UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation Into Solar Panel Options For The New SUB

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ABSTRACT

Sustainability is the key concept and goal behind the construction of the new Student Union Building. This document will report the research that has been done on solar panels as a renewable energy source and the feasibility of using it in the new Student Union Building (SUB). Upon further research and through contacts with the designers of the new SUB, two possible models of photovoltaic are being considered, Sanyo Mono-Si HIP-195BA3 and Canadian Solar CS6P 230W. This report will make a detailed assessment to determine the advantages and disadvantages of these two models and then utilize the Triple Bottom Line assessment to analyze the economical, social, and environmental impacts of installing photovoltaic panels onto the new SUB. This will take into account the full costs of implementing the technology and will allow the designers of the new SUB to make informed decisions to meet their resource efficiency goals.

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GLOSSARY

Photovoltaic Solar Cells: Arrays of cells containing a solar photovoltaic material that converts solar radiation into direct current electricity.

Renewable Energy Sources: Energy that comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are naturally replenished.

Photovoltaic Effect: The photovoltaic effect is the creation of a voltage (or a corresponding electric current) in a material upon exposure to light. Photons of light knock electrons into a higher state of energy to create electricity.

Monocrystalline cells: Solar cells that are created from monocrystalline or (single crystal) technology are cut from a silicon boule that is grown from a single crystal, in other words a crystal that has grown in only one plane or (one direction). Single crystalline are more expensive to manufacture and typically have a slightly higher efficiency than do conventional polycrystalline cells resulting in smaller individual cells and thus typically a slightly smaller module.

Polycrystalline cells: Solar cells that are created from polycrystalline or (multicrystalline) technology are cut from a silicon boule that is grown from multifaceted crystalline material, or a crystal that grows in multiple directions. Conventional multicrystalline solar cells typically have a slightly lower efficiency resulting in larger individual cells and thus typically a slightly larger module.

LIST OF ABBREVIATIONS

UBC	University of British Columbia
SUB	Student Union Building
HIT	Heterojunction with Intrinsic Thin Layer
PV	photovoltaic
IEC	International Electrotechnical Commission
TUV	Technischer Ueberwachungs-Verein [Technical Watch-Over Association]
UL	Underwriters Lab (Canada)
UMG Si	Upgraded Metallurgical-grade silicon

1.0 INTRODUCTION

In today's climate of growing energy needs and increasing environmental concerns, extreme pressure has been applied in the research and application of energy alternatives to the use of non-renewable and polluting fossil fuels. One such alternative is solar energy. Solar energy is the energy produced directly by the sun. Only a small fraction of this energy produced by the sun reaches the Earth. But the energy that does reach the Earth is the indirect source of nearly every type of energy used today.

Solar energy as a renewable energy source is harnessed through solar radiation from the sun and captured by photovoltaic cells. The photovoltaic cells convert solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect**,** the creation of a voltage in a material upon exposure to light. As of 2010, solar photovoltaic generate electricity in more than 100 countries and, while it currently comprises a small fraction of the total global power-generating capacity from all sources, it is the fastest growing and most widely researched renewable power-generation technology in the world.

In this report, we will focus on 2 panels from different manufacturers, we will compare the Sanyo Mono-Si HIP-195BA3 solar panel to the Canadian Solar CS6P 230W. These two panels are the ones being considered by the new SUB designers.

2.0 SANYO MONO-SI HIP-195BA3

2.1 OVERVIEW

The Sanyo Mono-Si HIP-195BA3, the 195BA3 represents the 195 watt version, is a product introduced as part of the Sanyo HIP brand of photovoltaic solar cells, also known as Sanyo HIT (Heterojunction with Intrinsic Thin Layer). Sanyo Mono-Si HIP solar cells are made of a thin single crystalline silicon wafer surrounded by ultra-thin amorphous silicon layers, hence the name Mono-Si. It is created utilizing advanced manufacturing techniques to produce an end product of photovoltaic modules that are some of the most efficient in the industry, achieving an efficiency of approximately 17%.

