1. 2008 LADM Proposal 4279-Lighting the Way

2. Project Summary

OBJECTIVE

The goal of the University of California (UC), Davis' *"Lighting the Way"* project is to design and distribute an inexpensive, modular white LED lighting system that can displace or supplement kerosene lighting in Sub-Saharan Africa through existing market-based mechanisms. Using Lighting Africa Development Marketplace (LADM) seed funding, the University of California, Davis Center for Entrepreneurship and the Energy Efficiency Center will work with DISACARE, a local partner, to create "*Lighting the Way Zambia*", a venture responsible for product distribution. Activities during the LADM support period will include the development of the product and dissemination model, pilot launch in Zambia, and evaluation.

RATIONALE

Fuel-based lighting costs the World's poor $38 billion each year and emits ~190 megatons of CO_2. Although widespread, typical kerosene lamps provide poor light and contribute to respiratory problems when used indoors. Zambia has a population of approximately 10 million and 98% of the non-electrified households use kerosene lamps as their primary lighting source. By providing a renewable-based lighting alternative, these households will have better light for less money with a lower environmental and public health impact. The effect of good quality lighting is well documented for small business owners as well as subsistence farmers: With better quality light shops can stay open and children and adults can study and learn after dark.

INNOVATION/EFFECTIVENESS

To avoid dependency on micro-finance or charitable dissemination models, *Lighting the Way Zambia* will focus on developing a lighting system that can be purchased in increments, in much the same way that kerosene fuel is currently purchased in the developing world. Rather than specifying the lighting performance, our objective is to mimic the economics of how kerosene fuel is bought and sold, focusing on advanced lighting and micro-power technologies. Features such as "package-is-the-product" and price/product modularity will enable *Lighting the Way Zambia* to use supply chains and a cost structure similar to kerosene.

The final product will cost less that $3 per module and $25 per watt, yield a minimum of 50% reduction in life-cycle carbon emissions, and provide better light than a kerosene lamp. Initial roll out during the LADM support period will be to 5,000 households in rural and urban communities in Zambia and then scaled up. In five years, we anticipate *Lighting the Way Zambia* to have over $2.3 million in sales and create 100 new Zambian jobs. In this time a half-million new light-emitting diode (LED) customers will benefit

from better lighting, improved indoor air quality, and the potential reduction of CO_2 by 10,000 tons.

3. Problem Definition

Over 1 billion people in developing countries rely on kerosene for their primary light source. Unfortunately, kerosene is inefficient, emitting 40 times more CO_2 per light unit than grid–based incandescent and 180 times fluorescent lighting. Kerosene also has a high cost to its owner, resulting in a pay out 50 times grid-based lighting, and 4 to 20 times existing LED options (Mills, 2005). In developing countries, fuel-based lighting often represents up to 30% of a household's income and, although many lower-impact alternatives have been developed, their penetration is low in these markets.

In Zambia, like much of the Sub-Saharan Africa, kerosene is the lighting fuel of choice with over three-quarters of the population using it nightly. A typical lamp uses 2-4 liters per month, but it is common for poorer people to purchase this kerosene from re-sellers in small quantities for more than double the national average price of $1.50 per liter. Candles are rarely used and although flashlights with disposable batteries are common, about 1.2 million Zambians use cooking fire as their only source light. Zambia's urban poor are often without electricity since a typical grid connection costs $500-1000 and can take years to install. The average urban household uses 2 hours of kerosene per night. Ninety percent of Zambia's electricity is hydro-power and suffers from frequent load shedding in the dry season. So even though kerosene lighting is expensive, inefficient, and is responsible for allergies and other illnesses, it is still widespread.

Many development groups and research institutions have examined this problem and come to the same conclusion: photovoltaic (PV) solar with florescent lighting or battery-powered white LEDs (WLEDs) when used as ambient or task lighting, can offer better quality light at a much lower cost of ownership than kerosene. Unfortunately, much like the solar cook stove and other "appropriate technologies", advanced lighting technologies have not been adopted on a large scale in developing counties. Traditional PV solar, for example, has less than a 0.2% penetration in the African market.

In Bangladesh, Grameen Shakti, a subsidiary of Grameen bank, is installing over 1000 25-50 Watt solar systems per month but requires a field staff of 1000 to maintain the systems and service the loans. At $150-$350 per unit with 15% down payment these medium systems are affordable only to affluent rural households and medium-scale businesses. Similarly, surveys of end-users in Kenya found them willing to pay less than $25 for lighting systems and subsidies were found to be ineffective in promoting growth of larger solar home systems. In Zambia, with a lower GDP per capita than Kenya ($1400 and $1600 respectively), we would expect the price to be even lower. Zambia does not currently offer subsidies nor do they have the existing administrative infrastructure to maintain loans. Thus, total deployment of PV solar has been less than 2000 systems.

The Lumina Project points out that after groups spent a decade promoting $100 solar lanterns in the developing world sales were slow, even among relatively wealthy end

users. The manufacturers have relied on a non-sustainable subsidy model in which donors purchase lanterns and make them available to end users.

