P08428 LED Lighting Technologies for a Sustainable Entrepreneurial Venture

Concept Review

January 18, 2008

Presentation Outline

Description ……………………………………………………………………Page

Project #	Project Name	Project Track	Project Family
P08428	LED Lighting	Sustainable Products, Systems, and Technologies Track	Sustainable Technologies for the RIT Campus
Start Term	**Team Guide**	**Project Sponsor**	**Doc. Revision**
072	Dr. Stevens	FMS (unconfirmed)	A

Project Description

Project Background:

RIT is dedicated to environmental issues and sustainability. This project entails developing a product that will conserve electrical energy, and reduce Maintenance costs. It was found from project P07421 that off-the shelf LED light fixtures are inadequate.

Problem Statement:

Current exterior lighting technologies are resource intensive and not electrically cost effective. RIT spends about $6 million per year in electrical costs, which half is due to lighting. RIT also dedicated a large portion of resources in the maintenance of exterior lighting.

Objectives/Scope:

1. Reduce energy usage.
2. Reduce maintenance costs.
3. Create a marketable end product.
4. Gain experience with LED lighting system design.

Deliverables:

- Scalable lighting product prototype to accept multiple voltage inputs.
- Life cycle report.
- Return on investment.
- Budget.
- Plan for commercialization (Finish in SDII).
- Drawing plan.
- Manufacturing plan.
- Conference paper.
- Technical poster.

Expected Project Benefits:

- Design feasibility has been determined at the end of SDI.
- Prototype and plan for implementation has been accomplished at the end of SDII.
- Expected energy and cost savings to RIT.
- Improve RIT's image by reducing its global footprint.
- RIT gains experience in alternative lighting systems.

Core Team Members:

- Shawn Russell
- Christine Lagree
- Taylor Shivell
- Arthur Deane
- Philip Pietrantoni
- David Eells

Strategy & Approach

Assumptions & Constraints:

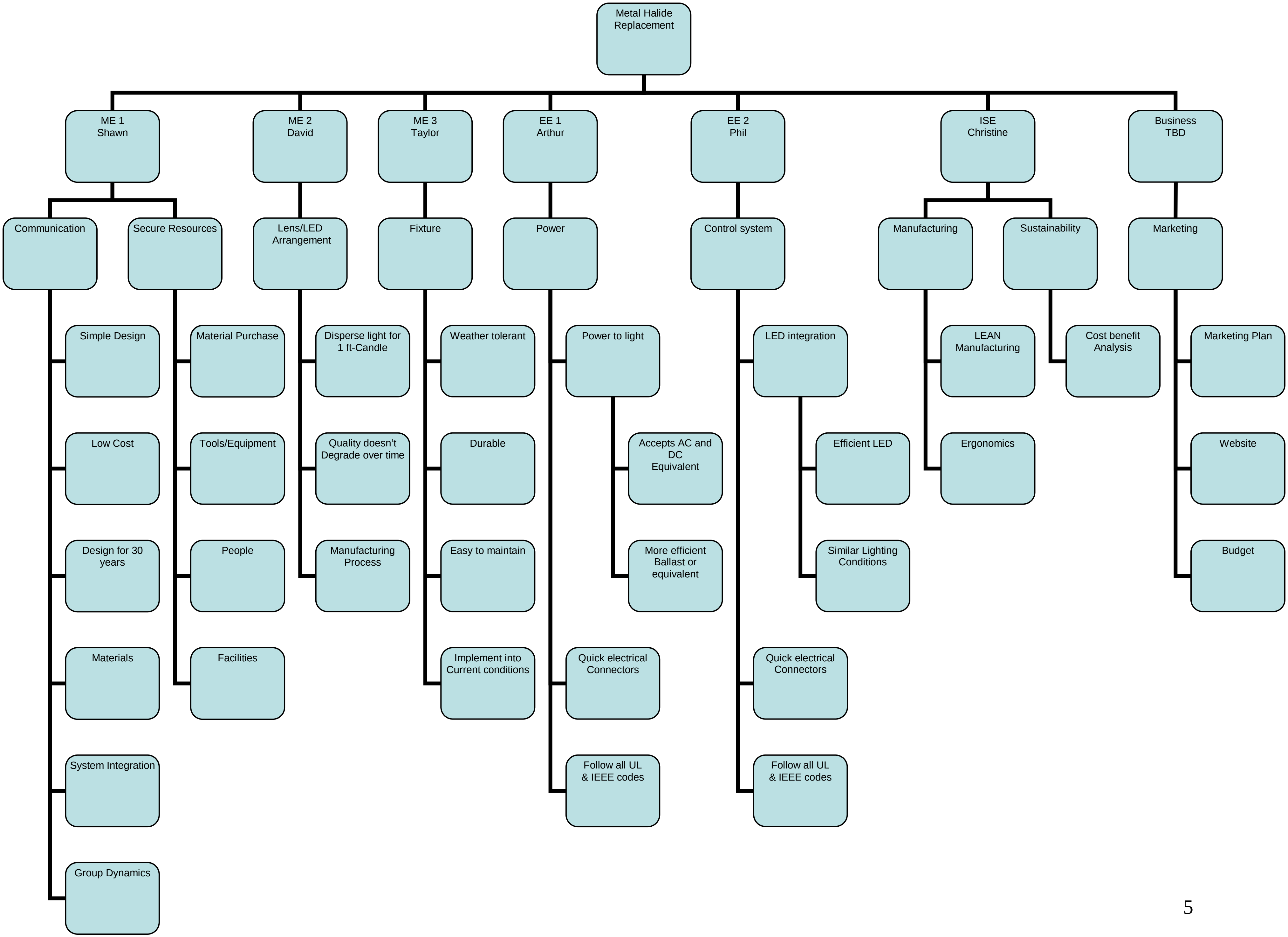
1. Current shoebox fixture will be used.
2. Use of Light Emitting Diodes (LED).
3. LED performance is comparable to current lighting systems.
4. LED's will be more cost effect over its lifetime.
5. Lighting system decreases maintenance costs.
6. The new lighting system will be safe and durable to outdoor conditions.
7. The new lighting system will be compatible with the existing power grid.
8. The light output must be measured at 1-2 a minimum of ft-candles at the ground along walkways.
9. Lighting system conforms to all safety regulations and electrical standards.
10. Easily manufactured.
11. CRI higher than that of HPS lamp.
12. Color temperature is between 3000K and 5400K.
13. Use common parts amongst fixtures.

