical Regulations	01/8/2007
67/2009/NĐ-CP	Decree amending a number of articles of the Government's Decree No. 127/2007/ND-CP dated August 1, 2007, detailing the implementation of a number of articles of the Law on Standards and Technical Regulations and Decree No. 132 /2008/ND-CP dated December 31, 2008, of the Government detailing the implementation of an article of the Law on Product and Goods Quality.	03/08/2009
80/2013/NĐ-CP	Decree on sanctioning of administrative violations in the field of standards, measurement and quality of products and goods	19/07/2013
21/2007/TT-BKHCN	Circular guiding the development and application of standards	28/09/2007
22/2007/QĐ-BKHCN	Decision of the Minister of Science and Technology on the promulgation of the "Regulation on organization and operation of the National Technical Committee for Standards":	28/09/2007
23/2007/TT-BKHCN	Circular guiding the formulation, appraisal and promulgation of technical regulations:	28/09/2007
27/2007/TT-BKHCN	Circular guiding the conclusion and implementation of Agreements and agreements on mutual recognition of conformity assessment results:	31/10/2007
26/2007/QĐ-BKHCN	Decision on the promulgation of "Regulations on organization and operation of accreditation bodies"	31/10/2007
145/2009/TTLT-BTC-BKHCN	Joint Circular guiding the management and use of funds for the development of national standards and	31/08/2009

No	Name	Issued Date
	technical regulations promulgated by the Ministry of Finance - the Ministry of Science and Technology	
28/2012/TT-BKHCN	Circular stipulating standard conformity announcement, regulation conformity announcement and methods of assessing conformity with standards and technical regulations	12/12/2012
26/2019/TT-BKHCN	Circular detailing the construction, appraisal and promulgation of technical regulations	25/12/2019
11/2021/TT-BKHCN	Circular guiding the development and application of standards	18/11/2021

10. Appendix D. List of Legal Documents in Electricity Branch Related to the PV Sector

1. General rules

- Electricity Law 2004
- Law amending and supplementing a number of articles of the Electricity Law in 2012
- Law amending Electricity Law in 2022
- Law on economical and efficient use of energy
- Decree 137/2013/ND-CP guiding the Electricity Law and the amended Electricity Law

2. Regulations on power system management

- Circular 39/2015/TT-BCT regulating distribution power system
- Circular 25/2016/TT-BCT regulating transmission power system
- Circular 30/2019/TT-BCT amending Circular 25/2016/TT-BCT regulating the transmission power system and Circular 39/2015/TT-BCT regulating distribution power system.

3. Licensing and inspection of electricity activities, power purchase and sale contracts

- Circular 21/2020/TT-BCT regulating the order and procedures for granting electricity activity licenses.

4. Government support policy for electricity

- Decision 500/QĐ-TTg in 2023 approving the national electricity development plan for the period of 2021 - 2030, with a vision to 2050.

5. Guides

- Decision No. 25/QD-DTDL dated March 26, 2019, of the Electricity Regulatory Authority promulgating testing procedures and testing supervision.

11. Appendix E. List of Viet Nam National Measurement Standards

No	Measuring quantity	National standard name	Main measurement technical characteristics
I	**Length measurement field**		
1	Length	He – Ne Laser standard wavelength source 633 nm is frequency stabilized with Iodine	
		Iodine-stabilized He-Ne laser 633nm model 100	- Frequency stability: 2.5´10-11 (12 kHz) - Standard frequency: f = (473 612 214 714.1 ± 6.2) kHz - Wavelength: l = 632.99139822 nm - Power Laser output: + Minimum: 75 µW + Average: (100 ÷ 125) µW
		Offset-locked iodine-stabilized He-Ne laser model 200	- Frequency stability: 2.5.10-11 (12 kHz) - Standard frequency: f = (473 612 476,966 ± 0.011) MHz - Maximum power: 1 mW
2	Flat corner	National standard for small flat angles	Measuring range: ± 30'; Resolution: 0.01''; Uncertainty U = 0.08''
		National standard for full circle flat angle	Measuring range: ± 360o (Two-way rotation, forward and reverse); Resolution: 0.035''; Uncertainty U = 0.1''
II	**Field of mechanical measurement**		
3	Mass	Standard weight 1 kg	General standard uncertainty Uc = 20 µg
III	**Field of force and hardness measurement**		
4	Stiffness	HNG-250 hardness standardizer with HRC scale	Measuring range and accuracy: according to Rockwell method C scale (20 ÷ 70) HRC; Uncertainty U = 0.3 HRC

