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Catalyzing Markets for Modern Lighting

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# **The Lighting Africa Experience**: Market Transformation and Research for Off-Grid Lighting

Peter Alstone
(content generated by many on the team, with key contributions from Dr. Arne Jacobson)

October 17, 2012

# India Blackout 2012

## 600 million people -- 2 days

THE ASIAN AGE

NEW DELHI WEDNESDAY 1 AUGUST 2012

WORLD 9

NATION | Politics 2

SPORT | Cricket 20

India clinch 4th ODI, wrest series from Sri Lanka

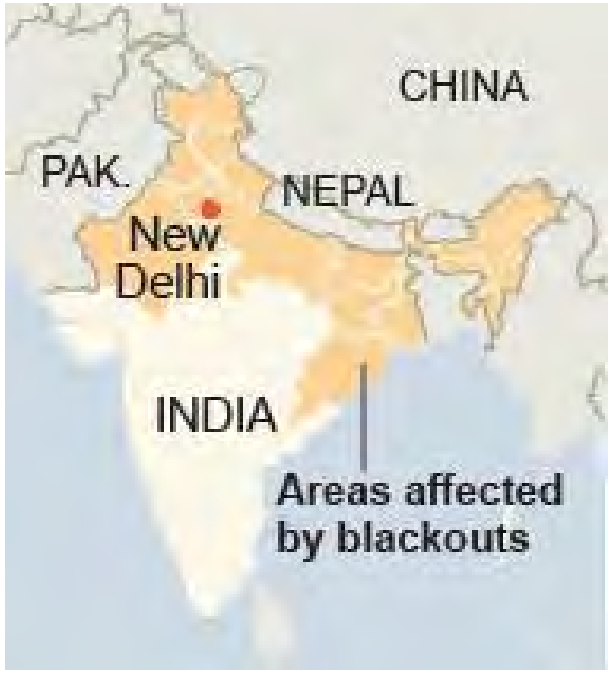
TRIPLE TRIP HITS HALF OF INDIA, OVER 600M PEOPLE

POWER PARALYSIS

PC finance mantri again

Power minister Shinde promoted

POWERLESS

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Permanent Blackout…1.4 billion people.

# The Promise of Modern Off-Grid Lighting

- LED-based lamps are emerging as an affordable substitute for fuel-based lighting for low income people
- Not a substitute for grid power, but can serve well as affordable form of pre-electrification
- Quality of products is mixed; market spoiling is occurring

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"I stay open longer now than before. I've noticed more customers are attracted to my business in the evening compared to before, and they can see my goods more clearly. **More customers means more sales and more money for me.** Some people come from far [out of their way] to see the lamp, [due to the novelty of the lamp.]" [1/2009]

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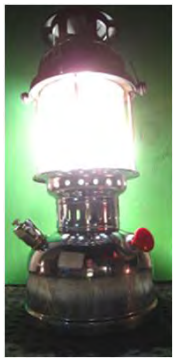
# Fuel Based Lighting is the Incumbent Technology

## Fuel Based Lighting : Expensive, Unhealthy, and Inefficient



Kerosene for lighting is a $10 billion per year industry in Africa; sales volumes in Asia are even larger

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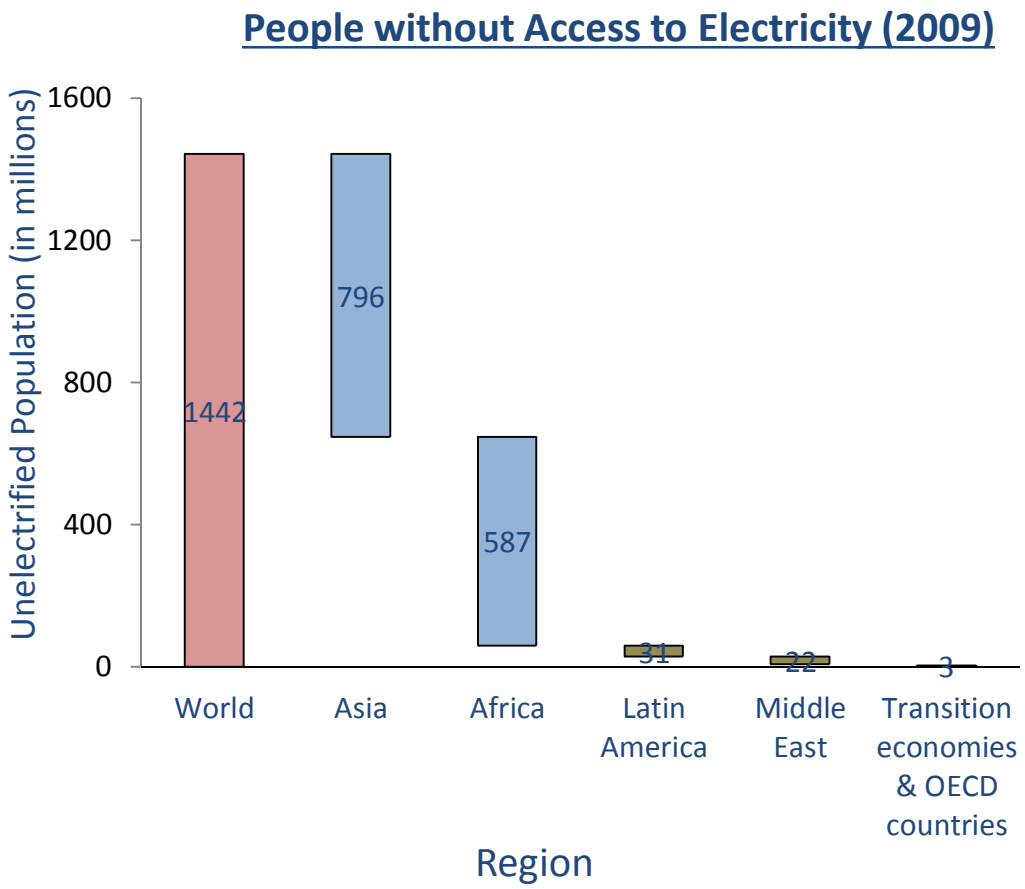
# Large Potential Market for Modern Off-Grid Lighting




- 1.4 billion people lack access to grid electricity
  - 96% in Africa and Asia
  - Many cannot afford higher cost alternatives to grid electricity
- Solar and LED off-grid lighting products can provide affordable and good quality lighting to un-electrified populations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# Benefits from switching to clean lighting

- **Economic** – simple payback from 1-6 months…on a macro scale, cash stays in country.
- **Health and Safety** – reduced fire and fuel ingestion risks, reduced exposure to PM
- **Service Quality** – more light, better control…non-lighting service also highly valued
- **Environmental** – GHG reductions, EROI similar to wind power

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# Goals for today

- Understand (at least a little) the **Lighting Africa** experience
- Focus on **Quality Assurance** strategy
- Highlight **examples of research** opportunities
- Identify **next steps for RAEL**: extending LA lessons and finding opportunities for interesting research questions

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# What is Lighting Africa?


- A "**Market Transformation**" effort that supports and builds institutions that make an energy market work for rural people.
- A **World Bank / IFC** program
- Relatively well funded (10's of Millions USD)
- Pilot in **Kenya and Ghana** with six key elements from 2008-present
- **Expanding** in 2012 to multiple countries in Sub-Saharan Africa and partially replicated in India
- **FINITE** – WB/IFC can't sustain – key elements must be spun off.

# Lighting Africa, Lighting India, Lighting Global

- Originally launched as Lighting Africa, a joint IFC-World Bank initiative
- Now involves collaboration between IFC, World Bank, and U.S. DOE
- Lighting India activities began in 2011; official launch in May, 2012

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**Lighting Africa Program:**

- Quality Assurance
- Consumer Awareness
- Access to Finance
- Market Intelligence
- Policy and Regulatory Reform

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U.S. DEPARTMENT OF ENERGY

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## Lighting Africa provides support across the supply chain.


Lighting Africa/Global/India **interprets, communicates and coordinates** between diverse stakeholders, from factories in Shenzhen to rural people who purchase and use the products. The program aims to be a **trusted source for good information**—a market support institution.

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# Lighting Africa Program Areas:

*Some jump start the market and others are long term needs.*

1) **Product Quality Assurance** – gatekeeper for program services and leading the global market towards a harmonized approach
2) **Market Intelligence** – provide timely market information to broad stakeholders
3) **Consumer Education** – outreach on solar lighting in general with opportunity for direct marketing for "Associates"
4) **Business Development Support** – custom program services for companies with good products and business plans
5) **Public Sector Engagement** – pushing regulators and institutions to use harmonized best practices, eliminating barriers to entry
6) **Access to Finance** – catalyze growth with capital across the supply chain

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# Quality Assurance Activities:

## *Foundational long-term need for a well functioning market*

- Understand end-user needs and state of technology
- Test quality and performance
- Communicate quality to buyers
- Provide technical assistance to manufacturers
- Work towards harmonization to reduce transactions costs

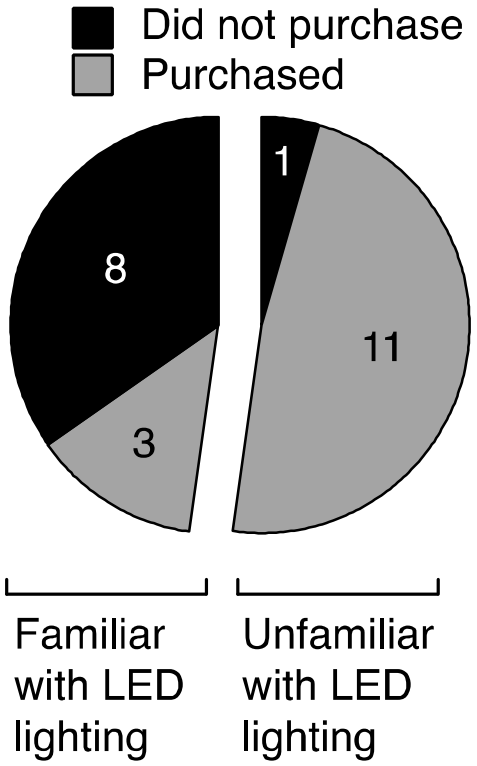
# QA is also vital to the nascent market…avoid spoiling!