Issues & Risks:

- Have not obtained funding.
- Adequate light distribution might not be possible with current LED technology.
- Adequate light intensity might not be possible with current LED technology.
- Incoming power might not be easily converted to usable source for LED lighting.
- Design for 30 years could be expensive.
- Cost of materials and manufacturing.
- Product might not be easy to install.
- Timeframe for completion is small.
- Resources might not be available.
- Product may not have a favorable market outlook.
- Environmental considerations (manufacturing and use).
- Systems integration.

Roles & Responsibilities

Name	Project Area of Responsibility	Functional Area of Responsibility	Hardware Area of Responsibility	Role	e-mail	Phone Number
Shawn	Project manager	Mechanical	System Integration	Lead	spr2237@rit.edu	607-351-2777
Arthur	Individual Contributor	Electrical	Power systems/LED integration	Support	ajd8109@rit.edu	347-306-7640
Philip	Individual Contributor	Electrical	Control systems/ LED integration	Support	ppp5425@rit.edu	585-737-4434
David	Individual Contributor	Mechanical	Lens/LED arrangement	Support	dme0759@gmail.com	845-558-8904
Christine	Individual Contributor	Industrial	Systems Integration	Support	CLL3219@rit.edu	716-864-5778
Taylor	Individual Contributor	Mechanical	Fixture Design/Packaging	Support	wts5717@rit.edu	203-623-8028


Metal Halide Replacement
ME 1 Shawn
ME 2 David
ME 3 Taylor
EE 1 Arthur
EE 2 Phil
ISE Christine
Business TBD
Communication
Secure Resources
Lens/LED Arrangement
Fixture
Power
Control system
Manufacturing
Sustainability
Marketing
Simple Design
Low Cost
Design for 30 years
Materials
System Integration
Group Dynamics
Material Purchase
Tools/Equipment
People
Facilities
Disperse light for 1 ft-Candle
Quality doesn't Degrade over time
Manufacturing Process
Weather tolerant
Durable
Easy to maintain
Implement into Current conditions
Power to light
Accepts AC and DC Equivalent
More efficient Ballast or equivalent
Quick electrical Connectors
Follow all UL & IEEE codes
LED integration
Efficient LED
Similar Lighting Conditions
Quick electrical Connectors
Follow all UL & IEEE codes
LEAN Manufacturing
Ergonomics
Cost benefit Analysis
Marketing Plan
Website
Budget

