

LIGHTING AFRICA

Catalyzing Markets for Modern Lighting

Off-Grid Lighting and Product Quality in Kenya

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THE WORLD BANK



Off-Grid Lighting Market in Kenya

- Off-grid lighting has great promise to deliver affordable, high quality lighting services to low income Kenyans





Emerging Market for Off-Grid Lighting Products in Kenya

Market for Off-Grid Lighting Products is Growing in Kenya



- Variety of technologies
 - CFL and LED lights
 - Multiple charging modes
- Range of prices; many inexpensive, some not
- Rapidly changing designs
- Big differences in quality



Danger of Market Spoiling is Real

Low cost LED torches are entering African markets in large numbers. Many perform poorly.



Low cost LED torches for sale in Kenya



Counterfeit LED torch (powered by 3 non-rechargeable button batteries; the mechanical charger was non-functional)



Off-Grid Lighting Products in Shops in Kericho, Kenya

- Survey of 37 shops in Kericho in June 2009



← Street Vendors

Wholesale Shops →

← Retail Shops

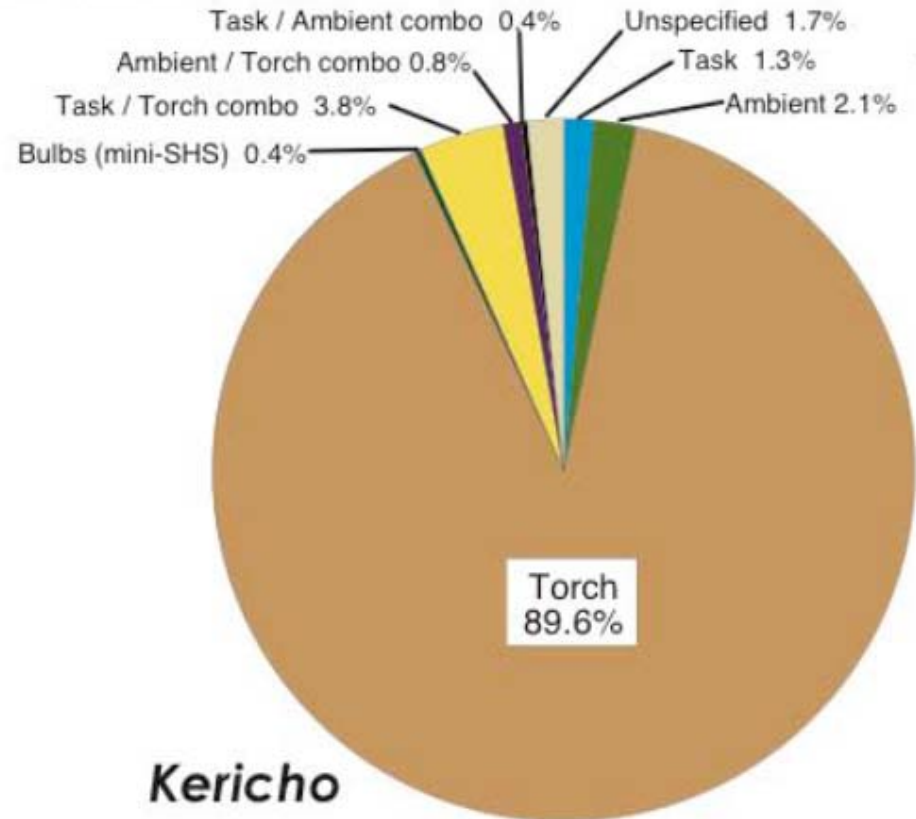




Off-Grid Lighting Products in Shops in Kericho, Kenya

- Most off-grid lights are low cost torches

Form Factor



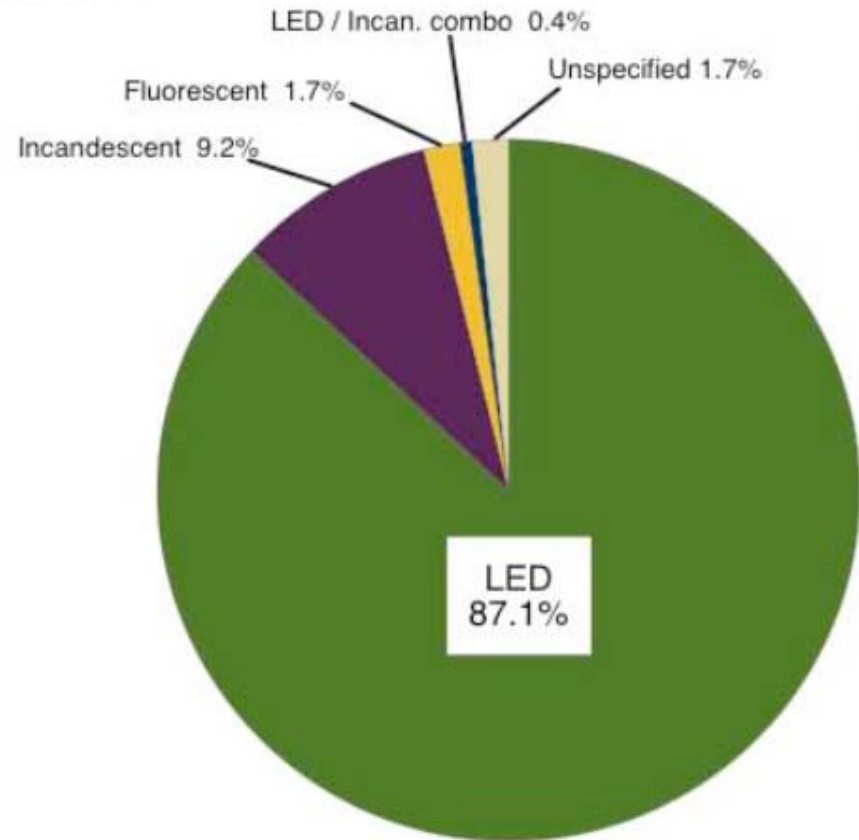
Johnstone, et al. (2009) "Market Presence of Off-Grid Lighting Products in the Kenyan Towns of Kericho, Brooke, and Talek," *Lighting Africa*, <http://lighting africa.org>



Off-Grid Lighting Products in Shops in Kericho, Kenya

- Most off-grid lights are low cost torches
- LED technology is now dominant

Light Source



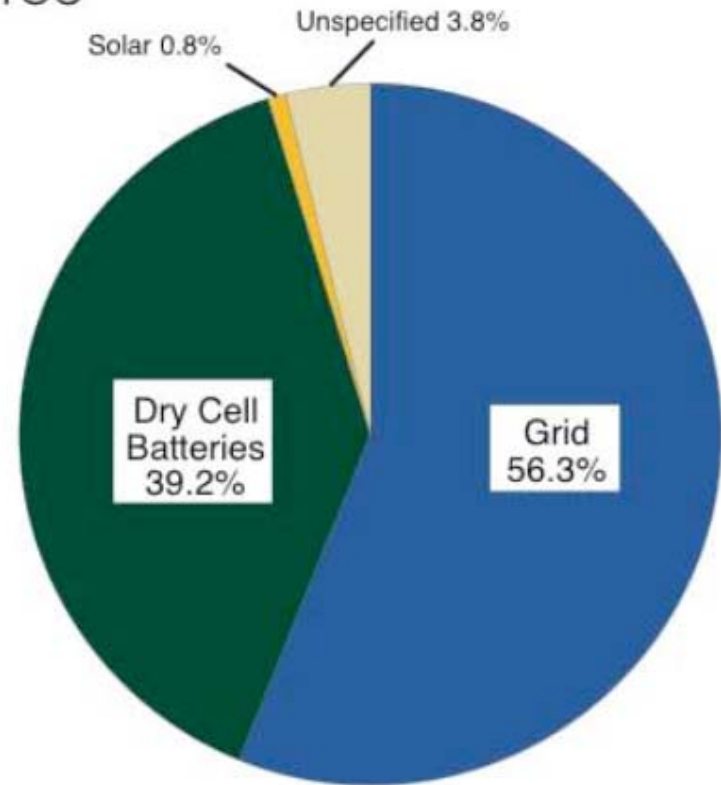
Johnstone, et al. (2009) "Market Presence of Off-Grid Lighting Products in the Kenyan Towns of Kericho, Brooke, and Talek," *Lighting Africa*, <http://lighting africa.org>



Off-Grid Lighting Products in Shops in Kericho, Kenya

- Most off-grid lights are low cost torches
- LED technology is now dominant
- Common products include rechargeable (grid) and dry cell energy storage