- **Low cost / low quality flashlights** dominate the market.
- **End-users are deeply disappointed** with the performance and quality.
- Despite the quality issues, people use them because they beat the incumbent technology.
- These LED products form peoples' **first impression** with the technology, resulting in market spoiling for high quality LED products.

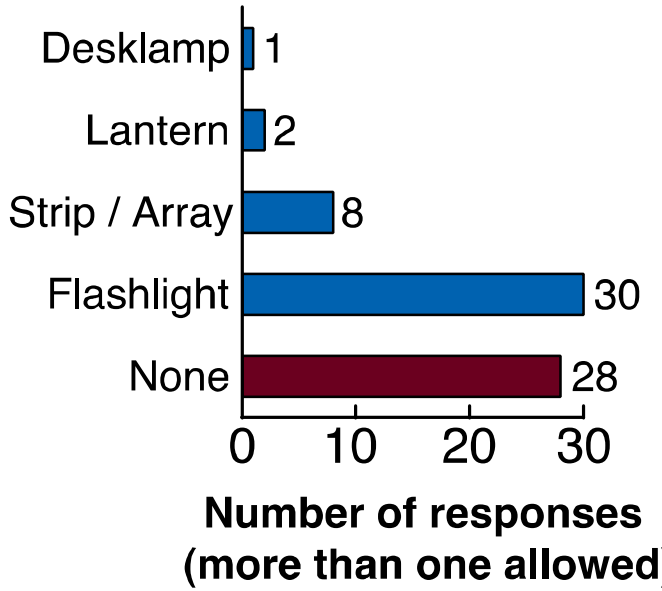
# Market spoiling by substandard torches is happening

Data from 2008 Lumina Study; Consumers offered LED task light with 1 year warranty for purchase

**[A] LED task lamp Purchase choice (n=23)**




**[B] Familiarity with LED lighting by type (n=50)**




People in study who were familiar with LED torches were less likely to purchase a higher quality LED task light

# Market needs drive our **Quality Assurance Principles**

- **Affordability:** Seek an appropriate balance between product quality, performance, and cost
- **Diversity and Innovation:** leave space for product diversity in technology, utility, and price; encourage innovation by using non-prescriptive, outcomes-based goals
- **Rigor:** Use rigorous tests that can be carried out using reasonably low cost instruments
- **Stability:** Maintain stable and transparent QA policies so stakeholders know what to expect
- **Insight:** Effectively communicate key product quality and performance information so buyers can make informed purchasing decisions

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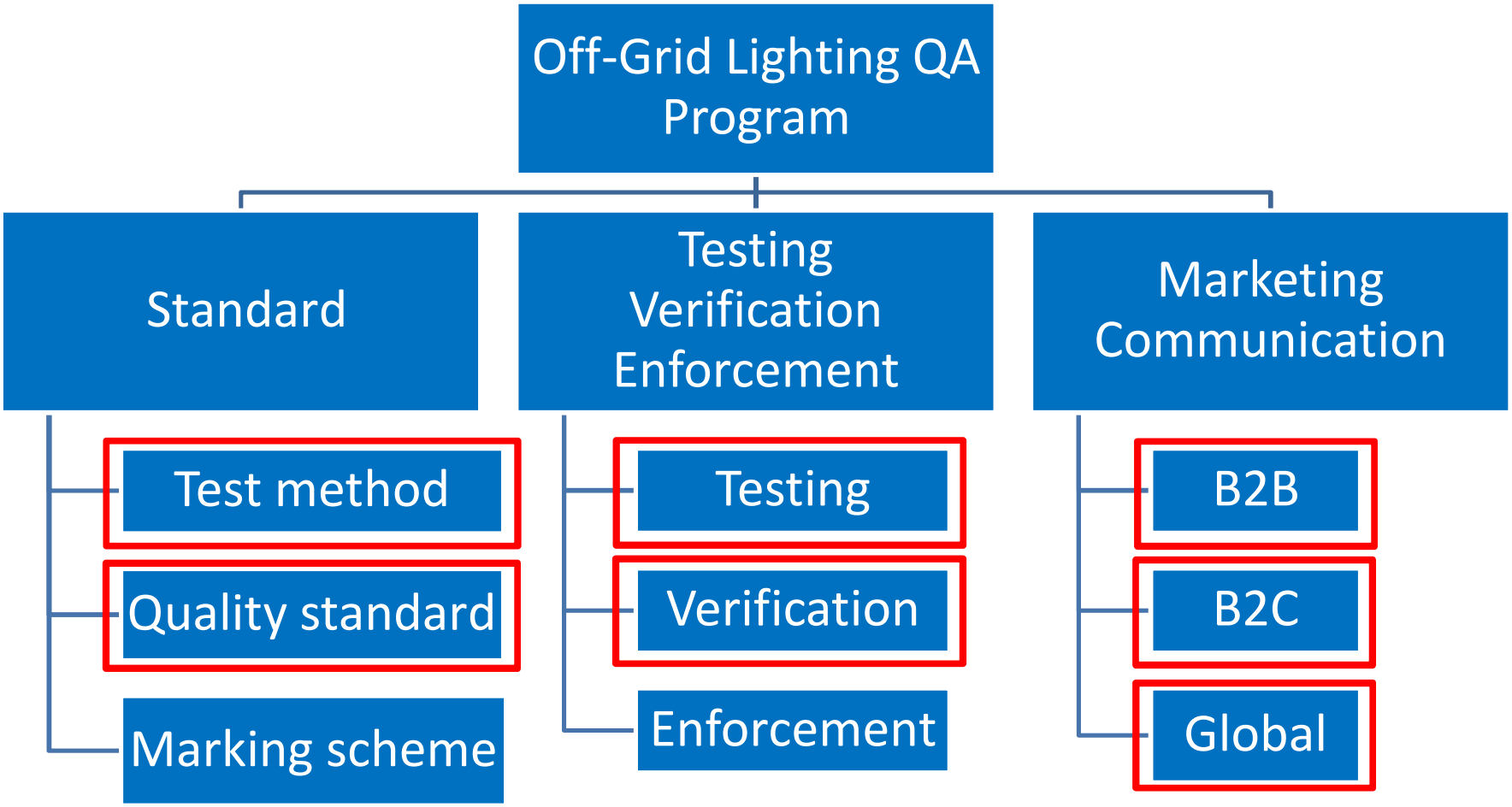
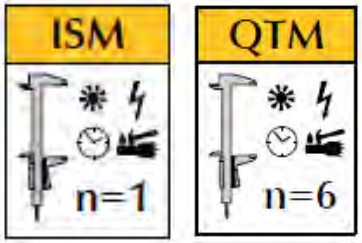
# Quality Assurance Program Structure



# Lighting Global QA Program Elements

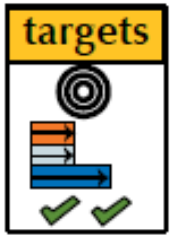



## Standardized Testing Methodologies (multi-level)

QTM = quality test method; ISM = initial screening method

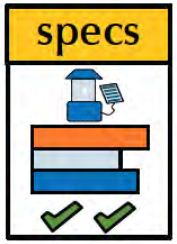

## Minimum Quality and Durability Standards

Metrics and thresholds for ensuring truth in advertising and minimum product quality




## Program Specific Performance Targets

Program-specific performance levels that go beyond minimum standards; used to determine access to specific program services




## Standardized Specification Sheets

Standardized framework for reporting verified performance for products that meet minimum quality standards; available at www.lightingafrica.org/specs

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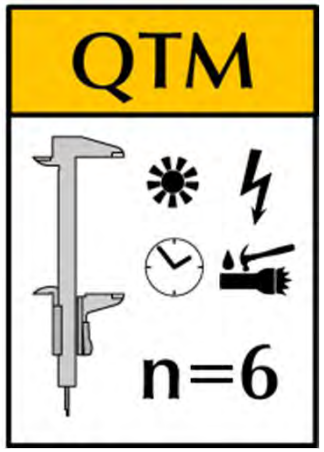
# Lighting Global Quality Test Method




Flexible for diverse products

Inexpensive…about $1,000 / sample

Results targeted for end-user needs

| | | |
|---|---|---|
| | Sampling | Å Randomly selected from warehouse or marketplace |
| Component Tests | Photometrics | Å Luminous flux (lumens—total output)<br>Å Standardized distribution (illuminance) |
| Component Tests | Battery & Charge Control | Å Battery Capacity (Amp-hours, voltage)<br>Å Degree of protection (voltage cutoffs) |
| Component Tests | Solar Module | Å Power output (Watts)<br>Å Current-voltage characteristics (I-V Curve) |
| System Tests | Full Battery Run Time | Å Measured using standardized cycle (hours of operation) |
| System Tests | Solar Charge Run Time | Å Modeled estimate (daily hours of operation after solar charging) |
| System Tests | Physical Ingress & Water Protection | Å Incorporates enclosure (IP class) and system-level protection (coatings, etc.) |
| | Durability | Å Drop test from one meter (pass/fail)<br>Å Switch and connector durability<br>Å Internal wiring and solder inspection<br>Å Lumen maintenance |

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# Diverse form factors are used on-grid…