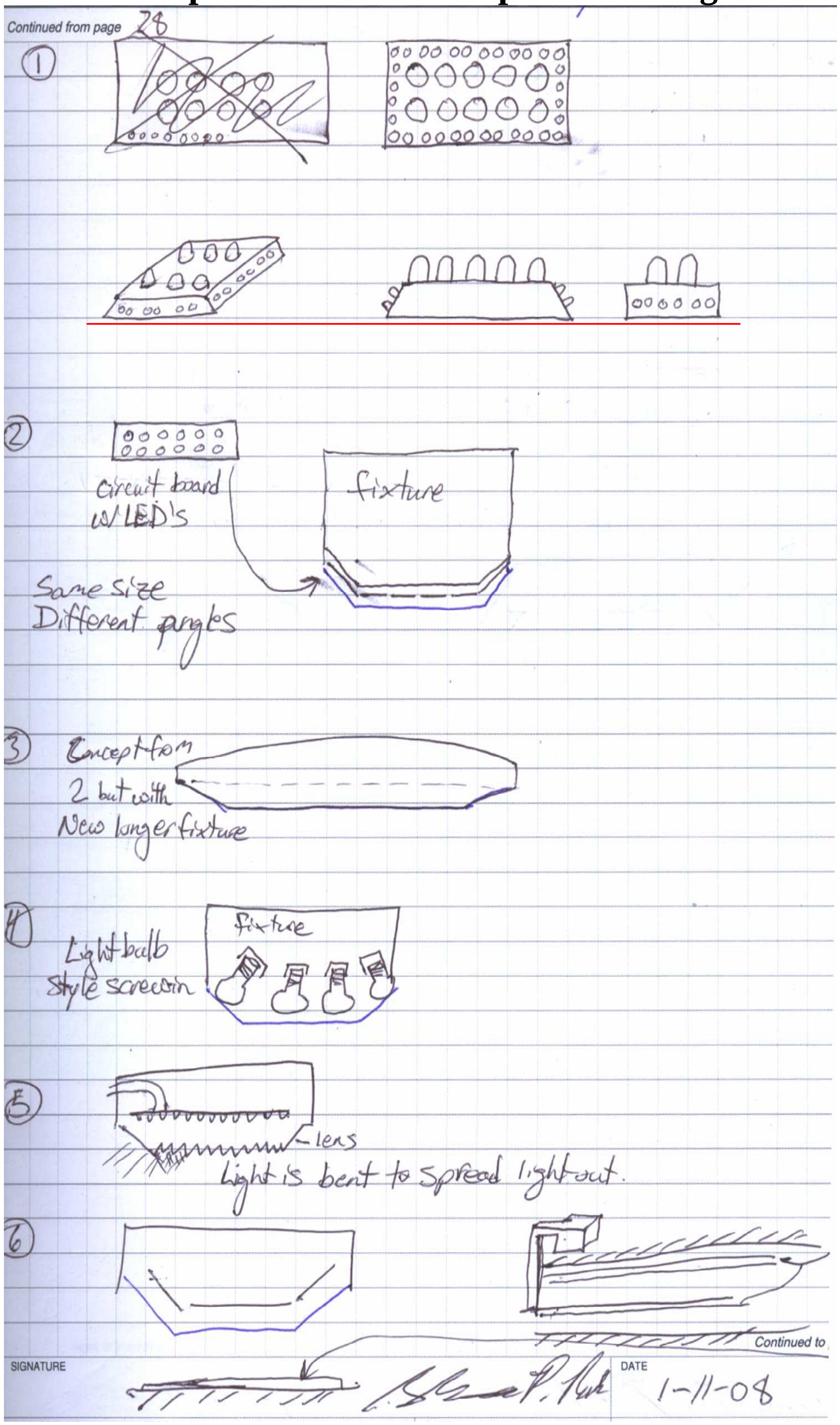
Engineering Specifications

Need No.	Subsystem	Need	Importance
1	Fixture and light	Conform to regulations put in place by OSHA, IEEE, UL and EPA	9
2	Fixture and light	Use less energy than existing systems	3
3	Fixture	Be recyclable	1
4	Fixture and light	Be sustainable	3
5	Light	Decrease the light pollution that the existing lights create	1
6	Fixture	Standardize between fixtures	9
7	Light	Specify colors	9
8	Fixture	Be easy to install and replace lights	3
9	Light	Provide as much light as current systems	9
10	Light	Spread the light out	9
11	Light	CRI higher than that of HPS lamps	9
12	Fixture	Aesthetically pleasing	1
13	Fixture and light	Decrease energy bill	3
14	Fixture	Keep fixture price low	3
15	Fixture and light	Decrease the amount of time and money maintenance spends on the system	9
16	Light	Allow the bulbs to be recyclable	1
17	Fixture and light	Provide a product that can be easily manufactured	9
18	Fixture and light	Allow the energy savings and cost of the product to balance out with the initial costs of installing and maintaining the fixture	9
19	Fixture	Be vandal resistant	1
20	Fixture	Have a long life span	9
21	Light	Have a long life span	9
22	Fixture	Withstand the elements of the outdoors	9
23	Fixture	Weight	9

