Quality Assurance for Off-Grid Solar Home Systems:
A comparison of strategies employed by Lighting Global and the Bangladesh IDCOL Solar Home System Program

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Executive Summary

As we work to design a quality assurance framework for solar home system kits, the Lighting Global Quality Assurance team has sought to draw from available standards and to learn from existing quality assurance efforts. One quality assurance framework that we examined carefully was the one used by the Infrastructure Development Company Limited (IDCOL) in the Bangladesh solar home system (SHS) market. This framework is important in part because Bangladesh has the largest off-grid solar market in the world, with over 3 million systems installed over the past decade, and in part because the IDCOL approach to QA has enjoyed a significant degree of success in that market. However, it is important to recognize that the IDCOL QA framework was designed to operate in a particular context, and the Lighting Global program is designing a QA framework that must operate in a very different context. As such, there are limits to the lessons from the IDCOL QA framework that can be applied in the Lighting Global case.

Quality assurance efforts typically combine a series of measures to achieve their objectives. In most cases, the primary goals are to help market actors make informed purchasing, investment, and regulatory decisions and to ensure that the systems delivered to end-users operate effectively and as advertised. Policy tools to achieve these goals can include product quality standards, warranty requirements, installer certification mandates, and a number of others. The program must also select an appropriate set of tools to evaluate whether these requirements have been met and to communicate the results of this evaluation to relevant market actors. Moreover, to succeed, the program must provide benefits to those that meet the requirements and establish and enforce a reasonable set of consequences for those that do not. The particular combination of measures selected to achieve these goals must, of course, be appropriate given the context, resources, and goals of the program.

The IDCOL program has selected a QA framework that combines testing of SHS components and financing for approved packages with field inspections of selected installed systems and strong and enforceable warranty requirements. Their use of component testing and restriction of financing to approved SHS packages helps ensure that systems sold meet a basic set of component quality and system design requirements. At the same time, their use of strong and enforceable warranty requirements reduces the need for more comprehensive product testing, since manufacturers must deliver high quality products in order to avoid the cost of servicing a significant number of warranty returns. Field inspections of installed systems round out the framework, as SHS vendors know that at least some of their installed systems will be inspected to evaluate compliance with IDCOL requirements.

This approach is logical in the Bangladesh market, given IDCOL's position in the sector and the limited geographic extent of the market.

The Lighting Global Quality Assurance program has goals that are similar to IDCOL's Bangladesh program, but it operates with a different set of resources and in a very different context. It is therefore unsurprising that its approach to quality assurance differs from the IDCOL approach in some key ways. The most important differences between the programs are as follows:

1) The IDCOL program is designed to operate in a single, densely populated country with a physical area of about 150,000 km^2. Because the market is geographically bounded, IDCOL can carry out field inspections and market monitoring throughout its operating area at a reasonable cost. Lighting Global is operating in an international market that involves a number of countries on multiple continents. As a result, while market monitoring is important element of its framework, it would be cost prohibitive for Lighting Global to rely on a QA strategy that relies heavily on widespread monitoring of warranty servicing or installation quality.

2) IDCOL provides long-term concessional financing for the sale of SHSs in Bangladesh that is more generous than commercial market financing, as well as a grant subsidy to consumers that is in the process of being phased out. The level of support is significant, and it is very difficult for SHS manufacturers and vendors to compete successfully in the Bangladesh market without participating in the IDCOL framework. As such, IDCOL has considerable leverage over market participants, and engagement with its QA program – while not technically mandatory to operate in Bangladesh – is essential for market success since products that do not meet the IDCOL requirements risk losing program support. While engagement with Lighting Global and its associated programs (Lighting Africa and Lighting Asia) provides considerable benefits to participating companies, the program does not involve the type of financial support offered by IDCOL. Moreover, while some financial institutions and distributors have expressed interest to work exclusively with SHS kits that have been quality assured through the Lighting Global framework, participation in the Lighting Global QA system is entirely voluntary. In short, Lighting Global does not exercise (or seek) the same degree of leverage with regard to participating companies that IDCOL enjoys. This limits Lighting Global's ability to effectively utilize and enforce certain types of QA measures such as compliance with mandatory warranty terms. As a result, Lighting Global must rely more heavily on measures such as system level product testing than on enforcement of warranty terms.