# …off-grid diversity is equally present


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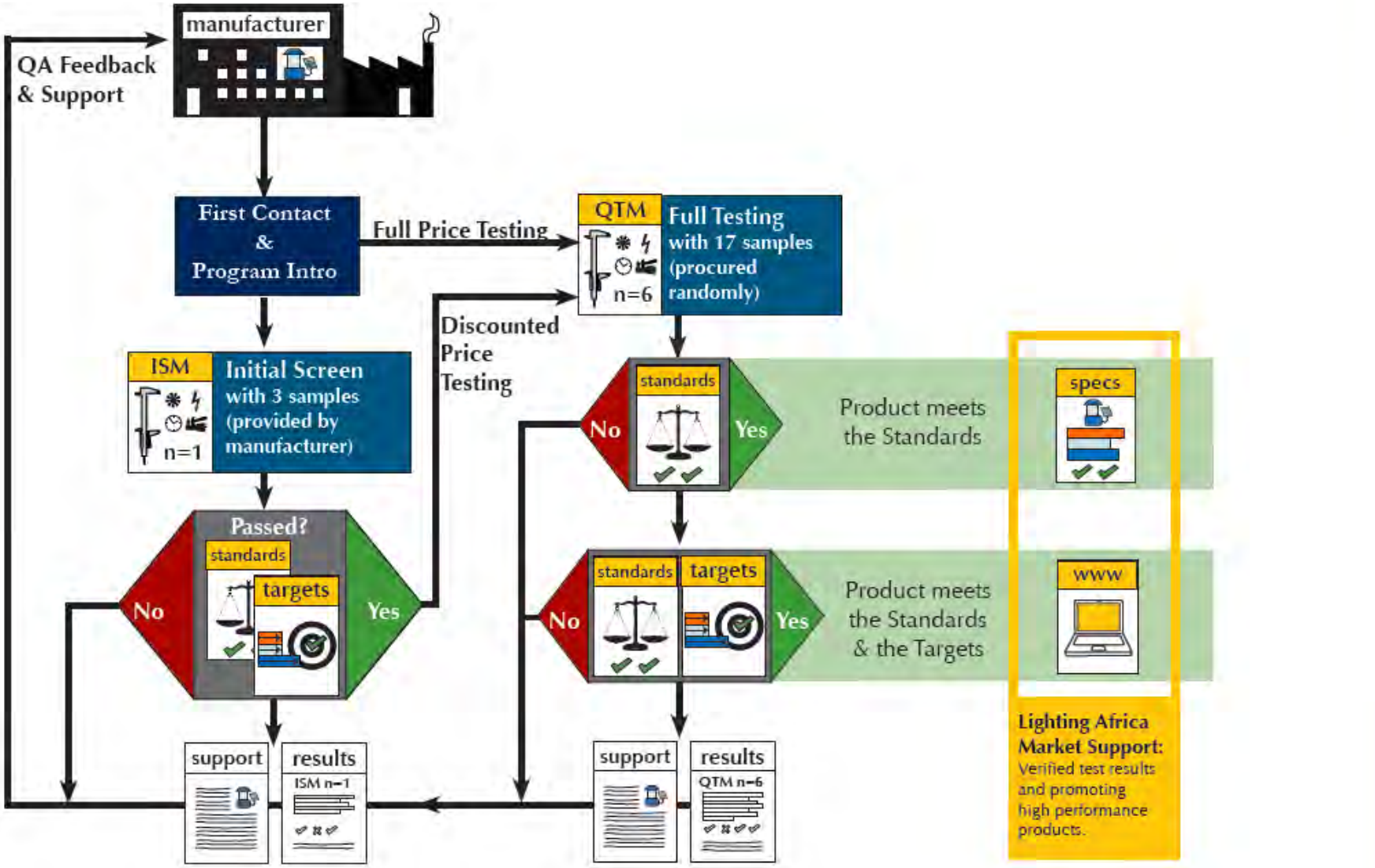
# Lighting Global QA Product Testing Flow Chart

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# Lighting Global QA Program Highlights

| | | |
|---|---|---|
| **2** | test methods | Å QTM and ISM are actively used |
| **4** | active test labs | Å Nairobi, Kenya / California / Germany / New York |
| **100+** | products tested | Å 10+ additional products currently under test<br>Å Ever-expanding coverage of the market |
| **40** | products passed quality standards | Å Allowed to use Standardized Specifications Sheets; differentiated from other products. |
| **0.78M** | quality assured products sold in Africa | Å Over 780,000 quality assured products sold in sub Saharan Africa, reaching an estimated 3.8M off-grid people. |
| **1** | institution referencing test method | Å UNFCCC harmonized with Lighting Global QTM for carbon finance (CDM) compliance |
| **2** | product awards competitions | Å 2012 awards underway now, built on success of 2010 |
| **11** | technical briefing notes | Å Part of the technical assistance to the market |

# Moving towards a global framework for off-grid lighting quality assurance

We are working with the **International Electrotechnical Commission** (IEC) to institutionalize a global quality framework for small off-grid lighting systems. This will **facilitate international harmonization**, as national governments and development programs are more likely to adopt an IEC endorsed framework.




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# IEC Technical Specification is built on the Lighting Global experience

- Technical specification IEC 62257-9-5: Selection of stand-alone lighting kits for rural electrification
  - Test methods
  - Metrics for quality and performance
  - Framework for communicating metrics
- Expected timeline:
  - Approved by national committees associated with TC82 (Sept 2012)
  - Final publication possible by the end of 2012

82/xxx/CD

COMMITTEE DRAFT (CD)

IEC/TC or SC: TC 82

Project number: IEC 62257-9-5

Title of TC/SC: Solar Photovoltaic Energy Systems

Date of circulation

Closing date for comments

Also of interest to the following committees: TC 21, SC 21A, TC 88, TC 105

Supersedes document

Functions concerned: Safety, EMC, Environment, Quality assurance

Secretary: Mr Howard O. BARIKMO

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Title:
Recommendations for small renewable energy and hybrid systems for rural electrification –
Part 9-5: Integrated system – Selection of stand alone lighting kits for rural electrification

Introductory note
Rural electrification is one of the predominant policy activities designed to increase the well being of rural populations together with improved healthcare, education, personal advancement and economical development.

The purpose of Part 9-5 of the IEC 62257 is to specify tools in order to help project developers and project implementors in the selection of relevant products (PV portable lanterns), able to match the lifetime economic requirements of the project they have in charge, portable PV lantern.

Note: The IEC 62257 series of Technical Specifications is based on IEC/PAS 62111 (1999-07) and is developed in accordance with the PAS procedure

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# Current Lighting Africa QA research: *focus areas and challenges*

- Institutional analysis
  - Global market but local projects
- Low cost test methods
  - Estimate field performance with low cost tests
    - Solar run time, water protection, durability, glare and light quality
- Broad technology trends
  - inform standards…ensure that we are “pushing” the market
- Sustainability and life cycle impacts
- User needs
  - Quality and performance priorities
  - Ability to pay and preferences for features

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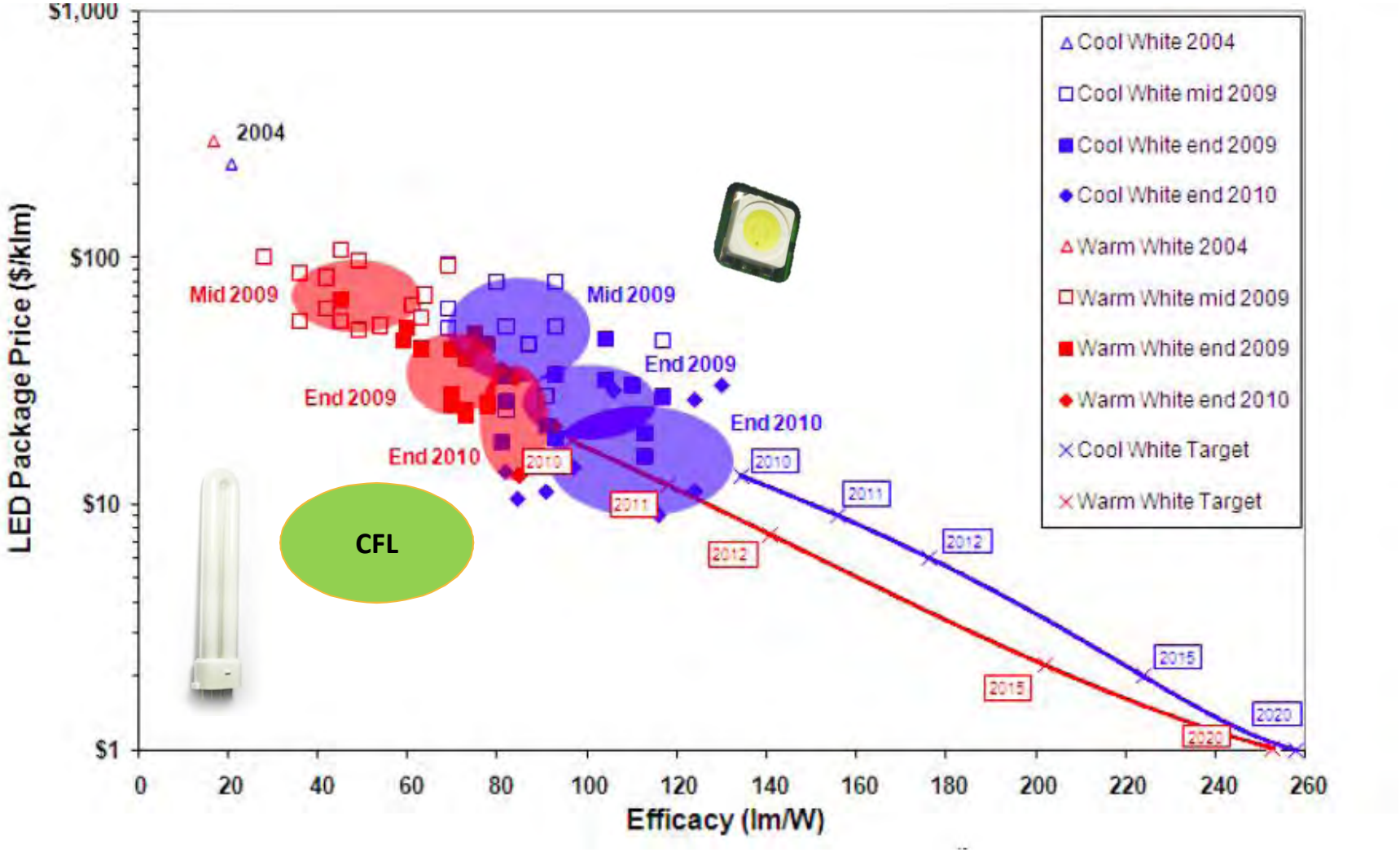
# Cost and Efficacy of LEDs and CFLs




