VeraSol

Quality Assurance for Productive Use of Energy (PUE) Technologies in Market Development Interventions

Selecting a proportionate approach to technology risk mitigation through categorization of PUE appliances and systems

GUIDANCE AT A GLANCE

This document presents a conceptual framework for designers and implementers of market development interventions like results-based financing (RBF) programs to help them structure practical and appropriate quality assurance (QA) mechanisms for PUE appliances and systems.

The recommended approach is based on two underlying principles. First, quality assurance is foundational to building a thriving market for PUE appliances and systems. In this context, **quality assurance is an essential component of RBF program design.** Secondly, there is a lack of product- and system-specific QA – namely testing, standards, and certification – applicable to the diverse range of PUE appliances, systems and applications. Because of the wide variety of PUE technologies that may be considered by programs, **effective quality assurance for PUE requires a combination of complementary risk mitigation measures, including standards and certification for some product types along with a wider set of strategies for others.**

The first step of this risk-based approach is to categorize PUE products and systems according to the applicable elements of a QA framework that already exist. Once program designers assign a product or system to a category, they can identify proportionate requirements and interventions that sufficiently mitigate the technical risks that PUE products and systems pose to users, the program, and more broadly.

This document lays out five categories of PUE products and systems. Each category is defined according to the technical configuration, as well as the applicable standards, test methods, and certification that currently exist. For each category, we provide recommendations for product and company eligibility requirements, the qualification process, as well as supporting documentation to be submitted by program applicants. The document concludes with examples of complementary support that program designers and implementers may need to incorporate effective QA and technology derisking into their programs. Types of support for PUE companies are also proposed to improve their equipment and service offering, and to reduce technical barriers to program participation.

INTRODUCTION

An increasing number of RBF and incentive programs are supporting diverse sets of technologies associated with productive uses of energy. While definitions vary, PUE products/systems are commonly defined as those that support agricultural, commercial, or industrial activities by providing new opportunities to use energy to achieve economic goals. The technology scope of RBF programs spans a wide range of PUE technologies, with some programs specifying particular types of technologies, some being open to any technology that meets the broader PUE definition, and others further specifying how the equipment must be powered (e.g., solar PV, mini-grid, on-grid).

Regardless of the technology scope, RBF and incentive programs want to ensure that the equipment and systems that they support are safe, durable, and perform as advertised. Programs seek to avoid investing in low-quality goods that may disappoint end users and fail to support program objectives. Robust yet practical quality assurance frameworks are needed to safeguard programs and their beneficiaries from the technical risks posed by PUE products and systems.

Product quality assurance is supported by several complementary elements: **(1) Test methods** establish standardized procedures for evaluating products; **(2) Requirements for product safety, quality and performance (i.e., standards)** define criteria for preventing physical harm or property damage, as well as ensuring durability, reliability, intended functionality and delivery of specified service levels; **(3) Testing** by accredited laboratories provides independent, technically competent evaluation of products against established test methods; and **(4) Certification** by qualified programs and certification bodies provides independent confirmation that products conform to specified requirements. Together, these elements form a foundation for assessing, verifying, and building confidence in the safety, quality, and performance of products and systems.

Incentive programs commonly utilize VeraSol certification of solar energy kits (SEKs) as an eligibility criterion for program participation. Many programs require that products meet the SEK-specific international quality standard, and they use VeraSol certification[1] to confirm that products are compliant. Relying on VeraSol certification has provided a simple, clear, and harmonized mechanism for reducing the risk of supporting substandard SEK products in the context of their programs.

This approach, however, becomes challenging in relation to the full range of PUE appliances and systems. RBF programs support many diverse PUE technology types, yet product-specific or applicable test methods and standards do not exist in all cases. Product testing and certification programs like VeraSol are unable to develop and operate certification frameworks for such a broad and rapidly expanding scope of PUE appliances[2]. Moreover, while certification is an effective tool for some product types, it may not be the right tool in all cases.