4. Idea

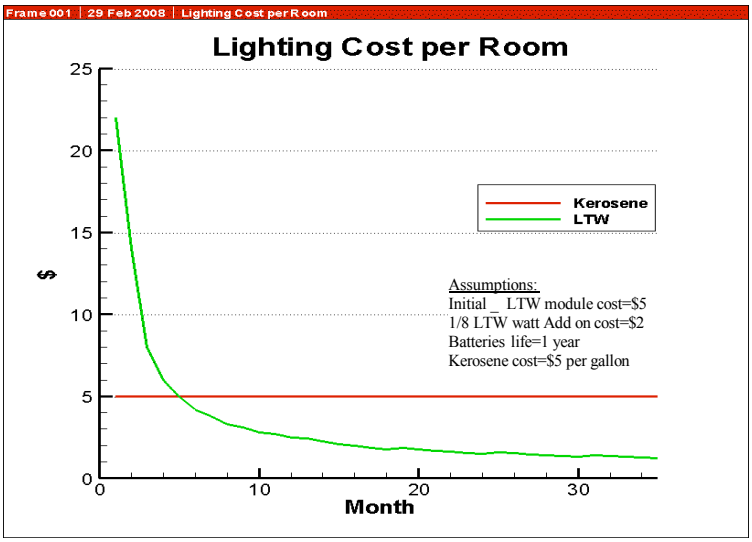
In order to achieve penetration into the lower-impact lighting market, alternatives must have an affordable entry price similar to kerosene.

Although C.K. Prahalad made "Marketing to the Bottom Pyramid" famous, Indian shopkeepers selling bicycle spares, cell phone companies with $2 phone cards and "Boom" $0.25 detergent packets have been using this "bottom pyramid" strategy successfully in Zambia for years. Thus *Lighting the Way Zambia* will focus on developing a lighting system that can be purchased in increments using existing supply chains. The guiding message will be "low-maintenance, quality lighting, at a good price". Lighting the Way will provide an alternative lighting system at the same entry price people now pay for kerosene, thus making it affordable.

To achieve this goal, *Lighting the Way Zambia* will incorporate advanced lighting and micro-power technologies and include innovations such as "package-is-the-product" and price/product modularity. Charity lighting models have been proven non-sustainable and micro-finance requires infrastructure and is very costly per transaction. Thus, to allow for widespread dissemination of this technology, we will work with local partners to create *Lighting the Way Zambia*, a for-profit venture which will also provide employment and build in-country capacity.

Lighting the Way Zambia will draw from the large body of research done by the Lumina Project in Berkeley, California, Schatz Energy Research Center in Arcata, California, and others to define user preferences and choose technologies appropriate for the application. Systems will be modular: Initial base modules ($5-6 retail) will provide a ¼ watt micro-power supply using PV solar and rechargeable batteries and 2-4 sub-watt LEDs. Add-on systems ($2-3 retail) will allow the customer to expand as little as 1/8 watt at a time up to a 1-watt system that will provide better ambient/task light than a kerosene hurricane lamp for significantly lower cost of ownership.

As the modules are added, the level of service will go up but the lighting cost per room will rapidly decline and the cumulative cost of ownership will be well below that of kerosene (see figure 1).



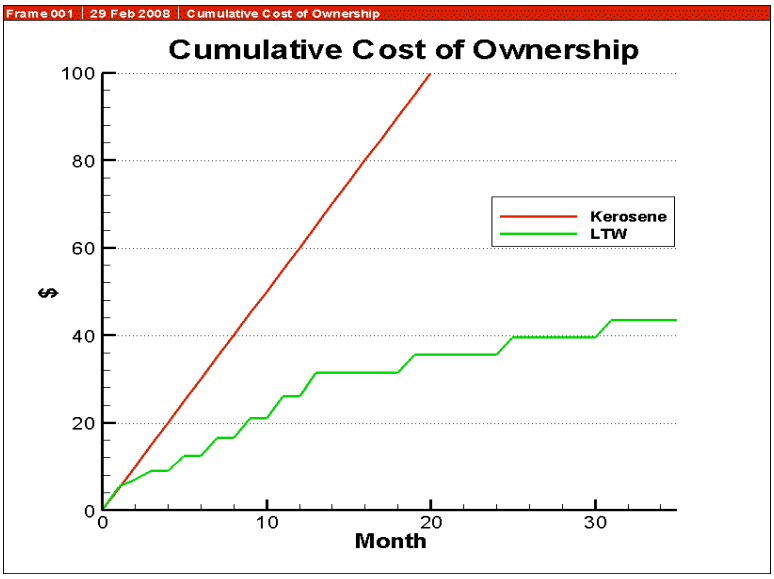


Figure 1: Cost of Ownership (Top), Cumulative Cost of Ownership (bottom)

5. Innovation

Lighting the Way Zambia targets a well-defined problem and applies proven technology in an innovative way.

Famous for his dissemination of the treadle pump in Zambia and other sub-Saharan countries, Paul Polack from International Development Enterprises (IDE) has targeted even poorer farmers with an inexpensive drip irrigation system. Emphasizing affordability, divisibility, and infinite expandability, the final product is made from a rice bag, some plastic tubing and wooden stakes. Paul says "The price is $3 retail, and you can add more bags if you can afford them. Drip irrigation isn't new, but most technologies can't be broken apart to make them cheap enough for developing nation

farmers." Similarly, WLED battery lighting systems aren't new but the modular, easily expanded approach is.

Innovation in the Product

Many groups, such as The Lumina Project and Schatz Energy Research Center, have done an excellent job of characterizing WLED lighting technologies for this particular application. The *Lighting the Way* innovation is to package this into a modular, scaleable, system that has a low manufacturing cost, low purchase price and can be expanded as the owner is able to.

