Upsilon Lab *Solar Analysis Report to the REA*

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Emma Peavler, Manager-TS
G. Chang, S.S. Chava, P. Godoy, A. Gonzalez, M. Neuwirth & R. Ramlow
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"A lab for undergraduates, by undergraduates."

1 Abstract

The goal of the study was to determine the best solar panel for use in a solar-powered rechargeable battery station, as requested by the Renewable Energy Association (REA). We first gathered data on various solar panels of different types, prices, efficiencies, and power from several companies. We analyzed this data through graphs, in addition to creating a point system to assign scores to each panel based off of their power and efficiency in relation to their price. From this analysis we found that the LONGi LR6 290 Watt panel best meets the REA's needs. Two other recommended panels are the Silfab Solar SLG-370M (370 Watts) and the Hanwha PEAK-G4.1 300 (300 Watts) panels.

2 Introduction

In the past few decades, the threat global warming poses to the world has gained increasingly more publicity. To counter this rising threat, the search for alternative and renewable energy sources has gained momentum. One of the most powerful results of this search is the drastic improvement to solar power; solar cells are reaching efficiency levels above 20%, increasing their feasibility as an alternative energy source. Because solar energy this potential to replace fossil fuels, the Renewable Energy Association (REA) at UCLA is working to implement solar energy throughout the UCLA campus. One of their projects- and the one that pertains to this report- is to construct a solar panel that charges batteries. These batteries, then, would be used to replace the propane usually used as a portable energy source, especially for keeping food warm. In this report, we analyzed a variety of solar cells for price, efficiency, and power to determine the ideal cell for the REA's project.

3 Methods

In order to gather data, our group took three qualities of solar panels; price, power and efficiency, and created a scoring scheme in order to determine an overall best solar panel for its price, power, and efficiency. Much of our data gathering stemmed from going onto solar panel wholesale websites as well as looking at solar panel tables in order to find a given price, power, and efficiency as determined by the company or research group. When finding data, we decided to focus mainly on consumer grade solar panels rather than industrial solar panels as we assumed they would be a better fit for the final purpose of the solar panel. From here, we simply gathered as many data points as possible on various solar panel types, brands, and sizes by reading through various product specification sheets provided by the manufacturer. With this data, we then took the power per dollar and efficiency per dollar of each solar panel and normalized both values with respect to all other entries within the table. This was done to more heavily incorporate price into our calculations, thus lower priced panels appeared more favorable in this grading scheme. The normalized power and efficiency per dollar were then added together to give us a "total score," of which, the panel with the highest sum was then determined to be our "recommended panel."

4 Analysis

Solar panels were ranked according to several different methods. Power and efficiency were analyzed as a function of price and a linear regression performed on each data set. Panels were given a score of one if they were above the median price, and a value of one if they were greater than the value predicted by the linear regression in either power or efficiency. Panels with scores of two were considered further.

A new scoring system based on the normalized cost per area and the normalized efficiency of each panel was then applied to each of the panels shown in Table 1.

The area of each solar panel was computed by the formula

$$A = \frac{P}{10e}$$

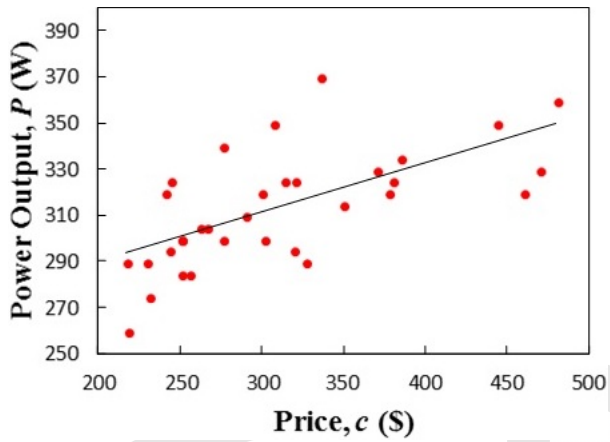

Figure 1: Power vs. Price: Power is plotted as a function of price with a linear regression. The relationship was found to be $P = 0.213c + 247.41$.