Given these challenges to assuring the quality and long-term, reliable service of PUE products and systems, VeraSol recommends the following decision framework that RBF program designers and implementers can use to determine an appropriate and effective QA strategy for mitigating technology risk.

DETERMINING THE "QA STATUS" OF THE TECHNOLOGY

PUE appliances and systems span a wide range of maturity in terms of design, availability, uptake, and quality assurance. Some PUE technologies are covered by existing internationally-recognized test methods and standards, while others only have applicable test methods, and many completely lack relevant testing and quality requirements.

The first step towards mitigating the quality risks associated with PUE technologies is categorizing them based on the applicable elements of a QA framework that already exist. Determining a technology's "QA status" allows RBF program designers to identify an approach to quality assurance that is proportionate to the risk profile of a product or system.

---

[1] A comprehensive database of VeraSol-certified solar energy kits can be used to find, compare and verify SEK product certification. https://verasol.org/database/

[2] VeraSol tests but does not certify several types of PUE appliances and equipment. VeraSol's database of tested appliances and equipment can be used to view product test results, search and compare products. PUE products listed on the database have not been evaluated against any quality standards, as VeraSol currently does not offer a certification process for them.

We propose five "QA status" categories that can be assigned to PUE technologies, which are described below and summarized in Table 1 .

1. **Category A: Established technologies with QA frameworks supported by VeraSol certification**
   PUE products/kits for which internationally recognized test methods and requirements for safety and quality exist; these products/kits are tested by ISO/IEC 17025 accredited laboratories, and VeraSol has an existing certification program for them.
2. **Category B: Established technologies with QA frameworks not part of VeraSol's certification program**
   PUE products/kits for which internationally recognized test methods and requirements for safety and quality exist; these products/kits are tested by ISO/IEC 17025 accredited laboratories. While VeraSol does not have an existing certification program for them, they may be certified under other programs such as the IECEE CB Scheme[3] or by accredited certification bodies.
3. **Category C: Emerging technologies supported by VeraSol's testing program**
   PUE products/kits for which there are currently no internationally recognized test methods and quality requirements; some products/kits have applicable international safety requirements. VeraSol has developed test methods for these products/kits and coordinates testing through a global network of laboratories. Comparable data from product testing is publicly available on VeraSol's product database, and the performance of tested products/kits can be compared with best-in-class products/kits through a benchmarking approach[4].
4. **Category D: Emerging technologies without QA frameworks**
   PUE products/kits for which there are currently no internationally recognized test methods and quality requirements; in some cases, international safety requirements are applicable. VeraSol has not developed test methods for this category, as these technologies may not be mature enough to merit a product/kit-specific testing and standards framework.
5. **Category E: Custom-designed systems**
   PUE component-based systems that are custom designed to meet the specific needs of the end user; internationally recognized test methods and requirements for quality and safety may exist for some of the system components, and these components are tested by ISO/IEC 17025 accredited laboratories. Guidelines or Codes of Practice for the design and installation of these systems are also required for this category but may not exist.

[3] The IEC System for Conformity Assessment for Electrotechnical Equipment and Components Certification Body Scheme (IECEE CB Scheme) is an international system for mutual acceptance of test reports and certificates dealing with the safety of electrical and electronic components, equipment, and products. https://www.iecee.org/who-we-are/cb-scheme

[4] Product benchmarking involves comparing the performance of products within a given category using results from standardized testing to assess their relative performance against comparable products or established reference values. RBF programs can use benchmarking to establish minimum performance thresholds that products must meet to qualify for program participation, particularly where internationally recognized quality standards do not yet exist. These thresholds can be informed by the performance of products tested by VeraSol and published in its product database.