**Sources**: LED data: U.S. DOE, 2011
CFL data: Navigant, 2012

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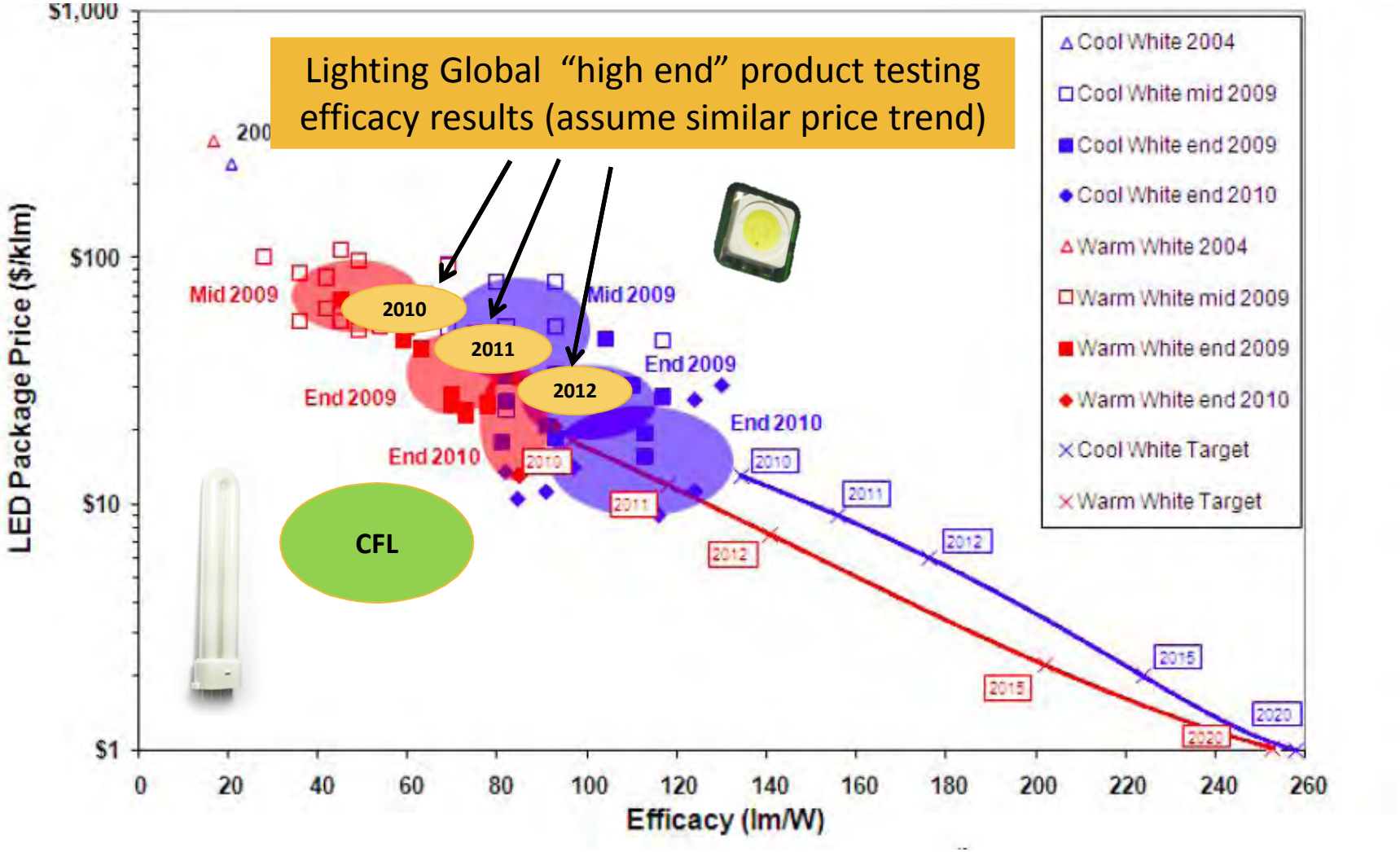
# Cost and Efficacy of CFLs and LEDs

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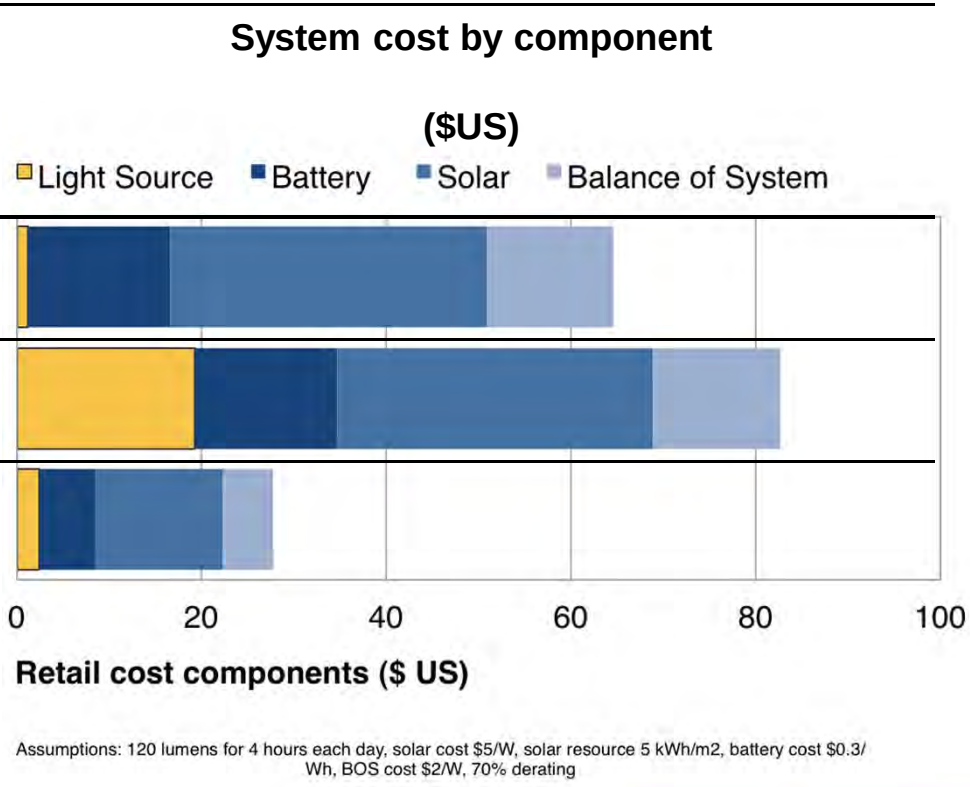
# LED cost / performance trends translate to big savings

Cost components for a 120 lumen product that provides 4 hours of light a day

| | Efficacy (lm/W) | Unit Cost ($/klm) | Power req. (W) |
|---|---|---|---|
| **CFL** | 40 | 5 | 3 |
| **2009 LED** | 40 | 80 | 3 |
| **2012 LED** | 100 | 10 | 1.2 |




Assumptions: 120 lumens for 4 hours each day, solar cost $5/W, solar resource 5 kWh/m2, battery cost $0.3/Wh, BOS cost $2/W, 70% derating

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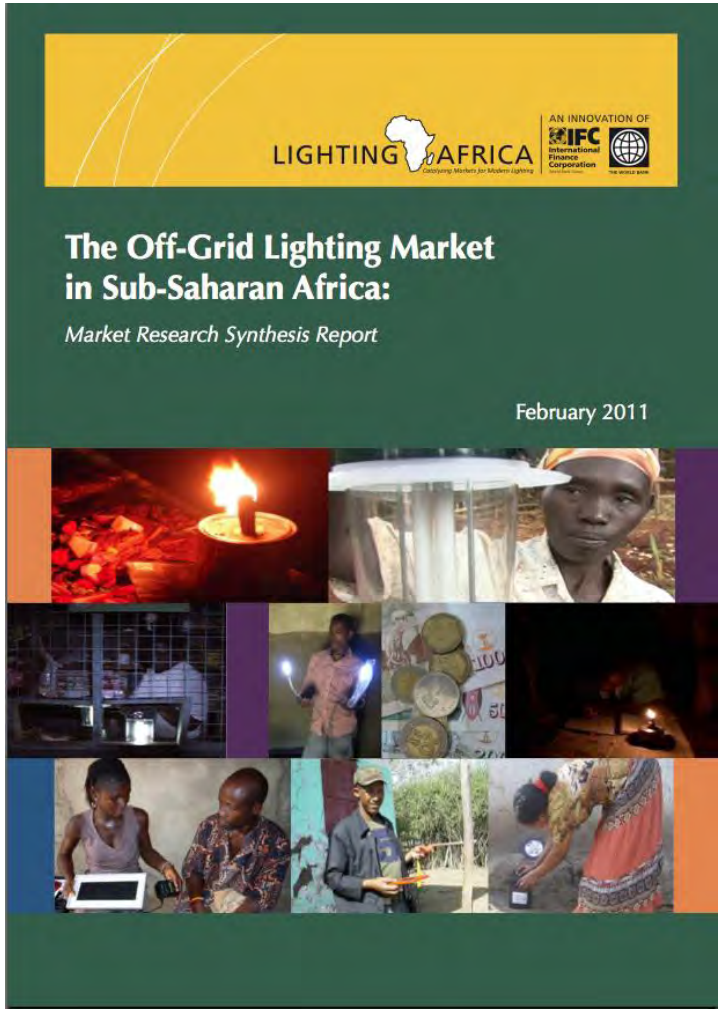
# Market Intelligence: “Evolving” willingness to pay in five-country study





