PHC Northwest
Beyond Limitations™

Hybrid Solar
&
Grid Area Lighting System

Hybrid Photovoltaic Street Lighting Systems

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1.0 General

1.1 Introduction to Hybrid Design Prototype One

The Hybrid Design of the Area Lighting System uses both Solar Power and Electric Grid. This concept was developed to not only increase the usage of the Renewable Energy but also provide the grid connectivity to compensate for the environment while maintain the lighting requirements. The global objective of this retrofit system is to reduce the Maintenance Cost over the life of the product and substantially reduce the Carbon Foot Print associated with Lighting in addition to use less power for similar/better light quality.

1.2 Scope of Work

Manufacturing of a retrofit package that will utilize the current infrastructure and replace the lighting unit with LED light and a sustainable power management system.

1.3 Definitions

- “Ampere-hours (Ahr)” is the electric charge transferred past a specified circuit point by a current of one ampere in one hour.

- “Absorbed Glass Mat (AGM)”batteries are the latest step in the evolution of lead-acid batteries. Instead of using a gel, an AGM uses a fiberglass like separator to hold the electrolyte in place. The physical bond between the separator fibers, the lead plates, and the container make AGMs spill-proof and the most vibration and impact resistant lead-acid batteries available today. Even better, AGMs use almost the same voltage set-points as flooded cells and thus can be used as drop-in replacements for flooded cells.

- “Depth of Discharge (DOD)” is a measure of how much energy has been withdrawn from a battery, expressed as a percentage of full capacity. For example, a 100 Ah battery from which 30 Ah has been withdrawn has undergone a 30% depth of discharge (DOD). Depth of discharge is the inverse of state of charge (SOC); the example battery would be at 70% SOC. See also deep discharge.

- “Photovoltaic” is the field of technology and research related to the application of solar cells for energy by converting sunlight directly into electricity.

2.0 Electrical System Components

The electrical prototype of a hybrid PV lighting systems involve a number of factors, including:

- The PV module/array is to be configured in series wiring to provide an input to the hybrid controller 24Vdc at a maximum of 10amps.
- Battery selection for this prototype was based with conjunction of the solar charge controller. AGM type lead acid batteries with a voltage of 12Vdc nominal and 25Ahrs were selected. Two batteries in series to provide 24Vdc are wired to the hybrid controller.
- Selecting types, sizes and ratings for conductors based on location, temperature, ampacity, and voltage drop requirements
- Identifying the appropriate ratings and locations for over current protection and disconnect devices
- LED 50W fixtures were selected as a max loading of 100W output was designed for the 4500K light quality and better
- Design a switching circuit between the off grid and on Grid operation is done within the hybrid controller
- The solar charge controller within the hybrid control box was selected to be Morningstar MPPT type controller rated for 24Vdc at a max. load of 15Amps.

2.1 LIGHT FIXTURE SELECTION

The selection of a medium sized (36-50 W) LED street light fixture is best suitable to light areas specifically for pathways, parks, parking lots and pedestrian lighting will be used for this system. The LED type luminaries are provided by Light Power based in Vancouver, BC and has proven itself in the installed field and is manufactured in Portland Oregon at PHC. As the fixture is designed for 110-347Vac type voltages, and is modified for a 24Vac or 24Vdc operation.. The full spec sheet of the light is shown in Figure 3.1.

LightPower

Outdoor Lighting

JSB - Pole Top

JSB Product Description

The JSB is a medium sized, pole top LED area light designed specifically for pathways, parks and pedestrian lighting. The LED light engine provides significant savings in operating costs by reducing energy consumption up to 75% and eliminating maintenance. The optical design reduces glare and light trespass while providing superior pole to pole uniformity. The JSB is available in both Standard Output and High Output versions.