5	Force	National standard force calibration machine up to 100 kN	Measuring range: (1 ÷ 100) kN; Degree of uncertainty U = 2 × 10-5
IV	**Pressure measurement field**		
6	Pressure	Air piston manometer	- Measuring range: (1.4 ÷ 172) kPa; Accuracy 0.001 % - Measuring range: (12 ÷ 700) kPa; Accuracy 0.001 % - Measurement range: (14 ÷ 3500) kPa; Accuracy 0.001 % - Measurement range: (14 ÷ 7000) kPa; Accuracy 0.001 %
		Piston manometer	- Measuring range: (0.05 ÷ 5) Mpa; Accuracy 0.0038 % - Measuring range: (0.5 ÷ 100) Mpa; Accuracy 0.0046 %
		Air piston manometer	- Measuring range: (5 ÷ 175) kPa; Accuracy 0.0025 %
		Piston manometer	- Measuring range: (5 ÷ 175) kPa; Accuracy 0.0053 % - Measuring range: (3.5 ÷ 138) kPa; Accuracy 0.0053 % - Measurement range: (7 ÷ 276) kPa; Accuracy 0.0053 %
		Piston manometer measures extremely low pressure	Measuring range: (0 ÷ 15) kPa; Accuracy 0.003 %
		National standard piston manometer measures differential pressure	Measuring range: (0 ÷ 20) MPa; Uncertainty U = 0.006 %.
V	**Field of measurement: Capacity - Flow**		
7	Capacity	National measurement standard system for capacity	Measuring range: (0.001 ÷ 500) L; Degree of uncertainty: U = 4 × 10-5.
8	Fluid volume flow rate	National measurement standard system for liquid volume flow rate	Measuring range: (1 ÷ 200) m3/h Uncertainty U < 0.1 %
9		National standard measurement system for air flow:	

	Gas volume flow rate	Bell-type air flow standard	Measuring range: (0.1 ÷ 100) m3/h Uncertainty U = 0.2 %
		PVTt type gas flow standard	Measuring range: (0.1 ÷ 500) m3/h Uncertainty U = 0.2 %
10	Fluid volume flow	National standard equipment system for standard volumetric flow of gasoline and oil	Maximum flow (Qmax): 150 m3/h; Uncertainty U = 0.08 %
11	Fluid mass flow	National standard equipment system for water mass flow rate	Measuring range: (1 ÷ 10) kg/s; Uncertainty U = 0.05 %
12	Air velocity	The national gas velocity measurement standard system includes two discs: the standard velocity disc and the Laser Doppler gas velocity measurement standard.	Standard speed disc - Angular speed: (0 ÷ 1800) rpm (rotation in both directions forward and reverse) - Converted long speed: (0 ÷ 4.5) m/s - Uncertainty U = 0.02 % - Disc diameter: 50 mm; UD = 0.5 mm (k = 2) - Rotary encoder: 18000 pulses/rev
			Laser doppler gas velocity measurement standard - Measuring range: (0 ÷ 70) m/s (2D) - Uncertainty: U = 0.15 % - Division value: 0.001 m/s - Laser power: 150 mW - Laser wavelength: 532.0 nm and 561.0 nm.
13	Flow capacity, gas volume flow rate	National standard for measuring piston-type gas volume flow	- Measurement range: (0.002 ÷ 24) L/min - Uncertainty U = 0.12 %
VI	**Field of physico-chemical measurement – standard sample**		
14	Liquid density	National standard for liquid density	Measuring range: (0 ÷ 3000) kg/ m3; Uncertainty U = (0.02 ÷ 0.05) kg/ m3.

15	Kinematic viscosity	National standard capillary viscometer standard	Measuring range: (0.3 ÷ 10 000) mm2/s; Uncertainty U = (0.19 ÷ 0.32) %.
16	Amount of substance	Zinc metal standard solution (Zn)	Solution concentration 1000 mg/kg: Uncertainty U ≤ 0.2 % (with k = 2, P = 95 %)
VII	**Electrical measurement field**		
17	Industrial frequency electrical power	Single phase power converter	Accuracy level: 0.005 (10 Vdc), 0.01 (10 kHz)
		Capacity comparison - 3-phase electricity	Accuracy level: 0.01
18	Industrial frequency electrical energy	Single phase power converter	Accuracy level: 0.005 (10 Vdc), 0.01 (10 kHz)
		Capacity comparison - 3-phase electricity	Accuracy level: 0.01
19	One-way resistor	DC resistor standard	Nominal value: 1 Ω Stability: 0.12 ppm/year (at 25oC)
20	DC voltage	DC voltage standard	Nominal value: 10 V Stability: ± 1.2 ppm/year Average error: < ± 2 µV
21	Amperage	National standard for direct current	Current ShuntCS – 0.1: - Expressed value: 100,000 mA; - Uncertainty U = 8×10-6.
			Current ShuntCS – 1: - Expressed value: 1,000 00 A; - Uncertainty U = 7×10-6.
22	Alternating voltage	National standard AC voltage	- Value shown: Voltage: 4,000 00 V (at frequency f = 1 kHz); Conversion difference δAC-DC diference = 20 ppm; - Degree of uncertainty U = 5 x 10-6.
VIII	**Field of measurement of electromagnetic fields**		
23	High frequency attenuation	National high frequency attenuation standard	- Measurement range: 10 MHz ÷ 18 MHz; 1 dB ÷ 10 dB; 10 dB ÷ 100 dB. - Uncertainty level U = 0.06 dB.