Initial base modules ($5-6 retail) will provide ¼ watt micro-power supply using PV solar, rechargeable batteries and 2-4 sub-watt WLEDs. Add-on systems ($2-3 retail) will allow the customer to expand 1/8 watt at a time to a 1-watt system that will provide better ambient/task light than a kerosene hurricane lamp with a total system price of less than $25.

Although initial product runs will be under 10,000 units, manufacturing tooling will be based on quantities of 100,000 or more to lower the future unit cost. *Lighting the Way Zambia* will work with manufacturing and packaging experts to reduce the cost, weight, waste, and shipping. The product should be able to withstand rough distribution channels and shape factor will maximize units per shipping container. Incorporation of recyclable components and packaging will be an integral part of the product.

We will consider the perceived light-quality differences between spot lighting (e.g., lantern, flashlight) and distributed lighting (e.g., track lighting). Connectors for the add-ons to the system will be critical, so particular attention will be focused on this aspect of the product design. Switches and a battery-pack are also important aspects. Absolute lifetime is not as important as the entry-level and cumulative cost of ownership. A 5-year lifetime is desired for the base system, with some individual components (i.e. batteries) with one-year lifetime and easy to replace. Life-cycle carbon foot print is targeted to be less than 50% of kerosene. Batteries will be recyclable and this aspect will be built into the economic/marketing model.

Innovation in the Dissemination Model

In order to promote adoption, entry cost will be as low as possible, on par with a typical weekly or monthly purchase of kerosene fuel, allowing the product to be sold in a proven market and price structure and eliminating the need for micro-finance. *Lighting the Way Zambia* will attempt to mimic the supply chain of existing technology-kerosene and kerosene lamps.

During the first 18 months of this project UC Davis Center for Entrepreneurship and the Energy Efficiency Center will help create, "Lighting the Way Zambia", a venture responsible for expanding distribution after the project period. During the project period Zambia Lighting Entrepreneurs (ZLE) will be trained by our local partner, DISACARE, based in Lusaka. These ZLEs will partner with existing urban and rural product

distributors (i.e. shop owners) in the same way kerosene distributors have done in Zambia (FIGURE 3).

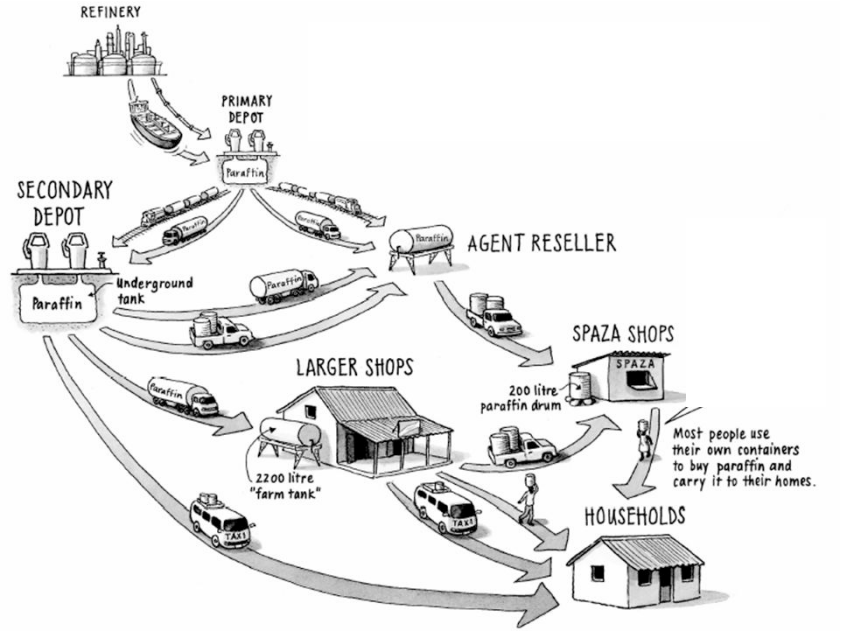


Figure 2

FIGURE 3 (adapted from The Paraffin Safety Council)

Although the target market are Zambia's poorest, other customers include affluent rural households and shop owners, street vendors, urban poor, and as back-up lighting for those on the grid. *Lighting the Way Zambia* WLED systems will be as available in the marketplace as kerosene is via a Zambian owned, in-country distribution network.

Barriers

Even if the modular systems are affordable and readily available there will be market barriers. The product needs to be proven, especially because there is a history of poor-quality LED and solar products already available. Customers and distributors that have invested in existing stock (kerosene lamps, etc.) must be persuaded to try the new systems. As part of this project Zambian Lighting Entrepreneurs will be trained to explain the differences in quality and performance of the product.

In addition, governmental bureaucracy with respect to importation, tariffs, and transportation may slow down dissemination and add to final product cost increases. DISACARE has experience with importation and distribution and will start work early with government to overcome these barriers.

Competition

The high cost of ownership notwithstanding, kerosene has a well-developed supply chain and strong customer loyalty and, thus, will be the main competition for *Lighting the Way Zambia*. The figures below show how we expect the *Lighting the Way* LED systems to perform with respect to kerosene and other existing technologies. *Lighting the Way* systems are projected to have a total cost of ownership less than kerosene, but more expensive than grid lighting (not including connection) and competitive with other LED systems on the market. While the cost of ownership of the *Lighting the Way* system may be higher than grid electricity, it offers similar light quality and cost of ownership to LED lantern systems (figure 3).