3) As a result of the two key differences above, the IDCOL approach is focused largely on component level QA for systems that are sold in pre-approved configurations. Under this arrangement, the components of SHSs must be tested and approved before they can be used in an IDCOL financed SHS. Moreover, the components must be configured into a package that meets IDCOL system design requirements and must be sold with a warranty that meets IDCOL's requirements. Compliance of SHSs with IDCOL specifications is then assured through extensive monitoring, technical audits, field inspections, and the enforcement of financial penalties. Lighting Global, on the other hand, operates in an international market context, and – in order to fully enable manufacturer innovation – it does not seek to limit the range of system design configurations that a company might offer. In this context, a framework

that focuses on evaluation of system level quality and performance against truth-in-advertising and a set of selected durability metrics provides a rigorous yet cost effective approach while also providing manufacturers with design flexibility. In the Lighting Global QA framework, complete systems are selected using random warehouse sampling and are tested using internationally accepted methods. Market level testing is then carried out periodically to ensure compliance.

In designing its quality assurance strategy, Lighting Global has sought to develop a rigorous, yet cost effective approach that matches its goals, resources, and context. The approach uses a combination of system level testing of complete products/kits and market check testing to verify the quality and performance of off-grid solar systems. This approach has been applied successfully to off-grid pico-solar products, and the program is working to extend a similar framework to cover plug and play SHS kits. The overarching goal is to develop a program that will be applicable across many countries, thereby enabling companies to reach many markets by having their products evaluated through a single framework. It is our view that the approach taken offers a very cost effective strategy to rigorously ensure quality across multiple markets. We nonetheless remain open to new strategies and ideas that seek to improve the effectiveness of the effort. A comparison of key aspects of the two QA frameworks is provided in Table E.1.

Table E.1 Summary Comparison of the Lighting Global and IDCOL Quality Assurance Frameworks

Aspect	IDCOL SHS Program	Lighting Global Program
Purpose	Support rural electrification goals by delivering concessional finance to off-grid consumers to install SHSs and supporting the sustainability of the installations through a QA framework.	Support the commercial development of markets for affordable, quality assured off-grid lighting and energy products in order to promote increased access to modern energy products and services.
Geography	Operates only in Bangladesh.	Operates in an international market involving a number of countries on multiple continents.
QA Testing Approach	Component-based testing – Each SHS component model must be tested and approved before it can be used in an IDCOL financed SHS. Systems must consist of pre-approved configurations of qualified components. Five percent of newly installed systems are inspected before funds are disbursed.	System-based testing – Companies voluntarily submit their pico-solar products (or in future, complete SHS kits) for testing. Testing includes both system and component level evaluation. Test results are valid for two years.
Testing Standards	SHS specifications developed specifically for use in Bangladesh for the IDCOL SHS Program. PV modules are evaluated using IEC standards.	Pico-solar testing methods developed for use internationally and institutionalized in IEC 62257-9-5. The SHS kit testing methods in development will be submitted to the IEC for publication.
Field Monitoring	Technical inspectors are employed throughout the country to continuously inspect SHSs, a call center number is provided to all customers to report issues, and independent technical audits are carried annually to inspect and test products from households, partner organizations and suppliers.	Products that meet the program's quality standards are subject to market check testing at any time to ensure that they continue to provide the same level of quality and performance. Samples for market check testing are collected from retail locations without prior notice and tested by qualified labs.
Warranties	A range of minimum warranties are required for each component including at least 20 years for PV module power output, 3 or 5 years for batteries, and 3 years for charge controllers and LED lights.	Companies are required to offer a minimum 1-year warranty for pico-solar products. For SHS kits, a warranty of at least 3 years on the system and 2 years on the battery is being proposed.

The sections that follow provide a more detailed overview of the key elements of the IDCOL SHS program QA framework for the Bangladesh SHS market, an overview of the Lighting Global QA framework, and a conclusion.