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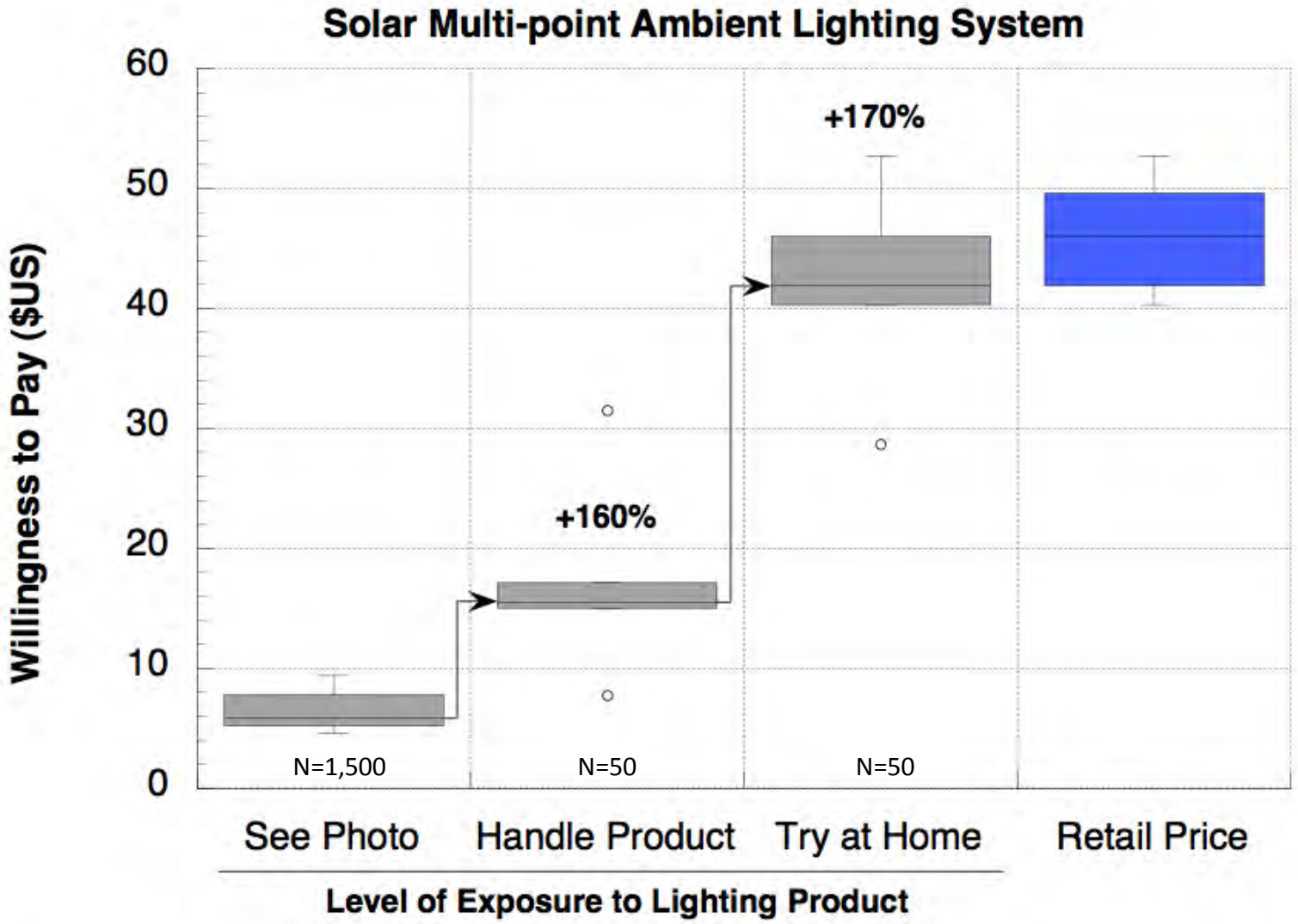
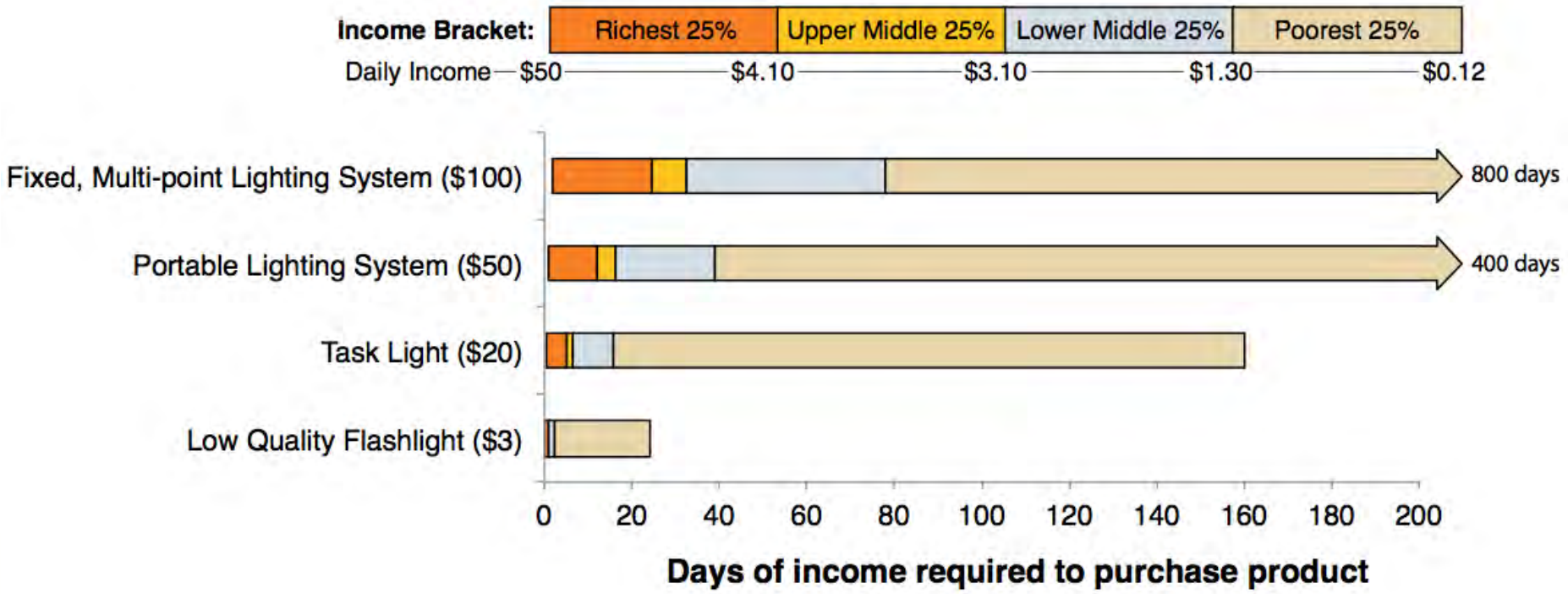



***Graph 6.*** Evolution of potential buyers' willingness to pay for a solar multi-point ambient lighting system at different levels of exposure. Each point in the box plots represents the average in one of the five countries covered in the project. The percentage changes are based on the difference between the median country-wide result at the new and the previous levels of exposure.

# Regardless of “willingness to pay” – ability lags behind…




N=5,000 across five countries: Kenya, Ethiopia, Ghana, Tanzania, Zambia (2008 survey)

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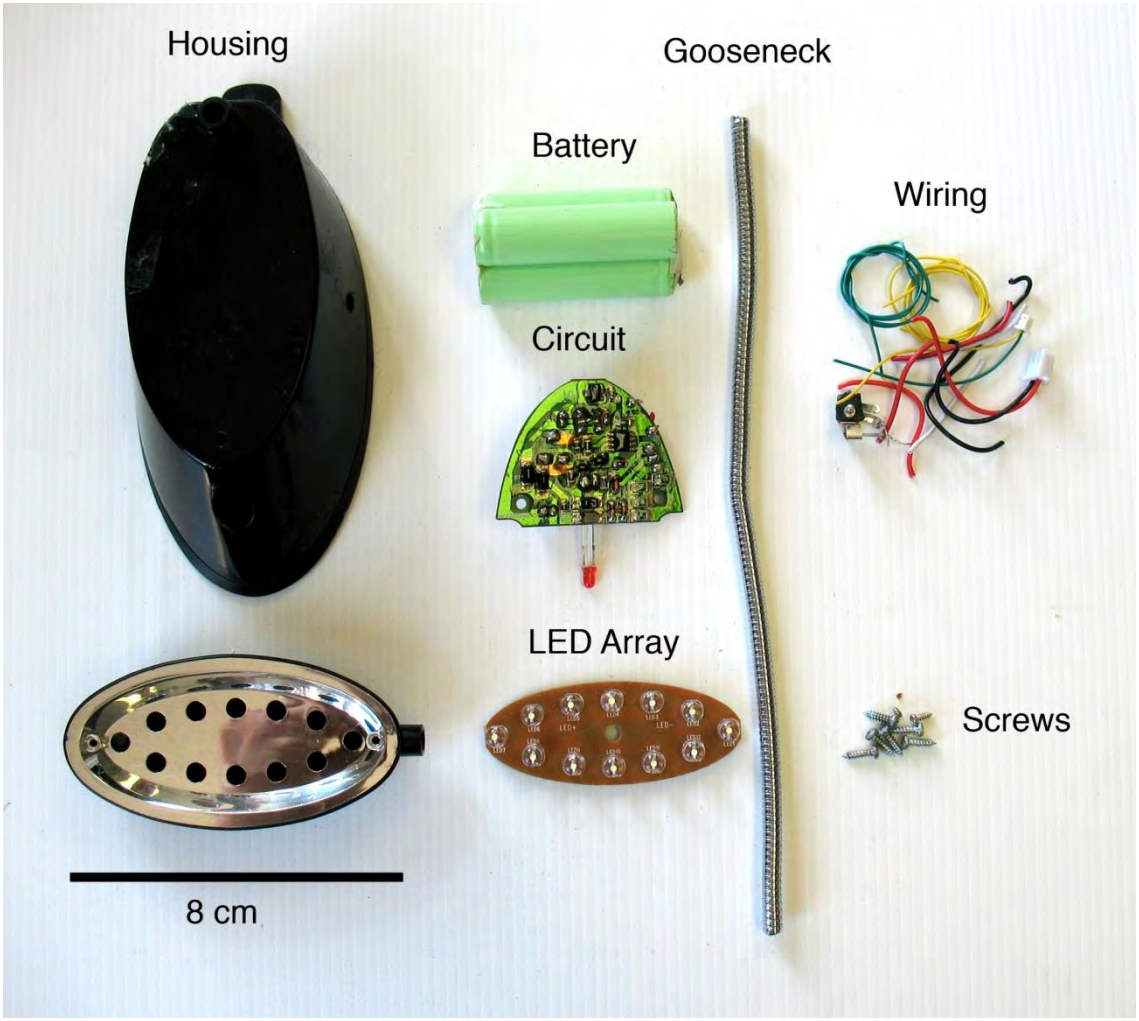
# Life cycle energy impact study


Novel energy impact method combines materials processing accounting methods with careful field observation of incumbent and replacement technology.

