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Affordable Alternatives to Kerosene and other Fuels for Lighting in the Developing World



Presented to CARE

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Links to Core CARE Issues

- **Women & Children:** access, burden
- **Natural Resources:** fossil fuel and fuelwood
- **Economic Development:** poverty; productive use
- **Education:** conditions for teachers & students
- **Emergency Relief:** lighting services & environmental footprint of camps
- **Health:** indoor air quality, burns, clinic lighting

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“We will make electricity so cheap that only the rich will burn candles”



- Thomas Edison

India

As of 2000: in the developing world, 14% of urban households and 49% of rural households had no electricity ...

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... In fact, there are more non-electrified households today than the total number in Edison's time.



Ghana

Photo: Rick Wilk

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Fuel-based lighting equals ~2 million barrels of oil per day ~ Iraq's pre-war production

~ 60 million “cars”

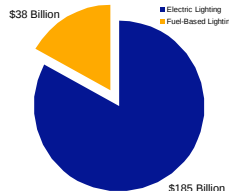


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ALREADY a Large Market

Global Annual Spending on Lighting



■ Electric Lighting
■ Fuel-Based Lighting

\$38 Billion

\$185 Billion

A commercial, functioning market, with an established value-chain, collection systems, “technical support”, access to spare parts, repairs services, etc.

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Lighting Inequities

Although one in three people obtain light with kerosene and other fuels - **paying \$40 billion/year** - about 20% of global lighting costs, they receive only 0.1% of the resulting lighting energy services

Category	Percentage of Global Lighting Costs	Percentage of Resulting Lighting Energy Services
Electricity	20%	0.1%
Fuel	80%	99.9%

Population (6 billion) Lighting Energy Cost (\$216 billion) Lighting Energy Services (91,600 TWh)

■ Electricity ■ Fuel

LBNL Analysis

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Inequities: Studying by roadlight at Guinea airport (80% of population unelectrified)

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Inequities: Fetching Kerosene in a Coke Bottle; Dippers

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Inequities: Low Service Levels

- Classroom light levels as low as 2% of western standards
- Teachers grading homework with light levels 1% of western standards

Kenya (Kibera Slum - flash photo)

Tanzania (Periurban Area)

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Existing Battery Charging Enterprise: Dominant mode of off-grid electrification

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Existing Lighting Marketplace

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Battery and Torch Micro-enterprise



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Traditional Solar-Fluorescent Systems Have only 0.2% Market Penetration (and less at the bottom of the pyramid)



Rajasthan, India

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White Light-emitting Diodes ("LEDs")

- Efficient
- Long life
- Low voltage
- Directional
- Portable
- Rugged
- Common batteries
- 10-100x the service level of flame light

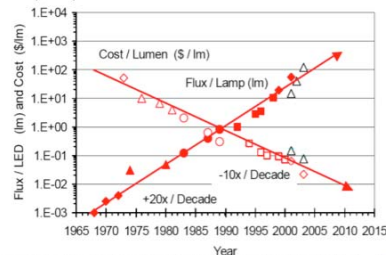


Integrated systems require negligible after-market service

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LEDs: Rising Light Output; Falling Cost

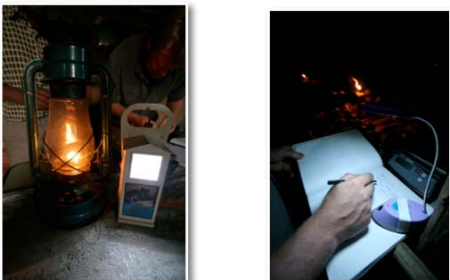


Source: White Lighting (Illumination) with LEDs, Werner Goetz, Fifth int'l Conf. on Nitride Semiconductors, ICNS-5, Nara, Japan, May 25-30, 2003.

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Improved Light for <1 Watt



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Side-by-Side Comparisons



Tanzania: fruit seller - flame [left]; 1-watt white LED [right]

Tanzania: sandal seller - flame [left]; 1-watt white LED [right - no flash]

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Last-generation Fluorescent; Next-Generation LED

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Millennium Villages:

Pilot project in Sauri, Yala, Kisumu

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Seeking End-users' Assessment of Products Kenya: June 2007

LED lanterns presented to the focus group and interview participants for evaluation.

LED flashlights for sale in Luanda market (Western Kenya).

