ECE 481

OSU ENGINEERING ETHICS DESIGN PROPOSAL

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SUSTAINABLE LOW-COST LIGHT

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INTRODUCTION

In any engineering problem involving the design of a product for a specific market, there are ethical issues inherent in the design process. These issues usually involve product safety, environmental responsibility, and cultural impact. Such ethical questions are more explicit in certain instances, such as when a product is designed for an economically depressed region, or when a product is expected to have a profound impact on the culture that it targets. This project deals with the design of a low-cost, long use personal lighting source for use in rural areas in underdeveloped countries. Because the target market for this product is people who have hold very little economic sway, and because it is hope that our product will change these cultures for the better, there are obvious ethical, environmental and global concerns that need to be considered during the design process, in addition to the basic top-level engineering design.

COMPETITION

There are several designs on the market already which might conceivably fulfill the design criteria for the project. They can be seen in Appendices A-C. These generally use solar cells, kinetic battery chargers, or long-life batteries to provide electric light, and generally cost about $30. These products generally have very limited warranties, nonexistent support, and are mostly available in the US. Additionally, these designs (for the most part) are probably not suited to the environments that we are targeting, since they tend to lack the robustness or utility that we require. For instance, the Coleman electric lantern requires batteries that require regular replacement. Such batteries aren't available in our target area, so this design isn't really workable. The solar flashlight requires many hours of direct sunlight to work, but this kind of light isn't available during the rainy season in the villages where our product will be deployed. The kinetic charger requires nearly constant shaking to work, making it only marginally useful as a work light. Additionally, none of these designs have sufficient brightness; it would also be difficult to position them to provide good work lighting.

RECONAISSENCE

In order to determine the best strategy for deploying a new product in a competitive and responsible manner, it is necessary to conduct some market research in the area. The best way to do this

would probably be to hire an anthropologist of some sort to conduct a brief survey in an unobtrusive way over the course of about six months. He/she would determine how much families would be willing to spend on a lighting source, how much use such a device would get, what level of service the locals would be able to provide, and how far people would need to travel in order to obtain support. Additionally, this survey would need to determine the attitude of local cultures towards outside technology. If the indigenous people of a region are suspicious of industry or outside technology, they might not be receptive to a product unless they see other nationals using it.

The way that product research is done, along with the way that our product is marketed, will affect the way that the target population views our company, technology, and western civilization as a whole. It is very important that our company makes an attempt to communicate our good intentions to the community in tangible ways. It might be advantageous to partner with organizations or companies that already have a good local reputation so that we can gain the trust of the locals more quickly. It might also be wise to demonstrate goodwill to the locals by distributing some of our units for free so that people can become familiar with them without having to invest money in an untrusted device.

CONSTRAINT SUMMARY

The following section is going to outline the constraints for the design of the low cost lighting solution. This lighting solution is going to replace the dangerous and improper use of kerosene lamps. For a full constraint listing see the project description. The following was included as a summary.

The customer is located in a very remote region. The customer has no access to an electrical system and no reliable way to obtain fossil fuels. It is a 6 hour walk to the nearest neighboring village. There is a rainy season where sunlight is only available for 2 to 3 hours a day. For the other portion of the year it is sunny all day. Temperature ranges from 20 to 110 degrees Fahrenheit. There is no access to a portable water source. Living conditions are harsh and described as “hut like”.

CUSTOMER FINANCIALS

The first task in designing the lighting system was to identify the overall amount of money that could be

spent on the product. Unfortunately in this case, that target market is very poor. Per the customer constraints, only 1 week's worth of pay could be sacrificed to the purchase of the product.

The first task was to determine a geographical area in which the product would be targeted. We identified a fairly poor nation with a very low GDP. The nation that was chosen was **Rawanda** in Africa. According to the CIA, the GDP of an average citizen in Rawanda is approximately 1300 US Dollars. Rawanda is ranked 200 out of 232 and therefore is a very poor nation. We will use this as a low end target.

http://www.cia.gov/cia/publications/factbook/rankorder/2004rank.html

This would imply that an average citizen could only contribute 19 dollars to the purchase of the product.

1300$ / 52 weeks = 25$ per 1 week

It was determined that the lighting system would be used by one or two family's. By making it a family purchase, the amount of capital that could be spent on the system is greatly increased. We determined that for two families there would be at least three people per family that could contribute to the lighting solution. This would yield the buying power of at least six people towards the cost of the lighting solution. It is assumed that both a mother and father work along with at least one child.

19.23$ * 6 people = 150$

This yields an amount of 150 dollars that the system could potentially cost. This is a very restrictive amount and will be challenging to design a system. We believe it is reasonable to expect that the design should cost between 130 and 170 US dollars.