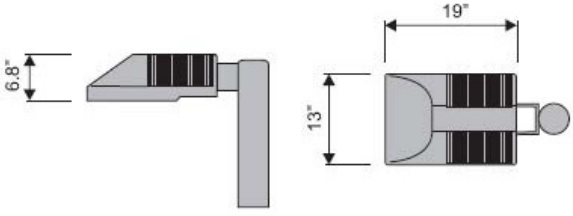
Features and Benefits

- High system efficacy
- Type 3 distribution
- Full cut-off for reduced glare and light trespass
- Suitable for pole heights up to 20'
- Nominal input power of 45 or 75 Watts
- Replaces 100W metal halide and 70W high pressure sodium
- Useful life of 70,000 hours (to 70% of initial light output)
- CRI of 90+
- Standard 5000K or 4100K*
- Aluminum die cast housing
- Adapts to most standard pole mounting options
- Powder coat finishes

Ordering info

Model	Finish	Colour Temp*	Power
JSB-045-50-02-80-000	Black Powder	5000K	45W
JSB-045-50-03-80-000	Silver Powder	5000K	45W
JSB-045-50-04-80-000	Green Powder	5000K	45W
JSH-075-50-02-80-000	Black Powder	5000K	75W
JSH-075-50-03-80-000	Silver Powder	5000K	75W
JSH-075-50-04-80-000	Green Powder	5000K	75W

* 4100K also available.



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2.2 SIZING OF THE PV MODULES

As the design has been revised to allow for roughly a one (1) day supply requirement (rather than five (5) days) for the battery capacity as it is all that is need for a hybrid design, the PV design shall only be needed to be able to charge the batteries based on the total load used for that day. As the lighting load shall be design in the range of 36 to 100 watts (without losses). The Hybrid PV is designed to allow for the recharging of the batteries for this and therefore shall be designed to be larger than 100W.

As our complete design shall conform to a 24 Volt DC system from the batteries, charger and the load, the PV system shall be required to be a 24Vdc as well. Therefore, the system shall be a two (2) 65 watt 12Vdc nominal panels in series to be able to provide a sufficient recharge of the battery for a total of 130 watts at 24Vdc input to the hybrid controller.

Product Name and Description	KD 205GX-LP	KD 180GX-LP	KD 135GX-LP	KC 130TM	KC85T	KC65T	KC50T	KC40T
Part Number	**501015**	**501014**	**501013**	**501004**	**703004**	**703005**	**703007**	**703008**
Rated Power (Watts)	205	180	135	130	87	65	54	43
Series Fusing (Amps)	15.0	15.0	15.0	15.0	7.0	6.0	6.0	6.0
Current at Max. Power (Amps)	7.71	7.63	7.63	7.39	5.02	3.75	3.11	2.48
Voltage at Max. Power (Volts)	26.6	23.6	17.7	17.6	17.4	17.4	17.4	17.4
Short Circuit Current (Amps)	8.36	8.35	8.37	8.02	5.34	3.99	3.31	2.65
Open Circuit Voltage (Volts)	33.2	29.5	22.1	21.9	21.7	21.7	21.7	21.7
Length (Inches)	59.1	52.8	59.1	56.0	39.6	29.6	25.2	20.7
Width (Inches)	39.0	39.0	26.3	25.7	25.7	25.7	25.7	25.7
Depth of frame (Inches)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Depth including j-box	1.4	1.4	1.4	2.2	2.2	2.1	2.1	2.1
Shipping Weight (lbs.)	45.8	41.4	33.0	33.0	24.0	18.0	16.0	13.0

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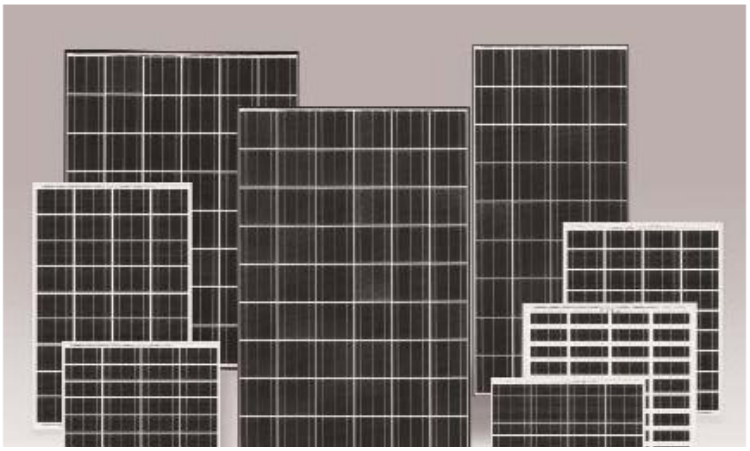
Module type	Power	Width		Length	
501004	130	25.7	(65 cm)	56	142 (cm)
703004	87	25.7	(65 cm)	39.6	101 (cm)
703005	65	25.7	(65 cm)	29.6	75 (cm)
703007	54	25.7	(65 cm)	25.2	64 (cm)
703008	43	25.7	(65 cm)	20.7	53 (cm)