TABLE 1: CATEGORIZING PUE PRODUCTS AND SYSTEMS BASED ON THEIR "QA STATUS" AND CONFIGURATION

QA Category	Title	Existing test methods	Existing quality requirements	Existing safety requirements	Tested by ISO/IEC accredited lab	VeraSol tested	VeraSol certified	Technology Examples
A	**Established technologies with QA frameworks supported by VeraSol certification**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	Solar energy kits sized up to 350 watts
B	**Established technologies with QA frameworks not part of VeraSol's certification program**	**Y**	**Y**	**Y**	**Y**	**V**	**N**	Commercial refrigerators/freezers; Air conditioners; Heat pumps
C	**Emerging technologies supported by VeraSol's testing program**	**Y**	**N**	**V**	**N**	**Y**	**N**	Solar water pumps; Off-grid refrigerators/freezers; Walk-in cold rooms; Egg incubators;
D	**Emerging technologies without QA frameworks**	**N**	**N**	**V**	**N**	**N**	**N**	Solar/electric threshers, sprayers, dryers, and other agro-processing equipment
E	**Custom-designed systems**[5]	**V**	**V**	**V**	**V**	**N**	**N**	Solar irrigation systems; Milk chilling systems

Y = Yes **V = Varies** **N = No**

[5] All PUE categories except for Type E "Custom-designed systems" are standalone products or pre-designed kits.

SELECTING A PROPORTIONATE QA APPROACH

Categorizing a PUE product or system as described above allows program designers to establish a sufficiently robust framework for mitigating technology risk that leverages existing QA elements. Programs can then choose to put additional safeguards in place to fill any gaps that pose risks to the quality, safety and sustainability of the application. A proportionate and comprehensive approach to QA is comprised of technical requirements for the PUE equipment, requirements related to the technical capacities of system designers, suppliers and installers, as well as requirements for aspects such as warranty and after-sales service. When needed, these can be reinforced by additional safeguards such as enhanced due diligence, field testing, monitoring, and modification of RBF disbursement schedules, among others.

Table 2 presents recommended technical eligibility requirements for each category of PUE products and systems, as well as some suggested requirements for the companies participating in RBF programs. The table identifies documentation that companies should provide as evidence that their products, systems and services meet program requirements. It also summarizes key steps for evaluating the QA eligibility of equipment and companies. Table 2 is a useful reference for RBF programs that are designing QA frameworks that span a broad scope of PUE products and systems. These recommendations are not exhaustive and should be reviewed and adapted as appropriate to reflect each program's objectives, supported technologies and applications, risk profile, and implementation context.

TABLE 2: RECOMMENDED TECHNICAL ELIGIBILITY REQUIREMENTS AND QUALIFICATION PROCESS FOR THE DIFFERENT CATEGORIES OF PUE PRODUCTS/SYSTEMS

QA Category for the PUE product/system	Product/system eligibility requirements	Company eligibility requirements	Supporting documentation	Qualification process
A **Established technologies with QA frameworks supported by VeraSol certification**	PUE product/kit is VeraSol certified	Supplier of product/kit can effectively support warranty and after-sales service in the given country/region	• Test report(s) from an ISO/IEC 17025 accredited testing lab or VeraSol approved laboratory • VeraSol Product Certificate, which confirms that the product conforms to the specified standard • Description of the warranty and after-sales support provided and the company's implementation framework	• Validation of VeraSol Product Certificate • Assessment of implementation framework for warranty and after-sales support
B **Established technologies with QA frameworks not part of VeraSol's certification program**	• PUE product/kit conforms to international standard(s) for quality and safety applicable to the product type • PUE product/kit is covered by an adequate manufacturer's warranty *NB: The RBF program may specify the standard(s) to which the PUE product/kit shall conform or may allow firms to propose the applicable standard(s) for the product/kit.*	Supplier of product/kit can effectively support warranty and after-sales service in the given country/region	• Test report(s) from an ISO/IEC 17025 accredited testing lab • Test certificate(s) from an accredited certification body, confirming that the product conforms to the applicable standard(s). • Description of the warranty and after-sales support provided and the company's implementation framework	• Validation of test report(s) and test certificate(s) • Assessment of implementation framework for warranty and after-sales support