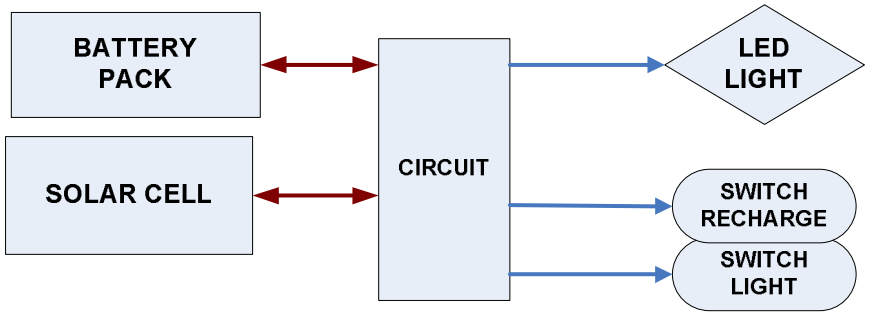
DESIGN SPECIFICATION

The design of the lighting system will take into account the above constraints. The following is a list of specifications identified that the design must meet.

- The lighting system should be able to provide lighting for at least 1 to 2 hours of light.
- The lighting system should be bright enough to provide illumination for crafts-like and learning activities. It was decided that this would be the equivalent to the luminance that a 40 watt light bulb would provide.
- The system should be able to operate failure free for a time period of at least 1 year. Overall reliability should be up to 15 years of operation with service.
- The system shall be deemed safer to both people and the environment than a traditional kerosene lamp.
- The system shall cost between 130 and 170 US dollars.
- The system should be portable and should weigh no more than 100 pounds. Two people should be able to carry the system.

PRELIMINARY DESIGN

The following is a systems level design of a potential solution to the above design constraints. The system contains three main components, a solar cell, a NiMH rechargeable battery pack and a LED light. The solar cell provides enough power to recharge the battery pack and the battery pack provides enough power to run the light. The following details these three components. The name of the system was decided on as Soluminate.



BATTERY PACK

There was a need to include some form of power source. It was decided that Nickel Metal Hydride batteries were the ideal energy storing device. They are memory less and can be recharged up to 1000 times. They are also relatively inexpensive and can be strung together to create virtually any voltage level. It was decided to use C size 5000 mAh 1.2 volt NiMH batteries. Ten of these batteries strung together will provide 12 volts of direct current and they last for 5000 mAh hours. See appendix F for more details.

SOLAR CELL

The cheapest and most reliable solution for providing energy is a solar cell. Even though there are only 3 hours of direct sunlight during the rainy season, solar cells can still work at efficient levels when there are clouds. Also, during the sunny season much more power available than needed. This provides more than ample energy to run the lighting solution above and beyond the 1 hour of light at nighttime. We felt that this was an acceptable tradeoff and choose a solar powered solution as the energy source.

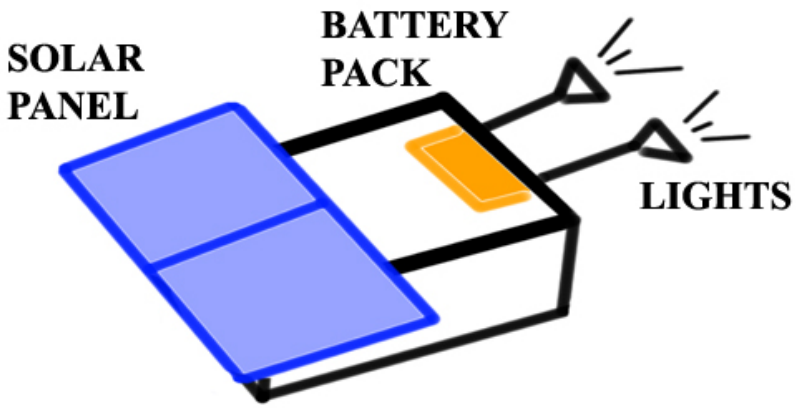
We chose a 7 watt, 12 volt solar panel that was ideal for charging NiMH batteries. These solar panels are durable and efficient in providing power. See appendix E for more details.

LED LIGHT

For the actual lighting solution we chose to use an array of LED lights. They have the advantage of being both cost and energy efficient. In this case we choose a bulb that includes an array of 30 LEDS. We will be using two of these LED bulbs. See appendix D for more details.

According to the specification sheet each LED bulb will provide 178 lumens of direction white light at only 150 milliamps (12volts) and 1.8 watts. For comparison an omni directional (less powerful than directional) 40 watt light bulb outputs roughly 400 lumens. Two of these bulbs should be an adequate level of light for the system.

