



G & P Machine Company, Inc.

Home-For-Sale-Lighting Concept
Feasibility Study

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Prepared for:

Prepared by:

G&P Machine Company, Inc.
Manitowoc, WI 54220

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Table of Contents:

1. Executive Summary	3
2. Definition of Concept	4
3. Background on Solar Power Generation	4
4. Definition of Components	6
5. Simplified Schematic of Concept	7
6. Calculation of Circuits	9
a. LED/Battery	
b. Solar Panel	
7. Available Sunlight by Regions	11
8. Analysis of Available Power	12
9. Conclusion	13
10. Appendix	
a. Anticipated Timeline	14
b. Analysis of Competitive Designs	15

Executive Summary:

G&P Machine Company is proud to present the following report summarizing our findings during the feasibility phase of this project. The project consists of analyzing the ability of solar power to energize a device which will project messages onto items that are for sale (e.g. homes, RVs, cars, buildings or personal messages) to drive traffic and improve sales rates.

The attached report provides the background research that was pulled together over the past week researching the application of solar power to this market. Our study included review of available sunlight per region, a study of available technologies, a study of available manufacturers and the other existing products in this market.

It is our opinion that the Home-For-Sale-Lighting concept is unique and should be pursued for production. Looking at the available solar energy, the required battery pack would range from 4.8V (4-AA cells) to 7.2V (6-AA cells). The highest wattage requirement for the design is 7.2 watts which is 1/10th the available wattage per day based on National Renewable Energy Institutes values for available solar energy by region. This available energy per day takes into account the low 7% “end-to-end” efficiency rate which solar panels are able to convert solar energy to electricity. Other technologies are able to convert solar energy at a higher rate, but they are cost prohibitive for a consumer product. The available light in various regions of the United States was reviewed and there does not appear to be an issue achieving the proper charging rates for this concept.

After analyzing various LED circuit designs, the LED lights can be arranged in parallel which helps keep the battery requirement down. This minimizes the overall package of the product. We recommend proceeding to the design phase to analyze three scenarios: a) 6-LED circuit, b) 12-LED circuit and c) 18-LED circuit. The solar panel cells can produce enough power for any of these scenarios, but each circuit needs to be analyzed as far as which is optimal for projecting onto a structure clearly. There are significant variables such as LED color and projection angle that will require some testing to finalize.

The target sale price range for the product was provided as \$60 to \$100. The following report provides estimates of component costs. These costs will need to be finalized once the final design and market demand are determined. It is our opinion that based on competitive product and initial cost estimates, this price range can be achieved.

After reviewing competitive product on the market, it is our opinion that this design needs to be reviewed for patent protection. The overall concept here is selling a message or advertising tool, not creating light. Other products exist on the market, but they all focus on creating light. Home-For-Sale-Lighting is taking this a step further.

The following discussion details out our findings and provides several tables to support the calculations.

Definition of Concept/Project:

G& P Machine Company, Inc was approached by the customer with the request to develop a concept (Home-For-Sale-Lighting) for a light which was self contained and generated the energy necessary to illuminate a home with messages regarding its pending sale. The concept showed a light head mounted onto a post which could mount anywhere in a yard. The request included:

- Solar panel on top for maximum sunlight exposure
- Interchangeable front signs which could provide the end-user the option for various statements to be illuminated on the home, vehicle, etc.
- A housing design which can pivot to provide the best placement on the home, vehicle, etc.
- The ability to offer different colors in the projection of the message to indicate various sale stages or options
- Durable, lightweight plastic shell design (chromed)
- Lifetime warranty
- The ability to sense sunlight levels and switch on or off as light levels varied
- Optional battery charging stations
- Illumination at night of 4-5 hours maximum. Assume winter conditions of sunset at 4:30 pm and light stops illuminating at 9:30 pm.

After reviewing the project on a phone conversation, the customer agreed to move forward with a feasibility study to determine the best approach to powering the unit. Based on illumination requirements, there was concern that the solar panel may not be able to provide a sustainable charge to operate properly. This report details out the results of the feasibility analysis on solar power and whether to proceed with this design or an A/C option.