Energy Source

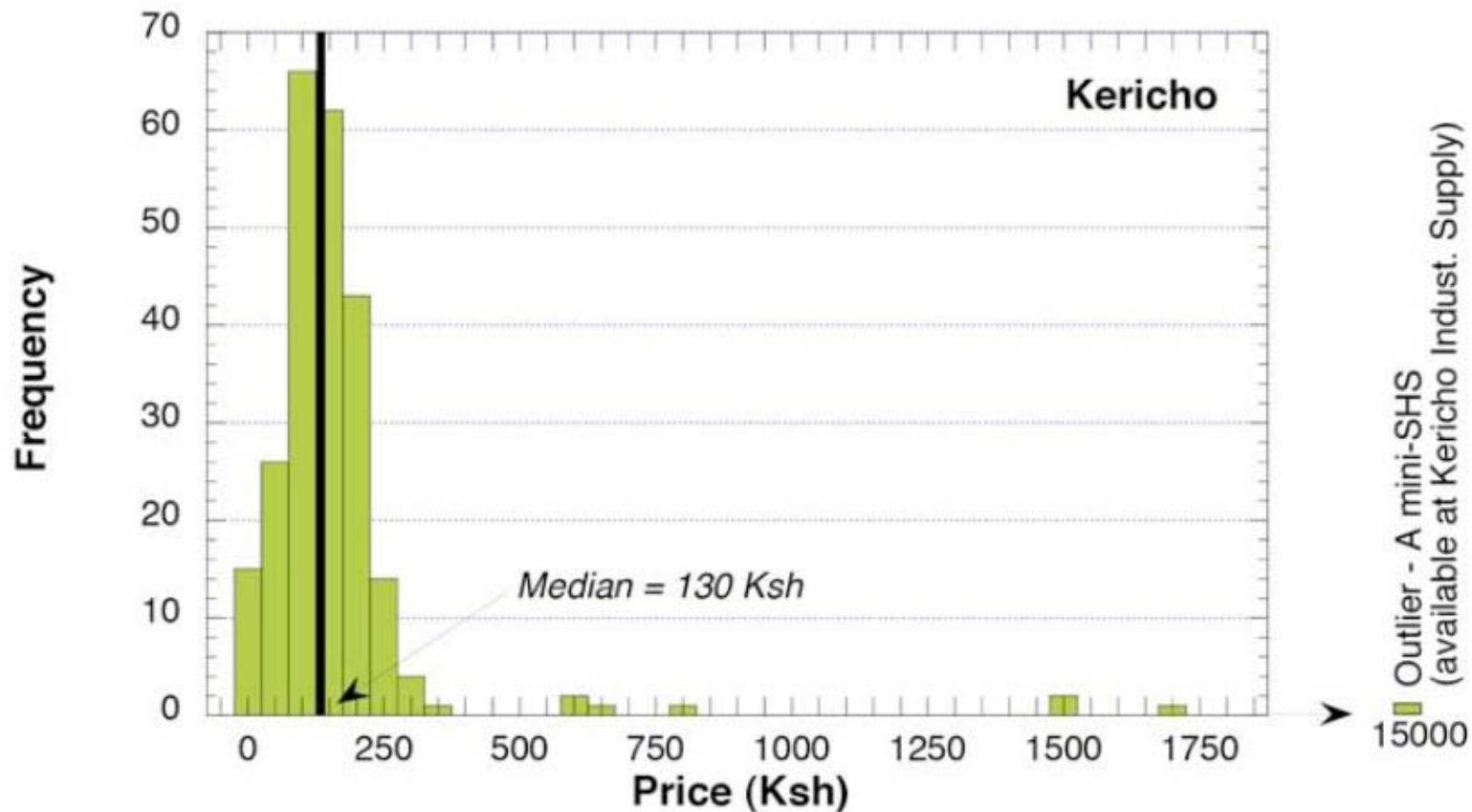


Johnstone, et al. (2009) "Market Presence of Off-Grid Lighting Products in the Kenyan Towns of Kericho, Brooke, and Talek," *Lighting Africa*, <http://lighting africa.org>



Low Cost Products Dominate Market

- Retail price of most products is very low (<400 KSh)



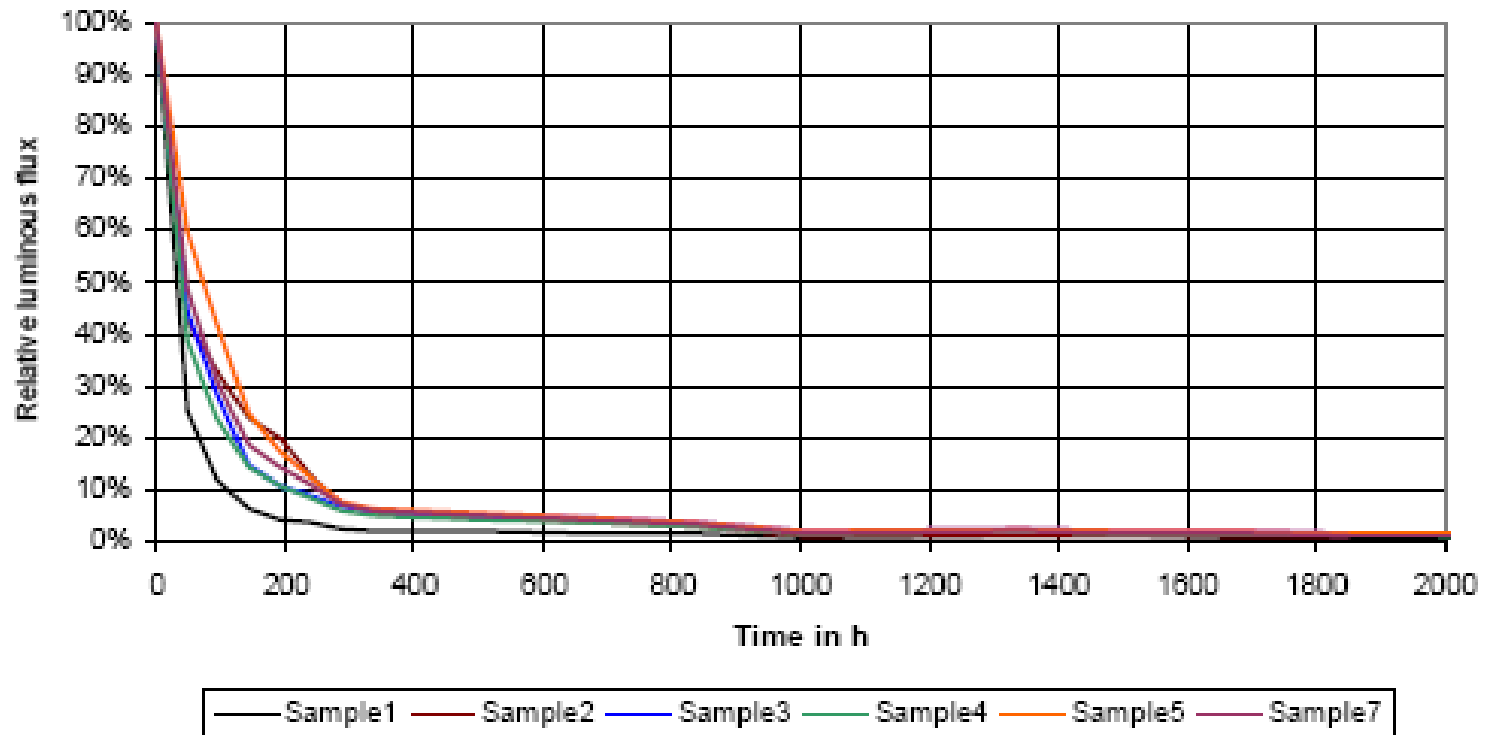
Johnstone, et al. (2009) "Market Presence of Off-Grid Lighting Products in the Kenyan Towns of Kericho, Brooke, and Talek," *Lighting Africa*, <http://lighting africa.org>



Lab results and field tests show that quality of low cost torches is very poor

- For example, light output from LEDs drops rapidly after less than 100 hours of use