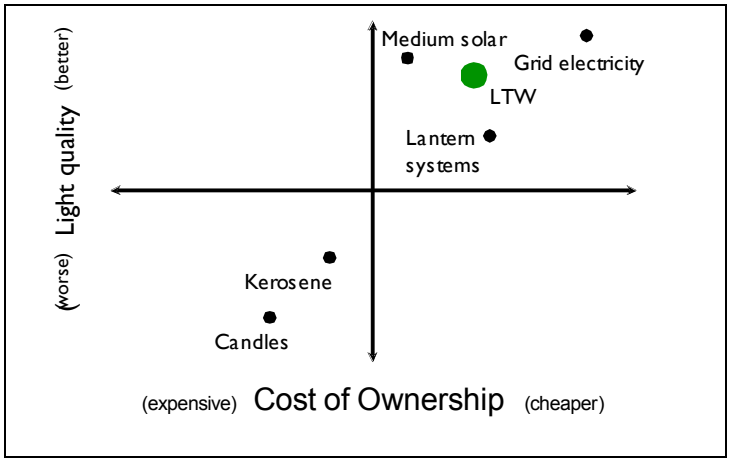


FIGURE 3 Cost Of Ownership

Figure 4 shows entry cost. In the case of grid electricity this is the connection cost, while in the *Lighting the Way* system case this is the price of the base module ($5-$6). *Lighting the Way* LED systems will have an entry cost similar to kerosene but offer better light quality.

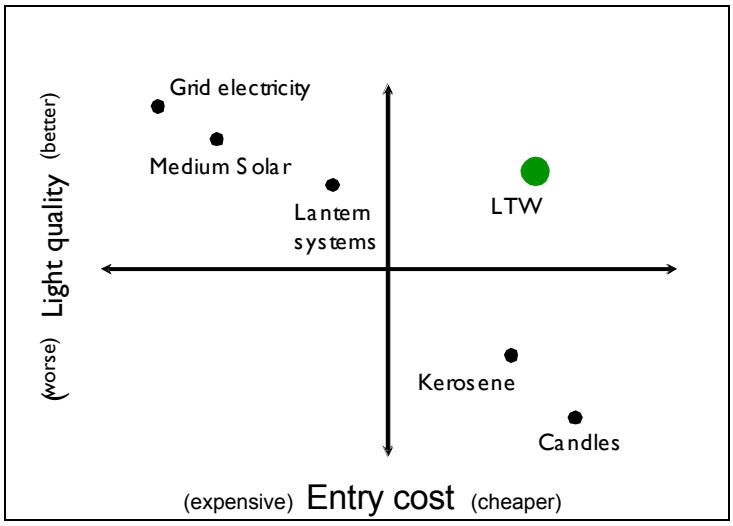


FIGURE 4 Entry Cost

6. Project Implementation

Researchers at the University of California, Davis Energy Efficiency Center (EEC) have performed the initial feasibility study, including a literature search, discussion with potential partners, and initial prototyping, testing, and cost analysis of the product that is presented in this proposal. Project implementation during and after the LADM support period will include the *Development of Product, Development of Dissemination Model, Pilot Product Launch, and Evaluation and Further Dissemination* (see timeline below).

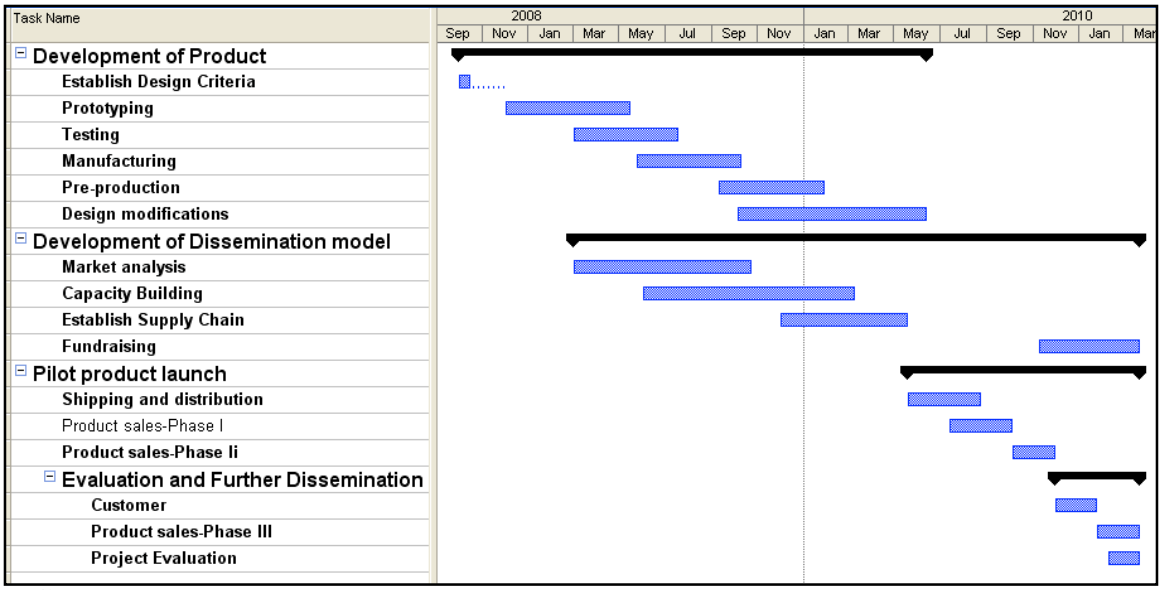


FIGURE 5

Development of Product (18 months)

Establish Design Criteria

The University of California, Davis is working with local partners in Zambia (DISACARE) as well as advisors (e.g., Schatz Energy Center) to perform market research, conduct focus groups, establish design criteria, and identify appropriate lighting technologies.