IX	**Time - frequency measurement field**		
24	Time – Frequency	Cesium atomic clock	Accuracy: ± 2×10-12 Reproducibility: ± 5.0×10-12 Long-term stability (30 days): ± 5.0×10-14
X	**Thermal measurement field**		
25	Temperature	National temperature standard complex, including: 1. Thermal standard points	
		Triple point of pure water	- Temperature value: t90 = +0.01 oC - Uncertainty U = 0.0001 oC
		Triple point of pure Mercury	- Temperature value: t90 = - 38.83307 oC - Uncertainty U = 0.0002 oC
		Melting point of pure gallium	- Temperature value: t90 = +29.76473 oC - Uncertainty U = 0.0001 oC
		Freezing point of pure Tin	- Temperature value: t90 = +231.9279 oC - Uncertainty U = 0.0005 oC
		Pour point of pure Zinc	- Temperature value: t90 = +419.5268 oC - Uncertainty U = 0.0009 oC
		Pour point of pure aluminium	- Purity: 99.9999 % (6N) - Temperature value: t90 = + 660.323 oC - Uncertainty U = 0.0013 oC
		Pour point of pure silver	- Purity: 99.9999 % (6N) - Temperature value: t90 = + 961.78 oC - Uncertainty U = 0.0024 oC
		2. High precision measuring bridge system	
		The bridge measures the resistance ratio	- Resistance ratio measurement range (0 ÷ 1.3) is equivalent to the standard platinum resistance thermometer range from (0 ÷ 130) Ω, standard resistance 100 Ω. - Uncertainty level: 0.02 ppm
		AC/DC standard resistor	- Resistance value: 24.9995213 Ω; 100.000135 Ω - Measurement uncertainty: 0.45 ppm

		Platinum standard resistance thermometer	- Working temperature range: (-40 ÷ 420) oC - Measurement uncertainty: less than 0.002 oC
		AC/DC standard resistor	- Resistance value: 0.9999946 Ω; 9.999964 Ω - Measurement uncertainty U95 = (0.44 ÷ 0.7) ×10-6(ppm)
		High temperature standard platinum resistance thermometer	- Working temperature range: 0 oC to 962 oC - Measurement uncertainty U95 ≤ 0.01 oC
26	Non-contact temperature measurement, thermodynamic temperature	Blackbody benchmarks (In, Sn, Zn, Al, Ag)	
		Blackbody benchmark Print	Temperature: 156.43 oC Uncertainty U95= 0.16 oC
		Sn blackbody benchmark	Temperature: 231.87 oC Uncertainty U95= 0.14 oC
		Zn blackbody benchmark	Temperature: 419.43 oC Uncertainty U95= 0.17 oC
		Al blackbody benchmark	Temperature: 660.13 oC Uncertainty U95= 0.23 oC
		Ag blackbody benchmark	Temperature: 961.61 oC Uncertainty U95= 0.35 oC
XI	**Optical measurement field**		
27	Light intensity	National standard for measuring luminous intensity	Current 5.9374 A, voltage 31.08 V, color temperature 2856 K, luminous intensity 286.6 cd; Uncertainty U = 0.50 %
			Current 5.9132 A, voltage 30.82 V, color temperature 2856 K, luminous intensity 285.3 cd; Uncertainty U = 0.50 %
			Current 5.9377 A, voltage 30.99 V, color temperature 2856 K, luminous intensity 277.4 cd; Uncertainty U = 0.50 %
28	Luminous flux		Current 5.895 A, voltage 31.41 V, luminous flux 2966 lm; Uncertainty U = 0.66 %

		National measurement standard for luminous flux	Current 5,920 A, voltage 31.58 V, luminous flux 3035 lm; Degree of uncertainty:
			Current 5.925 A, voltage 31.76 V, luminous flux 3015 lm; Uncertainty U = 0.66 %
29	Spectrum, transmittance	National measurement standard for transmittance spectrum	Spectral range (200 ÷ 800) nm, Transmittance (87 ÷ 94) %, Uncertainty U = (0.12 ÷ 0.24) %
			Spectral range (200 ÷ 800) nm, Transmittance (55 ÷ 82) %, Uncertainty U = (0.12 ÷ 0.28) %
			Spectral range (200 ÷ 800) nm, Transmittance (41 ÷ 52) %, Uncertainty U = (0.12 ÷ 0.28) %
			Spectral range (200 ÷ 800) nm, Transmittance (30 ÷ 36) %, Uncertainty U = (0.12 ÷ 0.21) %
			Spectral range (200 ÷ 800) nm, Transmittance (9 ÷ 14) %, Uncertainty U = (0.09 ÷ 0.14) %
			Spectral range (200 ÷ 800) nm, Transmittance (0.14 ÷ 1.3) %, Uncertainty U = (0.021 ÷ 0.047) %
			Spectral range (200 ÷ 800) nm, Transmittance (0.008 ÷ 0.14) %, Uncertainty U = (0.0046 ÷ 0.0089) %
30	Optical light, luminance	Luminance titration source	Voltage (VAC): 230; Frequency (Hz): 50; Correlated color temperature (K): 2856; Luminance (cd/m2): 1319.1; Uncertainty U = 0.66 % (k = 2)
XII	**Sound - vibration measurement field**		
31	Sound pressure level	National measurement standard for sound pressure levels	Model: 4180; Diameter: 12.7 mm (1/2 inch); Frequency range: 1 Hz ÷ 20 kHz; Uncertainty U = 0.04 dB (k = 2; 95 % CL) at reference frequency 250 Hz
32	Vibrate	Standard vibration	Charge: (0.004 ÷ 400) pC/ms-2; Voltage: (0.004 ÷ 400) mV/ms-2; Speed: (0.4 ÷ 99) mV/mms-1; Frequency range: 10 Hz to 6 kHz; Uncertainty U = 0.3 % (k = 2; 95 % CL) at 159.15 Hz