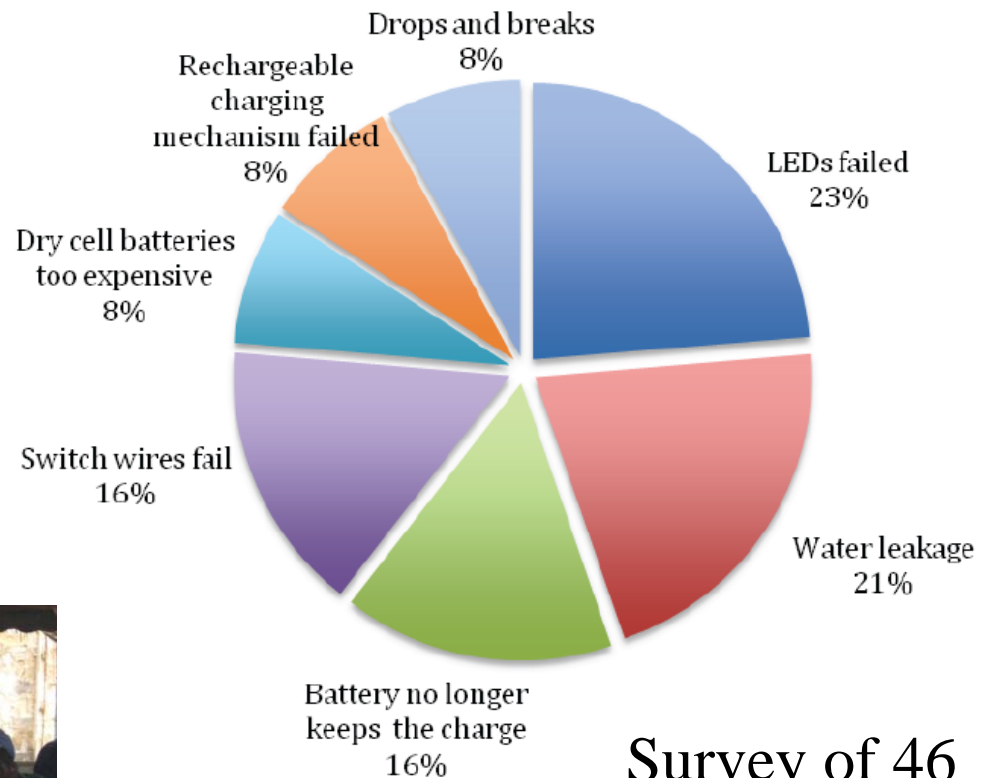
@ constant 4.0V [battery replaced by power supply]





Lab results and field tests show that quality of low cost torches is very poor

- End users report rapid failure due to LED quality, water leakage, breakage, battery failure, and others



Survey of 46 torch users in Kenya, '09

Tracy, et al. (2009) Quality and Performance of LED Flashlights in Kenya: Common End User Preferences and Complaints, Lumina Project Research Note #4, <http://light.lbl.gov>



Market Spoiling is a Major Concern



Will off-grid lighting realize its promising, or will low quality products dominate?

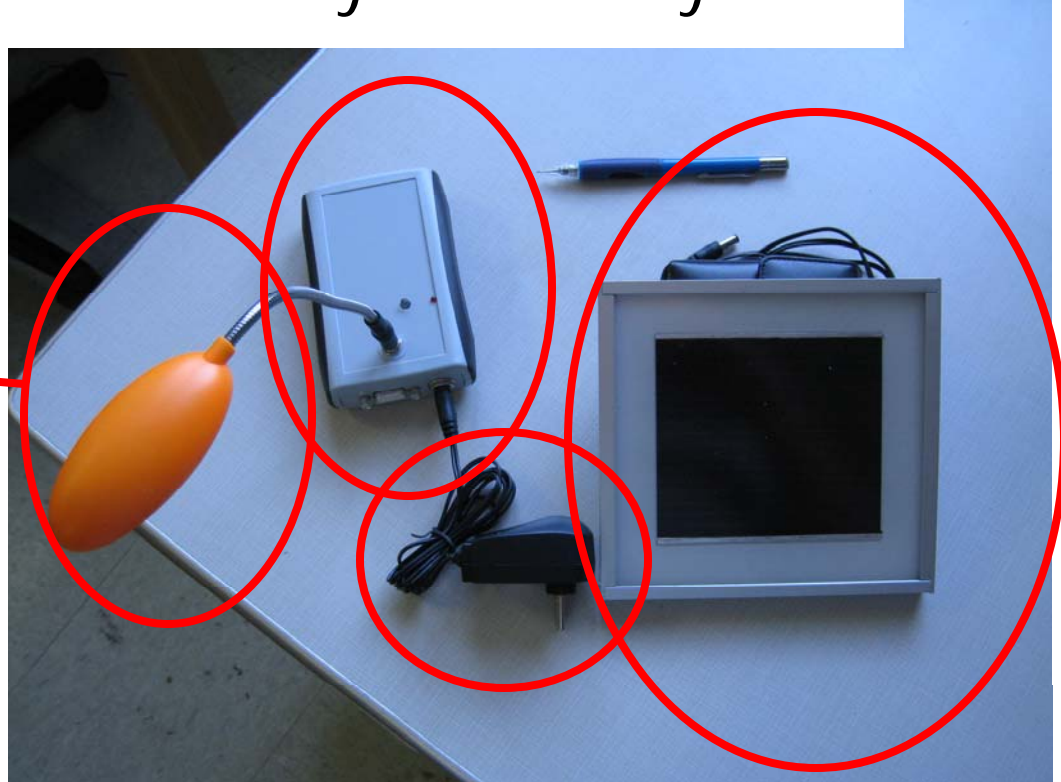


Off-Grid Lighting System Components

LED or CFL



Battery & Circuitry



Switches, Housing,
Wires, Connectors, etc.

Power Source
(solar, AC, dynamo)

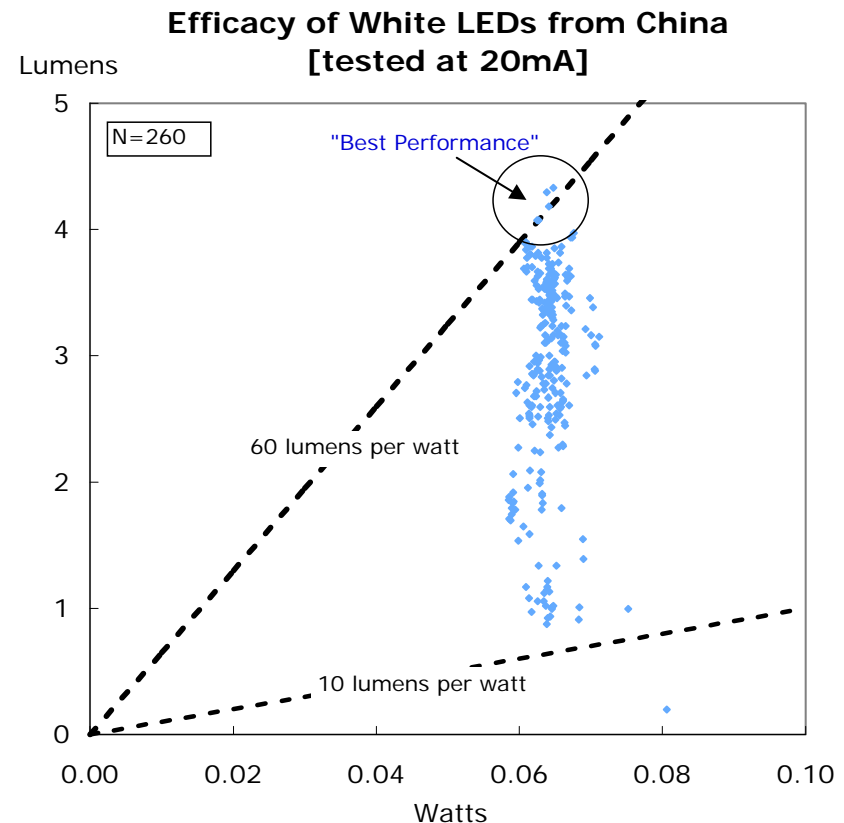


LED performance varies widely

Brand name LEDs perform very well, but the quality of no-name LEDs varies widely and can be very poor.