CONCEPT SKETCH OF SOLUMINATE



DESIGN ANALYSIS

Here we are going to prove how the design meets the specifications for the lighting system design. First we need to assure that the system provides at least 1 hour of light. This is easily done by showing how the two bulbs combined only draw 300 milliamps of current from the batteries. The batteries have a capacity of 5000 mAh hours. This would mean we have the following amount of light from a fully charged battery pack.

5000 mAh / 300 = 16.666 hours

The batteries can be fully recharged roughly 1000 times. This can be extended by ‘refreshing’ the batteries with constant energy. The solar cell chosen should be able to handle this. For now neglect this fact. Therefore we have from one battery pack approximately the following.

1000 recharges * 16.666 hours = 16666 hours from one battery pack

This would imply that one battery pack is useable for 16,666 hours worth of light. Per the system specification of only one hour of light a day this would provide 45 years worth of light from one battery pack! Now this is an ideal situation, much more realistically, the batteries would not last this long and the battery packs would need to be replaced every year or two for efficient operation. However, this is not a problem per the service plan that will be discussed below.

SERVICE AND REPAIR PLAN

The service plan would entail replacing the battery pack every two years and the light bulbs when needed. The LED light bulbs have an incredibly long lifetime of roughly 50000 hours. This far exceeds the amount that is needed and we do not expect the light bulbs need to be replaced frequently. Let's say that they need to be replaced every 5 years from accidental wear and tear (someone physically breaking the light).

COMPETING TECHNOLOGY DEFENSE

This is a highly competitive design. There are other alternatives that are low cost. However these alternatives suffer from a few factors. First, they are relatively cheap but they have very long charge times and the batteries do not last that long. Another problem is the luminance is roughly $1/10^{th}$ of the lighting system we have suggested. Our lighting system could illuminate the room of an entire hut. The products we researched below offer barely enough light to read. Lastly, the following products simply do not offer the rugged design that our system offers. Our system could be enclosed in a plastic housing and offer a very sturdy design. Some examples of other products include the following. In addition to being a more rugged and durable design, the cost of our design could be reduced by up to 30% by factoring in bulk and OEM purchasing.

COST ANALYSIS

The following section will analyze the costs of the system in light of the budgetary constraints of the customer. We have the following:

DEVICE	COST	QUANTITY	TOTAL COST
SOLAR PANEL	60	1	60
BATTERY PACK (10 C-Size NiMH)	30	1	30
LED LIGHTS	32	2	64
TOTAL			**154 $**
TOTAL WITH BULK DISCOUNT			**107 $**

This assessment assumes no recurring costs for a 1 year time period. Realistically the system will need to be serviced every two years. The service should be fairly simple and will include replacing damaged bulbs and replacing drained battery packs. A hypothetical lifetime cost analysis would be the following. Assume 16 year lifetime.

	COST	QUANTITY	TOTAL COST
INITIAL COST	154	1	154
BATTERY PACK 2 Yr Replacement	30	8	240
LED LIGHTS 5 yr Replacement	32	6	192
TOTAL (16 Yrs)			**586 $**

This yields a total cost of the system for 16 years at 586 dollars. This is not too bad for a system.

*Note, no costs such as travel to the region, sales and distribution were included.

ON SUSTAINABLE DEVELOPMENT

The ASCE definition of "sustainable development" has two aspects: Sustainable development should "meet present needs and aspirations," as well as not affect the environment in a way that harms people or adversely affects the environment for future generations. For several reasons, we believe that Soluminate is very much in harmony with the idea of sustainable development. Our design easily meets the first requirement in that it significantly improves quality of life for the demographic group at which it is targeted; it increases earning potential for poor families, protects people from kerosene-related fires, and potentially even gives poor children a chance at a better future by making it possible for them to read at night. With regard to environmental issues: Soluminate might generate some industrial byproducts during manufacturing, but as long as the manufacturing companies are responsible, these should be minimal. Our design uses strictly solar power, so its operation doesn't create pollutants. One small potential environmental concern is the NiMH batteries. These batteries generally have a long life and will require very infrequent replacement, and NiMH batteries are generally considered safe by current standards. Just in case, providing a discount on new battery packs if the old ones are traded in should ensure that the spent batteries don't leak into local water supplies. Another concern would simply be the effects of Soluminate once it is discarded altogether; this is a problem for pretty much any design, and while our device won't appreciably biodegrade, it will not release harmful chemical into the surrounding environment either. It is hoped that our product's long lifetime will mitigate this concern.