Source: Viet Nam Metrology Institute http://www.vmi.gov.vn

12. Appendix F. List of Solar Cell, Module & Inverter Manufacturers

Sr No.	Name of Company	Products
1	Trina	Modules & Cells
2	Firstsolar	Modules & Cells
3	Vsun/Toyo	Modules & Cells
4	Boviet	Modules & Cells
5	JA Solar	Modules & Cells
6	Vietnam Green Energy	Modules
7	IREX	Modules
8	Jinko	Modules & Cells
9	Dehui solar	Modules & Cells
10	HT Solar	Modules
11	Vinasolar	Modules & Cells
12	Redsun	Modules
13	Focus Production	Modules & Cells
14	Allesun Solar	Modules
15	AD Greens	Modules
16	ET Solar/Elite Solar	Modules & Cells
17	IC Energy	Modules
18	Canadian Solar	Module
19	Growatt	Inverters
20	Goodwe	Inverters

13. Appendix G. List of Solar Module Importers & Resellers

Sr No.	Name of Company
1	DAT J.S.C
2	Ginlong Technologies Co. Ltd
3	BPLogistics J.S.C
4	AxiTec Energy Co. Ltd.
5	D&H Industrial Equipment Co. Ltd
6	GoodWe Technologies Co. ltd
7	JA Solar Technology Co. ltd.
8	Jinko Solar Co. Ltd.
9	Jolywood Solar Technology Co. Ltd
10	Lilama 18.1 J.S.C
11	Lithaco
12	Long Tech Co. Ltd
13	Longi Solar Technology Co. Ltd
14	Lucy Electric
15	Sharp NSN Energy Solution J.S.C
16	Shenzhen Growatt New Energy Co. Ltd
17	Solar Mien Bac Co. Ltd.
18	Solax Power Network Technology Co. Ltd
19	Sungrow floating module SCI & Tech Co.
20	Toshiba Transmission & Distribution VN
21	Unisolar J.S.C
22	VATEC Energy Engineering Consulting

14. Appendix H. List of Solar PV System Installers

Sr No	Organization Name	Address
1	Automation & Control Solution Co., Ltd	8th floor, Petrolimex Building 122 2/9 Street, Danang, Viet Nam C3, Road No.2, Hoa Cam Industrial Zone, Danang, Viet Nam + 84 (236) 3675 666 + 84 (236) 3675 777 info@cas-energy.com
2	SAO NAM Integrated Technology	3rd Floor, SCID Building, 253 Dien Bien Phu, Ward 7, District 3, HCMC (+84-28) 6680 7945 info@sntek.vn www.sntek.vn
3	VIET NAM CONTROL SOLUTION JOINT STOCK COMPANY	50/14 Go Dau, Tan Quy Ward, Tan Phu District, Ho Chi Minh Phone: 0835591432 Email: nandoan@vietcontrol.vn
4	Powertech Technical and Trading Co., Ltd	City address. Ho Chi Minh: 6C Huynh Tan Phat, Kp. 1, Phu Thuan Ward, District 7, HCMC City address. Vung Tau: No. 166, Le Quang Dinh, Ward 9 City. Vung Tau Phone: 089 6622 606 - 093 773 2030 - 093 775 7479 Email: info@powertech.vn Website: https://powertech.vn/ Facebook: https://www.facebook.com/dienmattroipowertech
5	THANH HOA ELECTRICAL CONSTRUC-TION - TRADING CO., LTD	Headquarters: THANH HOA ELECTRICAL TRADING - CONSTRUCTION COMPANY LIMITED 26 Ha Huy Jipa, Thanh Loc Ward, District 12, City. Ho Chi Minh City Tel: (028) 37166020 - Fax: (028) 37166021 FACTORY OF ELECTRIC SHOCKET & CABLE TRAILER 214B Ben Than Street, Hoa Phu Commune, Cu Chi Dist., City. Ho Chi Minh City

APPENDIX H. LIST OF SOLAR PV SYSTEM INSTALLERS

Sr No	Organization Name	Address
		Tel: 028. 37166020 - Fax: 028. 37166021 Mail: thanghoaelectric@gmail.com
6	SAMETEL JOINT STOCK COMPANY	Headquarters: Long Thanh Industrial Park, Road No. 1, Tam An Commune, Long Thanh District, Dong Nai Province Phone: +84366895679 - (+84) 251 3514277 Email: khkd@sametel.com.vn Office in Ho Chi Minh City: No. 32 D5 Street, Ward 25, Binh Thanh District, HCM Phone: Email: khkd@sametel.com.vn
7	SUNTECH TECHNOLOGY JOINT STOCK COMPANY	49 Bui Dinh Tuy, Ward 24, Binh Thanh District, Ho Chi Minh City
8	VES. Joint Stock Company	232 Cong Hoa - Ward 12 - Tan Binh District 64 Duong Van Duong, Tan Quy Ward, Tan Phu Hotline: 19000 66877 sales@ves-vn.com
9	RED SOLAR ENERGY JOINT STOCK COMPANY	Office: 43 Tan Da, Ward 10, District 5, City. Ho Chi Minh Phone: (028) 38 535.333 Hotline: 0902470293 Fax: 028 62611072 Email: sales.redsun@gmail.com Website: https://redsun.com.vn Factory: C2 Duc Hoa Ha Industrial Park, Duc Hoa, Long An
10	SUNEMIT JOINT STOCK COMPANY	12th floor, Tech building 181 Nguyen Luong Bang, Dong Da, Hanoi Phone: 094 6868 498 - 0826 889 489 - 094 396 8848 Hotline 24/7: 0946868498 - 0943968848 Email: dienmattroi@sunemit.com