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Night Markets (Kisumu)

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Focus Group: Men on the Street (Yala)

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Focus Group: Teachers & Parents (Sauri)

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School Headmaster (Sauri)



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Focus Group: Students (Sauri)



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Focus Group: Village Residents (Sauri)



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Focus Group: Women Night Market Sellers



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Focus Group: Women Night Market Sellers



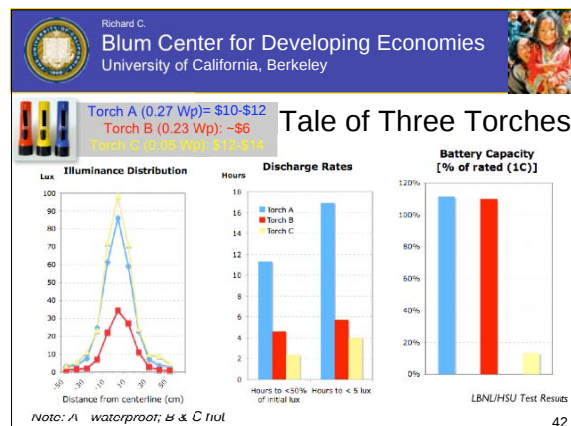
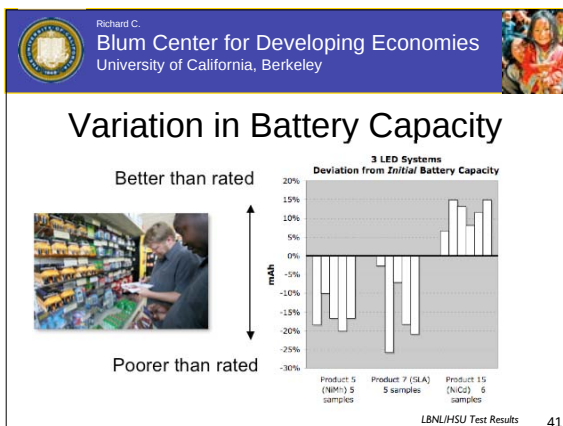
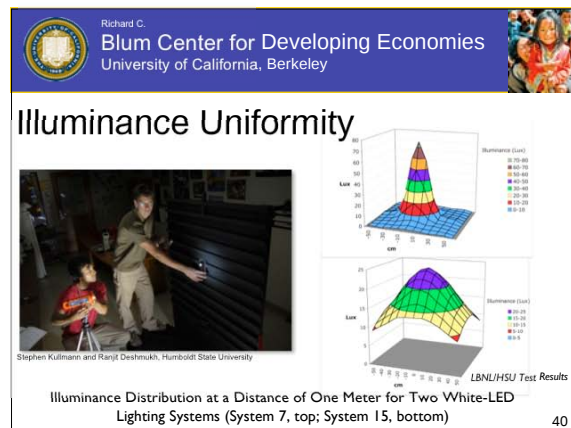
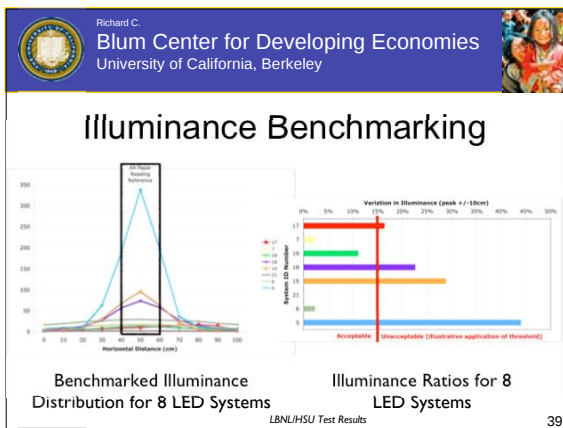
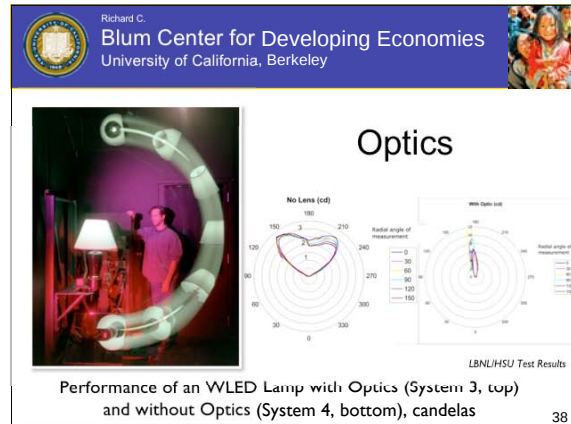
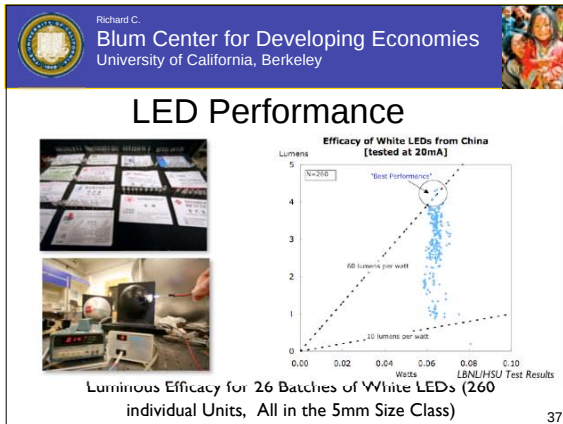
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Focus Group: Women Corn Sellers