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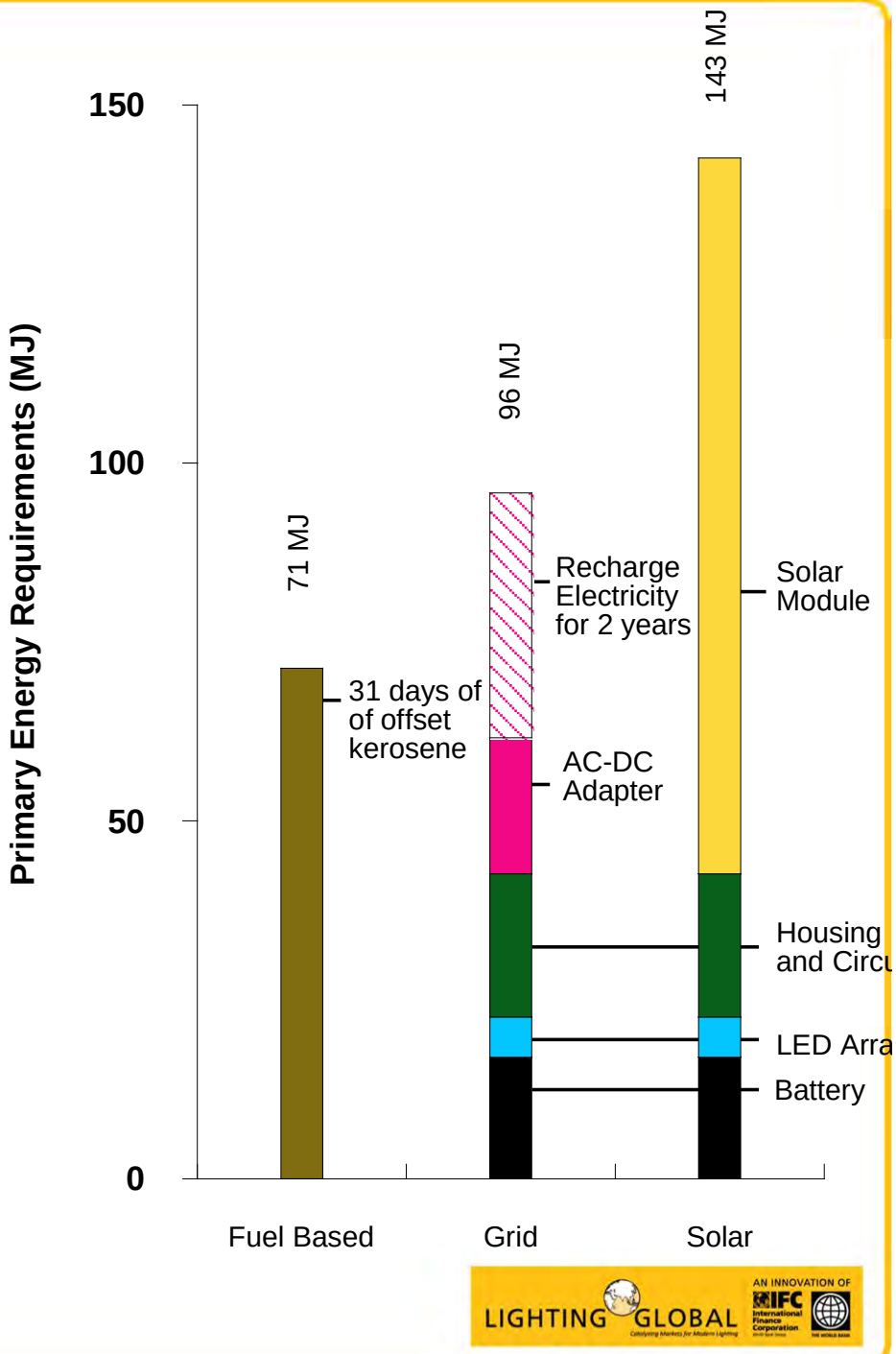
## Key LCA results:

Fast energy payback for a small task lamp with little service improvement:
1-2 months

Grid charging may be equally good as solar



# How can RAEL contribute to “Lighting Africa” type efforts?

- Build on the “energy wiki” idea…add a quality assurance layer incorporating the best practices & concepts from Lighting Africa.
- Work with a specific technology like cookstoves or super efficient appliances to lay initial groundwork for a similar effort, or provide research / technical support to market transformation efforts, identify institutional gaps, etc.

Questions?
Letôs discussé

# International Harmonisation Benefits

- Adopting an internationally harmonised framework will reduce costs and result in **better quality, more affordable solar LED lights** for consumers
- **Lower the transaction costs** for manufacturers:
  - Sell the same product into many different markets;
  - **One streamlined measurement method** (international testing standard) as opposed to a patchwork of national requirements;
- Voluntary, **multi-tiered international performance specification**, ensuring quality while facilitating bulk procurement, incentives and other MT schemes;
- A high degree of **legitimacy**, internationally supported and maintained.

# IEC Technical Specification product assessment framework has three decoupled categories:


## Quality Standards

**Protection** from early product failure and false advertising.
*Truth in advertising, durability, lumen maintenance*


## Performance Targets

**Benchmarks** for consumer satisfaction.
*Run time, brightness, features*


## Warranty Standard

**Assurance** that products are supported after the sale.
*Duration and coverage, market-specific support*

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# IEC assessment example: Lighting Africa program levels


| | |
|---|---|
| **Truth in Advertising** | Accurate and honest consumer-facing information |
| **Lumen Maintenance** | L70 or better at 2000 hours. |
| **Durability** | Wiring inspection, drop test, switch and connector test, gooseneck test, protection from physical ingress, protection from water exposure |


| | |
|---|---|
| **Brightness** | 20 lumens *OR*<br>25 lux over two sheets of paper |
| **Run Time** | 8 hours with full battery *OR*<br>4 hours from a solar charge |


| | |
|---|---|
| **Duration / Coverage** | 6 months for manufacturing defects under normal use, including battery and all other components. |
| **Market-specific support** | n/a |

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# Standardized specifications sheets communicate key information to the market

## Greenlight Planet Sun King Pro

Verify specs at:
www.lightingafrica.org/specs/glp-sunkingpro

**Overall Performance**

**"Turbo" setting: 110 lumens for 6 hours after one day of solar charging**
**"Normal" setting: 44 lumens for 15 hours after one day of solar charging**

| | |
|---|---|
| **General Information** | |
| Manufacturer | Greenlight Planet Inc. |
| Product Name | Sun King Pro |
| Model Number | SK-301 |
| Contact | sales@greenlightplanet.com |
| Website | www.greenlightplanet.com |
| Warranty | 1 year |
| **Run Time** | |
| Autonomous Run Time (full battery) | 6 hours "Turbo" 15 hours "normal" |
| Lighting hours per solar day (PV only) | 6 hours "Turbo" 15 hours "normal" |
| **Lighting System** | |
| Lamp type | LED |
| Light output | 110 lumens "Turbo" 44 lumens "Normal" |
| Light output at 2000 hours | 110 lumens "Turbo" |
| Light Distribution | Wide |
| Color Appearance | Warm (more red) Daylight Cool (more blue) |
| Color Rendering | (50%) (100%) CRI: 59 |
| **Charging System** | |
| Charge type(s) | PV |
| **Storage System** | |
| Storage Type | $LiFePO_4$ (LFP) Rechargeable Battery |
| Nominal Battery Voltage | 6.6 Volts DC |
| Battery Capacity | 1450 milliamp-hours |
| Battery Protection | Active HVD and LVD, Individual Cell Balancing |
| Easily Replaceable Battery? | No |
| **Additional Information & Special Features** | |
| Phone charging cables | Includes six common mobile phone adapters |
| Battery Life / Charging Display | Displays solar charging strength on a scale of 1 through 5, and displays remaining battery capacity during use. |
| Lamp Housing | Polycarbonate and ABS Shell, Steel Stand |
| Factory Certification | ISO 9001:2000 |
| **Date of Sample Procurement for Testing** | May, 2011 |

*Revision 2011.01*

- **Provide quality baseline:** only products that meet the standards can participate.
- Focus on communicating **system-level performance** and features that impact end-users (run time, brightness, etc.)

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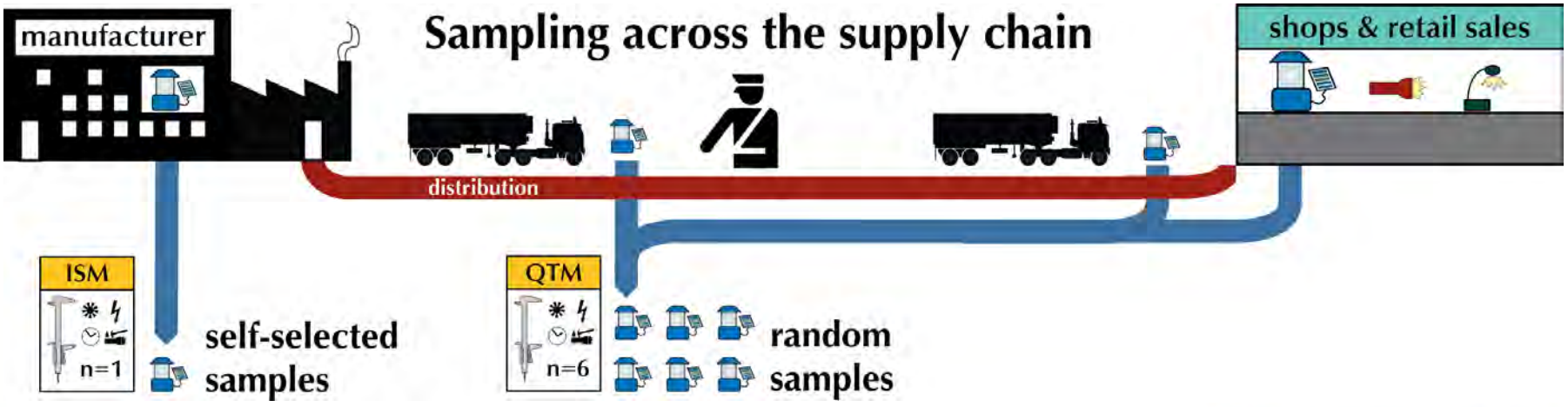
# Sampling Protocol for IEC Tech Spec

- **Random procurement** ensures that the test samples are unbiased and representative
- **Multiple samples** reduces the likelihood of false positive and negative results

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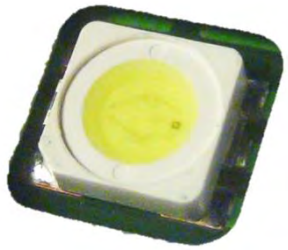
# Rigorous Testing: Lumen Maintenance

- Impossible to assess for buyers and key to product lifetime
- Lighting Global approach is to measure using low-cost equipment
- Standard is defined as XX% of initial brightness (LXX) or better at 2,000 hours of operation.