1. Summary of the IDCOL Solar Home System (SHS) Program

IDCOL is a Bangladeshi Government-owned financial institution that is implementing a large-scale solar home system (SHS) program in Bangladesh. IDCOL has invested about US$600 million so far, and the program has successfully financed 3.2 million SHSs as of October 2014. IDCOL projects that by 2016 it is likely to have invested a billion dollars cumulatively, and it has a target of financing 6 million SHSs by 2017. The funding for the program flows from multilateral agencies/donors (such as the World Bank) to the Government of Bangladesh and then to IDCOL. Loans and grants are provided by IDCOL to Partner Organizations (POs), such as NGOs and private sector companies, that identify customers, provide micro-credit, install the SHSs, and provide after-sales service. No collateral is required from customers, and the repayment terms are designed so that monthly instalment payments are competitive with equivalent kerosene costs. This approach builds upon Bangladesh's long history with microfinance and its pre-existing microfinance network. IDCOL also provides training and marketing and monitors the implementation of the program (including quality assurance, or QA). The program structure is illustrated in Figure 1, below.

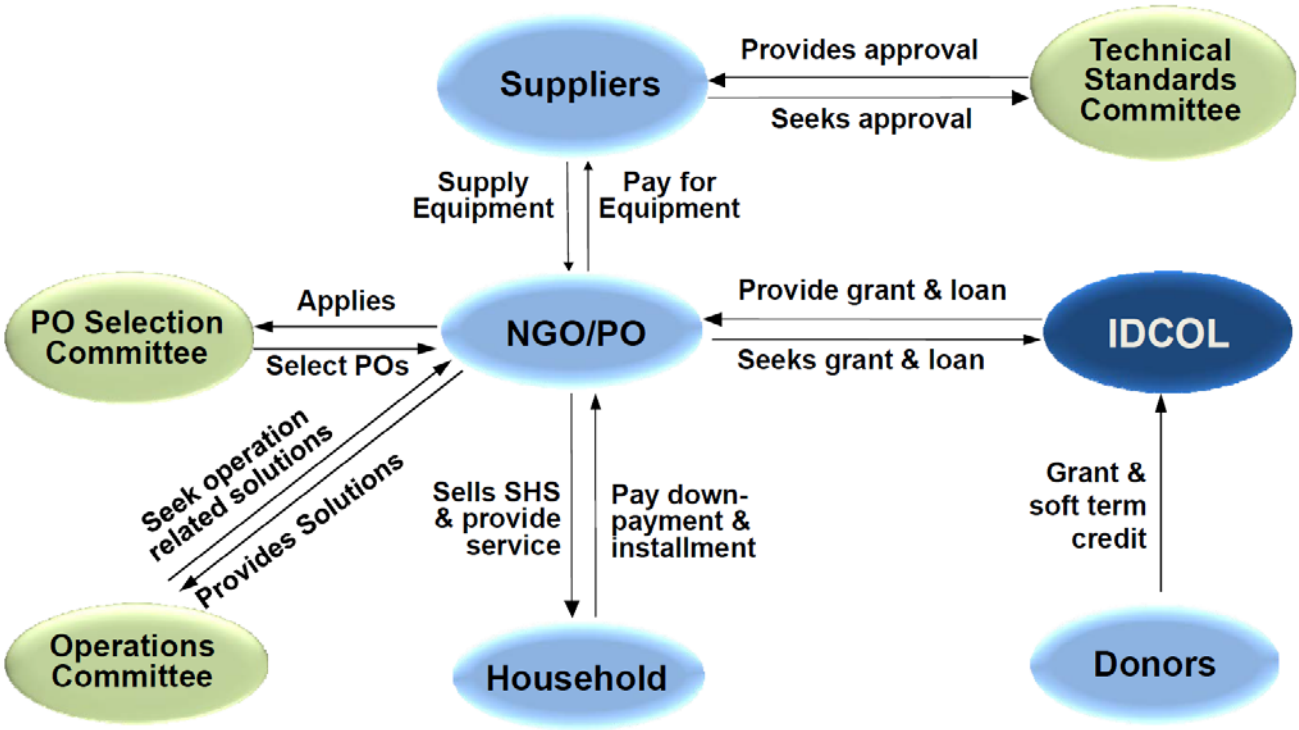

Figure 1. IDCOL Solar Home System (SHS) program structure (Islam, 2014)

IDCOL ensures quality through an approach that combines standards with inspection and monitoring. The sections that follow provide a brief overview of the IDCOL quality assurance framework, including topics related to component standards, warranty requirements, market monitoring, and consequences for non-compliance.