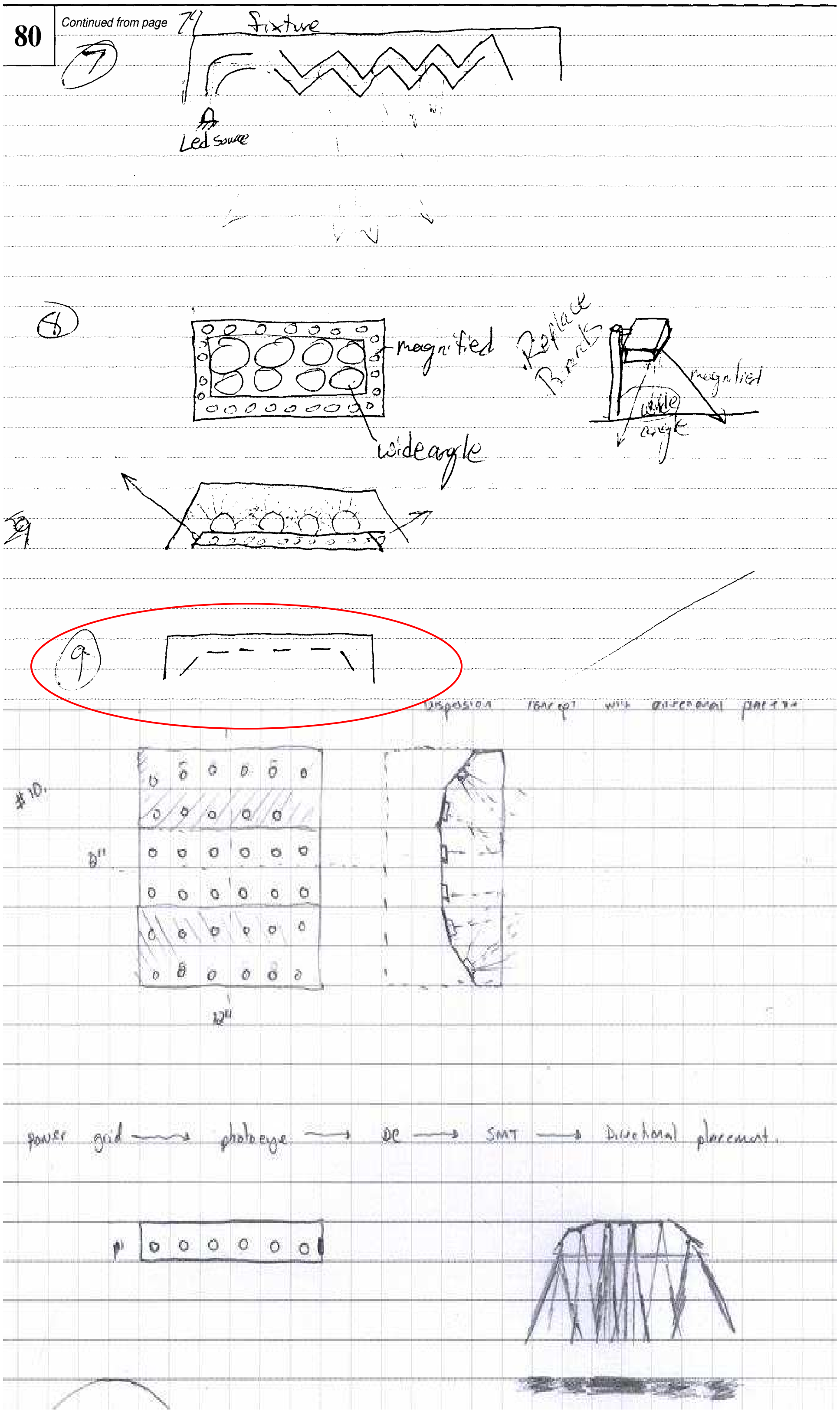
Engineering Specifications

Metric No.	Need Nos.	Metric	Imp.	Units	Marginal Value	Ideal Value
1	1, 3, 4, 14	Complies with applicable codes and regulations	16	Binary	Yes	Yes
2	2, 4, 5, 9, 10, 18	Power consumption	34	W	20-130	50
3	2, 4, 5, 9, 10, 18	Power efficiency	34	lm/W	30-80	70
4	1, 3, 4, 16	Recyclable	14	Binary	Yes	Yes
5	1, 3, 4, 14, 15, 16	Sustainable	26	Binary	Yes	Yes
6	2, 4, 9 10, 12, 13, 18	light pollution	35	Binary	Less	Less
7	6, 8, 14, 15, 17	Standardized parts	33	Binary	Yes	Yes
8	7, 12	Color Temperature	10	K	3000-5400	4100
9	6, 8, 15, 18	Install Time	30	hr	0.5 - 3	1
10	6, 8, 15, 18	Maintenance Time	30	hr	0.5 - 2	1
11	1, 8	Weight	12	lbs	10-50	30
12	2, 5, 6, 9, 10, 13, 18	Minimum light density for entire coverage area	43	ft-cd	0.5-2	1
13	2, 5, 6, 9, 10, 13, 18	Light spread (length)	43	ft	30-40	40
14	2, 5, 6, 9, 10, 13, 18	Light spread (width)	43	ft	3-5	4
15	7, 9, 10, 11, 12	CRI better than HPS	37	unit less	65-80	70
16	5, 7, 9, 10, 12	Aesthetically pleasing	29	Binary	Yes	Yes
17	5, 7, 9, 10, 13, 18	Energy usage	37	kWhr/ month	10-65	18
18	6, 14	Fixture cost	12	$	200-700	400
19	1, 3, 4, 14, 16	Disposal cost	17	$	10-100	50
20	4, 6, 14, 17	Manufacturing cost	24	$	150-400	300
21	2, 4, 6, 13, 14, 18	Break-even point	30	years	5-15	7
22	2, 4, 13, 15, 18	Savings per year	27	$/yr	40-100	60
23	19	Vandal Resistance	1	Binary	Yes	Yes
24	4, 14, 15, 18, 20, 22	Fixture lifetime	42	years	25-50	30
25	4, 9, 10, 15, 18, 21	LED lifetime	48	hours	70,000 - 120,000	100,000
26	1, 22	Operating Temperature	18	*F	-10 - 110	-30 - 130
27	1	Maximum Temperature range	9	*F	140 - 200	150