Solar Power Generation:

The sun produces 1 kw/m^2 of solar radiation that hits the surface of the earth per hour. The concept of solar power generation is to capture this energy and convert it into usable/sustainable power that can replace the un-renewable sources that currently provide power to most grids globally.

The first solar cells were manufactured from gold in 1883 and were used to limited success. In 1941, researchers were looking for a more robust, abundant resource to expand this technology and the silicon photovoltaic cell was created. The silicon cell captures the ultraviolet rays from the sun, uses this energy to excite captured photons and the reaction of this process is heat and electricity. The efficiency of the standard photovoltaic cell is 12%. Some new technologies have raised this efficiency to 35%, but for the targeted consumer model, the price limitations will keep the study in the amorphous silicon cells for power generation. Once you take into account the efficiencies of the other components in the design such as LED lights, batteries, wiring,

soldering, etc. the actual end efficiency of a solar powered device is between 7 - 8%. For this study we chose to use 7% to ensure proper factors of safety were included.

At the ideal state of $1\text{kW}\cdot\text{hr}/\text{m}^2$ solar radiation, the 7% efficiency will result in an optimal conversion capability of $70\text{ W}\cdot\text{hr}/\text{m}^2$.

One of the limitations to the technology is it is dependent on direct sunlight. The levels of available sunlight is significantly different in Seattle than in Fort Myers, Florida. Figure 1 shows the annual average of available $\text{kW hr}/\text{m}^2/\text{day}$. This average is referred to as insolation.

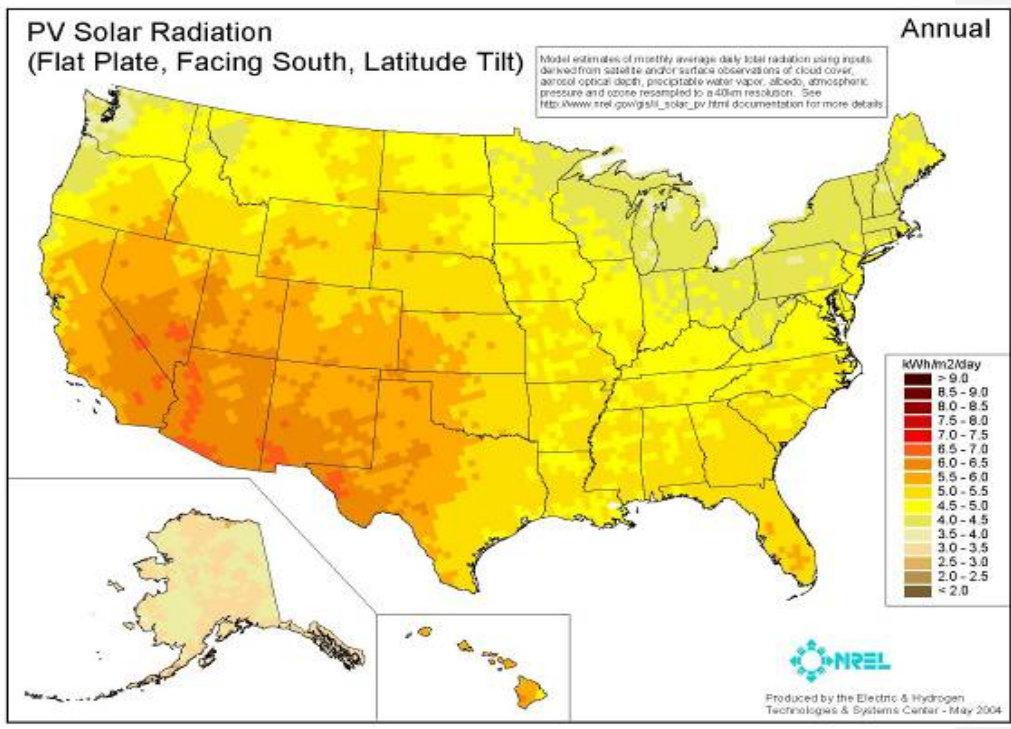


Figure 1: National Renewable Energy Laboratory map showing annual available energy from solar radiation.

The following charts (Figure 2) show the impact that the season has on available solar radiation.