QA Category for the PUE product/system	Product/system eligibility requirements	Company eligibility requirements	Supporting documentation	Qualification process
C **Emerging technologies supported by VeraSol's testing program**	• PUE product/kit has undergone testing by a VeraSol-approved lab according to the relevant VeraSol test methods • PUE product/kit conforms to international standard(s) for safety relevant to the product type, if applicable • Performance of the PUE product/kit has been satisfactorily benchmarked against the minimum performance benchmarks set by the RBF program (if the RBF program chooses to prescribe minimum performance benchmarks). • PUE product/kit is covered by an adequate manufacturer's warranty	Supplier of product/kit can effectively support warranty and after-sales service in the given country/region	• Test report prepared by VeraSol • Test report(s) / certificate(s) from an accredited lab / certification body, confirming that the product conforms to international safety standard(s), if applicable. • Description of the warranty and after-sales support provided and the company's implementation framework	• Validation of VeraSol test evaluation report • Validation of test report(s) and test certificate(s) for applicable safety standards • Assessment of implementation framework for warranty and after-sales support • Comparison between program benchmarks and PUE product/kit performance documented in VeraSol test report

QA Category for the PUE product/system	Product/system eligibility requirements	Company eligibility requirements	Supporting documentation	Qualification process
D **Emerging technologies without QA frameworks**	• PUE product/kit meets minimum functionality and performance requirements set by the RBF program • PUE product/kit conforms to international standard(s) for safety relevant to the product type, if applicable • User, operation and installation manual(s) comply with requirements set by RBF program • PUE product/kit is covered by an adequate manufacturer's warranty	Supplier of product/kit can effectively support warranty and after-sales service in the given country/region	• Technical specifications of the product • User and installation manuals for the product • Internal product test report (in-house laboratory and/or field evaluation) • Description of the warranty and after-sales support provided and the company's implementation framework • Product screening report (rapid lab testing or targeted assessment) from a 3rd party QA provider approved by the RBF program.	• QA risk assessment based on technical evaluation of the documentation provided and due diligence of the implementation framework for warranty and after-sales support is used to assign a risk rating to the PUE product • QA risk rating is used to determine whether the PUE product will be accepted into the RBF program and whether the acceptance will be conditional • Conditional acceptance of the PUE product entails specifying additional mitigation measures to be implemented based on the QA risk rating, e.g., prescribing a minimum warranty period, introducing additional monitoring requirements to track product performance and customer satisfaction, and modifying RBF disbursement schedules so that some funding is only disbursed after verification that the PUE product has functioned successfully in the field.

QA Category for the PUE product/system	Product/system eligibility requirements	Company eligibility requirements	Supporting documentation	Qualification process
E **Custom-designed systems**	• Each of the main components of the PUE system conforms to the relevant international quality and safety standard(s) applicable to the system component • PUE system complies with design and installation guidelines set by the RBF program • User, operation and installation manual(s) comply with requirements set by RBF program • PUE system, components, design, and installation are covered by adequate warranties	• Supplier of PUE system (and partners, if applicable) has adequate capacity and competence to provide system design and installation • Supplier of PUE system can effectively support warranty and after-sales service in the given country/region	• Design guidelines and tools for the PUE system • Installation and maintenance guidelines for the PUE system • User/operation manual for the PUE system • Test report(s) from an ISO/IEC 17025 accredited testing lab for the main system components. • Test certificate(s) from an accredited certification body for the main system components • Internal system test report (in-house laboratory and field evaluation of the system) • Description of the warranty and after-sales support provided and the company's implementation framework • Organization profile that demonstrates that the firm has the capacity and competence to provide system design, installation and after-sales services	• QA risk assessment based on technical evaluation of the documentation provided, due diligence of the implementation framework for warranty and after-sales support, and an organizational assessment is used to assign a risk rating to the PUE system. • QA risk rating is used to determine whether the PUE system will be accepted into the RBF program and whether the acceptance will be conditional • Conditional acceptance of the PUE system entails specifying additional mitigation measures to be implemented based on the QA risk rating, e.g., prescribing a minimum warranty period, and/or introducing additional monitoring requirements to track product performance and customer satisfaction, and modifying RBF disbursement schedules so that some funding is only disbursed after verification that the PUE system has

QA Category for the PUE product/system	Product/system eligibility requirements	Company eligibility requirements	Supporting documentation	Qualification process
				functioned successfully in the field.