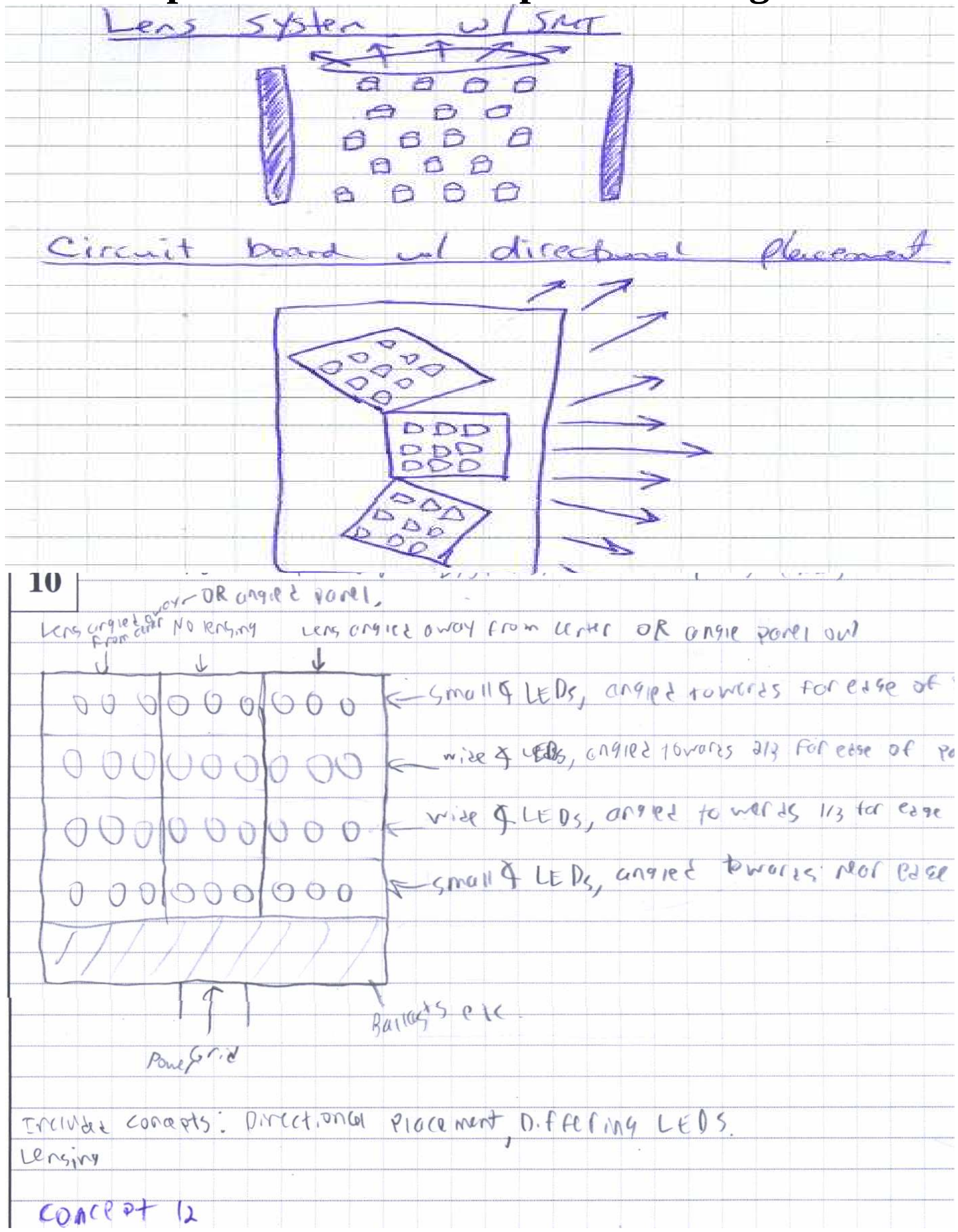
Concept Generation – Dispersion of Light



Concept Generation – Dispersion of Light cont.



Concept Generation – Dispersion of Light cont.



Pugh Matrix – Dispersion of Light

Disperse Light Energy	Concepts												
Selection Criteria	Plug in with LED Array	Circuit Board with Directional Placement	Circuit Board with Long Fixture	Screw in with Directional Placement	Plug in Circuit Board with Directional/indirect lighting	Plug in with Etched Glass (Light Tube)	Circuit Board with Different LEDs and Magnification	Lens System (Spreader Lens)	Directional Placement	Varied LEDs and Directional placement	Circuit Board(s) with Varied LEDs, Directional placement, and Lensing	Direct Bulb Replacement	(Reference) Metal Halide Lamp Reflector
Initial Cost	+	-	-	-	-	-	-	-	+	+	-	0	0
Ease of manufacturing	+	-	-	-	0	-	-	-	+	+	-	+	0
Durability	0	0	0	0	-	0	0	0	0	0	0	0	0
Bulb Replacement	-	+	0	0	0	+	+	+	+	+	+	+	0
Light Distribution	0	0	+	0	-	0	0	0	0	0	0	0	0
Ease of installation	0	0	-	0	-	0	0	0	0	0	0	+	0
Net Score	+1	-1	-2	-2	-4	-1	-1	-1	+3	+3	-1	+3	0
Rank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Continue?	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	NO	YES	NA

		LED-Directional		Varied LED/Directional Placement		Screw-in (Direct Bulb Replacement) (REFERENCE)	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Initial Cost	10	5	0.5	4	0.4	**3**	0.3
Ease of manufacturing	5	2	0.1	1	0.05	**3**	0.15
Durability	25	5	1.25	4	1	3	0.75
Bulb Replacement	15	1	0.15	2	0.3	3	0.45
Light Distribution	35	4	1.4	4	1.4	3	1.05
Ease of installation	10	1	0.1	1	0.1	3	0.3
Total Score:		3.5		3.25		3	
Rank:		1		2		3	
Continue?		Yes		Yes(Modified*)		Retain as reference	

* Changed so that Bulb replacement rating became 1, Light Distribution rating became 5, total score became 3.45

Selected Concept – Dispersion of Light

Eliminated concept 5 due to duplication with concept 9.

After ranking concepts in Pugh matrix, concepts 1, 10, 11, and 13 had all positive rankings; 2-9 and 12 were checked to see if benefits could be used in 1, 10, 11 or 13, then eliminated.

Concept 1 had same positive notes as 10, 11, and 13, but negative note on Bulb Replacement criteria caused elimination.

Concepts 10, 11, and 13 were retained for further investigation.