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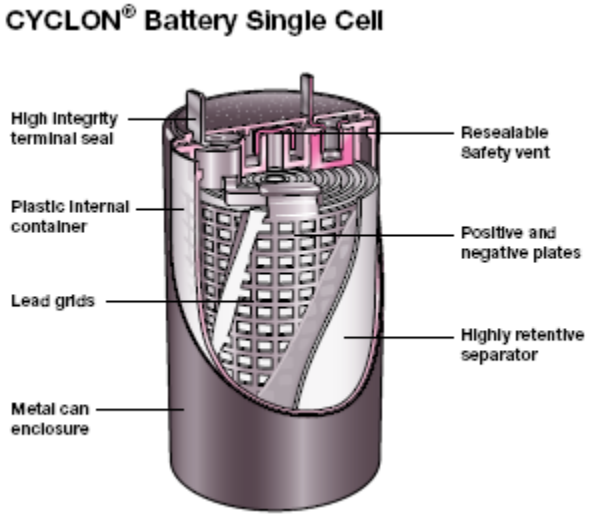
Other manufacturers, notably Sharp and Suntech, also offer modules for off grid applications. The design of the hybrid PV lighting system uses a battery charge controller that is rated for a maximum set input voltage and current levels independent of the PV module manufacturers.

2.3 BATTERY SELECTION

It has been determined the best suited battery pack device is the AGM type lead acid battery product. These advanced batteries provide the most compact and rugged batteries on the market best suitable for PV applications. A manufacturer called Enersys provides a product line labeled as Cyclon (Figure 3.4); these batteries are single cell 2Vdc batteries that are available in various capacities (Ahrs) indicated in Figure 3.5 and can be arranged in various configurations



Apart from standard rectangular shape packaging for the Cyclon battery packs, other types of packaging as shown in Figure 3.6 can be custom made to fit different enclosures. Rose Electronics is the main distributor of EnerSys in Portland, Oregon, and can provide these custom design packages.

2.4 SOLAR CHARGE CONTROLLER DESIGN

24Vdc nominal solar battery charger shall be required with a sufficient size to handle a minimum of 4 amps. As Morningstar type solar controllers are one of the leading companies with solar battery systems and have one of few that support AGM type batteries, they are the best qualified product to use for the system.

The solar battery charger selected for the system hybrid design is the Morningstar MPPT type controller that is available in 12Vdc/24Vdc and rated for 10 or 20 amperes. It has also been reviewed that the depth of discharge (DOD) desired of 50% must also be considered when selecting the controller. It has been confirmed by Morningstar that their MPPT controller supports AGM type batteries and the percentage of depth of discharge can be adjusted to the designed level of 50% by their provided software program.

2.5 HYBRID SWITCHING DEVICE

For the switching between Utility and charger/batteries to the load will be done with a simple dual Form C type relay with a rated coil voltage of 24Vdc nominal which are located within the hybrid control enclosure. The relay common pole side of the contact will be connected to the load side of the controller and allow the load (LED light) to be switched to utility once the solar controller disconnects the power for the load based on the batteries reaching the desired DOD to be set to 50%. Refer to the design drawings for more details.

3.0 Conceptual Drawings

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4.0 Hybrid Controller

As described within the design drawings, the Hybrid Pole mounted Light fixture is centrally controlled and powered through the main hybrid controller specifically designed for this prototype. The majority of the controls within this Hybrid controller are split between two areas:

- The MPPT Solar controller to determine when its time to switch between the battery/PV side and to the utility
- And the set of three relays for daylight control and physical switching of the two main sources Batteries/PV and utility

The hybrid control enclosure houses all three sources that are required for the system to function: PV Array rated at 24Vdc, Batteries rated at 24Vdc and the utility power rated for 120Vac. With these sources supplying all the power needs the final main component tied to the hybrid controller is the 24Vdc/24Vac load which is the 50W LED pole type fixtures.