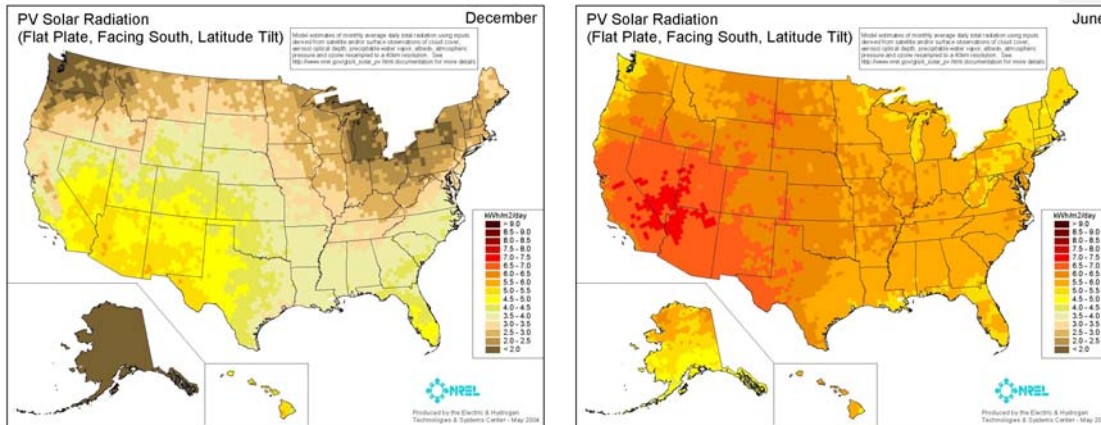


Figure 2: US comparison of PV solar radiation (June v. December)

The 7% efficiency will be coupled with data from these graphs to ensure the input energy levels are sufficient for powering this concept. The winter months will present the most difficult condition for charging the batteries and will result in the shortest available charge.

Definition of Components:

There are several components that are considered when designing a circuit to convert solar energy into usable power for projecting images. The following is a list of components which will be incorporated into the design:

- Photovoltaic Cell (PV Cell): Silicon wafer cell which can output .5V per cell at 7% efficiency when exposed to direct sunlight.
- LED light: LED (light emitting diode) is the ideal choice for solar light applications due to their small size and very low energy usage. The use of LED minimizes the required battery size. The standard LED has life expectancy up to 100,000 hours based on configuration.
- Diode: A device added to the circuit board with LED's to prevent the solar panel from providing excessive energy to the battery, thus burning out the battery.
- Resistors: Electrical devices added to each string of LED lights to limit the amount of current that the LED is exposed to. The lower the current level, the longer the life of the LED.
- Photo Resistor: A device added to the circuit board to function as a on/off switch. The device is specified to a desired resistance to tell the battery when it is time to discharge its stored energy. The resistance level in this device increases as the sun goes down. Once the resistance hits the specified amount, it turns off the charging circuit to battery and begins discharging to LED system. This prevents

the lights from turning on immediately, or if it is cloudy. It requires a set period of time with limited light to trip the discharge process.

- Battery Pack: A combination of AA cells which are used to store the energy produced by the photovoltaic cell during the day. The size of the battery is chosen such that it is lower than the voltage produced by the PV cells, but greater than the circuit requirement for the LED lights. If this relationship holds, the battery will charge and discharge properly. Each cell in the battery holds 1.2V.