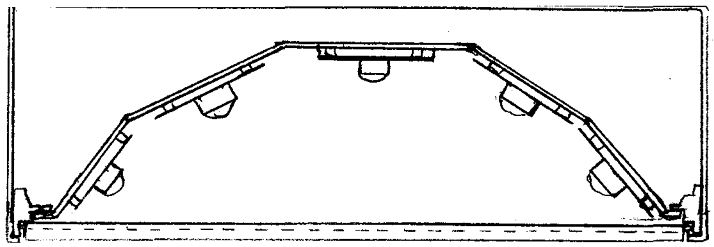
Advantages:

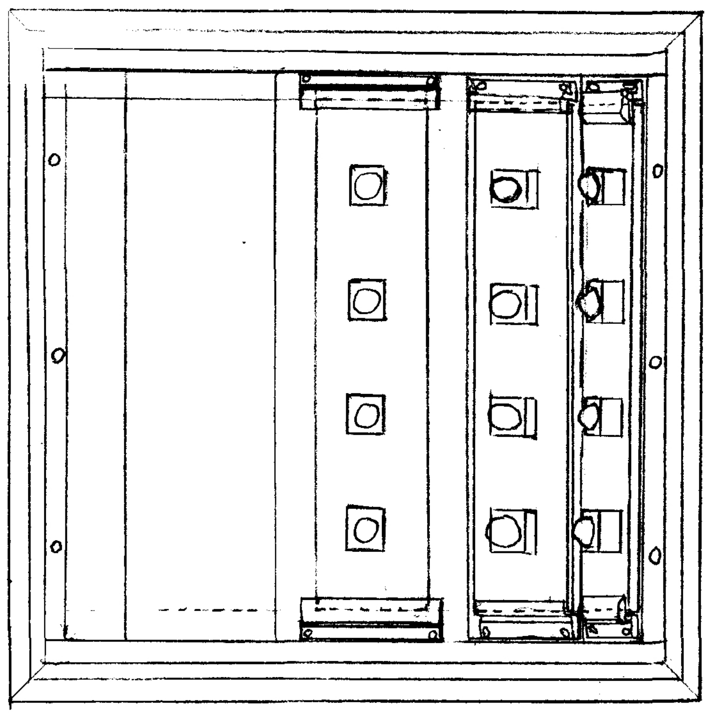
a. LEDs will be positioned to distribute light where needed.
b. Cheaper than current system available (screw in replacement bulbs).
c. With modular design, failure of one part does not lead to failure of the system, unlike the screw in bulb in which when one part fails, the entire system is down.

Disadvantages:

a. Initial installation is slightly more time consuming and intricate than screw in bulb replacement.
b. Maintenance requires replacing individual defective boards
c. Requires more parts than the screw in bulb and entire system is not currently in manufacture.

Selected Concept – Dispersion of Light





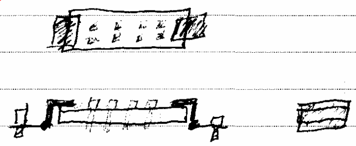
Concept Generation – Connection

Continued from page

Connection Concept Generation

83

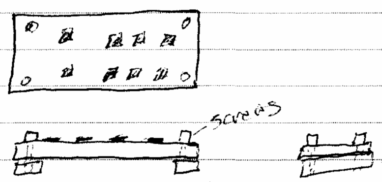
(A)



Snap in connection with through hole LED's

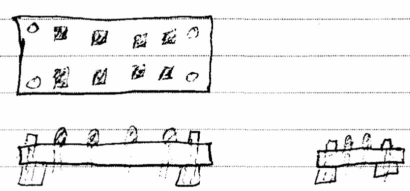
Snap in the Board of LED's that are manufactured with through hole LED's

(B)



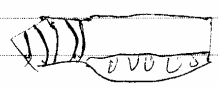
Screwdown board with SMT LED's

(AB)



Combined concepts of A+B where we have a screwdown board with through hole LED's

(C)



A screw-in replacement bulb that already exists

Pugh Matrix – Connection

Apply Electrical Energy to LED		Snap-in Board, Through hole LED Mount		Screw-on Board, Ribbon Cable, SMT LEDs		(NEW) Screw-on Board, Through hole LED Mount		Screw-in (Direct Bulb Replacement) (REFERENCE)	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Initial Cost	15	1	0.15	2	0.3	2	0.3	**3**	0.45
Ease of manufacturing	15	5	0.75	4	0.6	5	0.75	**3**	0.45
Durability	40	4	1.6	5	2	5	2	**3**	1.2
Bulb Replacement	30	3	0.9	1	0.3	1	0.3	**3**	0.9
Total Score:		3.4		3.2		3.35		3	
Rank:		1		3		2		4	
Continue?		YES		YES		YES			

Continue decision made on a prototyping basis. Different criteria and ratings would apply for large-scale manufacturing.

Selected Concept – Connection

Durability for apply electrical energy – screw in has fewer points to hold in therefore snap receives rating of 4, screw in receives rating 5, and screw in (Ref) receives rating of 3.

Through hole vs. SMT – since we are low level production and building a working prototype through hole is weighted higher.

We need to find through hole LED's to benchmark

Number one concept – snap in board through hole LED.

Advantages:

a. Through-hole is cheaper than SMT and does not require machinery to assemble.
b. With modular design, failure of one part does not lead to failure of the system, unlike the screw in bulb in which when one part fails, the entire system is down.

Disadvantages:

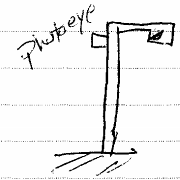
a. Requires more parts than the screw in bulb and entire system is not currently in manufacture.