APPENDIX H. LIST OF SOLAR PV SYSTEM INSTALLERS

Sr No	Organization Name	Address
11	ALENA ENERGY TECHNOLOGY CO., LTD	Address: 2G Nguyen Thanh Y, Da Kao Ward, District 1, Ho Chi Minh City, Viet Nam Sales Department : Tel: 028 39 26 26 83 Email: sales@alena-energy.com Technical and Service Department : Tel: 028 39 26 26 83 Email: hotro@alena-energy.com Working hours: 8:30AM-5:30PM Monday to Friday
12	Solar Top Co., Ltd	ADDRESS No. 29 - LK11 An Hung Urban Area, Ha Dong District, Hanoi City PHONE 0988345842 EMAIL info@solartop.vn
13	ON Energy Green Energy Joint Stock Company	Address: Lot 33, Street 7, Tam Phuoc Industrial Park, Tam Phuoc Ward, City. Bien Hoa Phone: 0898 659 689 - Fax: 028 6290 5578 Email: info@onenergy.com
14	KY THUAT DAT CO., LTD	Head office: B163 Nguyen Van Qua, Dong Hung Thuan Ward, District 12, City. HCMC Branch Hanoi Branch: Lot 05-10A, Hoang Mai Industrial Park, Hoang Van Thu Ward, Hoang Mai District, City. Hanoi Can Tho Branch: 45 Bui Quang Trinh, Phu Thu Ward, Cai Rang District, Can Tho City Hotline: 1800 6567 Email: solar@dattech.com.vn Website: www.datsolar.com
15	TECHPAL JOINT STOCK COMPANY	Head office: No. 71 Nguyen Quy Duc Street, Thanh Xuan Bac Ward, Thanh Xuan District, Hanoi City Northern Office: No. 50 Dang Thuy Tram Street, Dich Vong Hau Ward, Cau Giay District, City. Hanoi Hotline: 096.118.9428 Southern branch: No. 110/43/47 Ba Hom Street, Ward 13, District 6, City. Ho Chi Minh Hotline: 0962.869.762

APPENDIX H. LIST OF SOLAR PV SYSTEM INSTALLERS

Sr No	Organization Name	Address
		Email: Solar@techpal.vn
16	Phu Hung smart home and solar power solutions Co., Ltd	Address: No. 145, Dien Bien Phu, Hamlet 2, Ward 6, Tra Vinh City, Tra Vinh Legal representative: Nguyen Quoc Hung Phone: 0981131368
17	Viet Sun Manufacturing - Trading - Import-Export Co., Ltd	160/12 Phan Huy Ich, Ward 12, Go Vap District, Ho Chi Minh Branch Branch in Hue No. 5 Thanh Huong, Thuan Hoa Ward, Any, Hue City, Thua Thien Hue Tel: 028 2261 0033/028 2200 1037 Email: mattroiviet2018@gmail.com
18	THINH VUONG ELECTRICAL CONSTRUCTION DESIGN JOINT STOCK COMPANY	Address: 80/18 Huynh Van Nghe, Ward 15, Tan Binh District, Ho Chi Minh City Tax code: 0313050150 Phone: 098.3737.020 Email: info.solarthinhvuong@gmail.com Website: https://solarthinhvuong.com | https://solarthinhvuong.vn
19	SHARP NSN ENERGY SOLUTION JSC	No. 11 Alley 89, Kim Quan Thuong, Viet Hung Ward, Long Bien District, Hanoi
20	MEGASUN Production Co., Ltd	61 Nguyen Xi, Ward 13, Binh Thanh, City. Ho Chi Minh City Tel: (028) 3511 6118 Phone: 0944.554.554 - 0972.134.134 info@megasun.com.vn
21	STAR VIET NAM CONSTRUCTION DESIGN CONSULTING COMPANY LIMITED	39D Ly Chieu Hoang, Ward 10, District 6, Ho Chi Minh City Tel: 0888237878
22	Duc Hoa Manufacturing & Trading Co., Ltd	Lot 37 Ba Trieu, Dong Tho Ward, Thanh Hoa City, Dong Tho Ward, Thanh Hoa City, Thanh Hoa
23	HOANG GIA AUTOMATIC TECHNOLOGY CO., LTD	Address: No. 103 Khuc Thua Du, Vinh Niem Ward, Le Chan District, Hai Phong Phone: 0934.350.466 - Fax: 0225.351.3792 Hotline: 0934.350.466 Email: hgsolar.vn@gmail.com Website: hgsolar.vn