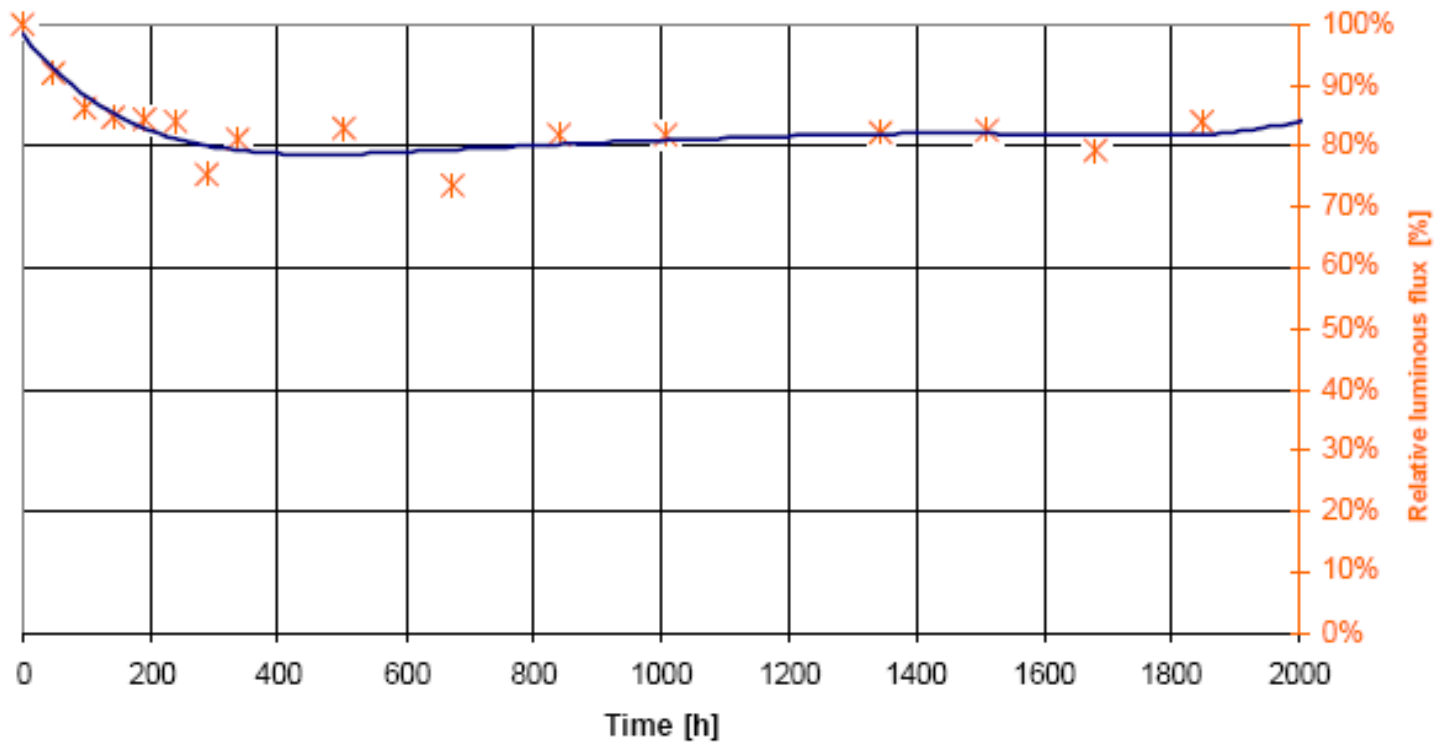
LEDs are especially sensitive to heat; poor thermal management leads to short lifetime.



Mills, Evan and Arne Jacobson (2008) "The Need for Independent Quality and Performance Testing of Emerging Off-grid White-LED Illumination Systems for Developing Countries" *Light and Engineering*, v16, n2, pp.5-24.



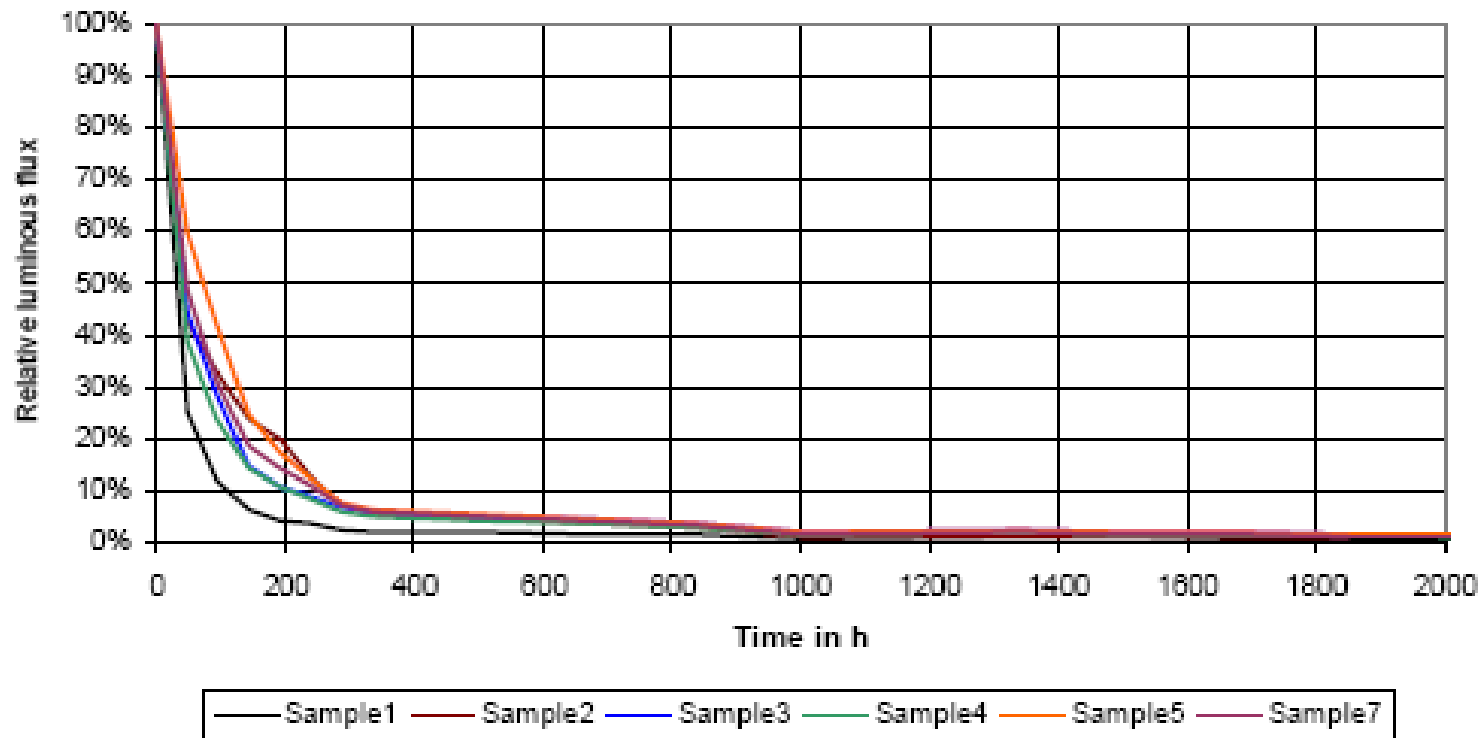
2,000 Hour Lumen Degradation Test Results (good quality product)





2,000 Hour Lumen Degradation Test Results (poor quality product)

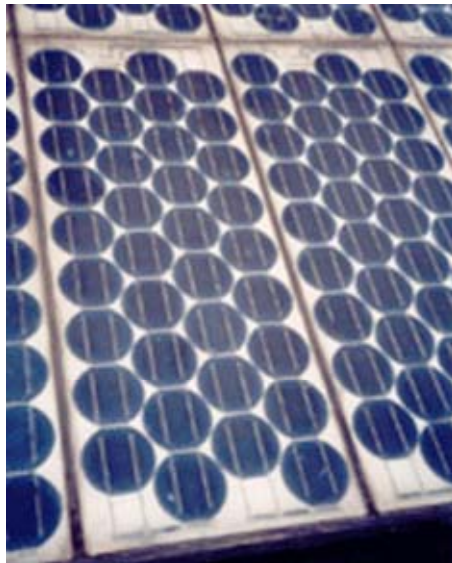
@ constant 4.0V [battery replaced by power supply]