Concept Generation – Sensing

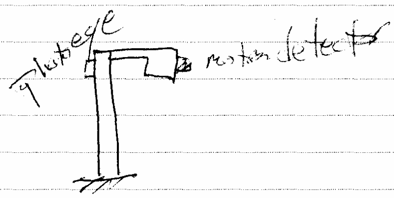
Continued from page

~~Concepts~~ Sensing Switch

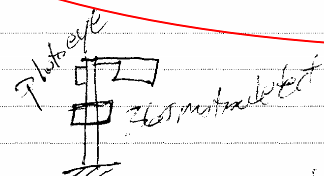
(A) motion detector inside fixture as part of replacement kit photoeye



(B) motion detector & photoeye are monted exterior

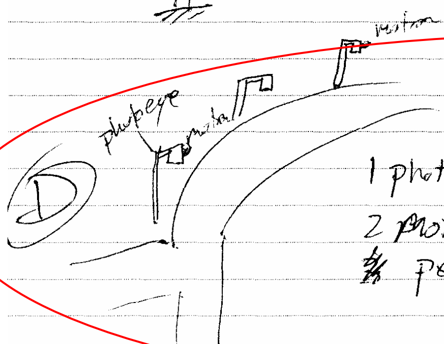


(C) exterior mounted photoeye & motion detector that has a 360° viewing angle

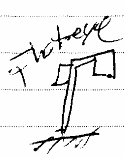


(D) Zone concept has exterior mounted

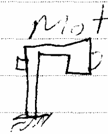
1 photoeye
2 motion detectors
per stretch of walkway



(E) Just a photoeye - No Motion Detect.



(DE) motion detector (optional) photeye - 1 per zone



Continued to page

Pugh Matrix – Sensing

Sensing/Switch		A: Individual controls. Photoeye w/internal motion sensor		B: Individual controls. Photoeye with external motion sensor		C: Individual controls. Photoeye with 360° Motion sensor on pole.		D: Zone control. Master Photoeyes, interlinked motion sensors. New zones from current system.		E: Existing Control System (Zone Photoeyes, no motion)	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Initial Cost	15	2	0.3	**3**	0.45	1	0.15	4	0.6	5	0.75
Sensor Replacement	5	1	0.05	**3**	0.15	1	0.05	4	0.2	5	0.25
Detection Range	30	2	0.6	**3**	0.9	5	1.5	2	0.6	1	0.3
Ease of installation	20	5	1	**3**	0.6	2	0.4	4	0.8	5	1
Energy Savings	30	5	1.5	5	1.5	5	1.5	4	1.2	**3**	0.9
Total Score:		3.45		3.6		3.6		3.4		3.2	
Rank:		3		1		1		4		5	
Continue?				Combine						Combine	

Combination stems from using existing Photoeye control zones with option for motion sensor on each light pole.

Selected Concept – Sensing

Internal motion sensor (A) is more expensive than (B) external.

Need to add cost savings to matrix.

Agree on concepts B & C combined with E. Motion detector is optional (customer option). Sensor may be used only in designated areas. Lights don't need to turn completely off when sensor is not activated. Use existing photo eye zone.

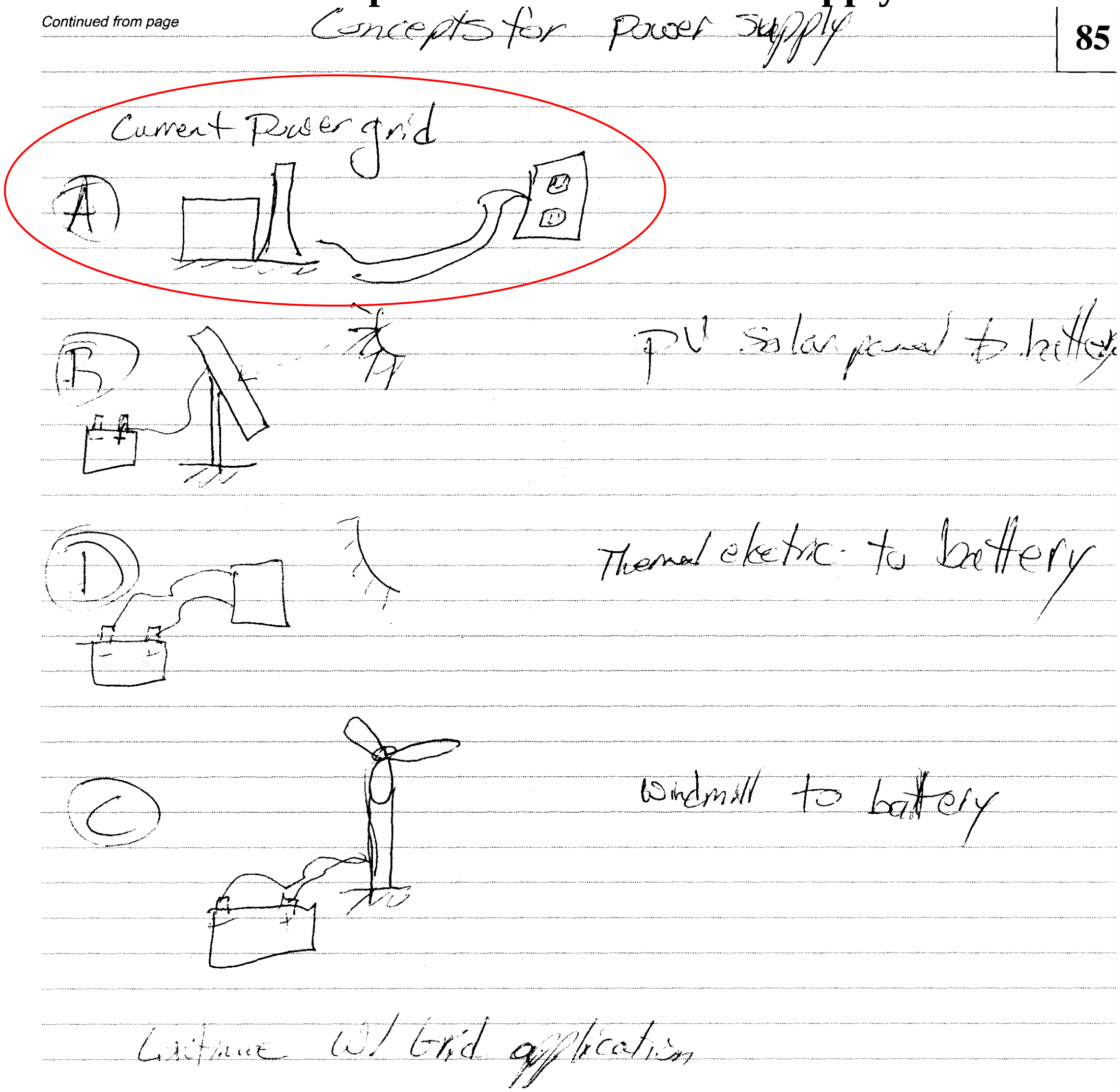
Advantages:

a. Motion sensors will lead to energy savings with potential decreased light output when area has low activity.
b. Uses existing photoeye zone.

Disadvantages:

a. Each individual motion sensor must be installed and replaced directly.
b. Failure may lead to dead spots in detection area.

Concept Generation – Power Supply



Pugh Matrix – Power Supply

Power Supply Method		Power Grid		Solar-> Charge Controller ->Battery		Wind->Battery		Thermo-Electric-> Charge Controller ->Battery	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Initial Cost	20	**3**	0.6	1	0.2	1	0.2	1	0.2
Durability	15	**3**	0.45	2	0.3	1	0.15	2	0.3
Power Production Emissions	5	**3**	0.15	5	0.25	5	0.25	5	0.25
Availability of supply	25	**3**	0.75	2	0.5	2	0.5	1	0.25
Energy Costs	20	**3**	0.6	5	1	5	1	5	1
Ease of installation	15	**3**	0.45	2	0.3	2	0.3	2	0.3
Total Score:		3		2.55		2.4		2.3	
Rank:		1		2		3		4	
Continue?		YES		Investigate if time		NO		NO	

Selected Concept – Power supply

The reliability of the Grid connected system surpasses alternative power sources, which is very important when considering safety.

Advantages:

a. Uses readily available electricity with no additional setup.
b. No external parts that may fail or break.

Disadvantages:

a. Not as environmentally friendly as solar/thermo-electric/wind.
b. Susceptible to rising energy costs.

Concerns/Issues & Risks

1. Ability to model LED light.

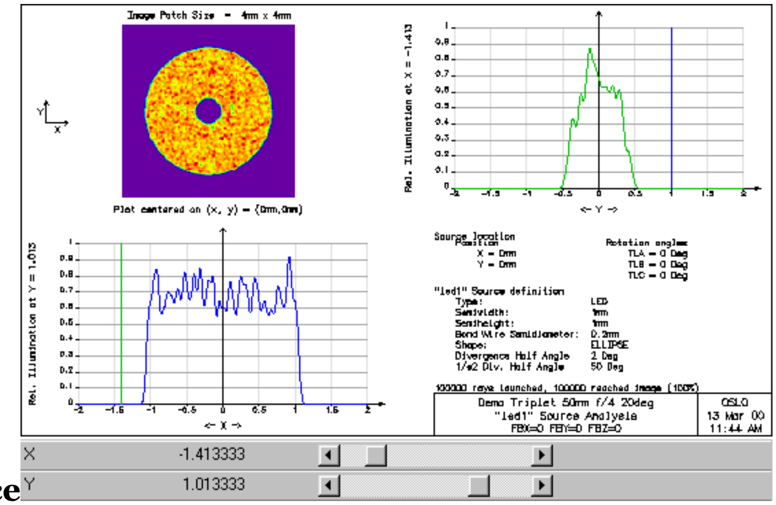
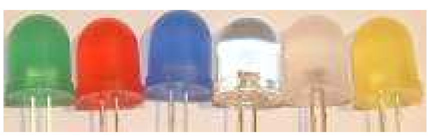


Image of a LED source

2. We have only found low power through-hole LED's, which we think that through-hole LED's are only offered for low power (<2watts) due to Heat dissipation issues. High power Surface Mount (SMT) LED's can be obtained, but they are harder to mount. Through-hole LED's will be much easier and inexpensive to mount where as the SMT LED's require machines to mount.



Through-Hole LED's

Vs.

SMT LED

3. Licensing agreements on PRO/ENGINEER.

Next Steps

1. Sub-system design of:
    a. Fixture and circuit board implementation
    b. Power conditioning
    c. Sensing circuits
    d. Modeling light to find optimum system
    e. Prototyping of LED's
2. Find facility to mount SMT LED's

Notes