There are a few additional notes that were allowed for in the first prototype:

- The utility power is designed to be rated at 120Vac for this prototype that in return is used for testing purposes. The utility power voltage can be adjusted for 277Vac operation with some minor revisions within the hybrid control enclosure.
- The two AGM type batteries are wiring individually to the hybrid controller as 12Vdc sources at which the hybrid controller configures them internally as a single 24Vdc rated source.
- The 12Vdc or 24Vdc PV modules/array can be either wired together in series as a single 24Vdc source to the hybrid controller or separately depending upon the rated voltage of the PV modules selected.

5.0 Testing

Once the first prototype was constructed, a small series of tests were done to ensure proper operations of the hybrid controller. Below is a summary of the test conditions:

- PV modules were not available during testing and therefore a 24Vdc power supply was used to simulate solar power generation and daylight sensing
- The AGM batteries were provided by the manufacturer fully charged
- 120Vac power was used to simulate supply from the utility
- Only a single 50W LED fixture was used during the tests

With the three sources connected to the hybrid controller and the single 50W load ready the following tests were done:

- Daylight Test
- Battery Failure Test
- Utility Failure Test
- Transitioning

5.1 RESULTS

The daylight test was the test to determine the functionality of Relay R3. This was done by switching the power supply simulating the PV modules on/off while the battery and utility sources fully functional. The result determined that if the PV modules supplied 24Vdc to the controller, the load will not turn on. However, once the PV modules supply a voltage below the rating of the relay coil of R3 or the current required to maintain the relay transition, the relay coil would de-energize and close the loop supplying power to the load.

The battery failure test determined in a condition that if any of the batteries drop below the DOD percentage or fail completely the solar controller would provide a indicator on the controller and disconnecting 24Vdc power to the load.

Utility failure test determined the status of the operation of the prototype if primary utility power was lost. In this condition, the load will remain functional unless daylight or battery conditions drop below set operating conditions. In this situation, the LED fixture would be turned shutdown.

PV Street Lighting Configurations

Table 1 below illustrates the number of possible configurations for PV street lighting :

Configuration	Battery	PV	Wind	Grid Tie Back up	Grid Tie Net Metering	Comments
1	X	X				Stand alone
2	X	X	X			Stand alone
3	X	X		X		Present Design
4	X	X	X	X		
5		X			X	Next Design
6		X	X		X	

Out of the possible 6 configurations, Configuration 3 is in design stage. In this configuration the battery is charged by the PV panel during the day and grid is used as back up only when the PV out put is not sufficient to keep the light energized during the dark hrs. Figures 3 & 4 below illustrate a simulation for a 50 W LED light that is energized by a 240 Watt PV panels (4 x 60) and uses the grid as the back up for Portland and Los Angles. The battery capacity is 56 AH @ 24 Volts.