APPENDIX H. LIST OF SOLAR PV SYSTEM INSTALLERS

Sr No	Organization Name	Address
24	Viet Nam Lien Thanh Electromechanical Joint Stock Company (Lithaco)	Head office: 514 Tran Van Giau, Tan Tao Ward, Binh Tan District, Ho Chi Minh Western Branch E34, street 56, KDC 586, Phu Thu Ward, Any, Cai Rang District, Can Tho Ho Chi Minh City branch 514 Tran Van Giau, Tan Tao Ward, Any, Binh Tan District, Ho Chi Minh Warehouse Branch D5/1E E. Duong Dinh Cuc, Tan Kien, Any, Binh Chanh District, Ho Chi Minh HOT LINE 0918.886.502 - 094.181.2233
25	VU PHONG ENERGY GROUP JOINT STOCK COMPANY	Headquarters: 111 Lot 1 Group 11, Dong An 3, Binh Hoa Ward, Thuan An City, Binh Duong Ho Chi Minh Branch 61 Cao Duc Lan, Any, District 2, Ho Chi Minh The Hanoi branch Sao Mai Building, No. 19 Le Van Luong, Nhan Chinh Ward, Any, Thanh Xuan District, Hanoi Da Nang branch 09 Thanh Luong 24, Hoa Xuan Ward, Any, Cam Le District, Da Nang Hotline: 1800 7171/+84 9 1800 7171 Email: hello@vuphong.com
26	Green Energy Technical and Trading Co., Ltd	Address: HCM Office 1: 119/5 Da Nam, Ward 3, District 8, HCMC HCM Office 2: 211 Street 13, Phong Phu Residential Area, Binh Chanh Dist., HCMC (near District 8 Bus Station) Hanoi Office: BT 01 Vimeco, Phone: (08) 6299.1893 - Fax: (08) 6299.1827 Website: gee.com.vn - Email: info@gee.com.vn
27	PHOENIX CLEAN POWER JOINT STOCK COMPANY	412 Nguyen Thi Minh Khai, Ward 5, District 3, Ho Chi Minh City Phone: (028) 3929 0939 Email: energy@pcp.com.vn Website: www.phoenixcleanpower.com
28	VS GROUP JOINT STOCK COMPANY	25 Street No. 55-TML, Thanh My Loi Ward, Thu Duc City, Ho Chi Minh City

APPENDIX H. LIST OF SOLAR PV SYSTEM INSTALLERS

Sr No	Organization Name	Address
		(+84) 888,808.608 info@vs-group.vn
29	Seco – Solar Trading And Technical Service Company Limited	Headquarters: Link 3 Block 43 Tan Tay Do Urban Area, Tan Lap Commune, Dan Phuong District, Hanoi Ho Chi Minh Branch No. 26, D1 Street, Linh Tay Ward, Any, Thu Duc District, Ho Chi Minh City Tel: 1900 588 834 EMAIL: info@secosolar.com.vn
30	Electrical Construction Consulting Joint Stock Company	Head office: No. 32, Ngo Thoi Nhiem Street, Vo Thi Sau Ward, District 3, Ho Chi Minh City Phone number: (028) 2221 1169 Email: pecc3@pecc3.com.vn
31	VO SON ELECTRICAL & ENERGY COMPANY LIMITED	Head office: 101 Provincial Road 44A, Long Dien TT, Ba Ria - Vung Tau Phone: 0908 936 736 – 02543 842 616 Branch: 1078 Quang Trung, Chanh Lo Ward, City. Quang Ngai, Quang Ngai Phone: 090 4499 091 – 02553 726 727 Email: info@vusonsolar.vn Website: www.vusonsolar.vn Facebook: fb.com/vusonsolar
32	VINASOL JOINT STOCK COMPANY	Address: 55 Street No. 9, Binh Hung Hoa Ward, Binh Tan District, HCMC - Warehouse: Street No. 14A, Vinh Loc residential area, Binh Tan district, HCMC Email: Sale.vinasol@gmail.com Facebook: Vinasol: Viet Nam Solar Power Website: http://vinasol-solar.com/ Hotline: 08 34 30 03 30.
33	TRAN LE ELECTRICAL ENGINEERING CO., LTD	60 D. Huynh Thi Hai, Tan Chanh Hiep, District 12, Ho Chi Minh City (028) 3 718 5606 info@e-tranle.vn
34		Phone: 1900888679 _ 028.62655656

APPENDIX H. LIST OF SOLAR PV SYSTEM INSTALLERS

Sr No	Organization Name	Address
	PHUC DUY KHANG TECHNOLOGY SERVICE TRADING CO., LTD	Email: phucduykhang2004@gmail.com Address: 137/22 Phan Anh, Binh Tri Dong Ward, BT District, HCMC PTBSP: 226D Phan Anh, Tan Thoi Hoa, Tan Phu, HCMC Branch 1: 226E Phan Anh, Tan Thoi Hoa, Tan Phu, HCMC Branch 2: 79/19 Highway 4, Binh Hung Hoa Ward. Binh Tan District, Ho Chi Minh City Branch 3: 14 Nguyen Trung Truc,Thanh Cong Ward, BMT city
35	DHC SOLAR CONSTRUCTION, TRADING AND SERVICES CO., LTD	K151 Au Co - Group 64 - Hoa Khanh Bac Ward - Lien Chieu District - City. Danang 133 Ho Tung Mau, Hoa Minh Ward, Lien Chieu District, City. Danang 0367,269,820 solardhc@gmail.com