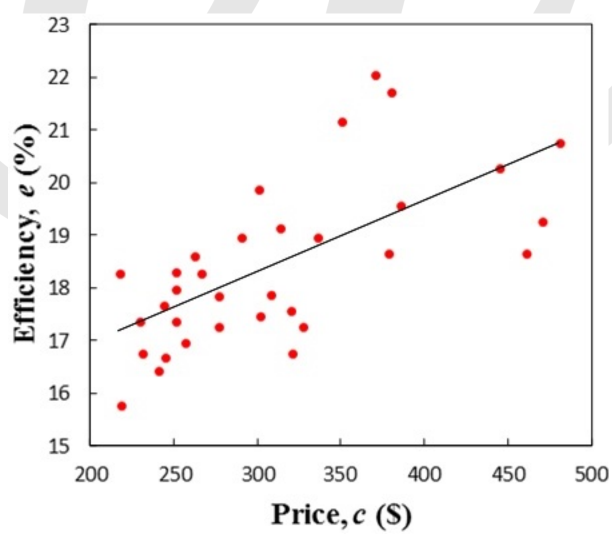

Figure 2: Efficiency vs. Price: Efficiency is plotted as a function of price with a linear regression. The relationship was found to be $P = 0.014e + 14.26$.

where A is the area in square meters, P is the power output in watts, and e is the percent efficiency, i.e. $e = 17$ represents 17% efficiency. P was assumed to be measured under 'ideal' STC conditions ($1000\ \frac{W}{m^2}$). The cost per square meter, $\rho = \frac{c}{A}$, was then computed and normalized to a 0-1 scale by the formula

$$\rho_N = \frac{\rho_i - \rho_{min}}{\rho_{max} - \rho_{min}}$$

The normalized efficiency was computed similarly by

$$e_N = \frac{e_i - e_{min}}{e_{max} - e_{min}}$$

and a score for each solar panel was calculated by

$$S = \rho_N + (1 - e_N)$$

Solar panels were ordered by score, with lower scores representing more favorable options. This scoring system was favored over several others because the cost should increase linearly with area, and thus provides a fairer ranking than a system that uses, for instance, cost per watt. Since the normed efficiency is also taken into account, it also weighs panels based on performance. The results of this analysis are shown in the tables at the end of this report.

5 Conclusions

We found that the LONGi LR6 290 Watt panel is the best choice. This solar panel is the most efficient and powerful for its price. This solar panel costs $216.50 and yields 290 Watts with an efficiency of 18.3%. This selection is biased towards price because cost is a very limiting factor. While this solar panel greatly leads among the others in its price versus efficiency and power, two other options that we recommend are the Silfab Solar SLG-370M (370 Watts) and the Hanwha PEAK-G4.1 300 (300 Watts) panels. These secondary options are very similar to the other solar panels in our database and do not strongly differentiate themselves as the LONGi panel does. These panels are available from `ecodirect.com`.

Table 1: Solar panels adhering to the initial criteria. Solar panels that are below the median price and that were greater than the efficiency or power predicted by the linear regression are listed here.

Price ($)	Power (W)	Eff. (%)	Type	Brand	Model
216.50	290	18.3	Mono	LONGi	LR6-60-290M
228.50	290	17.4	Mono	Hanwha	PEAK BLK-G4.1 290
239.68	320	16.46	Poly	Canadian Solar	CS6U-320P
242.35	295	17.7	Mono	Hanwha	PEAK BLK-G4.1 295
243.42	325	16.72	Poly	Canadian Solar	CS6U-325P
250.00	300	18.33	Mono	Canadian Solar	CS6K-300MS
250.00	300	18	Mono	Hanwha	PEAK-G4.1 300
261.00	305	18.63	Mono	Canadian Solar	CS6K-305MS-T4
265.00	305	18.3	Mono	Hanwha	PEAK-G4.1 305
275.00	340	17.3	Poly	Hanwha	PLUS L-G4.2 340
289.00	310	19	Mono	Silfab Solar	SLA-310M
299.00	320	19.9	Mono	Hanwha	PEAK DUO-G5 320

Table 2: Solar panel scores. The five most attractive solar panels are presented according to the area-based scoring system described in the report.

Price ($)	Power (W)	Eff. (%)	Brand	Model	Score
216.50	290	18.3	LONGi	LR6-60-290M	0.689
299.00	320	19.9	Hanwha	PEAK DUO-G5 320	0.755
250.00	300	18	Hanwha	PEAK-G4.1 300	0.771
275.00	340	17.3	SolarWorld	SW300	0.776
261.00	305	18.6	Canadian Solar	CS6K-305MS-T4	0.785