1.1 SHS and Components Standards

An independent Technical Standard Committee (TSC), consisting of 6 members, maintains a "Technical Specifications For Solar Home Systems" document, which is available on the IDCOL website here. This document defines the technical and warranty specifications that systems and components must meet in order to be financed under the IDCOL SHS program. Components in particular must be approved by the TSC and included on IDCOL's lists of approved SHS equipment. The TSC maintains approved component lists for batteries, charge controllers, compact florescent lamps (CFL), LED lamps and lanterns, photovoltaic (PV) modules, DC-DC converters, and appliances. The approval fees to be paid to IDCOL are summarized in Table 1. As noted below, these fees do not include the cost of component testing.

Table 1. IDCOL program quality assurance fees by component

Component	Fee Per Model (Bangladeshi Taka)	Fee Per Model (Converted to US Dollars[1])
PV module	10,000	130
Battery	10,000	130
Charge controller	5,000	65
LED lamp/tube light/bulb	5,000	65
CFL, DC-DC converter, energy meter, cable, TV, fan	5,000	65

The minimum required warranties for the respective components are listed in Table 2.

Table 2. Minimum required warranty periods for SHS components under the IDCOL framework

Component	Warranty
PV module (power output)	20 years
Pole mount module supporting structure	10 years
Battery (in systems sized above 30 Wp)	5 years
Battery (in systems sized 30 Wp and below), charge controller, DC-DC Converter, energy meter, LED lamp/tube light/bulb, cables used for wiring, switches-socket and other accessories-appliances	3 years
PV module (defects and/or failures)	2 years
CFL / fluorescent lamp, built-in rechargeable battery for LED lantern	1 year
System-integrated parts and labor	6 months

To have a component approved, the component supplier must submit a number of documents to the TSC and pay the associated approval fee. Documents required include: a letter to IDCOL, a test report from a local authorized testing institution, certificates that the component meets certain international standards related to quality and environmental health and safety, a specification sheet, a warranty certificate, agreements, an audit report and a company profile.

The TSC defines the technical specifications that components must meet to be approved. Suppliers provide their components to a local authorized testing institution that evaluates the components against

[1] Using the 2014 average exchange rate of 77.6 Bangladeshi Taka per US Dollar and rounded to two significant figures.

the specifications. In some cases, the test methods that are specified for the evaluation of components are included in international standards such as IEC 61215 and IEC 61646, which are used to evaluate crystalline and amorphous silicon photovoltaic solar modules, respectively. However, internationally accepted test methods are not specified for component testing in all cases (e.g. internationally accepted test methods are not specified for batteries and charge controllers). Once testing has been completed, the resulting test report is provided to the TSC. Each testing institution charges its own set of fees for conducting the tests; these fees are in addition to the fees charged by IDCOL listed in Table 1, above. Compared to the cost of product testing at international commercial test labs, the fees charged in Bangladesh appear to be reasonably low.

The local authorized testing institutions have the capability to carry out testing of all components except PV modules. For PV modules, certificates produced by international labs are accepted. Bangladesh University of Engineering and Technology (BUET) is currently in the process of receiving funding to establish a full PV testing laboratory that can be used to test PV modules according to the relevant IEC standards. It is scheduled to begin operation in 2015.

1.2 Inspection & Monitoring

There are a number of checks and balances involved in IDCOL's QA framework for SHS, detailed as follows. The costs for the activities described below are borne by donors and IDCOL. The costs are not borne directly by component suppliers or POs.

- **Technical inspectors** – IDCOL has technical inspectors/engineers, numbering about 150 as of November 2014 and based in 12 regional inspection offices. Originally, funds were only disbursed by IDCOL to POs after each new SHS installation had been inspected. As the program has grown substantially, the inspectors are now just required to inspect 5% of newly installed SHSs before funds are disbursed. Each inspector is able to inspect around 300 randomly selected SHS installations per month, and information on inspections is entered into a central database. If an inspector determines that a SHS does not meet the technical specifications, then the responsible PO is advised to fix the problem within a certain time. Future disbursements against the SHS are withheld by IDCOL until the problem is resolved. Re-inspection checks of inspected systems are also carried out by IDCOL officials. Inspections are also intended to be carried out by representatives of POs who are responsible for collecting monthly installments. IDCOL has advised that more than 50% of installed systems have actually been inspected and the cost of the inspections is less than $1 per system. The cost of the inspections is divided evenly between donors (50%) and IDCOL (50%).

