How to Maintain Quality Standards in Rural Electrification

Source: Clean Energy Ministerial, 2016

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BRIEF PROFILE:

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Outline

1. Introduction
2. What are quality standards?
3. How can governments enforce standards?
4. Concluding remarks
5. Questions

Introduction

- A common cause of the failure of rural electrification initiatives is sub-standard quality: components, project design, etc.

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Introduction

- Rapid influx of low cost, sub-standard components is a major problem in many markets in Sub-Saharan Africa
- Lower quality rural electrification projects lead to a host of interrelated challenges:
  - Lower system output
  - Less reliable system operation
  - More frequent need for maintenance/replacement parts
  - Higher life-time system costs (i.e. tariffs)
  - Lower customer satisfaction

→ Introducing measures to ensure high quality standards is therefore key[1]

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[1] **ARE 2011: https://www.ruralelec.org/sites/default/files/are_technological_publication_0.pdf**

Introduction

- In Tanzania, it is estimated that 65-70% of pico PV systems are of sub-standard quality
- Tanzania Bureau of Standards is attempting to address the problem by promulgating new standards
- Of the 17 shops the Bureau visited recently, all were carrying sub-standard components
- The problem of sub-standard quality products is

widespread in virtually all (if not all)

jurisdictions across Africa

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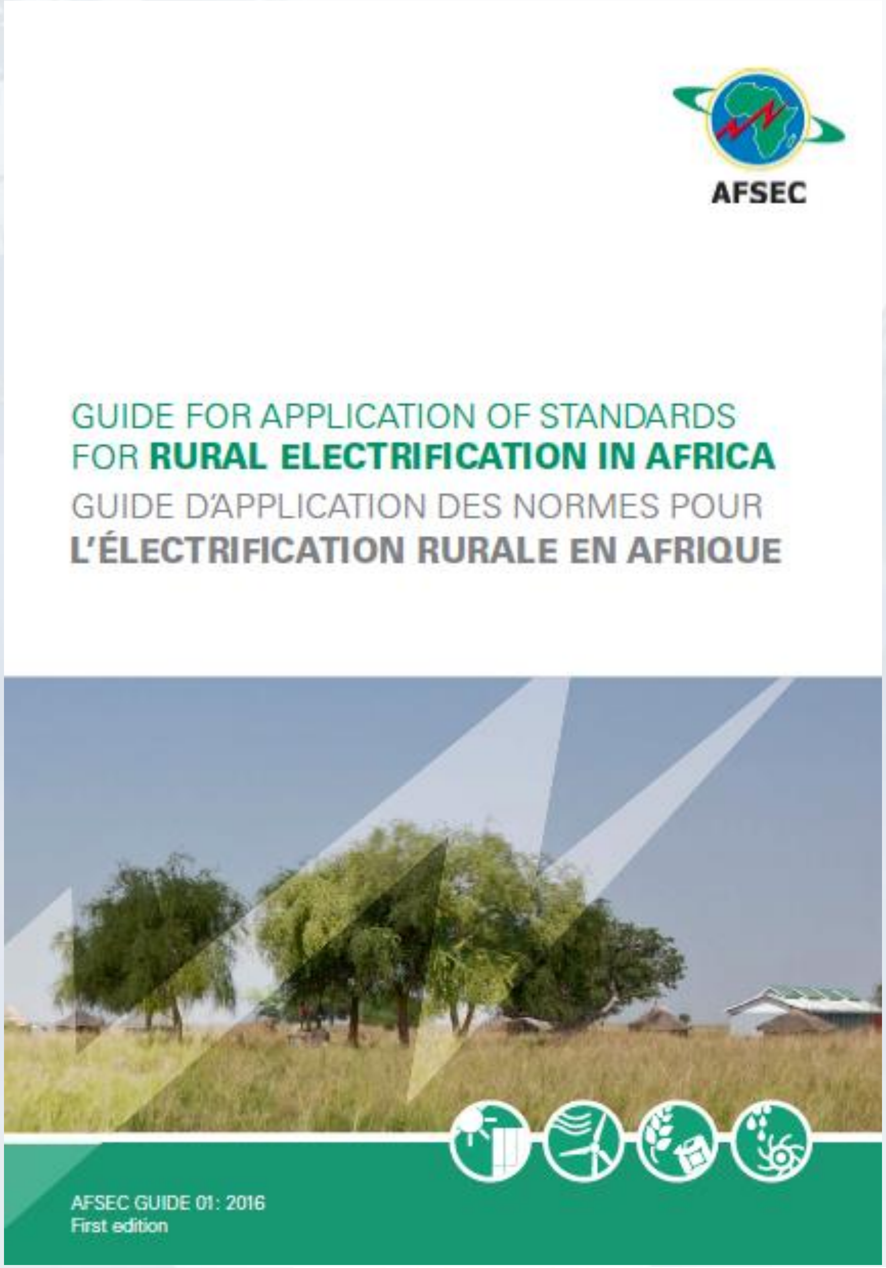
Introduction

- Recent guide published (both in French and in English) on applying and harmonizing standards in rural electrification

AFSEC 2016:http://www.afsec-africa.org/Portals/15/Documents/2016/ptb_AFSEC_Guide_Rural_Electrification_Africa_WEB.pdf



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2: What are Quality Standards?

Understanding Quality Standards

- Quality standards refer to the various technical specifications for line fittings, poles, transformers, PV modules, battery systems, inverters, etc. used in rural electrification projects

- Can also apply to voltage and frequency levels, plant components, relays, fuses, etc.

- In order to avoid duplication, mis-matched parts, the difficulty of securing replacement parts in a timely manner, etc., **having clear technical standards is critical**

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Understanding Quality Standards

- "Without international standards, there would be no confidence in the global supply chain of goods and services that most of us so readily take for granted."

- "From tech gadgets to office and household items, to services that fuel the global economy, standards are necessary to ensure safety, dependability and interoperability. " – Maria Lazarte, ISO

- Even a "World Standards Day": October 14th

http://www.iso.org/iso/home/news_index/events/world-standards-day2016.htm

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3: Overview of Specific Examples

The World Bank's "Lighting Global" Standards:

Includes five key standards:

1. **Truth in Advertising:** Advertising and marketing materials accurately reflect tested product performance.
2. **Durability:** Product is appropriately protected from water exposure, has durable switches and connectors and, if portable, survives being dropped.
3. **System Quality:** Product passes a visual wiring and assembly inspection.
4. **Lumen Maintenance:** Product maintains consistent light output after 2,000 hours of operation.
5. **Warranty:** A consumer-facing warranty is available

Meeting the Standards is a requirement for participation in Lighting Global support programs.

https://www.lightingglobal.org/qa/standards/
IEC/TS 62257-9-5 Standard

The World Bank's "Lighting Global" Standards:

The Lighting Global Standards include specific standards for:

- **Pico-PV systems:** https://www.lightingglobal.org/wp-content/uploads/2014/10/Pico_MQS_v6.pdf

- **Solar Home System (SHS) "kits":** https://www.lightingglobal.org/wp-content/uploads/2014/10/SHS_MQS_v1.pdf

- **Outdoor cables:** https://www.lightingglobal.org/wp-content/uploads/2013/12/OutdoorCablePolicy_v1.pdf

- **Pay-as-you-go (PAYG) Solar Systems:** https://www.lightingglobal.org/wp-content/uploads/2013/12/QA-for-PAYG-Final.pdf

- Plus a range of others

IEC Standards

- The International Electrotechnical Commission (IEC) maintains and publishes standards that provide a benchmark for the development of national standards: IEC Technical Committee 82 (TC 82)

In the future, TC 82 work will include:

- System commissioning, maintenance and disposal.
- Characterization and measurement of new thin film photovoltaic module technologies such as CdTe, CIS, CuInSe2, and so forth.
- New technology storage systems.
- Applications with special site conditions, such as tropical zone, northern latitudes and marine areas.

→ **Government regulators are increasingly adopting international standards** for a growing range of products in rural electrification

http://www.iec.ch/renewables/solar_power.htm

ISO Standards

- The International Standards Organization sets out clear, detailed standards across a wide range of products
- This table provides a select list of standards that apply to solar PV

http://www.iso.org/iso/home.html

Standard and/or project	Stage	ICS
ISO 9488:1999 Solar energy -- Vocabulary	90.93	27.160 01.040.27
ISO 22975-2:2016 Solar energy -- Collector components and materials -- Part 2: Heat-pipes for solar thermal application -- Durability and performance	60.60	27.160
ISO 22975-3:2014 Solar energy -- Collector components and materials -- Part 3: Absorber surface durability	60.60	27.160
ISO/AWI 22975-5 Solar energy -- Collector components and materials -- Part 5: Insulation material durability and performance	20.00	
ISO 9553:1997 Solar energy -- Methods of testing preformed rubber seals and sealing compounds used in collectors	90.93	27.160 83.140.50
ISO 9806:2013 Solar energy -- Solar thermal collectors -- Test methods	90.92	27.160
ISO/DIS 9806 Solar energy -- Solar thermal collectors -- Test methods	40.60	27.160
ISO 9808:1990 Solar water heaters -- Elastomeric materials for absorbers, connecting pipes and fittings -- Method of assessment	90.93	97.100.99 27.160 83.140.30
ISO/TR 10217:1989 Solar energy -- Water heating systems -- Guide to material selection with regard to internal corrosion	90.93	97.100.99 27.160
ISO 22975-1:2016 Solar energy -- Collector components and materials -- Part 1: Evacuated tubes -- Durability and performance	60.60	27.160

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http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_tc_browse.htm?commid=54018

International Standards for Off-grid PV Systems

Technology	Description	Reference
Solar	Panels	IEC 61215 IEC 61646
	Charge controllers	IEC 62509 IEC 62109-1 IEC 62109-3 IEC 62093 IEC CISPR 11 IEC 61000-4 PV GAP, PVRS6A "Charge controllers for photovoltaic stand-alone systems with a nominal voltage below 50V" accepted for use in the IECEE PV scheme.
	IInverters	IEC 61683 IEC 62109 IEC 62093 IEC CISPR 11 IEC 61000-4 PV GAP, PVRS 8A "Inverters for photo-voltaic stand-alone systems."
	Energy-efficient lights	IEC 60969 IEC 61347-1 IEC 61347-2 PV GAP, PVRS7A "Lighting systems with fluorescent lamps for photovol-taic stand-alone systems with a nomi-nal voltage below 24 V."
	BOS components and minor equipments	IEC 60669-1 IEC 60227-1-4

Source: AFSEC 2016

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Source: ARE 2011

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International Standards for Wind and Micro-Hydro

Wind	Turbine	IEC 61400-2 IEC 61400-11 IEC 61400-12
Microhydro power	Turbines and generator (rotating electrical machines)	IEC 60034 – 1 IEC 61362 IEC 61366-1 IEC 61116-1992
	Field Acceptance Test for Hydraulic performance of turbine	IEC 60041: 1991
	Governing system for hydraulic turbines	IEC 6030
	Transformers	IS 3156 – 1992 IS 2705 – 1992 IS 2026 - 1983
	Inlet valves for hydro power stations & systems	IS 7326 – 1902
	Guide for commissioning, operation and main-tenance of hydraulic turbines	IEC 60545 (1976-01)
	Hydraulic turbines, storage pumps and pump turbines – Model acceptance tests	IEC 60041 (1991-11)

Source: AFSEC 2016

Source: ARE 2011

Standards for Electrification

MINIMUM STANDARDS FOR PHYSICAL CHARACTERISTICS OF LEAD-ACID BATTERIES USED IN RE SYSTEMS:

Parameter	Minimum standards - Flooded and VRLA
General Design	Designed for deep cycle application. No shallow cycle or automotive SLI batteries.
Plate Design	Flat plate or tubular plate design may be used as long as other parameters are met.
Vent / Valve Construction	Vents (or relief valves for VRLA) should be constructed with anti-flame propagation mechanisms and should prevent electrolyte leakage.
Case Composition	The battery case should be constructed of polypropylene, ABS or PVC.
Terminal Polarity	Identification of battery terminal polarity should be indelibly visible.
Labels	Labels shall meet the general requirements of Battery Council International and local standards as required.

MINIMUM STANDARDS FOR CHARACTERISTICS OF LEAD-ACID BATTERIES USED RE SYSTEMS:

Parameter	Minimum standards - Flooded	Minimum standards – VRLA
Operating Temperature	-20°C to +45°C (< 90 % of humidity)	
Self -Discharge Rate	Maximum 15% of Rated Capacity at 25oC per month	Maximum 5% of Rated Capacity at 25oC per month
Efficiency	Efficiencies are to comply with IEC 61427 standard	
Cycle Life	12-Volt battery monoblock shall provide minimum 600 cycles at 50% DOD at 25oC, according to the IEC 61427standard. 2-Volt, 6-Volt cells configured battery bank shall provide minimum 1,000 cycles at 50% DOD at 25oC.	AGM 12-Volt battery monoblock shall provide minimum 1,200 cycles at 50% DOD at 25oC, according to the IEC 61427 standard and 1,000 cycles for GEL 12-Volt battery monoblock in the same conditions. 2-Volt, 6-Volt cells AGM configured battery bank shall provide minimum 1,500 cycles at 50% DOD at 25oC according to the IEC 61427standard.
Initial Capacity	The discharge capacity of a deep cycle solar battery may initially be approximately 75% of full rating and build up in capacity during normal operation.	

Source: ARE 2011

Standards for Electrification

MINIMUM STANDARDS FOR SYSTEM DESIGN AND INSTALLATION CHARACTERISTICS OF LEAD-ACID BATTERIES USED RE SYSTEMS:

Parameters	Minimum standards - Flooded	Minimum standards – VRLA
Depth of Discharge (DOD)	The daily average discharge shall fluctuate in the range of 2 to 25% DOD. The maximum occasional discharge shall be 80% DOD.	
Autonomy	The battery bank design should allow for 2 to 5 Days of autonomy, at 80% DOD at the worse case monthly average ambient cold temperature, according to the load demands of the application and to the type systems (e.g. hybrid power systems needs less battery capacity)	
Ambient Temperature	The battery bank size design shall be based on the worse case monthly average ambient cold temperature, per battery manufacturer de-rating factors recommendations.	
Controller Technology	The battery shall be charged via a charge regulator with Pulse-Width Modulation (PWM) charge algorithm and temperature compensation feature. Additionally, Maximum-Power-Point Tracking (MPPT) algorithm can be considered for larger loads.	
Controller Set Points	The charge regulator should allow for voltage set points consistent with battery manufacturer recommendations for normal and equalize charging.	
Inverter and Controller (LVD)	Load circuitry in the system shall feature Low Voltage Disconnect (LVD) to prevent over discharge of the battery. LVD is typically featured at the controller for the DC loads and at the inverter for the AC Load, or as a discreet relay driver.	
Hardware	Terminal connections should be made with stainless steel hardware (screw and nuts) and connections should be inspected regularly for corrosion.	
Storage Interval	At 25° C, new Flooded batteries should not be in storage without charging for more than 3 months before installation.	At 25° C, new VRLA batteries should not be in storage without charging for more than 10 months before installation.
Location	The battery should be located in a space directly vented to outside air with restricted access.	The battery should be located in a ventilated space with restricted access.
Maintenance	Electrolyte must be replenished with distilled water according to manufacturer recommendations at regular intervals.	VRLA batteries are considered maintenance free and because they are sealed do not allow for replenishment of electrolyte.
Ventilation	The battery room shall be properly ventilated to prevent accumulation of explosive hydrogen gas concentration and to prevent fumes inside living spaces.	
Safety	Provisions shall be taken to avoid accidental short circuit of battery terminals. Always wear protective clothing, gloves and eye protection when working with batteries. In addition, since the battery is a virtually unlimited voltage source, wiring must be protected by mean of over current protective devices sized according to the wire downstream as close as possible to battery terminals	

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Source: ARE 2011

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International Standards for Lighting Systems

Components	International Standards and Explanation
Energy-efficient lights	IEC 60969 Ed 2: Self ballasted lamps for general lighting purposes - Performance Requirements. IEC 61347-1: 2007, Lamp control gear. Part 1: General and safety requirements. IEC 61347-2: Lamp control gear. Part 3: Particular requirements for AC-supplied electronic ballasts for fluorescent lamps, Part 4: Particular requirements for DC-supplied electronic ballasts for general lighting. PV GAP, PVRS7A "Lighting systems with fluorescent lamps for photovoltaic stand-alone systems with a nominal voltage below 24 V."
BOS components and minor equipments	IEC 60669-1: Switches for household and similar fixed-electrical installations. Part 1: General requirements. IEC 60227-1-4: Polyvinyl chloride insulated cables of rated voltage up to and including 450 V/750 V-Parts 1-4: General requirements

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Standards for Lighting Systems

However, standards must be regularly updated.

E.g. CFLs are beginning to rapidly replace LEDs in rural electrification projects:

- More efficient (80 lumens/watt vs. 57 lumens/watt)
- Longer life (40,000 to 50,000 hours vs. 10,000 hours)
- More robust (better suited to conditions in rural regions)
- Fewer environmental and health impacts (no mercury, fewer GHGs)
- Superior light quality
- Create smaller “peaks” for mini-grid systems
- Etc.

Standards are necessary, but…

- … they are insufficient.

- The biggest challenge is not *adopting* standards:

→ **<u>it's ENFORCING them.</u>**

3: How can governments enforce standards?

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Enforcement Strategies

- There is an important distinction between **different types of rural electrification :**
  1. Grid extension
  2. Mini-grids
  3. Solar Home Systems (SHS)
  4. Do-it-yourself, off-the-shelf products

- For #1 and #2, enforcing quality standards is easier, as it can be done at the permitting stage, via tendering with clear technical specifications built into the tender documents; regular monitoring and site inspections; also, mini-grids can be required to comply with the national grid standards

- For #3 and #4, the problems are more difficult to tackle

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Enforcement Strategies

- For #3, if the Solar Home Systems model is partnered with donor or government funds or grants, quality standards can be made a condition for the disbursement of funds:
  → in this case, the standards for SHS should be developed by national regulators and stipulated clearly upfront

- **It is the un-regulated, informal, "off-the-shelf" market (#4) that poses the greatest challenge**

- On current trends, it *could* also become the largest segment by market volume by 2030

http://www.cleanenergyministerial.org/Portals/2/pdfs/Global_LEAP_The_State_of_the_Global_Off-Grid_Appliance_Market.pdf

Enforcement Strategies

There are three (3) broad strategies to enforce standards:

1. **Permitting and certifying** (*ex ante*): requiring certain minimum standards before a given activity can take place, or a given product can be sold

2. Targeted **inspections** (*ex post*): monitoring and inspecting an activity that is already taking place

3. **Sanctions** and **penalties** (both financial and non-financial): attempting to improve a business model or market segment by introducing fines and penalties, revoking operating licenses, etc.

Enforcement Strategies

- Performing actual enforcement measures (imposing fines, administrative or criminal proceedings, etc.) is typically based on **a pre-defined set of offences** (e.g. use of sub-standard PV modules or inverters, selling sub-standard light bulbs, etc.)

- Good enforcement also keeps track of repeat offenders, and difficult areas (e.g. particular parts of the supply chain, or particular retailers) in order to improve future inspection efforts

- Each stage of the enforcement process requires **judgment**, and a calibrated approach

- In certain cases, outright **product bans** may be warranted

Enforcement Strategies

- Enforcement strategies are ideally both **pro-active**, and **re-active**
- Stringent approaches (e.g. product bans) require awareness campaigns and large fines, which may be difficult to apply in practice
- In many countries, enforcement is designed to be "**responsive**": i.e. to adapt to the profile and behavioral responses of the actor
- However, even "responsive regulation" faces challenges when the behavior is difficult, if not impossible, to prohibit and control

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Enforcement Strategies

- **Example:** a shop owner is found to be selling sub-standard PV modules and inverters.
- Inspectors or regulators make the shop owner aware of the government standards in place: no fine imposed initially
- A subsequent inspection reveals that the shop owner is still selling the same sub-standard PV modules and inverters
- The inspectors impose a fine, and require the shop owner to stop selling sub-standard products

Photo: http://on.wsj.com/1JChvKu

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Enforcement Strategies

- Two months later, inspectors find that the same shop owner continues to sell the sub-standard PV system components
- At this stage, regulators revoke the shop owner’s right, or permit, to sell solar PV modules and impose an even larger fine

→ Sanctions escalate in response to the continued failure to comply

- However, in many cases, these approaches simply don’t work in practice

Photo: http://on.wsj.com/1JChvKu

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Enforcement Problem

- “Whack-a-Mole”: as soon as you hit one, another pops up

Enforcement Strategies

- The result is the continued availability of sub-standard products in markets across Sub-Saharan Africa:
  - Light bulbs
  - PV modules
  - Inverters
  - Etc.

- Porous borders and **lack of resources for inspection** exacerbate the problem

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Enforcement Strategies

What are governments/regulators to do?

Enforcement Strategies

- **Be pragmatic:** it isn't possible to eradicate all sub-standard products from a given market
- **Make it easier for the products *you want* to enter the market:** e.g. create streamlined approvals (including simplified customs processes!) for certified products
- **Customer education and awareness can also help** customers avoid sub-standard components
- Government or industry "seals" and other **visual symbols of quality** can be useful, but can be easy to abuse

Enforcement Strategies by Actor Type

- An alternative approach is to categorize actors into different categories, and to tailor the inspection/penalty model to each

	Well-informed	Ill-informed
Well-intentioned	- Standard compliance - Continue providing information and awareness as needed	- Inform - Provide guidance - Assist - Etc.
Ill-intentioned	- Instill fear of God	- Fines - Penalties - Revoke operating license - Criminal proceedings - Etc.

Based on Kagan and Scholz, 1984

Enforcement Strategies: Positive News

- Progress is being made
- 20 national governments, including the 15 ECOWAS countries[1] have adopted favorable policies to support the adoption of off-grid lighting products that meet IEC Technical Specifications
- Higher quality standards are also being adopted in a wide range of markets across Asia and Latin America
- Most donors already require minimum standards on grant-funded projects for electrification and off-grid lighting projects

[1] Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo

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Enforcement : Lessons from other sectors

Also, lessons are being learned from other sectors e.g. → the adoption and enforcement of **building codes**

- Building codes are often top-down and ineffectual
- Often set the bar too high, making it unaffordable for average citizens: e.g. in the Caribbean, only the wealthiest 15% of households can afford to build according to code
- Moreover, building codes often increase dependency on imported materials and components, pushing up construction costs
- It remains challenging to control informal construction, even in the wealthiest/most developed countries

Source: https://www.gfdrr.org/sites/gfdrr/files/Built%20Environment%20Project%20Description.pdf

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Enforcement: Lessons from other sectors

Lessons from the building sector include:

- **Standards should focus on preventing human harm first** (e.g. banning products that pose a real risk of electrocution, or of serious malfunction, or of damage to appliances, etc.)

- **Ensure standards remain realistic**

- Introduce measures to **minimize the price spread** between sub-standard and "standard-compliant" products

Source: https://www.gfdrr.org/sites/gfdrr/files/Built%20Environment%20Project%20Description.pdf

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4: Concluding Remarks

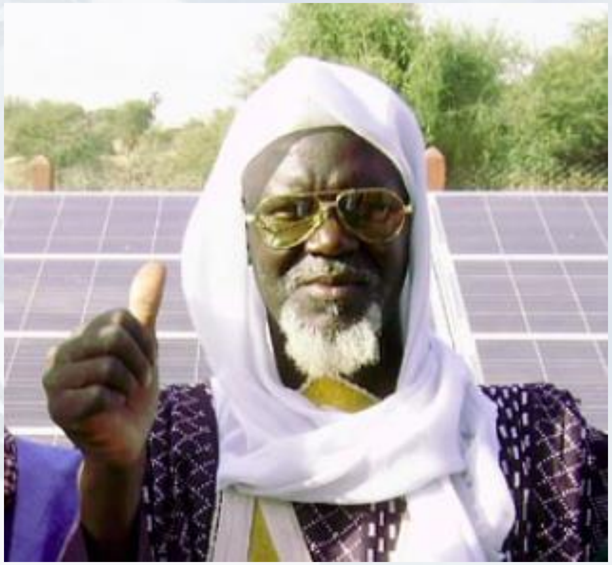
Concluding Remarks

- Sub-standard quality systems and installations contributes to under-performance, making the transition to cleaner and more reliable energy sources slower, and costlier

- Governments across Sub-Saharan Africa need to focus on adopting, and ***enforcing***, realistic quality standards

- Despite their importance, standards themselves need to be **adapted** over time to changing technologies

- **Be pragmatic**



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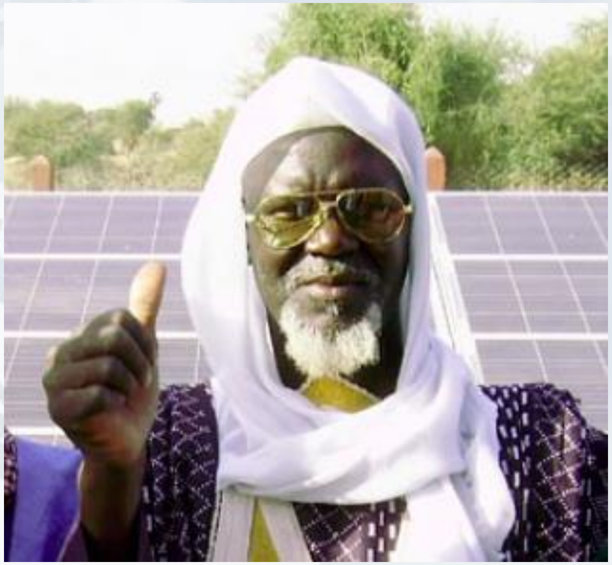
Concluding Remarks

- The goal of standards is to ***reduce***, rather than increase, the costs of doing business
- For companies, start-ups, and NGOs working in rural electrification, **clarity is key**
- **Standards should be published online, clearly written, and consistently enforced**
- **Make it easier for the products *you want* to enter the market** to be able to do so, while making it harder for the ones you don't.



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Thank you!

Questions?

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Useful Resources

AFSEC 2016:http://www.afsec-africa.org/Portals/15/Documents/2016/ptb_AFSEC_Guide_Rural_Electrification_Africa_WEB.pdf

IRENA (2016): Policies for Private Sector Mini-grids
http://www.irena.org/DocumentDownloads/Publications/IRENA_Policies_Regulations_minigrids_2016.pdf

Clean Energy Ministerial (2016).
http://www.cleanenergyministerial.org/Portals/2/pdfs/Global_LEAP_The_State_of_the_Global_Off-Grid_Appliance_Market.pdf

ARE (2012): https://www.ruralelec.org/sites/default/files/are_technological_publication_0.pdf

IFC Lighting Global: https://www.lightingglobal.org/wp-content/uploads/2016/10/global_off-grid_solar_market_report_jan-june_2016_public.pdf

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