Prototyping

The University of California, Davis' California Lighting Technology Center (CLTC) will serve as design consultants as we will build and test prototype systems, conduct performance testing, hold focus groups, and then iterate and finalize the product design.

Manufacturing

We will work with manufacturing partners (see section 10, Organizational Sustainability) to establish appropriate, environmentally sound manufacturing processes and secure manufacturers at a low-cost. Manufacturing goals will include pilot runs of 100, 1000, and 5000 systems. We will investigate final assembly options, including partial assembly in Zambia.

Pre-production
Pre-production runs will be made, inspections, testing, and final quality control completed.

Development of Dissemination Model and Building the Venture (18 months)
Organizational Capacity Building
Zambia Lighting Entrepreneurs (ZLEs) will be trained by DISACARE and project staff from the University of California, Davis. Training will consist of courses/workshops in sales and marketing, in addition to mechanisms for seeking partnerships with existing distributors to establish an initial supply chain.

Market Research
The University of California, Davis will work with consultants and in-country partners to categorize customers by income, geography, ability to pay, etc. We will also identify potential rural and urban customers for sales of the initial 5000 units.

Distribution Network
The University of California, Davis will work with the ZLEs to establish strategic partnerships with existing manufacturer/distributors of kerosene and similar priced/complementary products such as batteries, soap, etc. We will also establish a battery recycling program.

Fundraising
We estimate that this venture will require an additional $50,000-$100,000 investment beyond this project proposal. The University of California Davis team will work with *Lighting the Way Zambia* to find additional sources of funds and explore investment from Social Venture Funds to allow for expansion and scaling-up after initial rollout of the effort.

Pilot Product Launch (6 months)
Shipping and Distribution
We anticipate our initial shipment production will include 1000 units. A further run will be for 5000 units.

Product Sales
We anticipate distribution and sales to pilot communities in 2-4 rural and urban areas. We will test prototypes and "fine-tune" the product and re-train local personal as necessary upon conclusion of an evaluation.

Evaluation and Further Dissemination (12 months)
The University of California, Davis team will work with DISACARE to evaluate and modify the product, refine the dissemination strategy based on results from both quantitative and qualitative evaluation. University of California, Davis personnel along with *Lighting the Way Zambia* staff, and independent evaluators will complete the evaluation. For more details on evaluation criteria, metrics, and methods, see section 9,

Measurability. Sales revenues from the first 5000 units will be reinvested to expand the distribution.

7. Project Beneficiaries

Stakeholders Benefit
Proposal project outcomes include: 1) product launch, 2) establishment of supply and distribution chains for WLED lighting systems, and 3) a comprehensive business model that is appropriate for the country of Zambia and other Sub-Saharan regions. The existing kerosene market segment will be targeted as the most likely customer base for our CO2 reducing, clean, cheap, grid-independent lighting. Initial beneficiaries will be the pilot communities in Zambia, in addition to a wider set of beneficiaries which include:

1) The *Zambia Lighting Entrepreneurs* (ZLEs) who will market and distribute the systems. These individuals will receive training and be employed by a new venture, *Lighting the Way Zambia*. They will start earning a salary from day one and earn commission as sales increase.

2) *Rural Households and the Urban Poor* who do not have electricity and, thus, be provided with access to higher/better quality lighting for a lower cost of ownership. This will allow them to work and study after dark without the adverse heath impacts from kerosene.

3) *Rural Shop Owners* who will buy the systems and use light to extend business hours and earn more.

4) *Suppliers* of the product who will sell the systems in their stores and make a profit.

We expect to train and employ 6-8 ZLEs and reach 5000 customers during the LADM support period. In the 2 years following, *Lighting the Way Zambia* will employ 20-30 additional ZLEs and establish 50,000-100,000 more customers (see table 1, section 8).

8. Results

Anticipated Results

Our goal is have 5000 household customers utilizing the *Light the Way Zambia* WLED product within the LADM support period of 18 months. We anticipate manufacturing and distributing a total of 10,000 units by the end of the second year. By year three, we anticipate a 0.05% market penetration, having over 50,000 customers in Zambia. We will train and employ *Zambian Lighting Entrepreneurs* and establish *Lighting the Way Zambia* as a new venture to further disseminate the product. We will seek outside investment in this effort and a portion of net income from sales will be reinvested to purchase and disseminate additional systems.

By the end of the LADM support period we expect to:

- Have 5,000 new customers
- Reduce CO_2 by a potential of 80 tons
- Reduce kerosene use by over 55,000 liters
- Create 6-8 new Zambian jobs
- Raise an additional $100,000 in investment

In the following 4 years of this venture we expect to:

- Reach over 600,000 new customers
- Reduce CO_2 by a potential of 10,000 tons
- Reduce kerosene use by over 7.5 million liters
- Create 100 additional Zambian jobs

TABLE 1

Project month	New Customers	Watts Installed	Potential CO_2 Reduction (Tons /year)	Potential Kerosene reduction (L /year)	# of ZLEs
18 (LADM support)	5000	1250	81	56775	6
30	10,000	2500	161	113550	8
42	50,000	12500	806	567750	15
54	200,000	50000	3225	2271000	50
66	400,000	100000	6450	4542000	100
TOTAL	**665,000**	**166250**	**10,723**	**7,551,075**	**100**

Assumptions:
A 1-watt LTW system replaces one kerosene lamp
A kerosene lamp uses approximately 4 liters per month
Life cycle CO_2 for 1 watt LTW system is ½ of kerosene