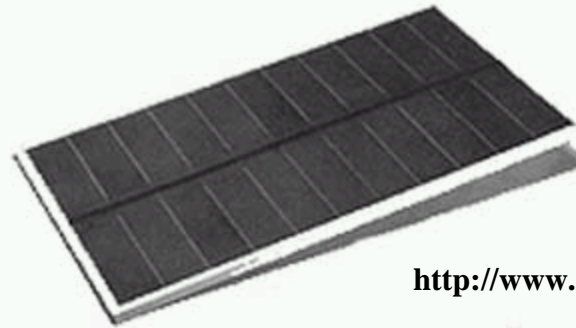
Common Solar Module Types

Monocrystalline PV



<http://www.arisetech.com/>

Amorphous Silicon PV



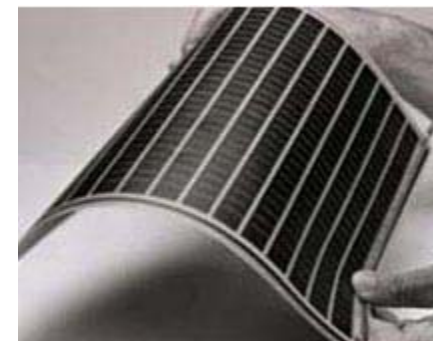
<http://www.energyalternatives.ca/>

Polycrystalline PV

<http://img.alibaba.com/>



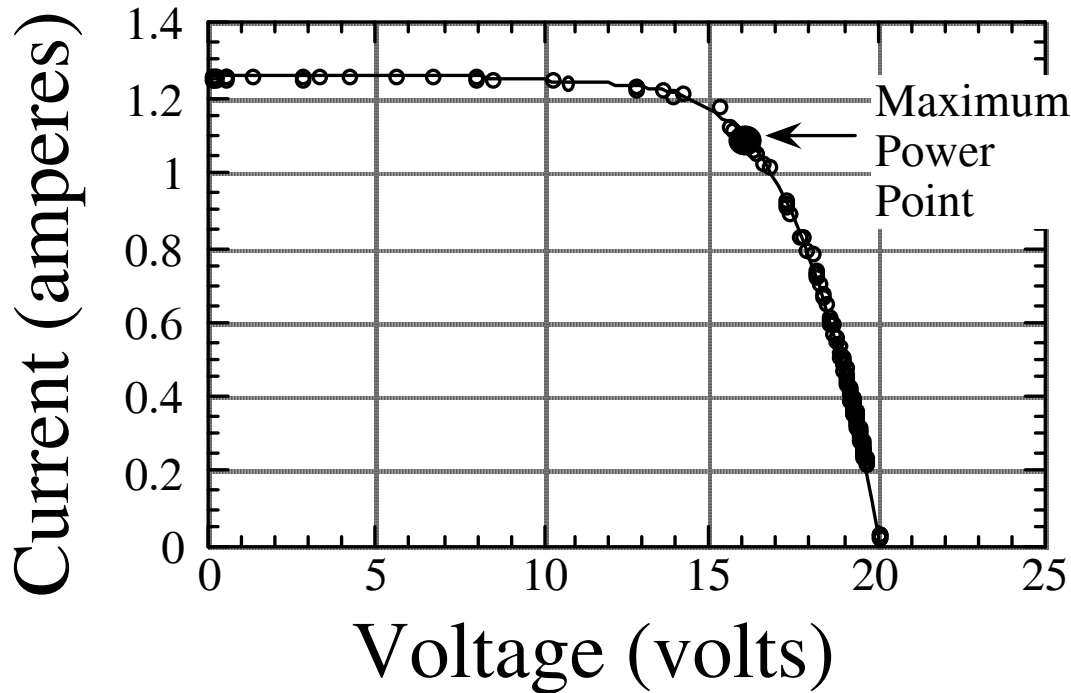
CIGS Thin Film PV



<http://www.cnn.com/>



PV Module Performance and the IV Curve



IV Curve for
20 W_p PV module

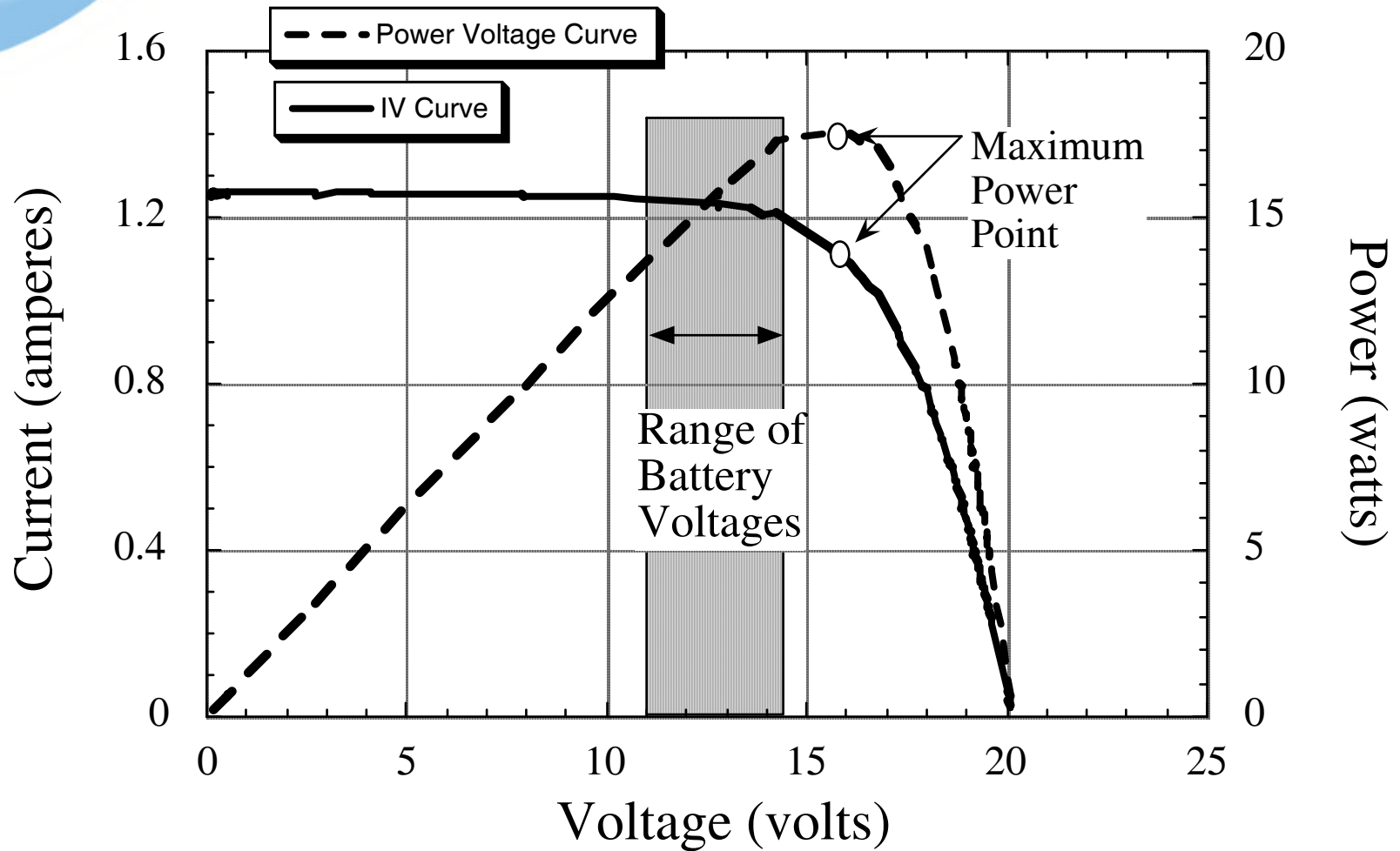
Standard Conditions:

1000 W/m^2

25°C

AM = 1.5

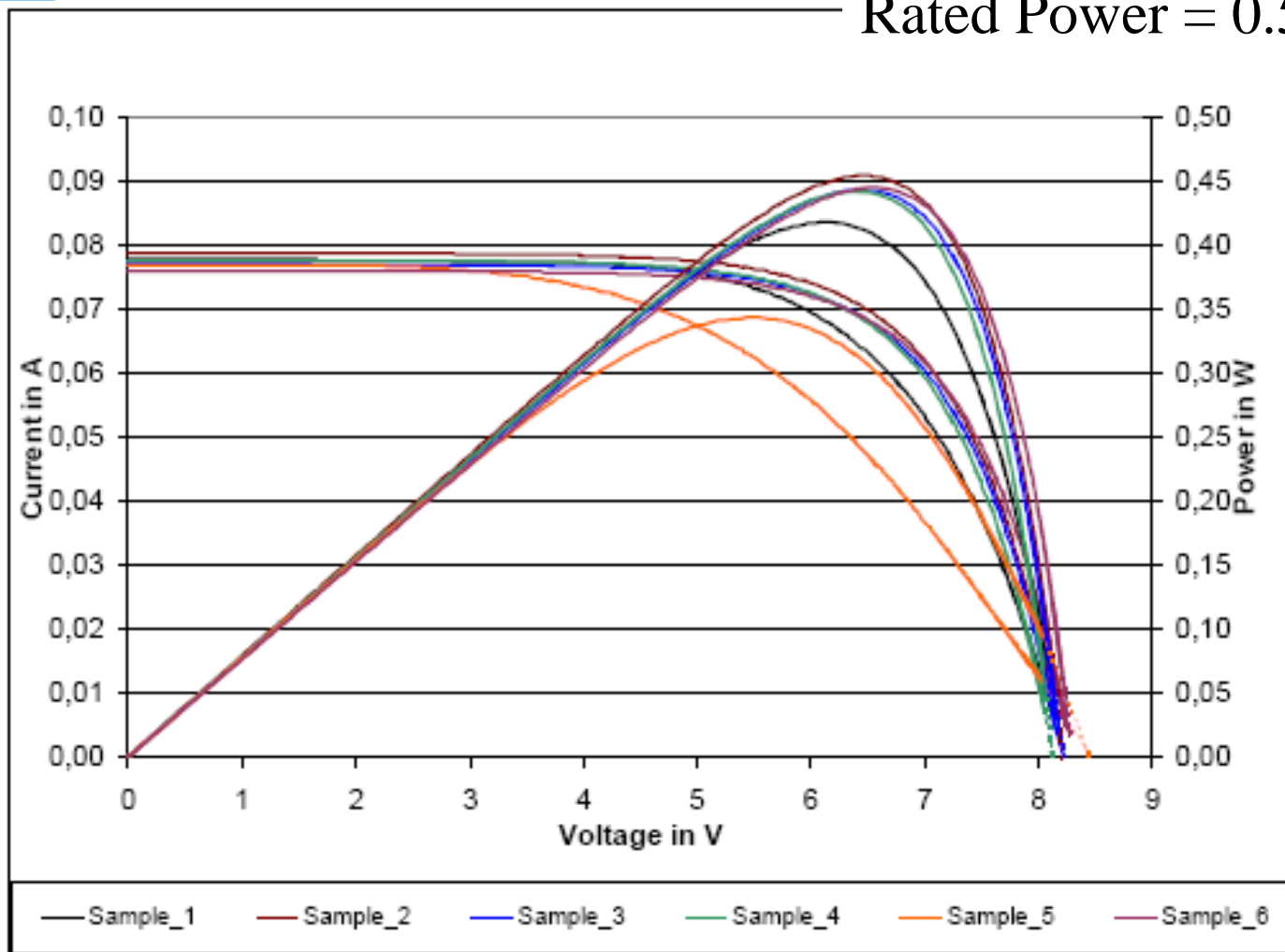
PV Module Performance and the IV Curve





Performance Variation for PV Modules

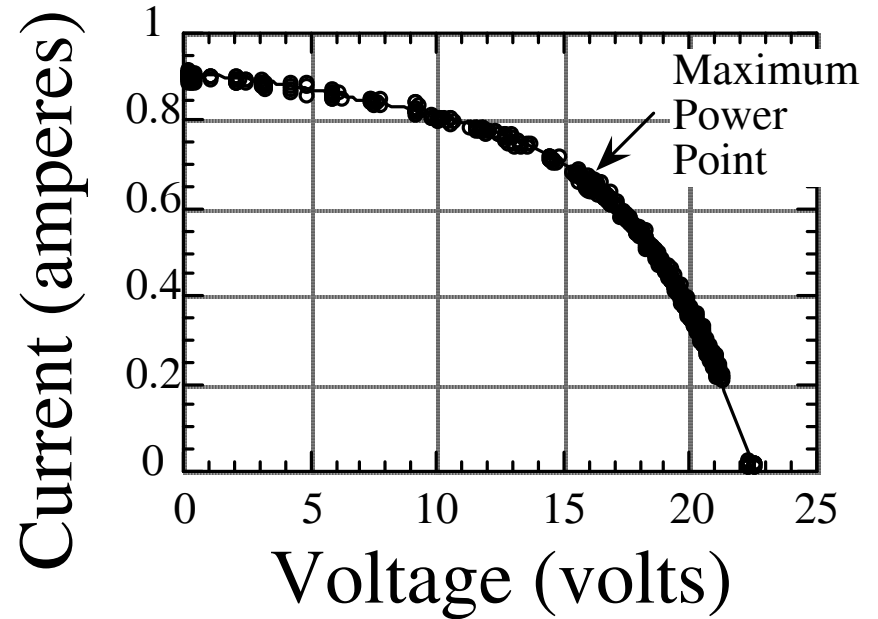
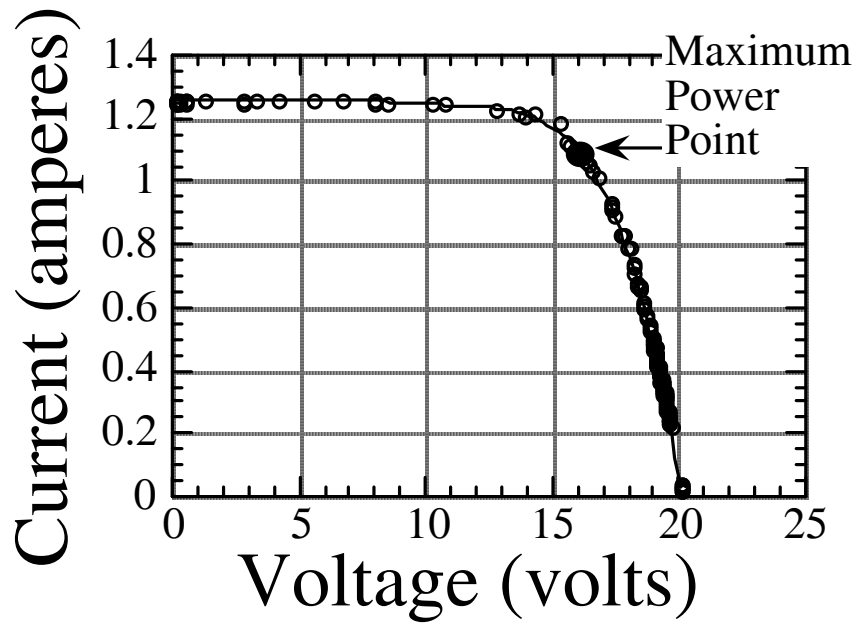
Rated Power = 0.5 Watts



Bopp, et al. (2009) "Stand-Alone LED Lighting Systems Quality Screening" Fraunhofer Institute for Solar Energy, Report commissioned by Lighting Africa

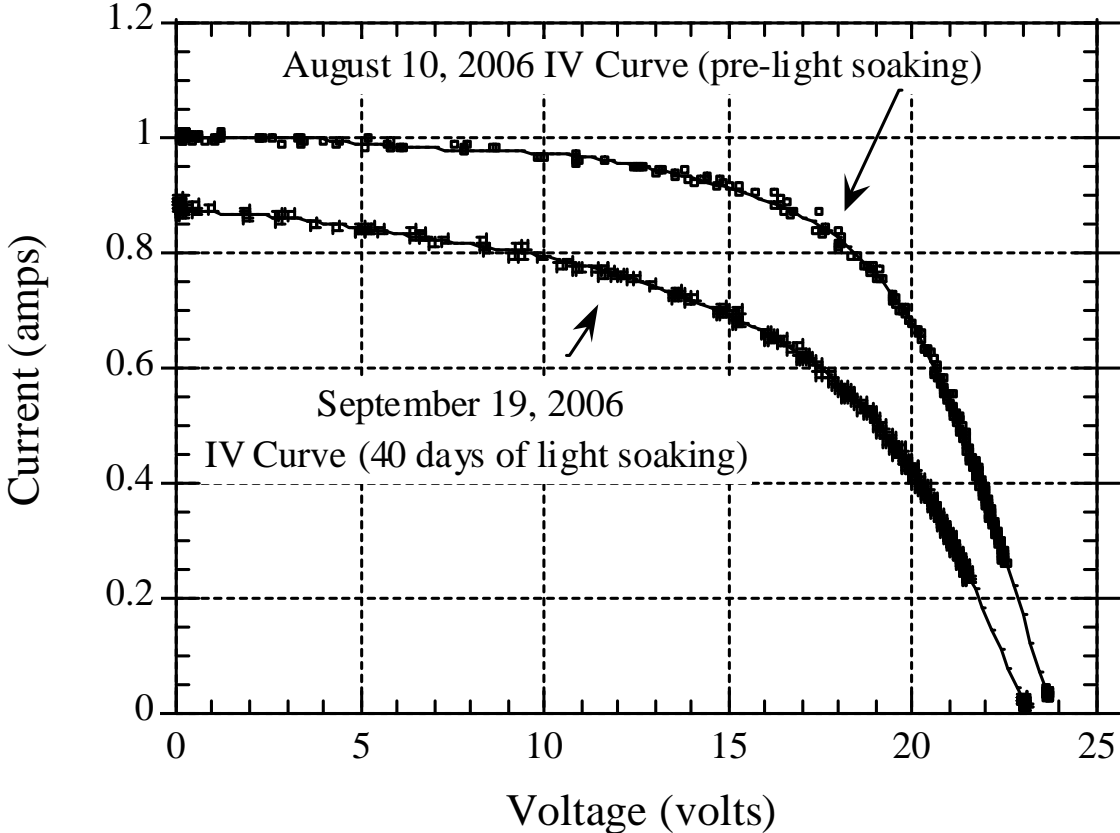


Crystalline vs. Amorphous IV Performance





Staebler-Wronski Degradation for an Amorphous Silicon PV Module



P_{\max} initial
= 14.8 W

P_{\max} @ 40 days
= 10.6 W



Common Battery Types for Off-Grid Lighting Systems

Sealed Lead Acid



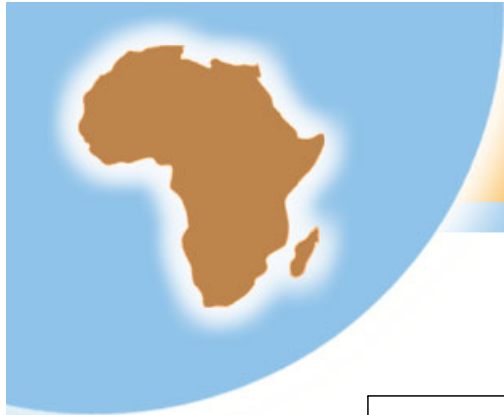
Nickel Metal Hydride (NiMH)



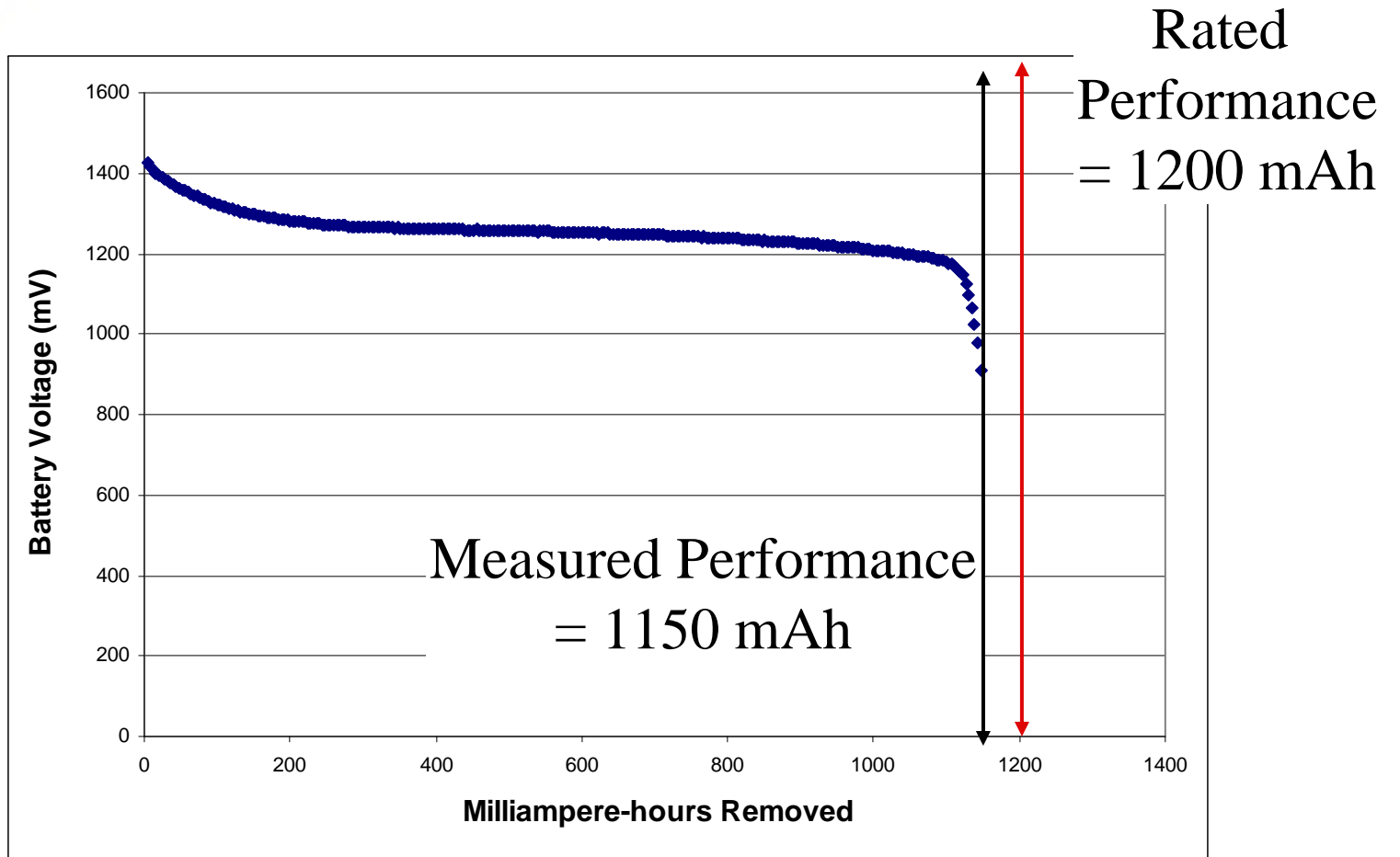
Lithium Ion



Nickel Cadmium (NiCd)