- **Call center** – IDCOL has set up a call center for receiving complaints directly from customers. The call center numbers are provided to the customers during the installation of the SHS and printed in big lettering on charge controllers. The call center is operated by two full-time staff members, and IDCOL advised that the call center receives up to 100 calls per day. IDCOL relays reported problems to the respective PO and advises the PO on how to fix the problem. Future disbursements to the PO for the affected SHSs are withheld until the problem is resolved. IDCOL verifies the status of the problem by calling the customers directly.

- **Independent technical audits** – Under the program, a technical audit of system components is periodically carried out by a third party. This is intended to occur at least once a year and involves

inspecting and testing products from individual households and collecting samples from POs and suppliers. The audit process takes 6-7 months and the results of the audit are shared with the respective POs as well as the suppliers. IDCOL follows up on whether the problems identified through audits have been addressed. POs and suppliers can be penalized as a result of the audit. The current independent technical audit is being carried out by BUET.

- **Training programs** – IDCOL provides training programs for inspectors, PO trainers and staff, customers, and technicians in order to ensure proper installation, operation and maintenance of SHSs.

This section has provided a description of key aspects of the IDCOL quality assurance program for SHS. In the section that follows, we will present a brief summary of the approach that Lighting Global has proposed with regard to SHS QA for comparison purposes.

2. Summary of the Lighting Global QA Framework and Extension into SHS Kits

Lighting Global supports the modern off-grid lighting market through the Lighting Global QA framework. The program is designed to provide rigorous quality assurance for off-grid energy products across a number of country and regional markets on multiple continents at a reasonable cost to the program and participating companies. Over the past five years, this quality assurance program has grown to become the leading international framework for pico-solar products. In Sub Saharan Africa alone, sales of products that have met the program's minimum quality standards have exceeded six million units. Key aspects of the QA framework are illustrated in Figure 2 below. Over the next year, Lighting Global will begin to extend support to "plug-and-play" direct current (DC) solar home system kits. The current Lighting Global QA framework for pico-solar products and other related off-grid lighting systems will remain in place, and the program will be extended to include testing of SHS kits.

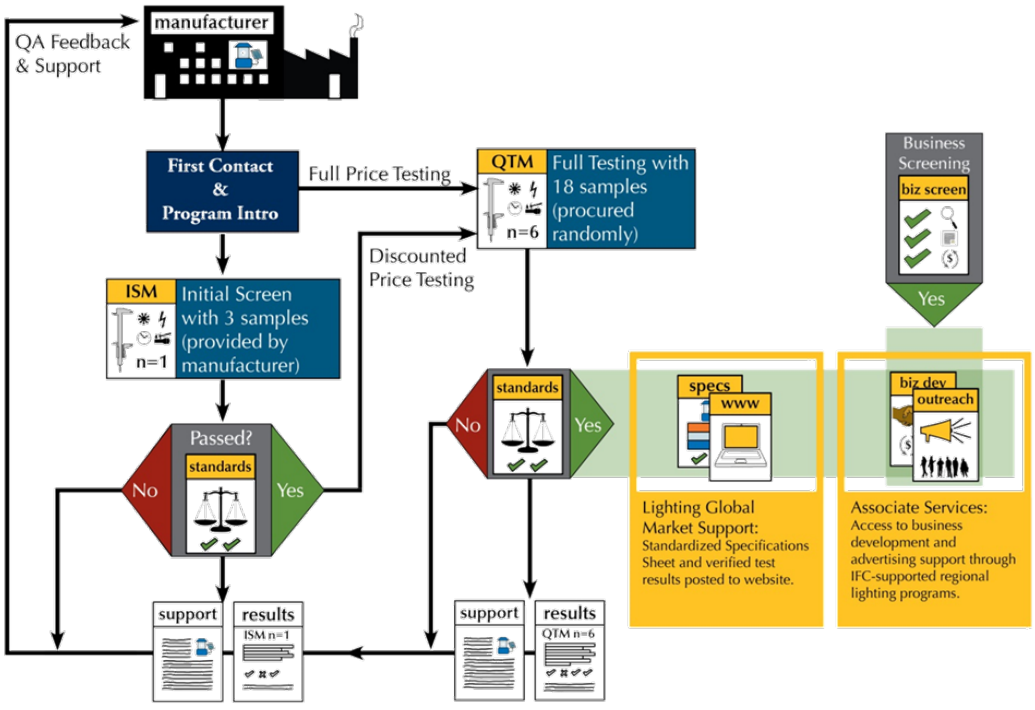

Figure 2. Overview of the Lighting Global Quality Assurance Framework

The Lighting Global QA framework consists primarily of three key components:

- Test methods and quality standards;
- Testing and verification; and
- Communication to stakeholders.