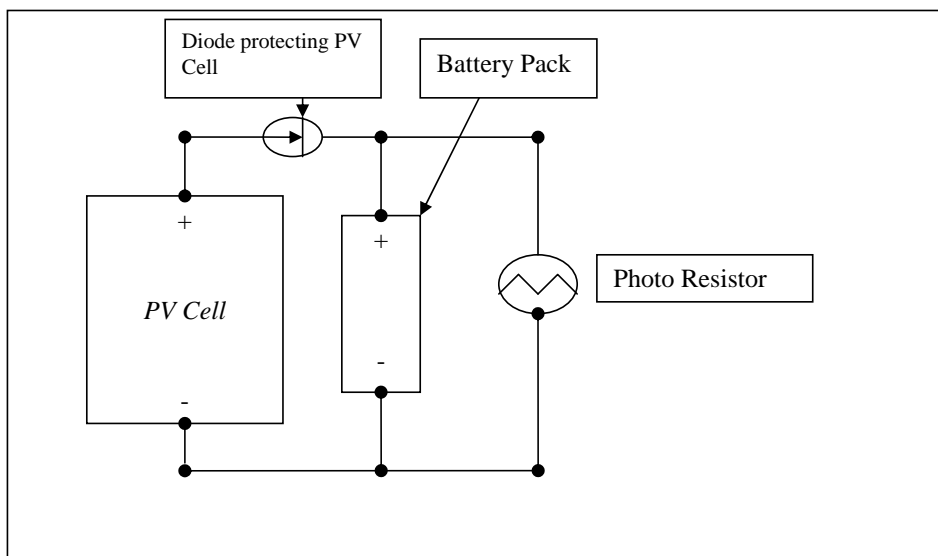
All in all, there are two circuits that we are concerned with in this design. The first circuit is the charging circuit which connects the PV Cell to the battery and operates during the daylight. The second circuit is energized when the photo resistor tells the circuit it is time to power the LED lights to illuminate the sign. At this point, the PV Cell is disconnected from the circuit and the battery becomes the power source discharging the energy it collected during the day.

Simplified Schematic of Circuits:

The following illustrates simplified schematics of the circuits required for this unit. The circuits highlight the key components which will be assembled to create the Home-For-Sale-Lighting design. The final schematics will be completed in the design phase.

Again, there are two distinctly separate circuits in operation in this unit. The only common components between the two cells will be the battery pack and the photo resistor which will turn the respective circuits on and off during the daily sun cycle.

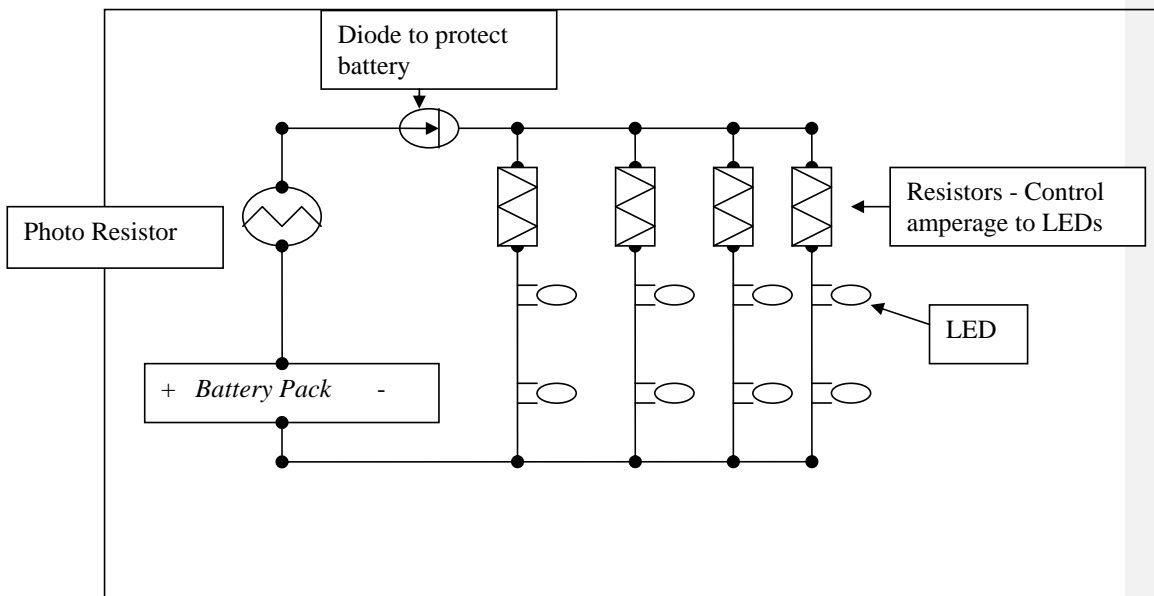
Schematic 1: Charging Battery Pack



Schematic 1 simplifies the circuit required to charge the battery pack. The battery pack will be a combination of AA rechargeable cells. The cells each have a maximum possible voltage value of 1.2V. The calculation of the circuits in the section below will provide an indication of the number of cells needed to drive the LED bank. Once the battery is calculated, the only requirement for the charging circuit is that the PV Cell must produce voltage (in the open circuit) in excess of the battery total circuit.