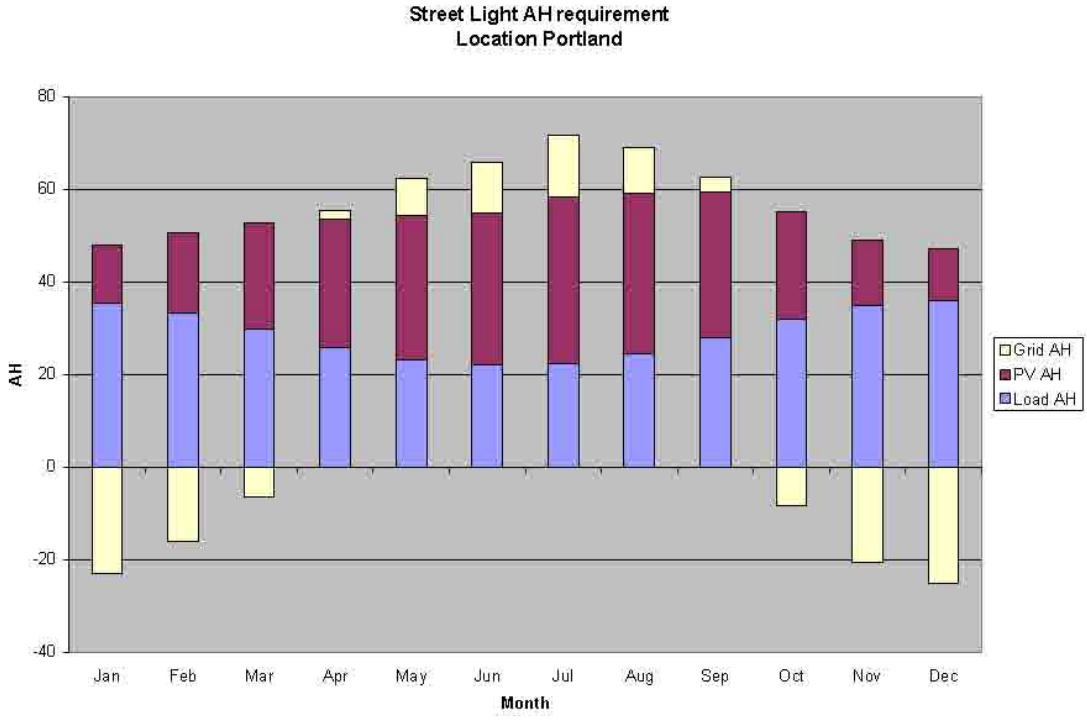

Figure 2 The monthly AH requirements for a 50 W LED light supplied by 200 Watt PV panel and the Grid in Portland. Annual % (AH Grid / AH Load) = 30%

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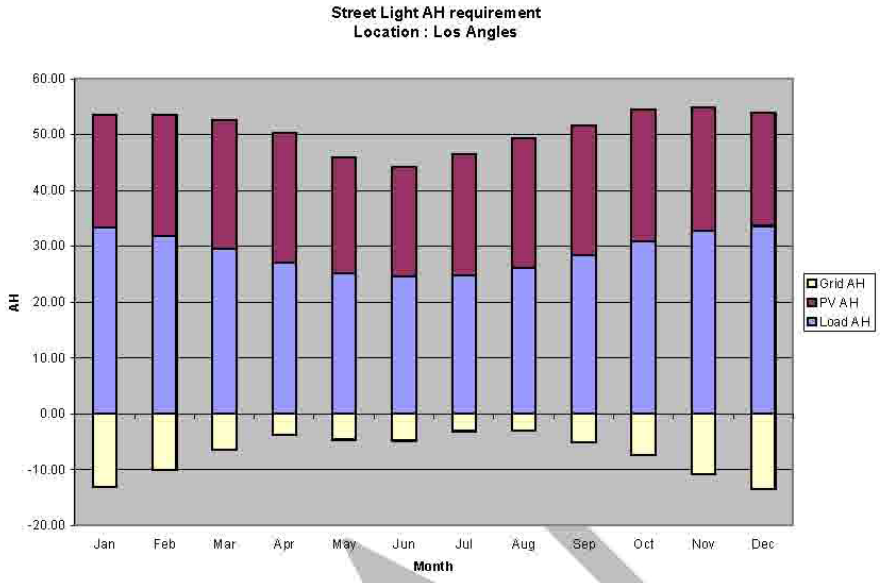


Figure 2.2: Hybrid Simulation for Los Angeles

The negative white bars represent the back up Ahr provided by the Grid.

In the case of Portland 40% of the load Ahr is provided by the Grid (60% by the PV modules & Batteries) while for Los Angeles for the same system configuration only 25% of the load Ahr is provided through the grid (75% through the PV modules & Batteries).

6.0 Pricing Schedule

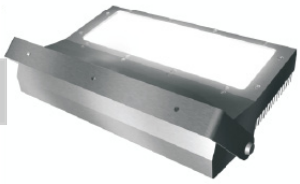
Item	Description	Quantity	Unit price	Total
65 W panels	65w solar panels	2	$375	$700
Mounting Bracket	AL Mounting panels	2	$145	$290
LED Light JSB -50	LED Light Assembly	1	$550	$550
Battery assembly	12 V battery pack	2	$350	$700
Control Unit	PHC hybrid Control Box	1	$485	$485
Hardware	Installation hardware	1	$75	$75
Total				$2800

The above pricing in for one retrofit package and component pricing will be lower for quantity 10 by 3% and 5% for higher than 10 systems. The U- bracket for the pole top will be purchased through the pole manufacturer for the installation of the panel assembly listed above.

7.0 Other LED Products

AQUE 6 LUMINAIRE

UPE - UPLIGHT

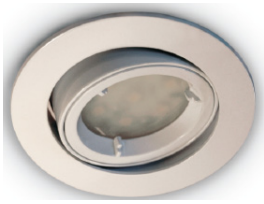


LUNA LUMINAIRE

SLW - STEP LIGHT

PTE - PARKING GARAGE

ALITA LUMINAIRE



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