Milestones

We will track the results of our project by meeting the following specific milestones:

Year One

- Establishment of *Lighting the Way in Zambia* as a viable business interest
- Establishing final design criteria
- Creating an effective, efficient, and viable product prototype
- Hiring a Zambia manager and 2 ZLEs
- Producing and distributing 1000 units

- Selling 1000 units

Year Two
- Sale of 10,000 unites
- $50,000 in additional capitol raised

9. Measurability

The goals of *Lighting the Way Zambia* project are to design and disseminate a lighting product superior to kerosene in Zambia as well as build local capacity and create jobs. We intend to create a sustainable dissemination model that will be replicable in Sub-Saharan Africa. Thus, we will judge the impact of our project by the following evaluation criteria:

1. *Product performance and customer satisfaction,* thorough both qualitative and quantitative methods.

2. *Environmental impact,* through quantitative methods using input-output life cycle assessment (LCA) modeling and analysis tools to predict total embodied energy/greenhouse gases in product components, transport, and assembly of the product.

3. *Success of dissemination mode,* through both qualitative and quantitative methods by an independent evaluator.

4. *Sustainability of venture,* by examining the strength of the team as well as financial and growth projections.

Table 2 below outlines the evaluation criteria, metrics, and methodology.

TABLE 2

	Criteria	Metric	Type of Evaluation	Evaluation Method
Product performance				
	Light level	Lumens/$	Quantitative	Lab test
	Efficiency	Lumens/Ton CO_2	Quantitative	Lab tests
	Customer satisfaction	Happiness	Qualitative	Surveys
	Durability	Hours of service	Quantitative	Lab /field trials
Dissemination Model				
	Employment	New Jobs created	Qualitative	Accounting
	Employee satisfaction	Happiness	Qualitative	Surveys
	Outreach	New Customers	Quantitative	Accounting
	Scalability	Potential for large scale dissemination	Qualitative	Financial analysis
Environmental Impact				
	CO_2 offset	Tons	Quantitative	LCA modeling
	Kerosene offset	liters	Quantitative	LCA modeling
	Health effects	Number of illness	Quantitative	Predictive modeling
Strength of venture				
	Sales	Units sold	Quantitative	Accounting
	Investment	$ invested	Quantitative	Accounting
	Projections	Investment/growth potential	Qualitative	Projections

10. Organizational Sustainability: The *Lighting the Way Zambia* Project Team

Applicant Organization

The University of California, Davis benefits from the administrative capacity of a large institution and is committed to participating in this project past the 18-month LADM support period. The *Energy Efficiency Center* (EEC) specializes in commercialization of green technology and has been investigating dissemination of low-power rural lighting for the past year. Learn more about the EEC at http://eec.ucdavis.edu/.

The University of California, Davis *Center for Entrepreneurship (http://entrepreneurship.ucdavis.edu/)* is experienced at creating ventures around new technologies and will be instrumental in designing the dissemination model for *Lighting the Way*.

Bringing appropriate energy solutions to market in underserved comminutes is integral to mission of the University of California, Davis' *Energy Institute*.

Other University of California, Davis resources that will be brought to bear on this project include the *Energy Graduate Group* and the *California Lighting and Technology Center* (CLTC). The CLTC (http://cltc.ucdavis.edu/)is a leader in low-cost, reliable

LEDs and will collaborate with *Lighting the Way Zambia* in product development and testing phases of this project. Currently the University of California, Davis Energy Graduate Group is designing curriculum to educate and expose students to the energy issues specific to developing countries and the *Lighting the Way* project will utilize student resources for a dual benefit.

The University of California, Davis will seek additional assistance from project partners for product development, manufacturing, training, and evaluation, as well to establish strategic alliances with existing distributors. So far *Lighting the Way* has identified the following partners:

Main Local Partner Organization

*DISACARE (*www.disacare.org.zm) is a Zambian NGO that has been manufacturing and distributing products in urban and rural areas since 1995. DISACARE has experience in product importation/exportation of components from Asia as well as neighboring African countries. DISACRE has performed international training and capacity building in the southern African region since 2003 as part of their Regional Resource and Training Center (RRTC). In 2005, DISACARE co-hosted the All-African Wheelchair Congress, an international conference with 120 international participants and a $120,000 budget.

Lighting the Way Zambia Team members have worked with DISACARE since 1997 in a consulting capacity for Whirlwind Wheelchair International. DISACARE has a solid administrative, accounting and sales capacity. Along with the University of California, Davis, DISACARE will work with community partners to establish design criteria, conduct focus groups and assist in product roll out as well as evaluation. DISACARE will receive LADM project funds to carry out these tasks and work with the University of California, Davis to implement this proposed project, *Lighting the Way Zambia*.

Potential Product Development and Manufacturing Partners

Rahimafrooz, (http://www.rahimafrooz.com/index.asp), a 50-year-old Bangladeshi manufacturer of solar systems with innovative solar products aimed at the rural poor, was the first to offer a locally-built, affordable PV solar system for rural use. *Rahimafrooz* can help with product development, to establish manufacturing processes, and to identify suppliers. *Lighting the Way* team member, Kurt Kornbluth, has an ongoing relationship with Rahimafrooz (established during Project Emergence), who has expressed interest in being a design/manufacturing partner in the *Lighting the Way* Zambia project.