Example: If four cells are needed, the total battery pack voltage would be 4.8V. The next standard PV Cell to charge the 4.8V battery pack would be a 6V solar cell.

Schematic 2: Discharge Battery Pack - Power LED lights



The photo-resistor will allow the battery to begin discharging when enough darkness has triggered the internal limit. The energy will be released through the diode into each of the strands of LEDs. The LED lights are mounted in parallel to minimize the battery size required for the light. If the lights were mounted in series, the voltage for each light is cumulative and would result in a battery that would make the light very large and heavy. By mounting the lights in parallel, the drop voltage of the lights can be limited to two or three lights per strand, thus minimizing the size of the battery.

Calculating the Circuit Requirements:

LED requirements - Sizing the Battery:

The design phase of the project will finalize the exact number of LED lights required to project the images onto the home. For reference, a typical garden light which utilizes solar energy for lighting a path with “warm white” lighting typically utilizes one to three LEDs and either two or three AA rechargeable batteries. Solar powered spotlights which offer increased illumination, but at a broader angle generally have six LED lights mounted to the circuit board.

The intensity of an LED light is determined by the angle with which the LED is designed. Research has shown that the typical garden applications LED's have a projection angle of 100°. In order to increase the throw of the lighting for this project, and the mounted message plaque, the design angle of the LED will need to be decreased. These angles can be taken down to 10° for focused light intensity.

With that being stated, it is our suggestion to analyze three scenarios in the design phase of the project. The circuit board should be analyzed utilizing a) six-LED lights, b) twelve-LED lights and c) eighteen-LED lights. This allows flexibility in design and could provide long term upgrade options to the design. The heat emitted from the LED lights is so low that there is minimal concern on packaging the units. The design phase will review if a tight projection angle on six-LED lights is enough to illuminate the message boards or would the design require more lights for success. As you will see below, the design and charging capabilities can be achieved at any of these LED levels.

Referencing the discussion in “Simplified Schematic of Circuit”, the number of LEDs per chain in the parallel arrangement can be arranged in each scenario above to minimize the battery size.

The following table indicates the voltage requirement for a typical LED, the resistor sizes needed per chain and the battery size required if yellow (warm white) or bright white LED lights are chosen. The angle of light projection does not impact the voltage or cost of the LED. Yellow LED lights are similar to a standard lamp light color with ~1.9V drop per LED. The bright white lights have 3.6V drop per LED which typically drives the battery size up. Illumination performance will allow the final arrangement to be chosen.

	Units	6-LED		12-LED		18-LED	
		Yellow	Bright White	Yellow	Bright White	Yellow	Bright White
LED Drop Voltage	V	1.9	3.4	1.9	3.4	1.9	3.4
LED Anticipated Amperage	A	0.015	0.018	0.015	0.018	0.015	0.018

Battery Size Options	V	4.8	4.8	4.8	4.8	4.8	4.8
	V	6	6	6	6	6	6
	V	7.2	7.2	7.2	7.2	7.2	7.2
<i>The battery cells come in 1.2V increments for AA size battery cells.</i>	V	8.4	8.4	8.4	8.4	8.4	8.4
	V	9.6	9.6	9.6	9.6	9.6	9.6

Allowable LEDs per Parallel Strand	2	1	2	1	2	1
	3	1	3	1	3	1
	3	2	3	2	3	2
	4	2	4	2	4	2
	5	2	5	2	5	2

Required Resistors Ohm	Ω	67	78	67	78	67	78
	Ω	20	144	20	144	20	144
<i>The resistor value is important to ensure the proper amperage is delivered to the LED. If the resistance is too low, we could burn out the LED.</i>	Ω	100	22	100	22	100	22
	Ω	53	89	53	89	53	89
	Ω	7	156	7	156	7	156
<i>Standard resistances are 100, 110, 120, 130, 150, 160, 180, 200, 220, 240, 260, 280 & 300. The values above will be rounded up to the next standard resistance once the final design is chosen.</i>							