These components are described in more detail below.

2.1 Test methods and quality standards

Lighting Global has developed three test methods to meet the unique needs of stakeholders in the market for off-grid lighting products. The test methods assess the performance of individual components of the product, such as the LED, battery, and PV module, as well as system-level metrics such as run time, physical ingress and water protection, and durability. The test methods and individual procedures for smaller off-grid lighting products are institutionalized in IEC 62257-9-5. Once completed, the methods for evaluating SHS kits will also likely be submitted to the IEC for publication. Moreover, many of the test procedures included in the draft SHS test methods draw from existing international standards such as those published by IEC. The three test methods are detailed briefly below:

- The **Quality Test Method (QTM)** is the flagship test method of Lighting Global. It is used to verify if products meet the Lighting Global Quality Standards, to verify companies' claims, and to provide input information for the Standardized Specification Sheets that are published through the Lighting Global website. For the QTM, product units are randomly selected for testing from a warehouse at the product's assembly location or in the commercial market. For SHS kits, selection of up to 16 product units is proposed to enable the designated laboratory to evaluate the product with a sample size of four for each test that is conducted. The full cost of the QTM for SHS kits is yet to be determined, but it may exceed the cost of testing smaller off-grid lighting products ($6,000 - $8,000) and will depend on the laboratory. QTM test results are valid for two years.

- The **Initial Screening Method (ISM)** is an abbreviated version of the QTM that is designed to be a lower cost and faster turnaround option. It provides rapid feedback about emerging products and offers a low-cost assessment of a new product's likelihood of passing the full QTM. For the ISM, four product units are selected by the companies themselves for testing. The four units allow the designated test lab to complete each test with a sample size of one.

- The **Market Check Method (MCM)** testing is carried out on products that have passed the QTM and currently have quality verified status. It uses test methods that are very similar to the ISM tests, but the samples for MCM testing are selected randomly from the retail market sales channels without necessarily notifying the company. The sample size for each test can range from 1 to 6, depending on the objective of the test. The MCM is used to confirm whether products that have met the Lighting Global Quality Standards according to QTM testing continue to provide the same level of performance over the two-year validity of the QTM test results. If the product fails MCM testing, additional testing may be required at the company's expense; if the product does not meet the requirements after this additional testing or if the company chooses not to pursue the testing, then the product loses its status as one that meets the Lighting Global Quality Standards.

The Lighting Global Quality Standards define requirements for truth in advertising, durability, quality, lumen maintenance, and warranty terms. Companies are required to offer a minimum 1-year warranty for pico-solar products. For SHS kits, a minimum 3-year warranty on the system is being proposed, with a lower minimum 2-year warranty on batteries. If the results of QTM testing of a product verify that it meets the Quality Standards, the product will be listed on the Lighting Global website and the company will be eligible to apply for Associate status and business support services from Lighting Global and the associated regional programs, Lighting Africa and Lighting Asia. The Lighting Global Quality Standards for pico-solar products are outlined in Appendix A. A draft Lighting Global Quality Standard for SHS kits is available on the Lighting Global website's Stakeholder Engagement section. The draft standard for SHS kits uses a similar approach to the pico-solar Quality Standard. Additional details can be found on the Lighting Global website.

2.2 Testing and verification

The second key component of the Lighting Global QA framework is testing and verification, which Lighting Global carries out using the test methods described above. Tests are currently conducted at seven independent test laboratories, and additional labs are in the process of being added to the network. Test laboratories outside of the Lighting Global network may also conduct testing to verify whether a product meets the Lighting Global Quality Standards; however, the lab must carry appropriate accreditations, demonstrate relevant capabilities, and be approved by Lighting Global prior to testing.

2.3 Communication

The third key component of the Lighting Global QA framework is communication of test results. Products that meet the Quality Standards after undergoing QTM testing receive a Standardized Specification Sheet (SSS). The SSS is used to communicate the results of QTM product testing by summarizing the results in an easy-to-read format that allows comparisons between products.

In addition, products that have met the Quality Standards receive a Lighting Global Verification Letter, which can be used as proof that a product meets the Standards. The SSS and Verification Letters are also posted to the Lighting Global website.

The SSS and Verification Letters are used primarily as an entry qualification to access business development services through regional lighting programs supported by the IFC and World Bank, such as Lighting Africa and Lighting Asia. In addition to this primary purpose, both documents are posted publicly to enable other organizations, governments, or consumers to assess whether products have met the Quality Standards and reference key performance results.

In the final section of this report, we provide a brief summary of key points presented in this document, including a summary of key differences between the IDCOL and Lighting Global quality assurance frameworks.

3. Conclusion

Both the IDCOL and Lighting Global programs have achieved substantial success in supporting the development of markets for off-grid solar systems. In both cases, an effective quality assurance framework has proved to be an essential element of this success. The quality assurance programs differ substantially, but the differences can be attributed to differences in the context and resources associated with the respective programs. The IDCOL QA framework is designed to manage quality in the

Bangladesh SHS market, which is characterized by sales based on long-term concessional financing. In contrast, the Lighting Global quality assurance program is designed to support the development of commercial markets for solar off-grid products in many country and regional markets on multiple continents. In each case, the design of the quality assurance program is logical, but the designs differ because the programs are operating in distinct contexts and with differing levels of access to resources.

4. Acknowledgements

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5. References

Islam, S. M. M. (2014, April 25). IDCOL Solar Home System Program. IDCOL.

Technical Standards Committee. (2014, July). Technical Specifications for Solar Home System (SHS). Retrieved from http://idcol.org/download/a86508e6f1ecc4bf3ac0f1c8ed6038cb.pdf

6. Further information

Lighting Global –
Website: www.lightingglobal.org
Email: qa@lightingglobal.org

IDCOL SHS Program –
Website: www.idcol.org/home/solar

Appendix A. Lighting Global Quality Standard for Pico-Solar Products

Category	Metric	Quality Standard	
Truth In Advertising	Manufacturer	Accurately specified	
	Product Name & Model #	Accurately specified	
	Light Output	If reported, accurately specified	
	Lamp Type	If reported, accurately specified	
	Run Time	If reported, accurately specified	
	Charger Rating	If reported, charger power rating accurately specified (e.g. PV power or mechanical charge time)	
	Other Aspects	If reported, accurately specified	
Lumen Maintenance	Lumen Maintenance at 2,000 hours	≥ 85% of specified light output at 2,000 hours OR ≥ 95% of specified light output at 1,000 hours (depreciated at highest setting)	
Health and Safety	AC-DC Charger Safety	Any *included* AC-DC charger carries approval from a recognized consumer electronics safety regulator	
	Hazardous Substances Ban	No battery may contain cadmium or mercury at levels greater than trace amounts	
Battery	Battery Protection	Protected by an appropriate charge controller that prolongs battery life and protects the safety of the user	
	Battery Durability	The average capacity loss of 6 samples must not exceed 25% and only one sample may have a capacity loss greater than 35% following the battery durability storage test as defined in IEC 62257-9-5 Annex BB	
Quality and Durability	Physical Ingress Protection	*Fixed Outdoor*	IP5x
		Others	IP2x
		All PV Modules	IP4x
	Water Protection	*Fixed Indoor*	No requirement
		Portable Separate	Occasional rain: *IPx1* OR *technical equivalent* OR *with warning label*
		Portable Integrated	Frequent rain: *IPx3* OR *technical equivalent* OR *IPx1/equivalent* + *warning label*
		Fixed Outdoor	Permanent outdoor exposure: *IPx5* OR *IPx3* AND *circuit protection*
		All PV Modules	Outdoor rooftop installation: *Modified IPx4* OR *circuit protection*
	Drop Test	*Fixed Indoor*	No requirement
		Others	5 out of 6 samples are functional after drop test (1 m onto concrete); none result in dangerous failures
	Soldering and Electronics Quality	Pass soldering and electronics inspection; the maximum prevalence of bad solder joints, poor wiring or overall workmanship failure is 1 out of 6 samples in each category	
	Switch, Gooseneck, Connector, and Strain Relief Durability	5 out of 6 samples are functional after 1000 cycles (switch, connector, gooseneck tests); 5 out of 6 samples are functional (strain relief test); None result in dangerous failures (all tests)	
Warranty	Minimum Warranty Terms	Accurately specified and consumer-facing; minimum coverage of at least one year on manufacturing defects under normal use, including the battery.	