Haddock Invention LLC, a United States and Hong Kong-based research and development company overcomes the prototyping and early-stage manufacturing hurdles by focusing on products with a dual-role in both emerging and wealthy economies, and has launched products in the fields of solar water disinfection, green packaging, and wind power generation (http://www.humdingerwind.com/). *Haddock Inventions* has close ties to low cost manufacturing opportunities in China (the Pearl River Delta region) and will identify potential manufacturing partners in that country.

Potential Technology Characterization, Market Research Partners

Although they have no experience in Zambia, *Schatz Energy Research Center (http://www.schatzlab.org/)* has worked extensively with performance and market issues of WLED and PV solar lighting in Sub-Saharan Africa and has offered to serve in an advisory role to this project in the areas of product testing and market research.

Potential Pilot Communities

Lighting the Way Zambia has identified the *Chiefdom of Mwape* in Zambia's Eastern province as a potential pilot site for rural distribution. *Lighting the Way* Zambia team member, Kurt Kornbluth, has been involved with community development projects in Mwape since 2003, has developed a relationship with the leadership of this chiefdom (Chief Sara Mwape) who has expressed interest in bringing low-cost, renewable-based lighting to their community of 3500 inhabitants. DISACARE has identified a non-electrified urban community within Lusaka as another potential urban pilot site.

11. Team Leader

Lighting the Way Zambia team leader, Kurt Kornbluth, is a Mechanical Engineer PhD candidate and a 2006 University of California, Davis Graduate School of Management Business Development Fellow. He is also an Edison International Fellow with the University of California, Davis Energy Efficiency Center (http://eec.ucdavis.edu/student-emerging-venture-analysts). His research focus is on renewable energy technologies and lifecycle analysis.

From 1993 to 2003, Kurt worked with Whirlwind Wheelchair International (WWI) managing and implementing technology projects in Africa and Central America. He led the 8-year project, "Networking and Capacity building Wheelchair production in East Africa", a cooperation between the Finish Government, a local Zambian NGO (DISACARE), and WWI which established a Regional Resource and Training Center for wheelchair production in LUSAKA.

In 2005, Kurt was the engineer onsite in Bangladesh for the "Emergence" village micro-utility project spearheaded by Iqbal Quadir (Founder of Grameen Phone) and Dean Kamen (Inventor of the Segway). Kurt led the pilot study which electrified two rural communities in Bangladesh and his responsibilities included working with stakeholders to establish design criteria, prototype design and construction, and in-country implementation and evaluation.

Kurt worked with Amy Smith at MIT to develop the curriculum for "D-lab" which exposed students to energy issues in developing countries and is currently bringing this curriculum to the University of California, Davis Energy Graduate Group. As part of the his work for the Energy Efficiency Center, Kurt has worked extensively with students, Engineers, and Silicon Valley design firms to determine the basic design criteria for the *Lighting the Way Zambia* initiative.

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Education

University of California, Davis, (Expected graduation: September 2008)
PhD Candidate, Mechanical Engineering, emphasis in clean energy technologies

San Francisco State University, 1998
Master of Science in Mechanical Engineering, emphasis in environmental engineering

Michigan State University, 1986
Bachelor of Science in Mechanical Engineering, emphasis in human powered vehicles

Work Experience

UC Davis Energy Efficiency Center, Davis, CA
Energy Analyst 2006-Present
- Review potential clean energy technologies for market viability
- Design market-based models for product dissemination

MIT Massachusetts Institute of Technology, Cambridge, MA
Instructor 2005-2006
- Taught and developed Design for Developing Countries courses (D-lab SP:721&722)

DEKA Research and Development, Manchester, NH
Design Engineer, Stirling Engine Project, 2003/2004
- Developed and patented biogas burner for DEKA Stirling generator
- Field-tested units in 2 villages in Bangladesh

Whirlwind Wheelchair International (WWI), San Francisco, CA
Development Engineer, 1994-2003
- Managed and implemented technical projects

Director of Operations, 1998-1999
- Prepared and managed $400,000 annual overall budget

San Francisco State University (SFSU), San Francisco, CA
Engineer/Analyst, 1993-1994 SFSU Industrial Assessment Center (IAC)
- Performed on-site energy "audits" and designed energy-saving alternatives

Teaching Assistant/Instructor, 1993-1995
- Upper Division Thermal Power Systems lab, Third-World Wheelchair Fabrication

Optimal Computer Aided Design, Ann Arbor, MI
Design Engineer, 1988-1989
- Performed finite element analysis of automotive components

General Motors Proving Grounds, Milford, MI
Measurement Engineer, 1987-1988
- Prepared vehicles for real-world tests including instrumentation and data recorders.

Grants:

Energy Innovation Small Grants (EISG), March 2006: Enhanced Combustion of Land-fill Gas with Hydrogen. Grant Total: $95,000 from California Energy Commission.

Load Leveling of Renewable Energy in the Galapagos Islands, December 2006. Grant Total: $9,000 from UC Davis Institute for Transportation Studies.

East/Southern Africa Wheelchair Congress, August 2003, Lusaka, Zambia. Grant total: $120,000.

Wheeling Wheels Project, 1997-2001: Training and Networking People with Disabilities in East Africa. Grant total: $200,000, over 5 years, funded by Finish Volunteer Service.

Wheelchair Production in Antigua, Guatemala, 2001. Grant Total: $50,000, funded by Rotary Club International.

All-Africa Wheelchair Congress**,** August 1997, Nairobi, Kenya. Grant total: $70,000.