SUPPORT FOR DESIGNING AND IMPLEMENTING THE QA APPROACH

Incentive programs often lack the internal capacity to design and implement QA frameworks that effectively mitigate the technology risk of diverse PUE products, systems and applications, while also responding to unique program needs. Participating PUE companies also tend to need assistance understanding and complying with programs' technical requirements. To address these gaps, RBF programs need to provide or leverage support to create the right mix of conditions for the program to achieve its objectives or to address constraints that may prevent it from meeting its objectives. Complementary program components can either be embedded within the RBF program or provided by other entities. Table 3 provides examples of complementary QA support that programs may need to incorporate quality assurance and PUE technology derisking. Table 3 also summarizes support that should be provided to companies to facilitate their successful participation.

TABLE 3: COMPLIMENTARY QA ASSISTANCE COMMONLY REQUIRED FOR RBF PROGRAMS AND PARTICIPATING COMPANIES

QA category for PUE product/system	QA support that may be needed by RBF program designers and implementers	QA support that may be considered for PUE companies pursuing participation in RBF programs
A **Established technologies with QA frameworks supported by VeraSol certification**	• Validating VeraSol Product Certificates submitted by RBF program applicants • Setting performance and/or functionality requirements, if applicable • Setting minimum requirements for the capacities and frameworks that companies need to deliver adequate after-sales service	• Providing guidance on product testing and certification • Subsidizing the cost of product testing to reduce the financial burden on companies and increase the number of eligible products. If provided, this should be offered prior to program launch, as lead times for testing can be long.
B **Established technologies with QA frameworks not part of VeraSol's certification program**	• Identifying the international standards (safety and quality requirements) relevant for products in this category • Reviewing test reports and test certificates to verify that the products proposed for the program comply with the standards identified • Setting minimum consumer-facing warranty terms and information, as well as minimum requirements for product information available to consumers • Setting minimum requirements for the capacities and frameworks that companies need to deliver adequate after-sales service • Developing a registry of eligible products prior to the launch of the RBF program. The registry platform enables interested firms to upload information about their PUE products, the applicable international standards, and supporting documentation to verify that their products conform to the standards. This allows the qualification process to be undertaken at an early stage of the program, streamlining program operationalization. The registry platform can be further leveraged by using/adapting it for programs with the same or similar eligibility criteria.	• Providing guidance on product testing and certification • Conducting preliminary review of available documents, reports and certificates; providing feedback to companies on addressing insufficiencies to meet program requirements • Supporting product registration in program eligibility platform