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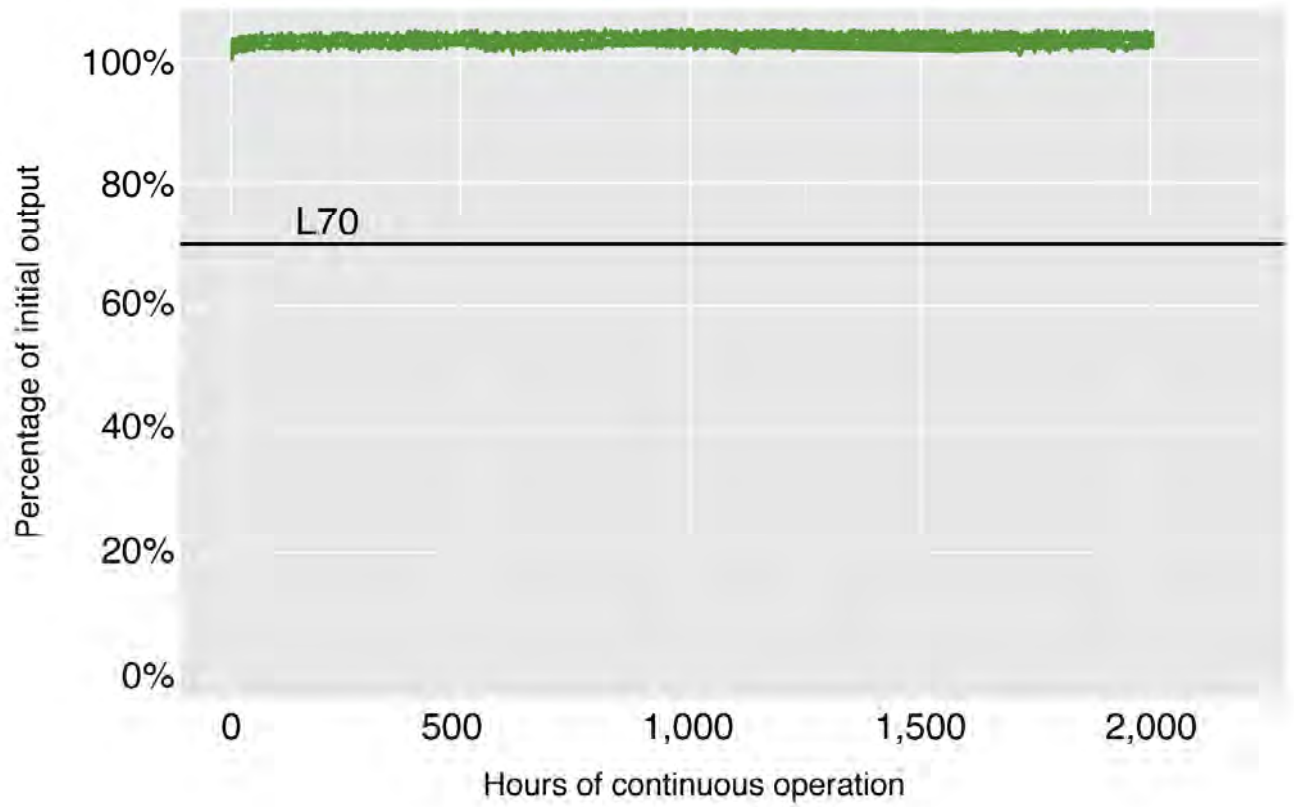
# **Good** Lumen Maintenance LED Product

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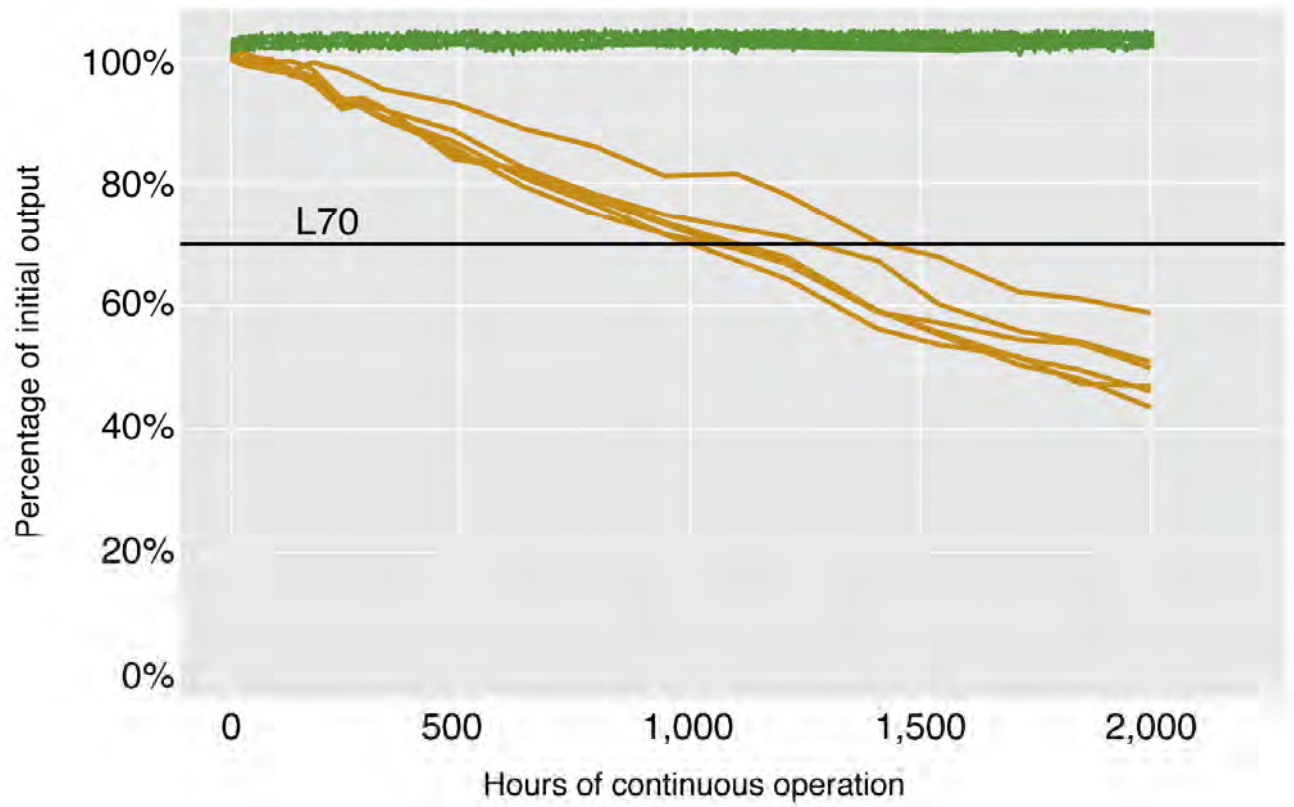
# **Bad** Lumen Maintenance LED Product

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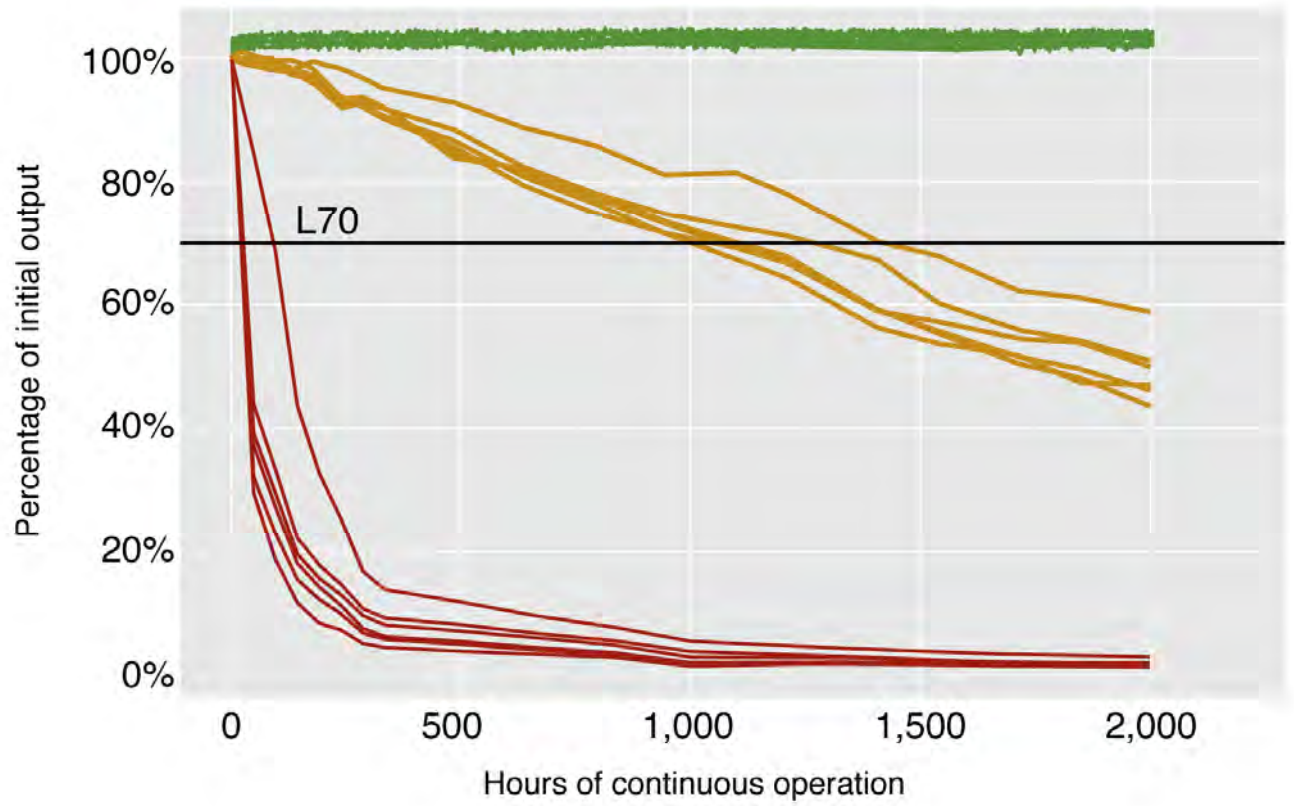
# **Ugly** Lumen Maintenance LED Product