15. Appendix I. List of Financing Bodies

TT	Organization name	Address
1	Ha Do Group Joint Stock Company	**HEADQUARTERS** No. 8, Lang Ha, Ba Dinh, Hanoi 024 3831 0347 - 024 3831 0348 024 3835 5526 hq@hado.com.vn **SOUTHERN REPRESENTATIVE OFFICE** 5th Floor, HaDo Airport Building, No. 02 Hong Ha, Ward 2, Tan Binh District, Ho Chi Minh City (028)39797966 – (028)39797988 – (028)39798232 hq@hado.com.vn
2	Sao Mai Group Joint Stock Company	**HEADQUARTERS ADDRESS** **Address:** No. 326, Hung Vuong, My Long Ward, City. Long Xuyen An Giang **Phone:** 02963 840 138 - 0296 3940 837 - 0296 3940 838 **Fax:** 02963 840 139 **Email:** thongtinkhachhang @saomaigroup.com - pr@saomaigroup.com
3	Bamboo Capital Group Joint Stock Company	**HEADQUARTERS ADDRESS** 27C Quoc Huong, Thao Dien Ward, Thu Duc City, Ho Chi Minh City, Viet Nam Phone: +8428 62.680.680 Fax: +8428 62.99.11.88 E-Mail: info@bamboocap.com.vn
4	Trung Nam Construction Investment Joint Stock Company (Trung Nam group)	**HEADQUARTERS** 7A/68 THANH THAI, WARD 14, DISTRICT 10, CITY. H OH CHI MINH. T: (+84.28) 6264 5178 - F: (+84.28) 6264 5180 E: contact@trungnamgroup.com.vn W: www.trungnamgroup.com.vn
5	Bim Group	**HEADQUARTERS** 2nd floor, Hanoi Aqua Central building 44 Yen Phu, Ba Dinh, Hanoi Tel: +84 24 7305 3555

APPENDIX I. LIST OF FINANCING BODIES

TT	Organization name	Address
6	Xuan Thien Group (Xuan Thien Group)	**XUAN THIEN GROUP** Xuan Thien Building, Xuan Thanh Urban Area, Ninh Khanh Ward, City. Ninh Binh, Ninh Binh Province, Viet Nam +84 2293 886 886 +84 2293 886 986 info@xuanthiengroup.vn **SPRING THIEN PEACE** Soc Bai Village, Yen Bong Commune, Lac Thuy District, Hoa Binh Province, Viet Nam +84 2293 886 886 +84 2293 886 986 info@xuanthiengroup.vn **SPRING THIEN SON LA** Sub-area 3, Bac Yen town, Bac Yen District, Son La Province, Viet Nam +84 2123 661 288 +84 2123 900 669 thuydiensonla@xuanthiengroup.vn **SPRING THIEN YEN BAI** Na De Thang Village, Khao Mang Commune, Mu Cang Chai District, Yen Bai Province, Viet Nam +84 2163 501 398 +84 2293 886 986 thuydienkhaomang@xuanthiengroup.vn **XUAN THIEN HA GIANG** Khuoi It Village, Vinh Hao Commune, Bac Quang District, Ha Giang Province, Viet Nam +84 2192 476 999 info@xuanthiengroup.vn **SPRING THIEN THANH HOA** Minh Thanh Village, Minh Tien Commune, Ngoc Lac District, Thanh Hoa Province, Viet Nam

APPENDIX I. LIST OF FINANCING BODIES

TT	Organization name	Address
		+84 2293 886 886 +84 2293 886 986 info@xuanthiengroup.vn **XUAN THIEN PHU YEN** No. 387, Hung Vuong Street, City. Tuy Hoa, Phu Yen Province, Viet Nam +84 573 818 883 info@xuanthiengroup.vn **SPRING THIEN DAK LAK** Ia Lop Commune - Ea Sup District - Dak Lak Province +84 908 888 882 info@xuanthiengroup.vn **SPRING THIEN NINH THUAN** Bac Phong commune, Thuan Bac district, Ninh Thuan province +84 2596 267 996 info@xuanthiengroup.vn
7	Kosy Joint Stock Company	**Head office according to business registration:** B6-BT5 My Dinh 2 New Urban Area, My Dinh 2 Ward, Nam Tu Liem District, Hanoi. **Transaction address:** 6th Floor, Viet Nam Journalists Association Build-ing, Duong Dinh Nghe Street, Yen Hoa Ward, Cau Giay District, Hanoi. **Phone:** 024 37833660 - 024 38378866 **Fax:** 024 37833661 **Email:** info@kosy.vn - Website: www.kosy.vn
8	Dai Duong Renewable Energy Company	**Head office:** Nguyen Quyen Street, Area 5 - Dai Phuc Ward - Bac Ninh **Tel:** 0222. 381.0962 | Fax: 0222. 381.1275 **Email:** info@daiduong.net.vn **Hanoi Office:** No. 131 Thai Ha, Dong Da, Hanoi **Tel:** 024.3537 1039 | Fax: 024. 3857. 4167
9	T&T Group	**Head office:** 2A Pham S u M anh , Phan Chu Trinh Ward , Hoan Kiem District , Hanoi , Viet Nam Phone

APPENDIX I. LIST OF FINANCING BODIES

TT	Organization name	Address
		(+84) 24 7308 1616 Fax (+84) 24 3972 1775 E-mail info@ttgroup.com.vn
10	Binh Duong Xanh Renewable Energy Investment Joint Stock Company	397 Huynh Van Luy , Phu My Ward, Oil Capital Capital City, Binh Duong Province, Viet Nam