Required Resistor Wattage	W	0.015	0.0252	0.015	0.0252	0.015	0.0252
	W	0.0045	0.0468	0.0045	0.0468	0.0045	0.0468
<i>The resistor wattage is important to understand how much of the power being sent to the LED is consumed in the resistor.</i>	W	0.0225	0.0072	0.0225	0.0072	0.0225	0.0072
	W	0.012	0.0288	0.012	0.0288	0.012	0.0288
	W	0.0015	0.0504	0.0015	0.0504	0.0015	0.0504
<i>The Wattages come standard in 1/4 and 1/2 Watt levels. Based on the values above, a 1/4 Watt resistor is acceptable.</i>							

From the table above, we see that for the lower voltage levels (4.8 and 6.0), the Bright White LEDs are not a good match. The board would become quite cluttered and complicated if only one LED was mounted per parallel strand. The goal is to achieve two to three LEDs per strand to simplify the circuit board. As the table indicates, the voltage requirements of the Bright White LED of 3.4V per light push the design into more expensive, heavier battery packs. The recommendation here is to start the design with 4.8V battery pack (4-AA cells) and determine if the Yellow LED cells with narrow projection angles are acceptable for projecting the image. If Bright White LED are required, the 7.2V (6-AA cells) would be the next most economical selection for a battery pack. Both of these battery packs are commercially available. The price will vary based on release quantities from the manufacturers.

Another factor to discuss is LED lights typically last between 10,000 and 100,000 hours based on the amperage that runs through the diodes. The higher the amperage sent to the LED, the lower the life of the LED. It should be determined how long of a product life needs to be designed into the circuit board. For reference, at the maximum of five hours per night, the range of the LED's is 6.5 to 65 years. By changing the amperage, it will impact the resistors chosen to control the energy flow to the LED's. This change should not dramatically impact the cost of the circuit board, but needs to be specified during final design.

Comment [B1]:

Solar panel requirements:

The solar panel requirement is simplified down to as long as the voltage of the panel is greater than the voltage of the battery, the battery will charge. What now has to be determined is the amperage that is produced by the PV cell circuit. The higher the amperage from the PV Cell, the quicker the battery pack will charge. The discussion of how quickly will the battery charge will be dealt with in the section *Analysis of Available Solar Power*. The design target is to have the battery charge to sufficient level to illuminate the message for four to five hours.

Looking at the options from the table above:

Yellow (Warm White) LED: 4.8V battery pack

Bright White LED: 7.2V battery pack

The required Solar PV Cell requirements would be

Yellow (Warm White) LED: 6.0V (100 - 250 mA) PV Cell module

Bright White LED: 9.0V (100-250mA) PV Cell module.

The final design will determine which manufacturer's specifications best meet the requirements of this design. This will determine final cost of cell, final size of cell and the amperage available to improve charging time.

Analysis of Available Solar Power

This section will focus on the required W-h/m² to charge the batteries with the panels associated amperage from above. The following table shows an analysis of four regions, a) Southeast, b) Northwest, c) Midwest and d) Northeast. Batteries can be designed to have any number of amperage outputs for a given voltage design. The volts are designed in 1.2V increments, but the amperage varies based on density of the given battery. For this analysis we chose 1000mAh (1 amp-hr) density. The lower the density, the more economical the battery selection.

		Specifics			
		Volts	Amperage	Watts	
Battery Pack Options		4.8	1	4.8	
		7.2	1	7.2	
W-hr/day required to charge Cells					
Battery Charging Loss Level		1.25			
Regional Sunlight Availability		NW (Seattle)	NE (Boston)	Midwest (Chicago)	SE (Ft. Myers)
	Summer	5	6.2	6.2	7.25
	Winter	3.75	4.65	4.65	5.4375
		Available Wattage	Hrs required		
Available Charge from Panels	100mA	0.6	8		
	200mA	1.2	4		
	250mA	1.5	3.2		4.8V Pack
		Available Wattage	Hrs required		
	100mA	0.72	10		
	200mA	1.44	5		
	250mA	1.8	4		7.2V Pack

Looking at the requirements of the battery packs and available light per day, it appears we need to specify a minimum of 200 mA for the specific PV Cells. The hours indicated above are considered direct sunlight available. We can assume that from sunup to sundown light will be entering the cell, but true energy conversion will occur as the sun is higher in the sky. The required watt levels (4.8 & 7.2) are well within the optimal solar energy conversion rates listed earlier in the report of 70 W-hr/m². The design phase of this project will finalize the exact manufacturer and cost of this cell. There are several firms that produce consumer focused, portable PV cells.

Conclusion:

G&P Machine Company is confident that based on the analysis above, all project requirements can be achieved with existing technology. The following table shows a preliminary bill of materials and estimated costs for this technology. The customer indicated on a conversation that a target sale price between \$60 and \$100 would be acceptable. The final cost will be heavily driven by market demand estimates, materials chosen for housing components and release quantities from the chosen suppliers. This estimate below is rough using online quotes for PV Cell, board and battery pack. These prices can be refined during conversations with actual suppliers in a competitive bidding process. The estimates for the housing costs are taken from estimated volume/size of housing multiplied at market prices for commodity plastics (e.g. Polypropylene, ABS, etc.). Final design will determine final plastic volume and cost. It does appear that this project can achieve the initial price targets and return a satisfactory margin.

This does not include assembly cost. The required cycle time for assembly will be influenced on the final design characteristics. G&P does have extensive experience in design for manufacturability which will assist in keeping the assembly and component costs low.

Component	Est. Piece Price	Comments	Estimated Process
PV Cell	\$10.00		Silicon wafer technology
Circuit Board**	\$13.00	Includes LED, resistors and soldering	
Battery Pack	\$12.00		
Housing			
Plastic Top	\$1.00	Body to hold battery and lens/circuit board	Injection molded
Plastic Bottom	\$1.00	Body to hold battery and lens/circuit board	Injection molded
Post	\$0.75	mounted adjustable housing	Injection molded
Lense Cover	\$0.75	Cover to snap onto housing and hold insert panels	Injection molded - Clear
Panels for PV Cells	\$2.50		Injection molded/ultrasonic welded to protect
Fasteners	\$0.25	Hardware to assemble post	
Insert Panels	\$0.65	per panel (e.g. "For Sale", "New Price")	
Assembly Charges	N/A	* - Will be finalized after finished design is approved	
Packaging	\$3.00	Assuming lithographed cardboard with several inserts	

Estimated Cost of System		\$44.90
Optional Sales Prices	Price	Margin
	\$60	25.17%
	\$65	30.92%
	\$70	35.86%
	\$75	40.13%
	\$100	55.10%

** - At the start of the design phase, we will request circuit board quotes to ensure economic value.


Anticipated Project Timeline

The following timeline is an estimate for this project's requirements. During the first conference call to discuss this report, the next steps can be finalized. Upon approval of this report, G&P will submit the quote to perform phase II of the project which is to complete the detailed design on the light assembly. The deliverables of Phase II will include all required drawings for the design (including individual components, assembly and circuitry) along with a report detailing the key findings and performance characteristics.

Project Steps	Anticipated Date	Resp. Party	7-Jan	14-Jan	21-Jan	28-Jan	4-Feb	11-Feb	18-Feb	25-Feb	3-Mar	10-Mar	17-Mar	24-Mar	31-Mar	7-Apr	14-Apr	21-Apr
Deliver Feasibility Report	10-Jan	Jack	█															
Discuss Feasibility Report	11-Jan	Jack/Bob	█															
Submit Quote - Phase II	14-Jan	Jack	█	█														
Submit PO - Phase II		Bob		█														
Engineering Design of Light		Jack			█	█	█											
CAD Drawings of Light		Jack				█	█	█										
Submit Drawings and Design Report		Jack							█									
Discuss Drawings - Determine Next Steps		Jack/Bob							█									
Prototyping		G&P								█	█	█	█					
Costing/Sourcing														█	█	█	█	


Analysis of Competitive Product

During our investigation of the products related to the PV market, the following products, which are also targeted toward the real estate market were discovered. Each product below is paired with a discussion on its relevance to the Home-For-Sale-Lighting design and how it may impact the project moving forward.



The SunPal 4X

Solar Real Estate Lighting



Features:

- Sleek, black body keeps attention on your sign, not the SunPal
- 2 Flux LEDs for complete, even illumination of your sign.
- Battery backup for overcast protection and uninterrupted operation
- Adjustable neck allows you to adjust the direction of the light
- Security bolts and tool to keep your investment safe from damage and theft
- Fits any real estate sign on a wood or pvc post (1 SunPal 4X per sign side)

- o **Pros**
 - o Unique feature which can mount to existing for sale sign posts.
 - o They highlight black body to prevent attention on the lighting unit and more attention on the sale sign.
 - o Brings up a good concern of theft for portable units.
 - o (2) LEDs will minimize power requirements resulting in longer battery life
- o **Cons**
 - o The (2) LEDs provides limited localized projection of light
 - o Must be fixes to sign...signs tend to stand perpendicular to the street so the illumination impact is reduced.
 - o Equivalent to garden light mounted to sign.
 - o Limited to projecting light...not a message.
 - o Limited to home sale signs. Cannot be extrapolated to other markets such as automobile, RV, boat, business, greeting messages etc..



The SunPal 2X

Solar Real Estate Lighting



Features:

- Sleek, black body keeps attention on your sign, not the SunPal
- 16 High-Output LEDs (8 per side) to evenly illuminate your whole sign
- Battery backup for overcast protection and uninterrupted operation
- Oversized solar panel charges battery pack in just a few hours
- Security bolts and tool to keep your investment safe from damage and theft
- Fits any real estate sign from 1" metal frames up to 4" post frames

- o **Pros**
 - o Unique feature which can mount to existing for sale sign posts.
 - o They highlight black body to prevent attention on the lighting unit and more attention on the sale sign.
 - o (16) LEDs will project significant light which will grab attention
 - o Landscape of design allows for much larger PV Cell capacity.
- o **Cons**
 - o The (16) LEDs will require larger battery pack
 - o Must be fixes to sign...signs tend to stand perpendicular to the street so the illumination impact is reduced.
 - o Limited to projecting light. this concept projects a message...not a light.
 - o Limited to home sale signs. Cannot be extrapolated to other markets such as automobile, RV, boat, business, greeting messages etc..



The SunBox

Solar Real Estate Lighting

Features:

- Brand New for 2007-2008 - great marketing tool!
- Oversized solar panel for fast, complete charging
- Battery backup for overcast protection provides operation even after a cloudy day
- classic white body with clear front slide out and "TAKE ONE" lettering
- Easily mounts in just minutes and features 4, 6, and all night operation
- Durable flip top, two LED lights, and a special business card holder spot for increased exposure



- **Pros**
 - Illuminates a message. Highlights the information sheet that is so valuable to prospective home buyers
 - Fits a market niche for real estate advertising
 - Size of packaging would require very little energy conversion, thus smaller battery pack.
- **Cons**
 - No advertising on performance
 - Limited to market scope

The Home-For-Sale-Lighting concept provides many features that are currently not available on the market. The ability to vary the message, vary the location and apply the concept to several market channels increases the value of the concept. The design will incorporate flexibility to make sure that these channels can be served with one design.

It is our opinion that the competitive products listed above (SunPal 4x, SunPal 2x and SunBox), although unique and first to market, are very limited in scope and target one niche which will result in lower overall returns.

An additional channel for the Home-For-Sale-Lighting concept may be to contact the above firm as a channel partner. They currently have advertising, warehousing and contacts in this industry. Offering them either exclusive features or channel exclusivity may minimize time to market for this new design.

It is also our opinion that the unique features of the Home-For-Sale-Lighting concept may require patent protection. The overall concept and ability to vary messages should be reviewed for protection moving forward. The ability to incorporate the unique features of this concept will be designed in such a way to provide additional protections in the market.