Publications:

"Project Appraisal of DISACRE Wheelchair Center", 2004, MIT open courseware. http://web.mit.edu/d-lab/resources/nciia_files/disacare.pdf.

"The Role of Hydrogen in Landfill Gas Utilization", 2005, report submitted to the California Integrated Waste Management Board.

"A Study on the Stirling Generator: Producing Bioelectricity in Bangladesh", 2006, Daffodil Journal, Vol 1. http://www.daffodilvarsity.edu.bd/diujst/pi-v1i1.htm.

"Design of a Freeway-Capable Narrow Lane Vehicle", SAE 2004 World Congress. http://pubs.its.ucdavis.edu/publication_detail.php?id=300.

"The High Stability Omni-Wheelchair". 1996 Rehabilitation Society of North America (RESNA) Journal of Proceedings.

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Languages:

English, Spanish, basic Swahili

Awards:

Winner of 1996 RESNA "Student Design Contest", 2003 and 2004 NSF IGERT fellow, 2007 UC Davis Graduate School of Management Business Development Fellow.

12. Risk Evaluation

Lighting the Way assumes customers will adopt this technology if the price/unit of useable light is similar to kerosene. Focus groups in East and Southern Africa as well as have shown interest in adopting lighting technology that is cleaner and brighter then kerosene, thus initial systems will be priced such that no other incentive will be needed to be competitive.

Even with an affordable product that meets the customer's needs there are many risks to this project's success. The main risks fall in the areas of *technological* (reliability, cost, performance), *dissemination* (Establishing and maintaining supply chains), *behavioral* (cultural hurdles to adoption, such as has repeatedly occurred with solar stoves) and project *management* (goals will not be met; project will not sustain itself past the initial funding period). To minimize these risks we have chosen partners that have experience in the areas of business and marketing, LED design, manufacturing, local dissemination.

Even if the customers can afford the modular systems there will be market barriers. The product will not be yet proven, important since there is a history of poor quality LED and solar products in the region. Kerosene customers and distributors have invested in existing stock and must be persuaded to try the new systems. To mitigate this Lighting Entrepreneurs will be trained to explain the differences in quality and performance of the product.

The survival and growth of the *Lighting the Way Zambia* will be key to the success of this project. Skilled dedicated in-country management and sales will be required to meet distribution and investment goals. Without a strong team this venture will flounder and fail as many others have. UC Davis will work with DISACARE to assemble a skilled, dedicated team and provide on-going support after LADM support period.

In addition, governmental bureaucracy with respect to importation, tariffs, and transportation may slow down the dissemination and add to product cost. DISACARE has experience with importation and distribution and will start work early with government to overcoming these Barriers.

13. Growth Potential

Like cell phones, LED/micropower technology is not region specific; as such, this can be replicated in many areas by studying the existing supply chain and cost structure for kerosene and mimicking it. Common replacement parts, (i.e. batteries, switches, wiring) will be made available locally.

Both the technology and the dissemination model can be easily scaled-up. The product and packaging are designed to be mass-manufactured in as newly industrialized country such as China or Bangladesh and assembled in any country, including Zambia. By utilizing the existing mass-distribution networks for kerosene fuel and other products, the dissemination of the product can be similar scaled quickly. The primary constraint will be related to adoption: If people are willing to pay for our advanced lighting as opposed to paying similar amounts for kerosene lighting, the product will be able to scale quickly. We expect to see early growth of 100%-200% for the first years after initial market testing is complete, leveling off to approximately 50% growth thereafter (table 3, fig. 6). Sales in year 6 (100,000 watts) could replace 100,000 or 1% of Zambia's kerosene lamps.

TABLE 3

Year	New Customers	Watts installed	# of ZLEs
1	0	0	4
2	5000	1250	6
3	10000	2500	8
4	50000	12500	15
5	200000	50000	50
6	400000	100000	100
TOTAL	665,000	166,250	100

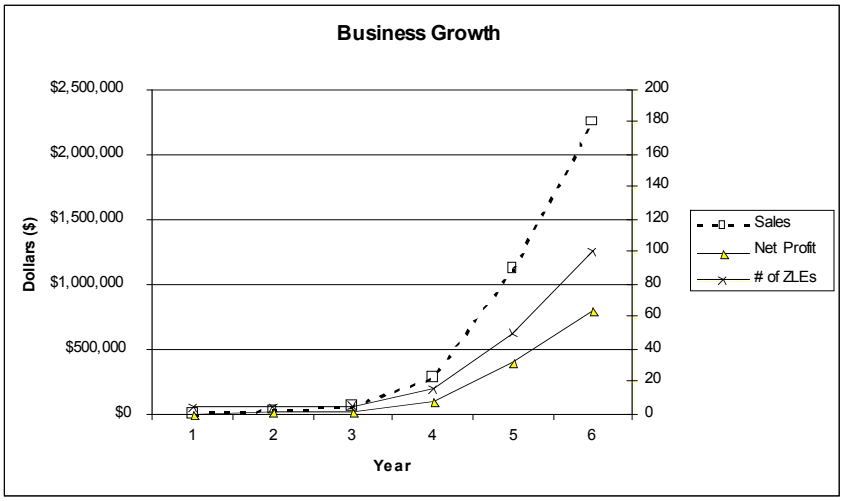

FIGURE 6

Assumptions:

- Total cost for a 1-watt LTW system price is $23-$25
- A 1-watt LTW system replaces one kerosene lamp
- Kerosene lamp uses 1 gal per month
- Life cycle CO2 for 1 watt LTW system is ½ of kerosene: