LIGHTING GLOBAL
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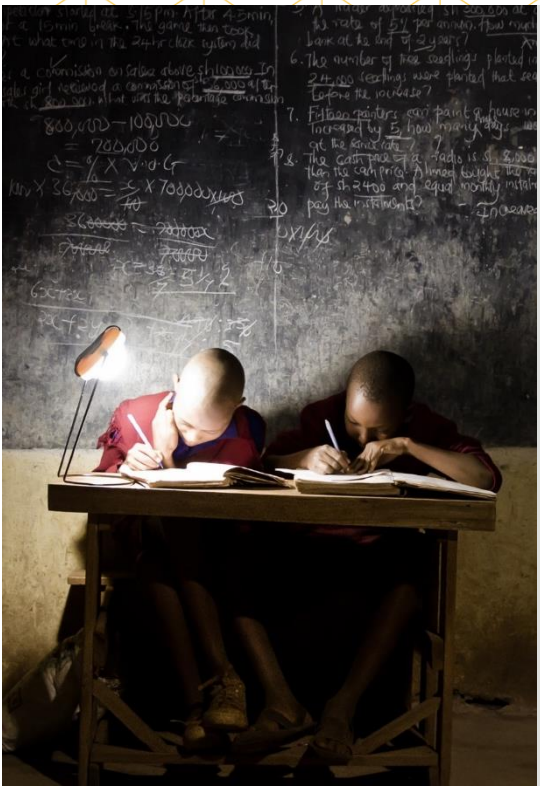
TECHNICAL NOTES



Quality Matters

In 2017, as part of ongoing efforts to bolster the off-grid solar market, Lighting Global Quality assurance tested a group of top-selling non-quality verified solar products in five domestic markets across Africa and South Asia. All 17 evaluated products— purchased from retail stores in Ethiopia, Kenya, Myanmar, Nigeria, and Tanzania—failed to meet the Lighting Global Quality Standards for pico-PV products.

Executive Summary

Recent studies indicate that pico-solar products[1] have a majority market share of off-grid solar devices, comprising 85% of cumulative global sales, followed by component-based solar home systems at 13% and plug-and-play solar home systems at 2% market share. Furthermore, studies have shown that the pico-solar market is dominated by non-quality verified (non-QV) products,[2] with an estimated 71% share of the global market.[3] Due to the high prevalence of non-QV pico-solar products, it is important to understand the quality of these products relative to those that do meet quality standards. The drive to establish mandatory standards for pico-solar products has been based on the premise that most of the non-QV products being sold in under-regulated markets are of poor quality, yet we have limited recent, quantitative data to support this assertion.

In an effort to fill this knowledge gap, Lighting Global Quality Assurance conducted laboratory testing of 17 non-QV pico-solar products that are top-sellers in Ethiopia, Kenya, Myanmar, Nigeria and Tanzania. **The test results show that all the products evaluated as part of this study fail to meet Lighting Global's Quality**

[1] Pico-solar products are defined as lanterns and simple multi-light systems (which may enable mobile phone charging) with peak PV module power up to 10 watts. These enable partial or full Tier 1 energy access for a person or household, according to the Sustainable Energy for All Multi-Tier Framework.
[2] Non-quality verified (non-QV) pico-solar products are defined as modern off-grid lighting and energy products with peak PV module power up to 10 W that have not been quality verified according to Lighting Global.
[3] The 2018 Global Off-Grid Solar Market Trends Report can be downloaded at https://www.lightingglobal.org/wp-content/uploads/2018/03/2018_Off_Grid_Solar_Market_Trends_Report_Full.pdf

Standards for pico-PV products[4], which confirms that these (and likely other) markets are indeed dominated by sub-standard pico-solar products. Some notable outcomes of the study:

- 94% of the tested products fail to meet the Standards due to one or more deficiency that affects product durability (including battery protection and durability, physical durability, water ingress protection, and lumen maintenance).
- 88% of the tested products inaccurately advertise product performance.
- 88% of the tested products do not include a consumer-facing warranty.
- 76% of the tested products would require significant changes to product design and components to meet the Quality Standards.

The results of this study show that non-QV pico-solar products most commonly available to base-of-the-pyramid consumers contain a combination of inaccurate performance claims and technical flaws, which mislead and provide low quality to the most vulnerable consumers. These results give credence to ongoing efforts to adopt and enforce pico-solar standards at the national level, as well as other market development strategies intended to increase the uptake of high-quality products. Furthermore, the outcomes of this study suggest that additional research is needed to more fully understand the quality of "cheap" pico-solar products, and to gain insights about consumer experiences with both sub-standard and high quality products.

Given the quality and performance issues identified through laboratory testing, the results of this study can be used by the public sector and by market transformation programs to inform continued efforts to promote high quality pico-solar products and to combat infiltration of low-quality products. This study also provides useful insight into the common shortcomings of non-QV products, which helps us develop a more nuanced understanding of the market and better target efforts to improve product quality.

Introduction

The Lighting Global Quality Assurance (QA) Program contributes to efforts to achieve universal energy access by helping industry stakeholders easily identify good quality off-grid solar products. The QA Program, which is part of the World Bank Group's broader set of off-grid solar market development programs under the names Lighting Global, Lighting Africa, and Lighting Asia, is founded upon internationally accepted test methods and quality standards that are used to evaluate off-grid solar products with solar PV modules ranging from less than 1 peak watt to 350 watts peak. Over the past 10 years, Lighting Global has overseen more than 800 off-grid solar product tests, which gives us detailed insight into the progression of product quality, technologies and design innovation. Our view of the industry, however, does have some limitations. Since our testing is generally focused on products from quality-oriented companies that have chosen to engage with Lighting Global, we have limited data for non-quality verified (non-QV) products of the type that are commonly available in key African and Asian markets.

Recent studies indicate that non-QV pico-solar products have a dominant share of the global market. The 2018 Global Off-Grid Solar Market Trends Report estimates that 71% of global sales are from companies that are not affiliated with Lighting Global or GOGLA, including products that are either branded or generic, with the latter including no-name brands, copycats, and counterfeits[5]. On a country level, the markets from which products were selected for this study also have a strong prevalence of non-QV products, as summarized in Table 1.

[4] The Lighting Global Quality Standards for pico-solar products can be downloaded at https://www.lightingglobal.org/resource/lighting-global-quality-standards/

[5] The 2018 Global Off-Grid Solar Market Trends Report can be downloaded at https://www.lightingglobal.org/wp-content/uploads/2018/03/2018_Off_Grid_Solar_Market_Trends_Report_Full.pdf

TABLE 1.

Prevalence of non-quality verified products in countries from which products were selected for this study

COUNTRY	ESTIMATED MARKET SHARE OF NON-QV PICO-SOLAR PRODUCTS
Ethiopia	57%[6]
Kenya	35%[7]
Myanmar	90%[5]
Nigeria	70%[5]
Tanzania	72%[8]

These prior studies do not assess, however, the quality and performance of non-QV products relative to those that meet Lighting Global's Quality Standards. Through a combination of field observations and anecdotal evidence, we know that at least some of the non-QV products exhibit low quality and perform poorly. However, there has been no rigorous quantitative assessment of the quality of non-QV products in recent years. This study is intended to answer a fundamental question: **Are the prevalent non-QV pico-solar products really sub-standard, and, if so, what are their main points of failure?**

Methodology

Between June and November 2017, the Lighting Global Quality Assurance Program carried out market surveillance testing of 17 pico-solar products (i.e. products with solar modules rated at 10 peak watts or less) that are not quality verified by Lighting Global. We worked with staff of the IFC Lighting Africa and Asia Programs in 2017 to identify 13 top-selling non-QV products (or "product models") from market outlets in Ethiopia, Kenya, Myanmar, Nigeria, and Tanzania. This study also includes four non-QV products that were purchased from the Ethiopia, Kenya and Tanzania markets in 2016. The product samples, which were purchased anonymously from retail outlets, were tested by laboratories in the Lighting Global Lab Network[9] according to the test methods specified in IEC TS 62257-9-5. For 12 of the 17 products, the labs were provided with 7 samples of each product, which allowed them to carry out each test with a sample size of two (n=2). Fewer samples were provided for five of the tested products, which allowed each test to be conducted on a single sample (n=1). We compared the test results to Lighting Global's Quality Standards for pico-solar products to illustrate how the non-QV products' performance and quality stack up to products that are quality verified by Lighting Global[10].

Detailed Results

In Table 2 below, we have compiled key information about the tested products and compliance with the Quality Standards. This is followed by a discussion of the results divided into two categories: *Consumer-facing Information* and *Durability & Safety*. The *Photo Appendix* at the end of the document provides visual examples of the low-quality components and workmanship found in several of the tested products.

[6] The October 2016 Lighting Africa / Ipsos report "Off Grid Market Study – Ethiopia" can be downloaded at https://www.lightingafrica.org/wp-content/uploads/2018/04/Lighting-Ethiopia-Deep-Dive-Retail-Report-Feb-2017-.pdf

[7] The Global Off-Grid Solar Market Report for Jan.-June 2016 can be downloaded at https://www.lightingglobal.org/wp-content/uploads/2016/10/global_off-grid_solar_market_report_jan-june_2016_public-1.pdf

[8] The November 2017 report "Deep Dive Supply Chain Report for Tanzania" can be downloaded at https://www.lightingafrica.org/publication/deep-dive-supply-chain-report-tanzania/

[9] Details about Lighting Global's Lab Network are available at https://www.lightingglobal.org/quality-assurance-program/test-laboratory-network/

[10] An up-to-date database of products that meet Lighting Global's Quality Standards can be accessed at https://www.lightingglobal.org/products/

TABLE 2: SUMMARY OF TEST RESULTS FOR NON-QUALITY-VERIFIED PICO-SOLAR PRODUCTS

Product Model[a]	Sampling Location	Meets Lighting Global Quality Standards	Warranty[b]	Truth-in-advertising					Battery & Charge Controller			Safety and Durability				
				Battery capacity	PV Power	Full-battery Run Time	Solar Run Time[c]	Luminous Flux[c]	Battery Storage Durability	Battery Deep Discharge Protection	Battery Overcharge Protection	Lumen Maintenance	Physical Durability	Physical Ingress Protection	Water Ingress Protection (portable products only)	AC-DC Charger Safety
Solar Lamp #1	Ethiopia	NO	FAIL	FAIL	NR	FAIL	NR	NR	PASS	FAIL	FAIL	PASS	PASS	PASS	FAIL	N/A
Multi-Light Solar Kit #2	Ethiopia	NO	FAIL	PASS	PASS	FAIL	NR	NR	FAIL	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL
Multi-Light Solar Kit #3	Ethiopia	NO	FAIL	PASS	PASS	PASS	NR	NR	PASS	PASS	PASS	PASS	FAIL	PASS	FAIL	FAIL
Multi-Light Solar Kit #4	Ethiopia	NO	FAIL	FAIL	PASS	FAIL	NR	NR	PASS	FAIL	FAIL	FAIL	PASS	PASS	N/A	FAIL
Solar Lantern #5	Nigeria	NO	FAIL	FAIL	NR	FAIL	NR	NR	PASS	FAIL	FAIL	PASS	FAIL	PASS	FAIL	FAIL
Solar Lantern #6	Nigeria	NO	FAIL	FAIL	NR	NR	NR	NR	PASS	FAIL	FAIL	PASS	FAIL	PASS	FAIL	FAIL
Solar Desk Lamp #7	Tanzania	NO	PASS	PASS	NR	NR	PASS	NR	PASS	FAIL	FAIL	PASS	PASS	PASS	FAIL	N/A
Multi-Light Solar Kit #8	Tanzania	NO	FAIL	PASS	FAIL	PASS	NR	PASS	PASS	PASS	PASS	PASS	PASS	PASS	N/A	N/A
Solar Desk Lamp #9	Tanzania	NO	FAIL	FAIL	NR	FAIL	NR	NR	FAIL	PASS	FAIL	FAIL	PASS	PASS	FAIL	N/A
Solar Lamp #10	Tanzania	NO	FAIL	NR	NR	FAIL	NR	NR	FAIL	FAIL	FAIL	PASS	PASS	PASS	FAIL	N/A
Solar Lamp #11	Kenya	NO	PASS	PASS	NR	NR	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS	FAIL	N/A
Solar Lantern #12	Kenya	NO	FAIL	FAIL	NR	FAIL	NR	NR	PASS	FAIL	FAIL	PASS	PASS	PASS	FAIL	FAIL
Multi-Light Solar Kit #13 *	Myanmar	NO	FAIL	FAIL	PASS	NR	NR	NR	not assessed	FAIL	FAIL	PASS	PASS	not assessed	not assessed	N/A
Multi-Light Solar Kit #14 *	Myanmar	NO	FAIL	FAIL	PASS	PASS	NR	NR	FAIL	FAIL	FAIL	PASS	PASS	PASS	N/A	N/A
Solar Ambient Light #15 *	Myanmar	NO	FAIL	battery non-functional	NR	NR	NR	NR	battery non-functional	battery non-functional	battery non-functional	FAIL	PASS	PASS	N/A	N/A
Multi-Light Solar Kit #16 *	Tanzania	NO	FAIL	PASS	PASS	FAIL	NR	NR	FAIL	PASS	PASS	PASS	not assessed	not assessed	N/A	N/A
Multi-Light Solar Kit #17 *	Kenya	NO	FAIL	FAIL	PASS	NR	NR	NR	battery non-functional	FAIL	FAIL	FAIL	not assessed	not assessed	N/A	FAIL

[a] Product manufacturers and models have been anonymized for this report.

[b] To comply with the Lighting Global Pico-PV Quality Standards, products must have a consumer-facing warranty with at least one year of coverage.

[c] To comply with the Lighting Global Pico-PV Quality Standards, products must accurately report on the packaging the light output (lumens) and solar run time (hours) for the highest setting.

* Indicates product models that were tested with a sample size of 1 (n=1)

"NR": Aspect not reported on consumer-facing information

"N/A": Not applicable (product not portable for water ingress protection, or product does not include AC-DC charger)

"not assessed": Aspect not tested due to product sample limitations

"battery not functional": Unable to perform test due to battery failure during testing

Consumer-Facing Information

The test results show that most of the non-QV products that were part of this study lack important consumer-facing information such as warranty, solar run time[11] and light output. In addition, most of the tested products had at least one advertised performance claim that was inaccurate. Lack of basic consumer-facing specifications combined with inaccurate performance claims makes it difficult for consumers to make informed purchasing decisions.

Warranty

Only two of the 17 products (12%) included a consumer-facing warranty. To meet the Lighting Global Pico-PV Quality Standards, a product must include a consumer-facing warranty that covers the entire product. Lighting Global's assessment of product warranty does not include verification that the warranty is being honored, nor an evaluation of the level of support that is being offered in practice.