DESIGN FOR ENVIRONMENT

Because our product is a venture investment into an environmentally sound technology, and because the profit potential from this technology isn't immediately known, there is a certain environmental interest inherent in our business model. While our primary goal is still to make some form of profit, it is hoped that this can be done in an environmentally and socially responsible way. This means that in addition the environmental analysis that we've subjected our product to, we need to create our production and distribution chains in an environmentally sound way. Practically, this means that we need to create a set of environmental for our suppliers, contractors, and distributors to follow. By doing this, we will be able to

ensure that our business model doesn't peripherally damage the environment, and we will also potentially gain some pubic goodwill from our willingness to abide by high standards.

TECHNOLOGY ISSUES

Since our business plan involves introducing electric lighting and solar power to areas where these commodities are nonexistent, the use of our design in remote areas will constitute significant transfer of technology. We expect, however, that this activity should be well within the bounds of "Appropriate Technology." To be "Appropriate Technology," a technology should be appropriate for its new setting with regards to many factors, such as scale, skill of operators, durability, cost, environmental impact, and relationship to local culture. Our design should be reasonable in terms of each of these criteria: Scale production, distribution, or operation of Soluminate shouldn't create significant detrimental impact on the local economy or environment. The device is very simple to operate, being controlled by a single switch. An unskilled operator could be train in its use in just a few minutes, and the device should prove tolerant to mistakes in case a user decides to experiment. A resilient, waterproof casing should make Soluminate extremely robust and able to survive in a dusty, damp, and accident-prone environment. While the cost of the device is non-trivial in terms of the per-capita income of the target region, the long life, low maintenance costs, and boost that it provides to both quality of life and income for rural families should make it well worth the initial expenditure. As discussed previously, Soluminate is has a low environmental impact because it uses solar power, and because it will have minimal environmental impact if discarded.

Soluminate's effect on local culture is a slightly more complex issue. Although in most instances this product will be the user's first personal experience with electric lighting, users will probably be somewhat familiar with electrics lights in cities and towns. This means that Soluminate might have certain cultural stigmas attached to it, making it anything from a symbol of affluence to an indicator of frivolous cosmopolitan decadence. The attitude that our product engenders will no doubt have an impact on the receptivity of the indigenous populations to the fielding of other industrial products or public works projects. It is also likely that enabling families to work more efficiently after hours will have an affect on the social interaction within communities using Soluminate, but it is difficult to predict exactly how. While

there is a potential for unintended social consequences, we still believe that our product will have an overall positive effect on the communities where it is used.

REFERENCE SECTION

LED LIGHT

http://www.led.lightwavesconcept.com/product_info.php/cPath/158_216/products_id/1097

LIGHTING LUMINANCE LEVELS

http://home.earthlink.net/~kitathome/LunarLight/moonlight_gallery/technique/LightAndCamera.htm

SOLAR PANEL

http://www.siliconsolar.com/12_volt_solar_battery_charger.htm

BATTERY

http://www.batteryspace.com/index.asp?PageAction=VIEWPROD&ProdID=217

NiMH BATTERY FAQ

http://www.starbatteries.com/batteryfaqs.html

APPENDIX A

http://www.lehmans.com/jump.jsp?itemType=PRODUCT&itemID=2029
Home > Lamps & Lights > Flashlights and Solar Lights

32450 – SolarVerter™ Solar Powered Flashlight

SolarVerter™ Solar Powered Flashlight
Daytime charging for nighttime use
The windowsill is the place to store your flashlight. During the day, the sun's rays recharge the NiCd batteries for up to 3 hours of flashlight use. Environmentally friendly since it uses renewable energy. Ideal for mounting on a bicycle (mounting bracket included), traveling and camping. Two switches – white light in front and 3 blinking red LED warning lights at rear. Hard plastic case protects solar panels, waterproof up to 60 ft, and floats. Includes two spare bulbs. Also runs on 2 AA batteries. Imported.

Item#	Product	Qty	Pricing, Availability
32450	SolarVerter™ Solar Powered Flashlight	0	$24.95, On Backorder
820776	4 AA-Cell Duracell® Batteries	0	$4.75, Stock Low

APPENDIX B

http://store.yahoo.com/giftsandgadgetsonline/hacrledflwim.html

Hand Crank LED Flashlight with Mosquito Repeller

Super Bright White LED and a powerful Mosquito Repeller. Never needs batteries with its built-in internal rechargeable energy cells.