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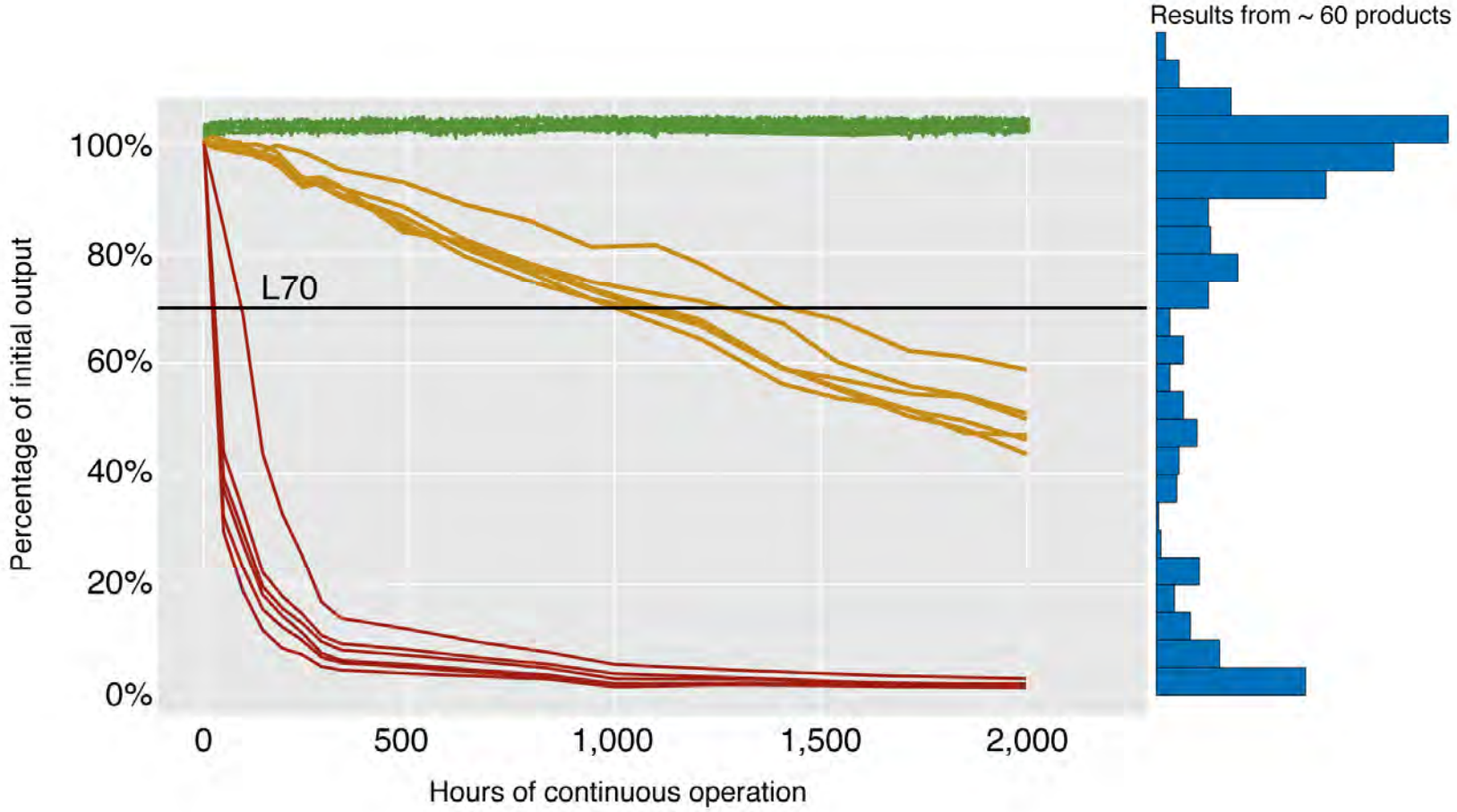
# Lighting Global Experience: a range of lumen maintenance results

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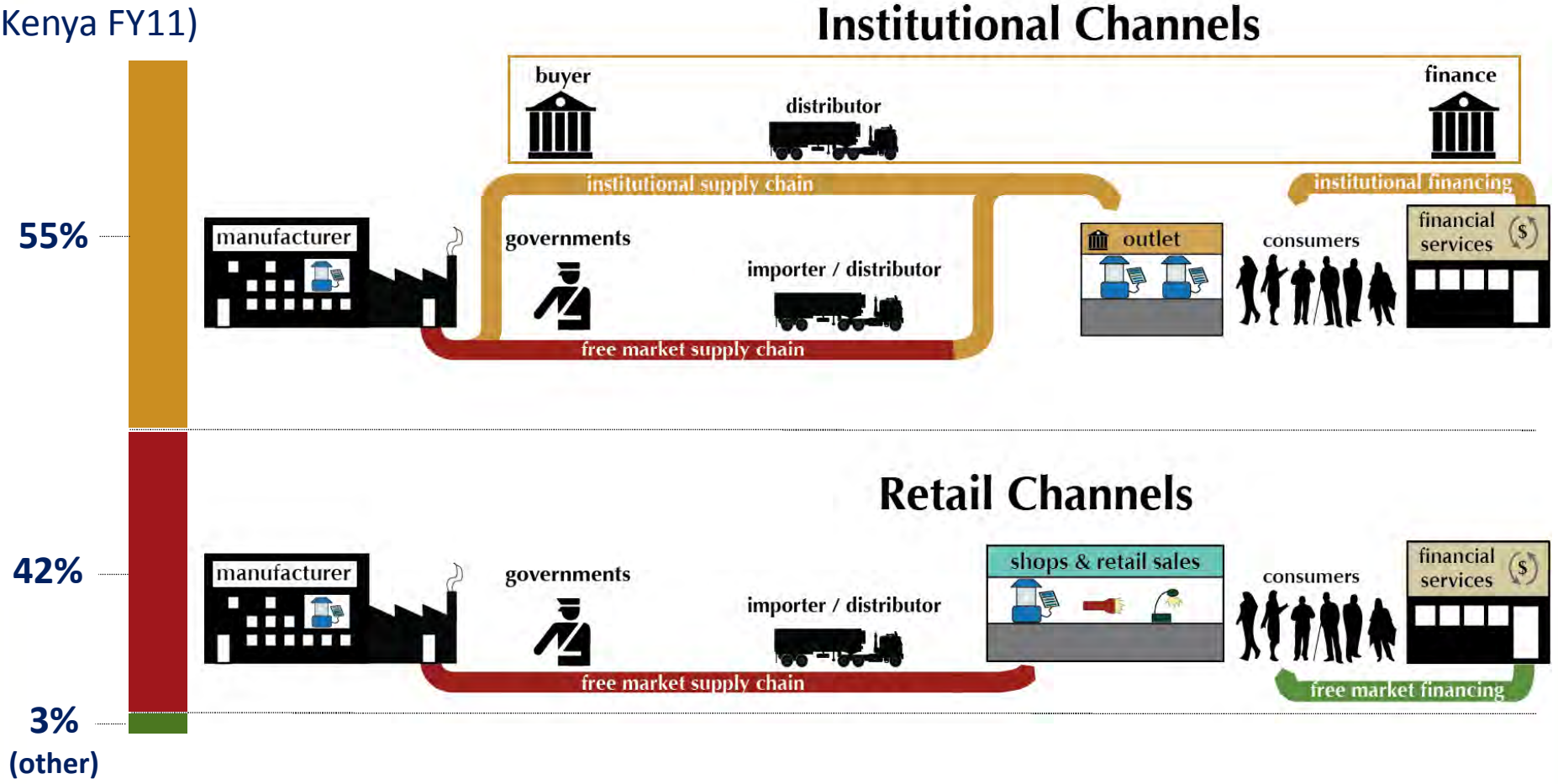
# Market for good quality products is currently driven by a handful of institutional buyers and financers

Upstream buyer / financer needs: Standardized Testing, B2B seal, Specs Sheets

**Market Share**
(Kenya FY11)

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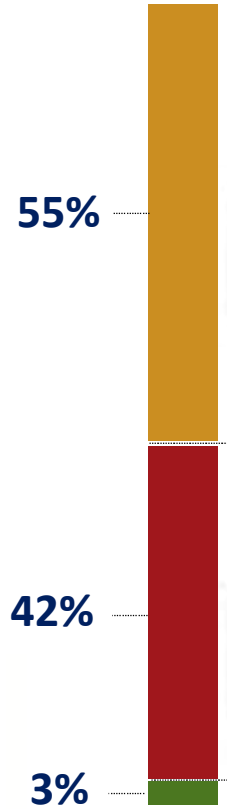
# Institutional and Retail Supply Chain Characteristics

**Market Share**
(Kenya FY11)




## Institutional Channels

- **Over 50% of purchase decisions in Kenya are strongly influenced by a handful of non-governmental institutions.**
- **Initial research indicates even more institutional influence in other African markets.**

## Retail Channels

- **Nascent retail channels are still weak and poorly defined; effective delivery of information about quality through these channels is important, but will be challenging in near term.**

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# Our international team for off-grid lighting quality assurance has deep experience

## Off-Grid Lighting QA Core Team

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U.S. DEPARTMENT OF ENERGY

IEC

SCHATZ ENERGY RESEARCH CENTER

NAVIGANT

Fraunhofer ISE

## Lighting Global QA Team Expertise

| | |
|---|---|
| Team Leadership | Rick Duke (DOE), Patrick Avato (IFC), Dana Rysankova (WB) |
| Technical Team Lead | Arne Jacobson |
| Energy Systems Experts | Peter Alstone, Kristen Radecsky, Norbert Pfanner, and others |
| Lighting and LED Experts | Erik Page, Kevin Gauna |
| QA Strategic Planning | Shannon Graham, Paul Waide |
| Industry Liaisons | Rodd Eddy, Leo Blyth |
| End user Liaison | Jenny Tracy |
| Technical Writers | Marc Marshall, Robert Hosbach |

## Regional Teams

| | |
|---|---|
| East Africa Team | Itotia Njagi, Nana Asamoahmanu, … |
| West Africa Team | Abdoulaye Ba, Chris Carlsen, … |
| India Team | Hemant Mandal, Anjali Garg, Naomi Bruck, Dr. TC Tripathi … |

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