Previous studies of consumer preferences conducted by Lighting Global indicate that availability of a warranty is an important consideration when consumers are making purchasing decisions. While absence of a warranty and lack of confidence that a warranty will be honored may deter consumers from purchasing a product, prior market research shows that the lower cost of many non-QV products without warranties often overcomes any hesitation associated with a product not having a warranty. Moreover, in some markets many end users aren't even aware that a valid and fully supported warranty is a real possibility, which undermines their interest to purchase warrantied products over those that do not have one. To address consumer skepticism about product warranties, manufacturers and retailers of high quality, warranted products should emphasize the validity of their warranty service and fully inform consumers about the warranty terms prior to purchase.

Product Specifications

Only two of the 17 products (12%) included either solar run time or luminous flux specifications on their packaging, both of which are required to meet the Lighting Global Quality Standards for pico-solar products. The products more commonly advertised aspects such as battery capacity and full-battery run time, yet product testing shows that the advertised battery capacity and full-battery run time values were often inaccurate. In contrast, advertised PV module power values were more likely to be accurate. In total, 14 of the 17 tested products had at least one advertised value that did not meet our truth-in-advertising requirements[12]. See below and Figure 1 for additional information.

Advertised Battery Capacity

Battery capacity was advertised for nearly all the tested products (16 out of 17 had consumer-facing battery capacity specifications). Of these 16 products:

- 6 products (38%) accurately specified the battery capacity;
- 9 products (56%) inaccurately specified the battery capacity, with measured results that were 35% less, on average, than the advertised values; and
- 1 product had a non-functional battery.

Advertised Full-Battery Run Time[13]

- Eleven of the 17 products (65%) included full-battery runtime specifications.
- Only 3 of these 11 products (27%) accurately specified the full-battery run time.
- For the 8 products that inaccurately advertised full-battery run time, the measured values were, on average, 43% less than the advertised value.

[11] Solar run time is the duration (hours) of lighting provided from one full day of solar charging. The standard solar charging day is defined as an incident solar resource of 5 kWh/m^2.

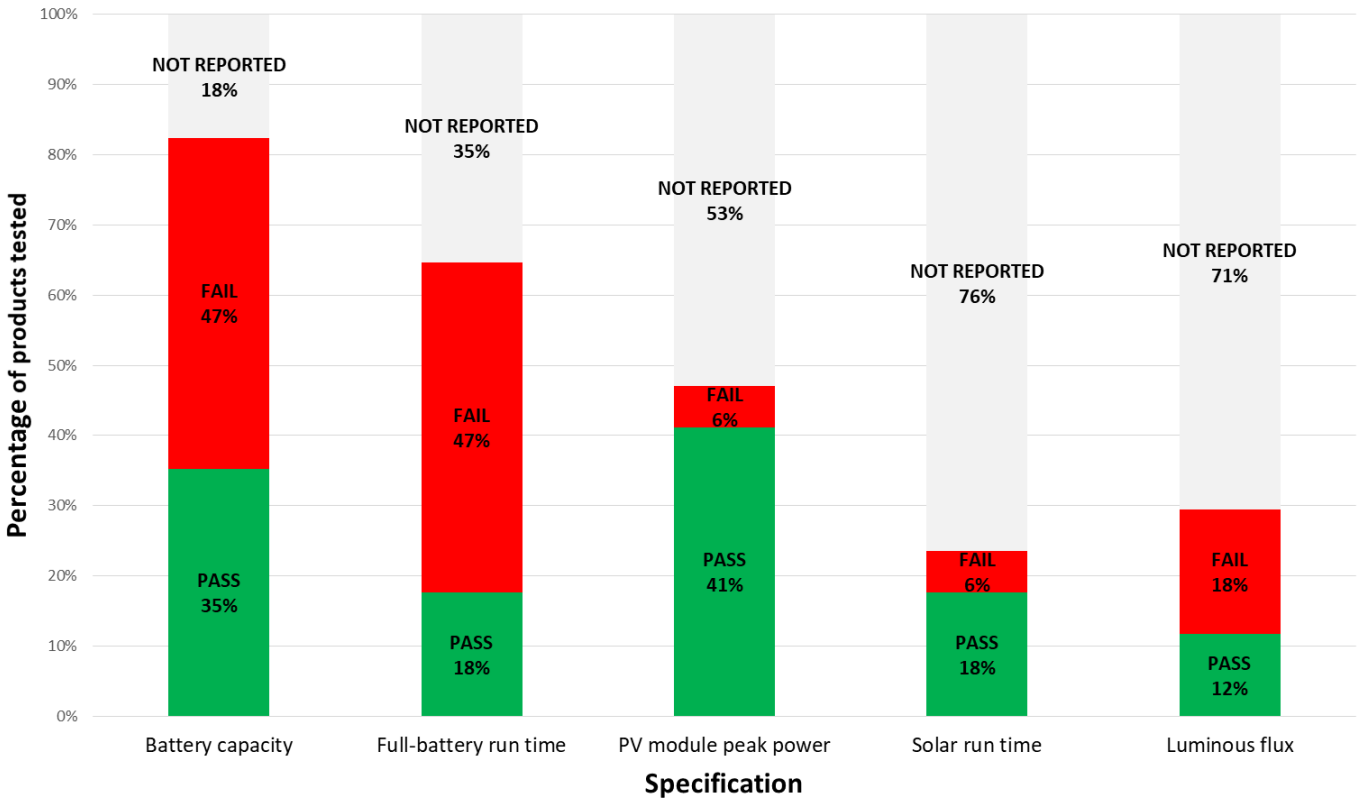
[12] To meet the Lighting Global Pico-PV Quality Standards, all consumer-facing information included with a product must be truthful and accurate. Any numeric aspects (such as battery capacity, PV power and run time) must be at least 85% of the advertised ratings. All advertised features shall be functional, and any consumer-facing description of the product must be truthful. No statements should mislead buyers or end-users about the features or utility of the product.

[13] Full-battery run time is the duration (hours) of lighting provided from a fully charged battery.

Advertised PV Module Power

- Eight of the 17 tested products (47%) advertised the PV module power. The results show that only one of these eight products (13%) inaccurately specified the PV power.

FIGURE 1: SUMMARY OF TRUTH-IN-ADVERTISING FOR CONSUMER-FACING INFORMATION



NOT REPORTED - Specification not reported in consumer-facing information

FAIL – Specification reported in consumer-facing information was more than 15% higher than the actual value, thereby failing to meet Lighting Global's truth-in advertising requirement

PASS **–** Specification reported in consumer-facing information was accurate, thereby meeting Lighting Global's truth-in-advertising requirement

Durability & Safety

The test results show that most of the non-QV products that were part of this study were not designed to be durable and/or safe for the users. For products to provide safe, reliable and long-term energy services, they must include:

- High quality batteries that are maintained within appropriate voltage levels
- LEDs that provide constant light output throughout the expected product lifetime
- Protection against damage due to ingress of water and foreign objects
- Components such as housing, switches and cables that can withstand typical use throughout the expected product lifetime
- Safe charging mechanisms

Battery Storage Durability[14]

Following testing, nine of the 16 tested products (53%) passed the battery storage durability test. Of the remaining products:

- 5 products failed with an average permanent capacity loss of 40% (where 25% capacity loss is considered a "pass").
- 2 products failed due to catastrophic battery failure during testing.

LED Lumen Maintenance[15]

Five of the 17 tested products failed the lumen maintenance test, with an average permanent decrease in light output of 9% after only 500 hours of operation.

Ingress Protection[16]

- We were very pleased to see that all the 14 products that were assessed for physical ingress protection met this aspect of the Lighting Global Quality Standard.
- However, all the portable products that were assessed for water ingress protection (10 products in total) failed to meet the Lighting Global Quality Standard.

Physical Durability

Of the 14 products that were tested for physical durability (including assessment of switches and connectors, cables, and drop tests), four products (29%) failed to meet this aspect of the Lighting Global Quality Standard.

AC-DC Charger Safety

Seven of the products evaluated in this study could be charged by AC mains. None of these products carried approval from a recognized consumer electronics safety certification organization for the included AC-DC charger.

Overall, none of the products met all of the durability and safety requirements specified in the Lighting Global Quality Standards for pico-solar products. See Figure 2 for a graphic summary of the results.

[14] Battery storage durability is a measure of battery capacity degradation from storage, which can indicate batteries that could degrade prematurely under typical use.

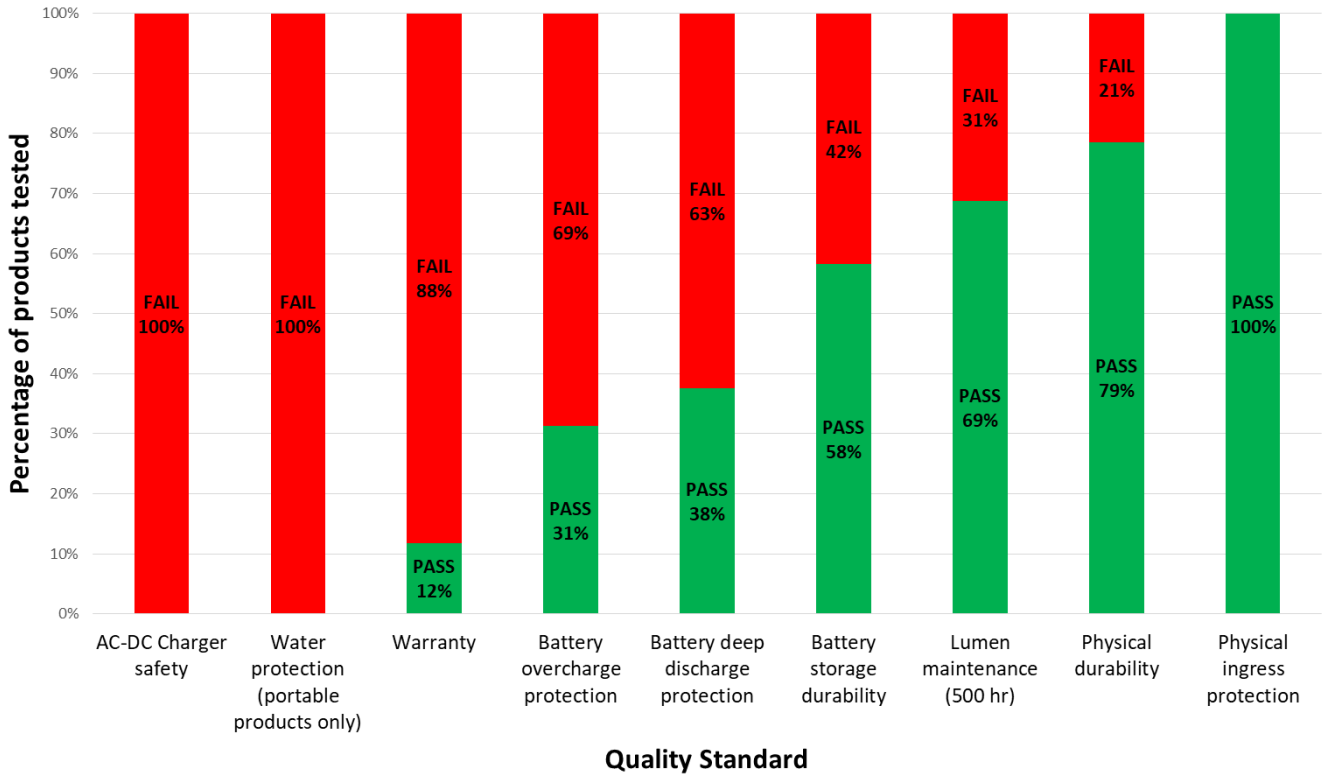
[15] LED lumen maintenance is a measure of the amount of light degradation after constant operation of an LED, which can provide valuable insight into the quality of the LEDs and/or the associated circuitry.

[16] Ingress protection is assessed by determining the degree of protection provided by enclosures of electrical equipment against penetration by foreign bodies, dust and water.

FIGURE 2: SUMMARY OF COMPLIANCE WITH LIGHTING GLOBAL QUALITY STANDARDS (NOT INCLUDING TRUTH-IN-ADVERTISING REQUIREMENTS)

FAIL – Product failed to meet the Lighting Global Standard for specific aspect

PASS – *Product successfully met the Lighting Global Standard for specific aspect*



Summary of Findings

The test results indicate that none of the 17 non-QV pico-solar products evaluated as part of this study met all the requirements of the Lighting Global Pico-PV Quality Standards. In the remainder of this section we present high level trends from the study, including both promising and discouraging outcomes identified through laboratory testing.

The Good News

While it is quite concerning that none of the selected products met the Lighting Global Pico-PV Quality Standards, the test results do show that, collectively, many products fared well with regards to the following aspects of the Standards[17]:

- 100% of the products met physical ingress protection requirements
- 79% of the products met requirements for physical durability
- 69% of the products met LED lumen maintenance requirements
- 58% of the products met battery durability requirements

A notable and encouraging outcome is that one of the tested products – a top-seller in the Tanzanian market – met all the requirements for physical durability, safety, battery durability and charge control. To meet the Lighting Global Quality Standards, this product would only need to provide a suitable warranty and modify consumer-facing information about PV module power and run time.

This leads us to believe that there are some non-QV products of nearly acceptable quality that could benefit from engaging with Lighting Global. These products would require relatively modest adjustments to bring them in-line with the Quality Standards, thereby providing consumers with better and more reliable energy services.

The Not-So-Good News

The tested products had limited and often inaccurate consumer-facing information. In addition, nearly all the tested products had some combination of technical issues that would lead to relatively short lifetimes and could contribute to consumer dissatisfaction. Following are the most common deficiencies identified in this study:

- None of the portable products met the standard for water ingress protection.
- Only 37% of the products had proper protection against deep discharge and overcharging of the battery.
- Of the seven products that included AC-DC chargers, none of them carried approval from a recognized consumer electronics safety certification organization.
- Only 12% of the products included a consumer-facing warranty.
- Of the products that advertised battery capacity or full-battery run time, less than half did so accurately.

Opportunities for Further Research

While this study provides useful evidence about the quality and performance of high market-share pico-solar products from selected countries, we must acknowledge that we can only gain a certain level of insight from laboratory testing. Additionally, the scope of this research covered a small fraction of the non-QV products available in selected markets. As a result, we should be cautious about drawing overly broad conclusions from this study.

Quantity of Product Models and Samples

Due to limitations in time, budget and capacity, this study was done on 17 pico-solar product models that were selected from five countries. While we targeted products that were identified as top-sellers in each

17 For detailed information about the requirements for physical ingress protection, physical durability, LED lumen maintenance and battery durability, refer to the Lighting Global Pico-PV Quality Standards: https://www.lightingglobal.org/resource/lighting-global-quality-standards/

market, this study could have been strengthened by testing a greater number of product models from each of the selected countries. Moreover, the results would be even more robust if we had been able to test products from other countries in Africa and Asia. As plug-and-play solar home system (SHS) kits continue to increase in prevalence, a similar study focusing on non-QV SHS may also be warranted.

As described above, product testing for this study was done with a sample size of either one or two. While test results from a small sample size can provide a good indication of product quality, there is inherently greater uncertainty in the results, as compared to results from full IEC 62257-9-5 Quality Test Method (QTM) testing[18]. In some instances, we received inconclusive test results due to catastrophic failures and the inability to conduct destructive testing. This could have been avoided if testing had been carried out on a greater number of samples.

Consumer Experience and Preference

When it comes to product quality and performance, laboratory test results are just part of the story; they do not tell us about the consumer experience with non-QV products and how they compare to QV products. There are many more questions that should be explored in greater depth to understand the prevalence of sub-standard products in off-grid solar markets, as well as the motivations behind consumers' preferences and purchasing decisions.

While we know that non-QV products have a major share of the global market and we can conclude that many top-selling non-QV products are sub-standard, this study does not provide insights about consumers' experiences with these products. As a starting point, further investigation is warranted to better understand product cost effectiveness. Retail prices for quality-verified and competing non-QV products can be assessed in conjunction with laboratory and field test results to compare the cost of energy services provided.

This kind of apples-to-apples comparison could be used to support or refute a common belief that high-quality pico-solar products are more cost effective than low-quality, low-cost products over the product lifetime. Assessment of the marginal cost to bring sub-standard products into compliance with the Quality Standards would be an important part of such an analysis.

Additional questions about consumer expectations and perceptions of product quality remain to be more thoroughly examined:

- Are non-QV products meeting consumers' expectations with regards to quality and performance?
- Are consumers making informed purchases of sub-standard products with the understanding that they are likely to fail relatively quickly?
- Is the purchase of sub-standard products due in part to a lack of confidence in more expensive, quality-verified products?

We also do not currently have a complete understanding of the level of after-sales service that is being provided. Further investigation of the provision of repair services, customer support and spare parts after making an initial sale would be valuable for both non-QV products and those that meet the Lighting Global Quality Standards. Some key questions include:

- If and how are warranties being valued?
- Are faulty products being repaired/replaced in a timely manner?
- Do consumers have access to technicians and spare parts after expiration of product warranties?

[18] The comprehensive QTM test in IEC 62257-9-5, used to assess products for Lighting Global quality verification, uses a sample size of six for pico-solar products.

Recommendations

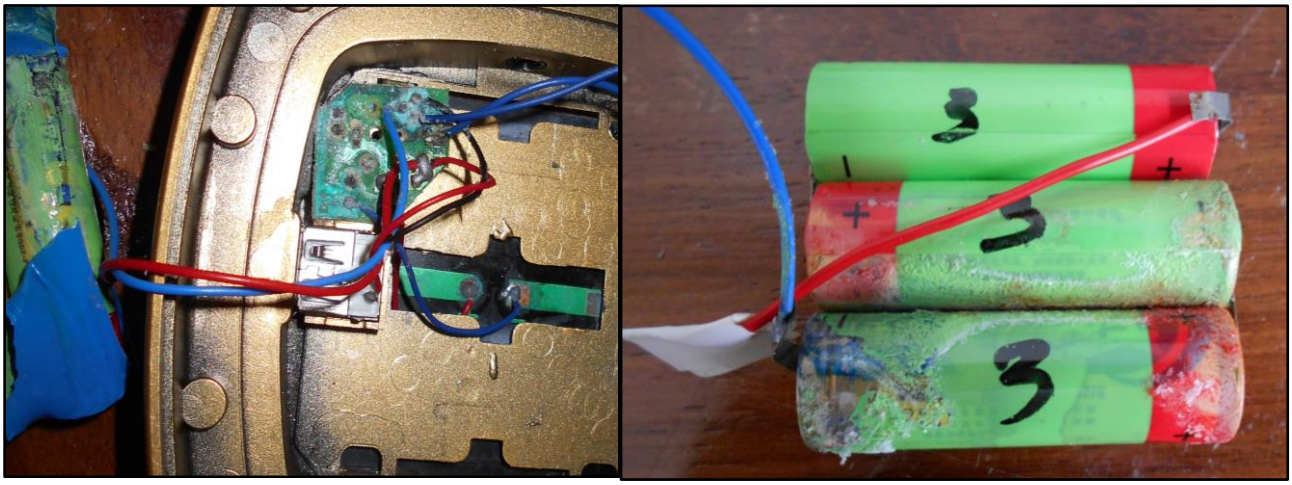
Manufacturers of off-grid solar products are encouraged to design and sell products that comply with the Lighting Global Quality Standards. In some cases, for the products evaluated in this study, only small changes to the design of a product or its packaging are needed to come into compliance with the Lighting Global Quality Standards.

Purchasers should continue to look for products that meet the Lighting Global Quality Standards when they are in the market for pico-solar products. There is substantial risk that non-QV products may not perform as advertised, fail prematurely, and, therefore, disappoint users.

Other market actors keen to better understand which products meet consumers' expectations for quality should conduct additional research, both in the lab and in the field. This is especially important for those with an interest to establish a baseline and improve conditions in a particular national market, as this study combines test results for products drawn from multiple markets.

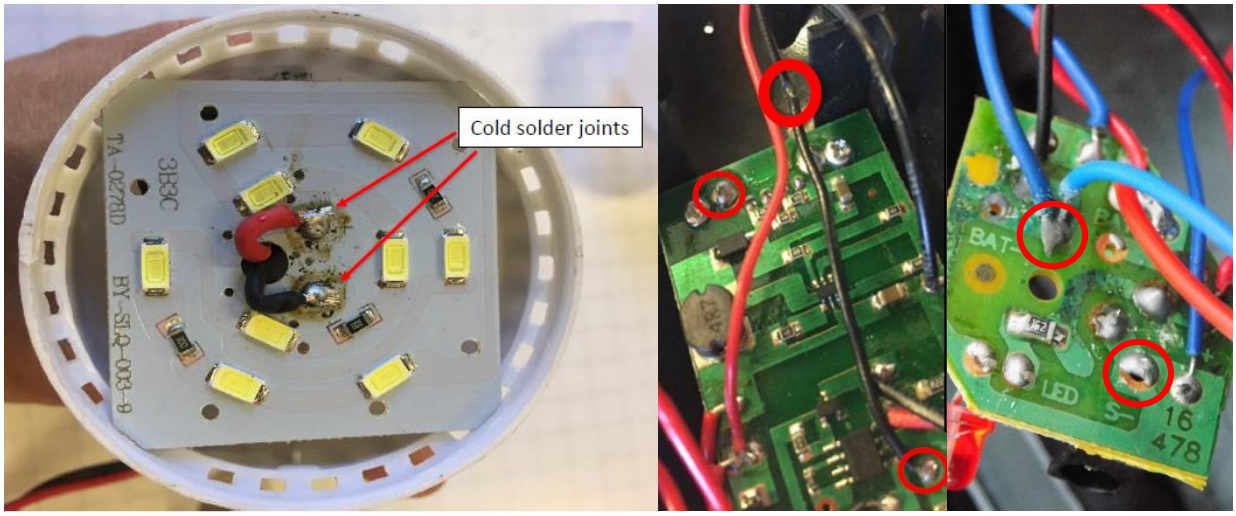
Photo Appendix

The test methods described in IEC TS 62257-9-5 include a visual inspection of the product, which is comprised of an assessment of all consumer-facing information and a detailed examination of the exterior and interior of the product. The following photos taken during the visual inspection illustrate problems identified when testing these non-quality verified products.



NiMH batteries with leaked electrolyte

When a battery is faulty, of low quality, or stored at a deeply discharged state, the battery cell can rupture and leak electrolyte. The battery pack in this product was not functional, and has leaked corrosive chemicals that damaged adjacent electronic components.



Poor quality workmanship

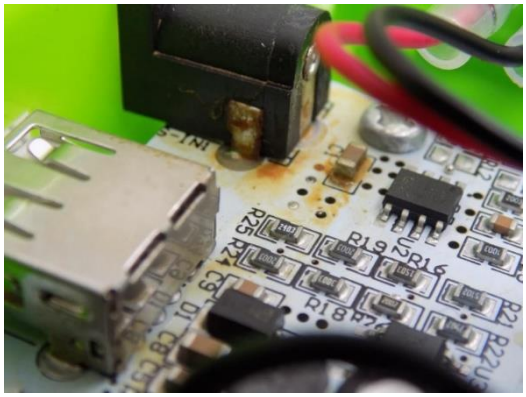
Several instances of poor workmanship were observed during the assessment of the non-QV products, including:

- Soldering problems
  - Cold solder joints – When the solder did not melt completely it forms a joint that is unreliable and prone to disconnecting over time.
  - Insufficient wetting – When too little solder is used, it forms an incomplete bond with the PCB. This can result in fragile and/or partial connections that are unlikely to be durable.

- Wiring problems
  - "Wire spaghetti" – When wires connecting a product's internal components are excessively long and poorly organized, they are prone to damage and disconnections. Long, tangled internal wiring is generally an indication of poor product quality.
  - Pinched and uninsulated wires – When a product is poorly assembled, wires can be pinched between components, which can sever the wire or make the connections fragile. Wires that lack insulation cause a risk of making damaging or dangerous electrical contact with other electronic components.

Limited and unclear consumer-facing information

Inadequate and/or unclear product information available to the consumer causes confusion and can be misleading. In this case, the warnings issued on the product packaging could be easily misinterpreted.



Corrosion on printed circuit board (PCB) and electronic components

Rusty PCB surface suggests exposure to high humidity, which can damage electronic components and cause short circuits. Corrosion damages the product, possibly resulting in reduced or non-functionality, and reduced