For emergencies, camping and travel. Just turn the crank and the built-in self-powered generator recharges the internal battery pack. Dual light selector - spot or blinking light. Hi/Lo level for mosquito repeller with a 13' range. Can be used as a Desktop Lamp – just twist up cap. Uses a rechargeable Ni-Cad battery (included). DC Jack 4.5V. Large crank for easy recharging. Splash Proof - so it's great for outdoors. 90 seconds cranking provides 15 minutes usage for flashlight & 40 minutes for mosquito repeller. Fully charged battery provides 3.5 hours usage for flashlight & 48 hours for mosquito repeller. Rubberized construction for easy handling. Includes a wall mount.

Available in Hunter Green w/Black & Silver Trim.

Availability: Usually ships the same business day.

Hand Crank LED Flashlight with Mosquito Repeller
SR-453 Regular price: $29.95 Sale price: **$18.95**

APPENDIX C

https://www.ebizenterprise.com/index.asp?PageAction=VIEWPROD&ProdID=40573

Coleman

Email this to a friend

Coleman Electric Northstar Lantern w/Night Light

EBIZ ENTERPRISE Item#: 40573
MFG Part#: 5359L701
UPC: 76501218282

This item is brand new and comes complete with all manufacturer supplied accessories and USA warranty.

For shipping cost, simply add the item to cart and use the shipping calculator on the right column.

Qty In Stock	List Price	Our Price	Qty	
Out Of Stock	**~~$39.95~~**	**$29.95**	1	add to cart

Detailed Description

- U-shaped fluorescent tube provides maximum brightness and stays cool to the touch
- Built-in nightlight
- Powered by 8 D-cell batteries (batteries arent included, but we recommend you use alkaline)
- Patented "no tools" tube replacement
- Lantern runs up to 25 hours on a single set of batteries, nightlight runs for more than 100 hours

APPENDIX D

MR-16 LED Bulb (12V, 30 LEDs, Warm White)
[LED-Bulb-MR16-30SFW]

$31.20

Add to Cart

▼Dimensions - Ø1.97" x 1.77" - 30° beam angle

▼LED Bulb Specifications by Color

Suitable operating temperature: -20 to 60 °C

Data	White	Warm white	Blue	Green	Red	Yellow	Orange
Luminous Intensity (mcd)	>7000	>7000	>5000	>8000	>4500	>4000	>4000
Nominal Voltage (V)	3.0~3.6	3.0~3.6	3.0~3.6	3.0~3.6	1.8~2.2	1.8~2.2	1.8~2.2
Nominal Current (mA)	20	20	20	20	20	20	20
Wavelength (nm)	----------	----------	465~475	515~525	635~645	585~595	600~610
Color Temperature (K)	≥ 5000	≤ 4000	----------	----------	----------	--------	--------
Reverse Voltage (VR)	<5	<5	<5	<5	<5	<5	<5
Reverse Current (IR)	<10	<10	<10	<10	<10	<10	<10

▼30 LEDs
Light output: 20W

Voltage	Item	**(Warm) White**	Blue	Green	Red	Yellow
12V	Current (mA)	150	150	150	90	90
	Wattage (W)	1.8	1.8	1.8	1.1	1.1
24V	Current (mA)	75	75	75	25	25
	Wattage (W)	1.8	1.8	1.8	1.1	1.1
Brightness	CD	>178	>127	>204	>114	>102

APPENDIX E

$59.95

7 Watt 12v or 6v Solar Battery Charger

Similar to our above 15w solar panel battery charger, our 7 watt folding solar battery charger offers a unique folding option enabling the panel to be compacted into half it's size. Great for taking on camping trips, hiking, boating, and many other outdoor activities.

Applications:

-Automotive batteries
-Marine Batteries
-12v telecommunication equipment
-Suitable for 6v battery recharging

FEATURES	
Easy connect battery clamps	Safe for charging 12v or 6v batteries (SLA, Gel, and Ni-MH)
5 year warranty	Durable aluminum frame
SPECIFICATIONS	
3lbs	14" x 14" x .75" (Unfolded) 7" width when folded
	7 watt of charging power

Estimated Shipping: $8.95	Price	Qty
Item #: 04-1077 **Availability: In stock***	**$59.95**	1

APPENDIX F

Email this to a friend

10 pcs C size 5000mAh Ni-MH Rechargeable with Tabs **MH-C5000TBx10**

10 pcs C size 5000mAh Ni-MH Rechargeable with Tabs

In Stock	Regular Price	Sale Price	Qty	
Y	**$59.99**	**$29.95**	1	Buy

Quantity Discounts

Quantity	Discounted Price
5-20	$28.45 (Per Item)
21-50	$26.96 (Per Item)
51-100	$25.46 (Per Item)