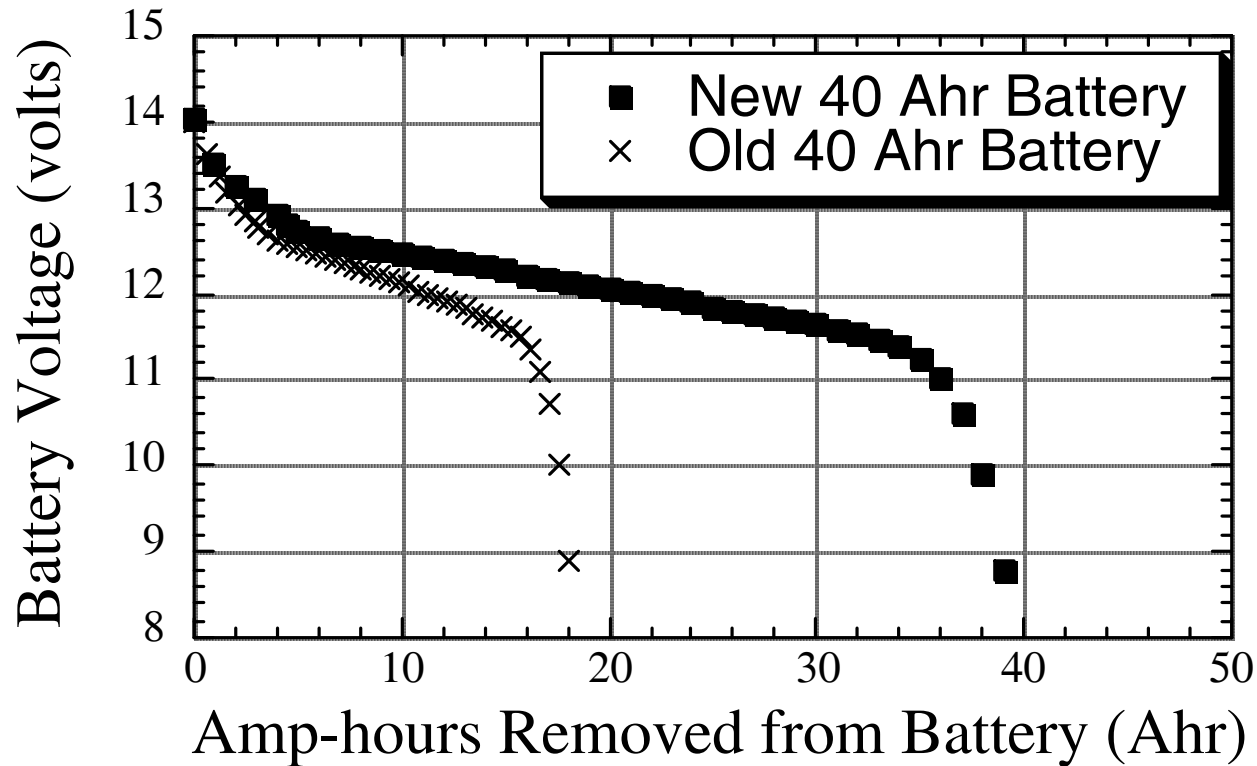
Measured Battery Capacity





Battery Discharge Curve @ C-10

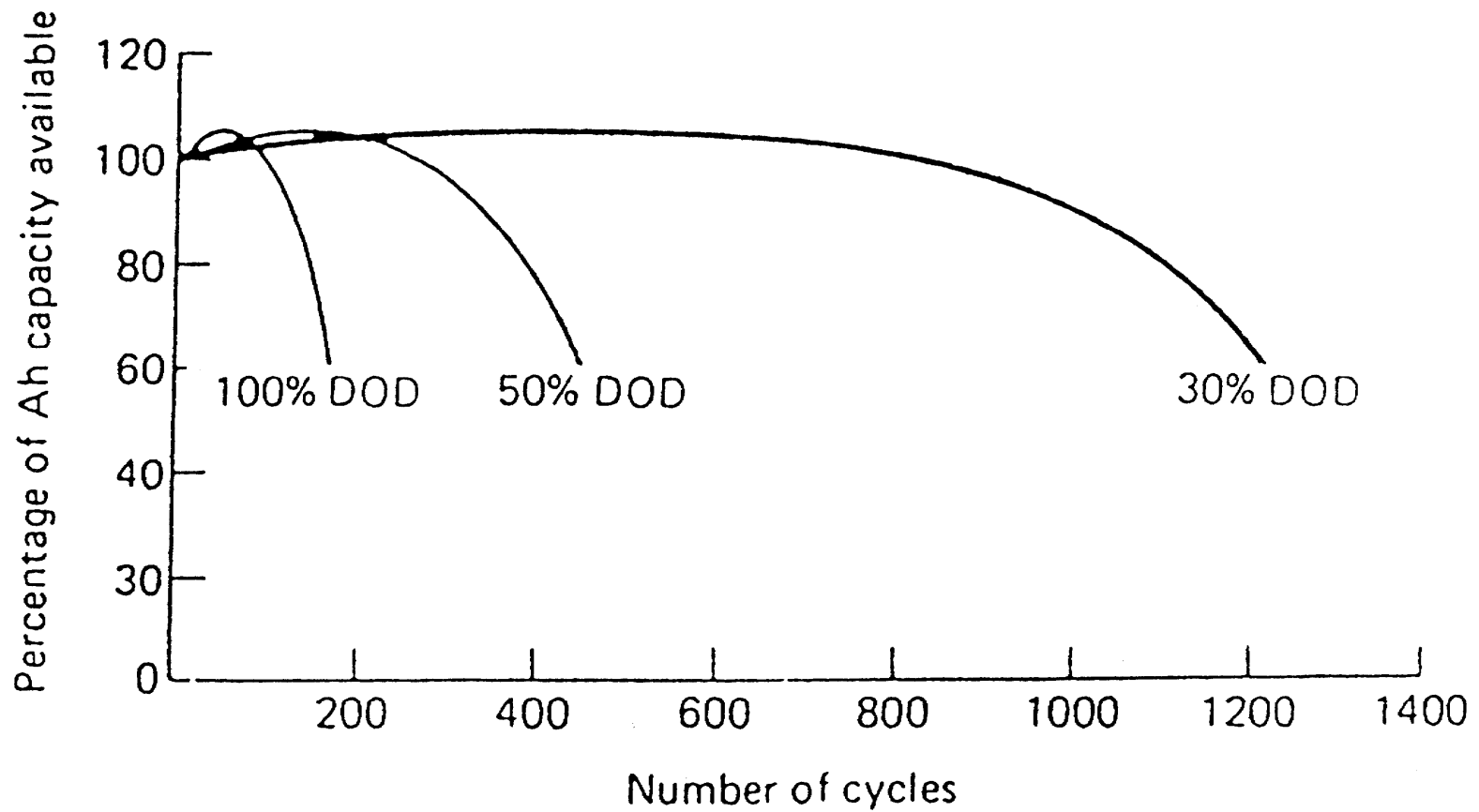
(graph shows loss of storage capacity for older battery)





Impact of DOD on Cycle Life

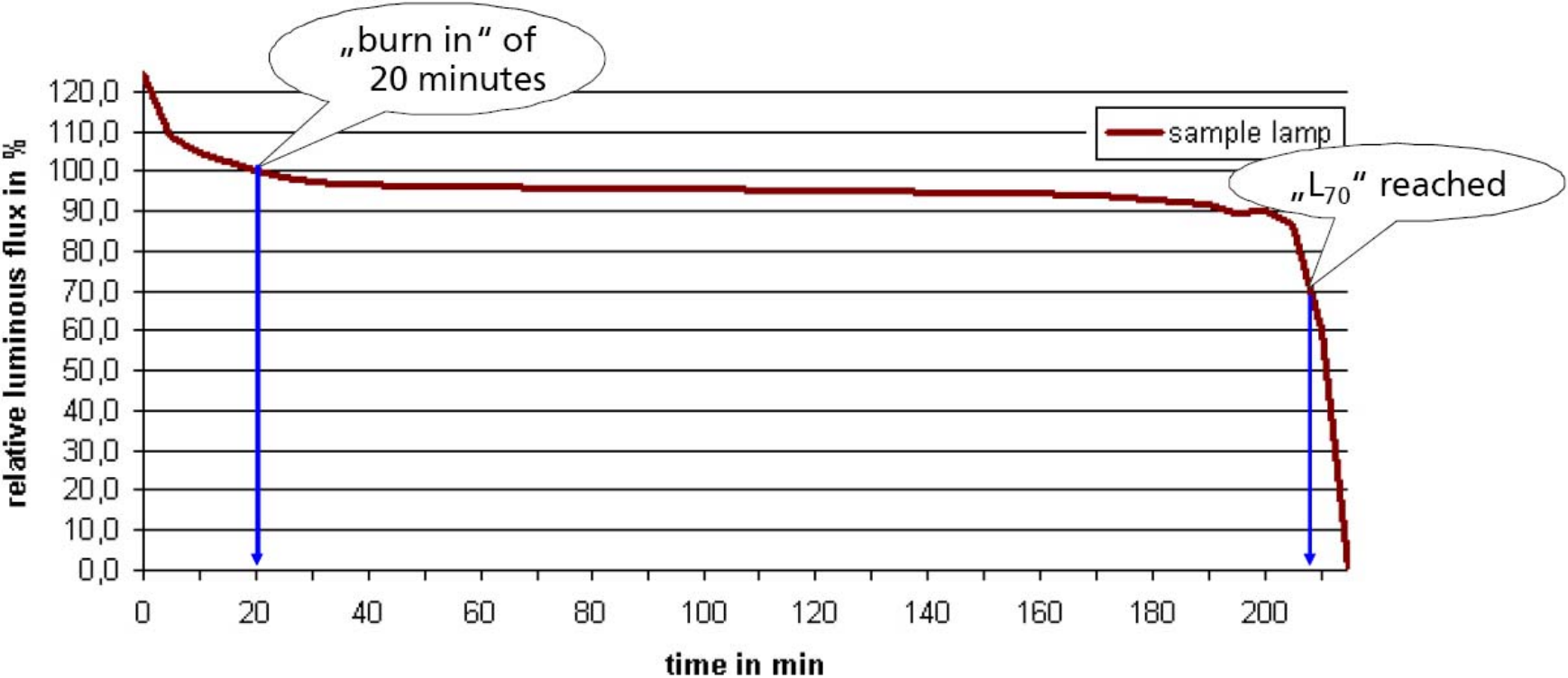
(data for gel cell type Pb-acid battery)





System Level Performance for Off-Grid Lighting Products

- How long will the light last on a full battery charge?





Quality of Wiring and Solder Joints



Figure 6-3: Cable spaghetti (*left*), wedged wire (*center*) and heavily corroded components (*right*)



Figure 6-4: Good solder joints (*left*), cold joints (*center, in front*) and poor joints (*right*).⁷



Purchasing Tips

- Ask about factory certification
 - (ISO = International Standards Organization)
- Ask about warranties
- Ask for system and component specifications, especially for LEDs, solar modules, and batteries
- Ask for samples and have them tested at a trusted laboratory
- In future, look for quality assured products



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