16. Appendix J. List of QI Institutions and Stakeholders Interviewed

Sr No.	Name of Organization
1	National Commission for Standards, Metrology and Quality of Viet Nam (STAMEQ)
2	Viet Nam Metrology Institute (VMI)
3	Quality Assurance and Testing Center 1 (QUATEST 1)
4	Quality Assurance and Testing Center 2 (QUATEST 2)
5	Quality Assurance and Testing Center 3 (QUATEST 3)
6	Viet Nam Certification Centre (QUACERT)
7	Institute of Energy
8	Accreditation Office for Standards Conformity Assessment Capacity (AOSC)
9	Bureau of Accreditation (BoA)
10	Northern Electrical Testing Company
11	Boviet Solar Technology Company, Ltd
12	Viet Nam Green Energy Company, Ltd
13	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
14	Viet Nam Electricity Technical Services Joint Stock Company (EVN-S)
15	Viet Nam Electricity Technical Services Joint Stock Company (EVN Ho Chi Minh)
16	TÜV Rheinland Viet Nam
17	Ton Duc Thang University (TDTU)
18	Southern Electrical Testing & Inspection Joint Stock Company/ VREC
19	Tekjoy Joint Stock Company
20	IREX Energy Joint Stock Company/ SolarBK

17. Appendix K. Recommendations to PTB

The following recommendations are addressed to PTB:

Raise awareness

- Raise awareness among regulatory authorities and standardization bodies on the safety risks associated with solar PV products and solar PV plants. Encourage the timely update of specific standards applicable to the solar PV products according to international standards.

- Organize conference and quality forums to provide a platform for solar PV product manufacturers, QI institutions, regulatory bodies, R&D institutes, and policy makers in Viet Nam to share issues faced by the stakeholders and their requirements and outlook.

- Conduct a study on the performance of existing PV power plants in Viet Nam and present the results to all stakeholders in the PV sector, including showcasing defects in components. Inform stakeholders about the best practices for installing PV power plants and the risks associated with financing PV plants.

- Organize physical or virtual experience-sharing sessions with QI institutions and PV industry stakeholders from other countries to share lessons learned.

- Organize workshops on solar PV standards, PV installations and conferences on emerging topics such as “End of Life of PV modules”.

Technical cooperation

- Support an institution in Viet Nam, preferably VMI, to offer sun simulator calibration services according to IEC 60904-9 to industry by providing consultancy on equipment needed, calibration methods, and the development of standard operating procedures.

- Provide technical support to EVN HCMC to set up an inverter lab, since there is interest and the necessary budget for creating a test facility for up to 100 KW inverters.

- Develop a certification scheme for installers together with QUACERT so that skilled manpower is available for the EPC companies in Viet Nam to install PV power plants, leading to better plant performance.

- Support QUACERT in obtaining the know-how needed to become a national certification body under IECEE CB scheme by establishing contact with IEC and arranging meetings.

- Conduct a workshop for test/calibration lab engineers and staff on ISO/IEC 17025, solar PV standards, and hands-on training on testing solar PV products

- Exposure visits for conformity assessment bodies’ staff to the labs in countries such as Germany and India should be arranged, which may help to establish labs in Viet Nam

APPENDIX K. RECOMMENDATIONS TO PTB

Financial cooperation

Find international sponsors to support Viet Nam (STAMEQ) in the following tasks:

- Facilitate the development of a quality policy (QP) for the PV sector in Viet Nam
- Develop a radiometry and photometry measurement system
- Establish a reference testing laboratory for PV modules
- Train technical staff
- Update on new technology concerning the PV sector

Mainstream QI for PV

- Develop a program jointly with ministries, branches, localities, organizations and individuals to mainstream quality infrastructure in the PV sector.
- Encourage businesses to invest in developing metrology and conformity assessment services in the PV sector.

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19. Authors

Saurabh Kumar's profile highlights his expertise in quality infrastructure development projects, particularly in the renewable energy sector. With over 19 years of experience, he has held various leadership roles, including Director at PI Photovoltaik-Institut Berlin Pvt. Ltd. (Indian subsidiary), CEO at Techlab Testing & Research Institute Pvt Ltd, Manager of the Green Energy Division at Fiem Industries Ltd, Senior Research Engineer at Moser Baer India Ltd. and Research Engineer at LG Electronics, South Korea. Currently, he serves as the National Project Consultant for India with PTB Germany, leveraging his expertise in quality assurance, research, and management to drive projects forward. His background suggests a strong commitment to advancing renewable energy initiatives.

Nguyen Hung Diep is a national consultant. He previously worked in the Metrology Department at the National Commission for Standards, Metrology, and Quality (STAMEQ) in Vietnam. He has also worked as a national expert for USAID, contributing to the "Research on International Best Practices, Situational Assessment, and Recommendations for the National Quality Infrastructure (NQI) of Vietnam" under the previous USAID Vietnam Trade Facilitation Program.

20. Notes

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Responsible
Dr. Marion Stoldt
+49 531 592-9300
marion.stoldt@ptb.de
www.ptb.de/q.3/en

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Saurabh Kumar, Nguyen Hung Diep

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Contact

Physikalisch-Technische Bundesanstalt
International Cooperation
Dr. Marion Stoldt
Phone +49 531 592-9300
marion.stoldt@ptb.de
www.ptb.de/q.3/en

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