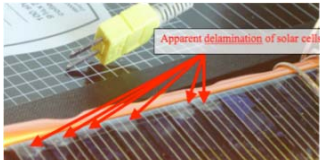


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Durability Example: PV Delamination



- De-lamination can lead to charging performance degradation or failure.
- The damage shown in the photo occurred after only 10 days of charging, probably due to thermal cycling (repetitive heating-cooling). Observed in 2 out of 2 products tested from one mfr.

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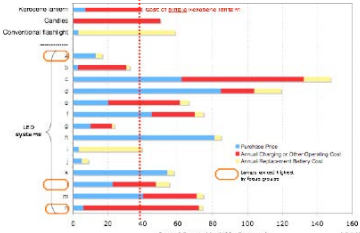
Deceptive Products



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Annual Cost of Ownership: 16 Products

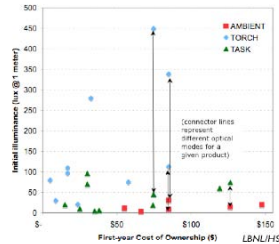


Total yearly cost of ownership for various LED lighting products, with comparison to kerosene lighting and conventional flashlights with disposable batteries

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Cost-quality correlation?



LED system cost of ownership versus lighting service level

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Non-Energy/Illumination Issues

- Safety
- Vulnerability to over/under charging
- Durability
 - rough treatment
 - PV delamination
 - water-proofness
 - sensitivity to humidity
 - battery temperatures
 - battery leaking
 - fouling (insects; dirt)
- Usability
 - intuitiveness
 - ergonomics (form, weight, bulk)
 - battery replacement frequency and availability
- Lifecycle considerations - solid waste; batteries



Photo credit: J. Apte, A. Gopal, K. Lindgren, M. Fuller

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Inspire Manufacturers

"I spent much of the weekend on the phone with the engineers at my factory and we will heavily depend on using your report on the new model. We are going to totally redo our light and your report will be invaluable."

- Anonymous manufacturer

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Quality Assurance (QA): Issues & Potential Pitfalls: Technical

- Inadvertently disadvantaging useful products (e.g. security light)
- Lab versus as-used (position, temperature, battery charging behavior)
- Defining "adequate" illuminance
- Defining acceptable variability
- What is adequate amount of sampling?
- Total cost of ownership varies wildly depending on performance, duties, and taxes (and value chain)

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Findings for LED Systems

- Danger of market spoiling is real
- Early action is important to mitigate problem
- Solutions require multi-pronged approach
 - International standards & certification
 - Independent testing by qualified groups
 - International collaboration that includes in-country partners
 - Information dissemination through local media & networks
- Key differences between off-grid lighting and PV
 - Off-grid lighting products smaller & cheaper
 - Negative: harder to regulate quality of "fast moving goods"
 - Positive: frequent buyers will learn quickly

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Challenges

- Avoiding market spoiling - Product quality
 - a. Innocent
 - b. Deliberate
 - c. Counterfeit

Ensuring affordability (of testing **and** end-user purchase)
 Understanding the role of fuelwood
 Understanding IAQ and other health links
 Identifying and valuing non-energy benefits / productive uses
 Verification of impacts / savings / consumer acceptance
 Enabling manufacturers to do right thing
 Enabling intermediaries
 Delivering objective and consistent information to all parties
 Building replicable & sustainable (self-supporting) deployment strategies

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Upcoming Work

1. Take temperature of industry re: rating council
2. Web-based product directory
3. Enhance testing protocol/criteria
4. Market test with night vendors (Kenya)
5. Develop novel methods for measuring use in the real world & estimating carbon savings

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