QA category for PUE product/system	QA support that may be needed by RBF program designers and implementers	QA support that may be considered for PUE companies pursuing participation in RBF programs
C **Emerging technologies supported by VeraSol's testing program**	• Determining suitable minimum performance benchmarks for products in this category • Evaluating product test results to verify that their performance has been satisfactorily benchmarked against the minimum performance benchmarks • Identifying the international safety standards relevant for products in this category • Setting minimum consumer-facing warranty terms and information, as well as minimum requirements for product information available to consumers • Setting minimum requirements for the capacities and frameworks that companies need to deliver adequate after-sales service	• Coordinating with test labs and QA programs to facilitate product testing needed to benchmark product performance • Conducting preliminary review of available documents, reports and certificates; providing feedback to companies on addressing insufficiencies to meet program requirements • Subsidizing the cost of product testing to reduce the financial burden on companies and increase the number of eligible products. This should be offered prior to program launch, as lead times for testing can be long.
D **Emerging technologies without QA frameworks**	• Identifying the international safety standards relevant for products in this category • Providing guidance on formulation of program requirements for product functionality and performance • Providing guidance setting program requirements for user, installation and operation & maintenance manuals • Setting minimum consumer-facing warranty terms and information, as well as minimum requirements for product information available to consumers • Setting minimum requirements for the capacities and frameworks that companies need to deliver adequate after-sales service • Establishing QA risk rating framework used to transparently and consistently determine whether PUE products are accepted in the program • Evaluating (or building a program's capacity to evaluate) documentation provided by companies to assess the QA risk of PUE products in this category • Recommending minimum requirements for acceptable in-house and/or field testing • Identifying third-party test laboratories and technical experts that are qualified to conduct rapid product screening to validate product safety, performance and reliability	• Conducting preliminary review of available documents, reports and certificates; providing feedback to companies on addressing insufficiencies to meet program requirements • Subsidizing the cost of rapid product screening by an approved third party to validate product safety, performance and reliability • Offering guidance complying with requirements for acceptable in-house and/or field testing • Providing guidance on company obligations related to monitoring and verification activities

QA category for PUE product/system	QA support that may be needed by RBF program designers and implementers	QA support that may be considered for PUE companies pursuing participation in RBF programs
E **Custom-designed systems**	• Identifying the international quality and/or safety standards relevant to main system components • Supporting the establishment of program requirements for system functionality and performance • Elaborating the system design and installation guidelines that companies must follow to be eligible for the program • Providing guidance setting program requirements for system operation and maintenance manuals, as well as delivery of user training • Setting minimum consumer-facing warranty terms and information • Recommending minimum requirements for acceptable in-house and/or field testing • Setting minimum requirements for the capacities and frameworks that companies need to deliver adequate after-sales service • Establishing QA risk rating framework used to transparently and consistently determine whether PUE systems are accepted in the program • Evaluating (or building a program's capacity to evaluate) documentation provided by companies to assess the QA risk of PUE systems in this category • Establishing monitoring and verification framework to ensure that systems deliver reliable and sustainable services • Operating (or building a program's capacity to operate) monitoring and verification activities	• Conducting preliminary review of available documents, reports and certificates; providing feedback to companies on addressing insufficiencies to meet program requirements • Providing guidance complying with requirements for acceptable in-house and/or field testing • Offering guidance interpreting and complying with user training requirements, system design and installation guidelines • Clarifying company obligations related to monitoring and verification activities

CONCLUSION

Quality assurance is essential to ensure that market development interventions for PUE deliver sustainable benefits to end users and contribute to the development of robust, trusted markets. However, the diversity of PUE technologies and applications, coupled with gaps in existing testing and standards frameworks, means that no single quality assurance approach is appropriate for all products and systems.

The framework presented in this guidance offers a practical, risk-based approach to addressing these challenges. By categorizing PUE products and systems according to their QA status and configuration, program designers and implementers can establish proportionate eligibility requirements, qualification processes, and complementary risk mitigation measures. These may include product testing and certification, performance benchmarking, technical assessments, supplier and installer qualifications, warranty and after-sales service requirements, and enhanced monitoring and verification.

Importantly, the absence of established test methods or standards need not prevent programs from supporting promising PUE technologies. Rather, it calls for alternative safeguards that appropriately manage technical risks while enabling innovation and market development.

Effective implementation may require specialized technical expertise, institutional capacity building, and targeted support to participating companies. By integrating these measures into program design and implementation, RBF and other market development interventions can expand access to PUE technologies while promoting product quality, protecting end users, and strengthening confidence in emerging markets.

VeraSol

VeraSol.org

@VeraSol_QA

info@VeraSol.org

VeraSol Quality Assurance

clasp | SCHATZ ENERGY RESEARCH CENTER | IKEA Foundation | British International Investment | STICHTING DOEN | Good Energies BY PORTICUS | Sida | UKaid | Transforming Energy Access | THE WORLD BANK | ESMAP