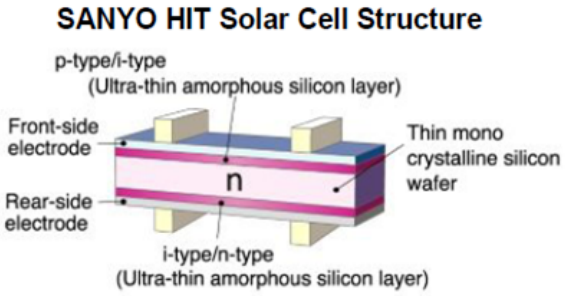

Figure 1. Sanyo HIT Solar Cell Structure

Below is a detailed table the designers of the new Student Union Building sent us, introducing some of the specifications of the Sanyo Mono-Si HIP-195BA3.

Total roof area dedicated to solar technologies	2745	m2
Total roof area	5439	m2
% dedicated to solar	50%	

	Sanyo Mono-Si HIP-195BA3
Module Efficiency	16.5
Panel Area	1.18
Rated output	165
*Potential solar installation	1922
# modules	1629
Array output	356
PV Solar factor	1123

* Assumes 70% of the available solar area can be occupied (considers

Option 1 Annual Electricity	1,844
PV % of total demand	19%

Figure 2. Sanyo solar panel energy plan for new SUB

2.2 FEATURES

2.2.1 User-friendly

The Sanyo Mono-Si HIP-195BA3 solar panels comes with a multitude of features that make it user-friendly. It has a black anodized double-wall aluminum frame that makes them extremely durable and allows modules to blend into architecture of residences and buildings. The Sanyo Mono-Si HIP-195BA3 also comes pre-equipped with a touch-safe junction box, lead wires, MCTM plug-n-play connectors, and a unique mounting lip. The MC connectors and cables come pre-wired into a channel ready junction box and are equipped with factory installed bypass diodes to provide circuit protection. Various voltage and current configurations are available for users to adjust according to the buildings needs. All these features make the Sanyo Mono-Si HIP-195BA3 easy to set up, helping minimize support structure materials and installation time and cost.

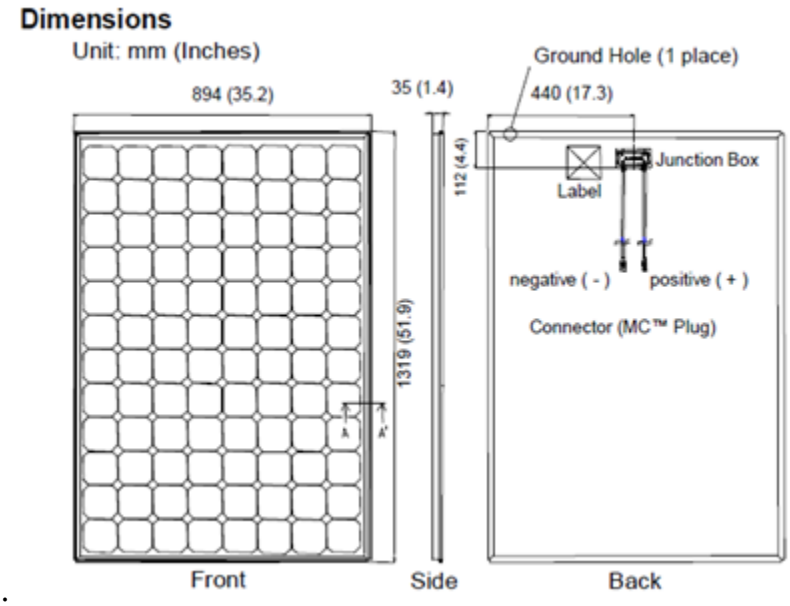

Figure 3. Sanyo solar panel dimensions

2.2.2 Temperature Attributes

One of the key features of the Sanyo Mono-Si HIP-195BA3 solar panels is that as temperatures rise, the solar panels produce more electricity, kWh, than conventional crystalline silicon solar panels at the same temperature. Through our research, we found out that Sanyo Mono-Si HIP-195BA3 solar panels provide up to 10% higher power output in hot-temperature conditions and approximately a 36% increase in projected annual power output compared to conventional models, making it more efficient compared to conventional solar panels.

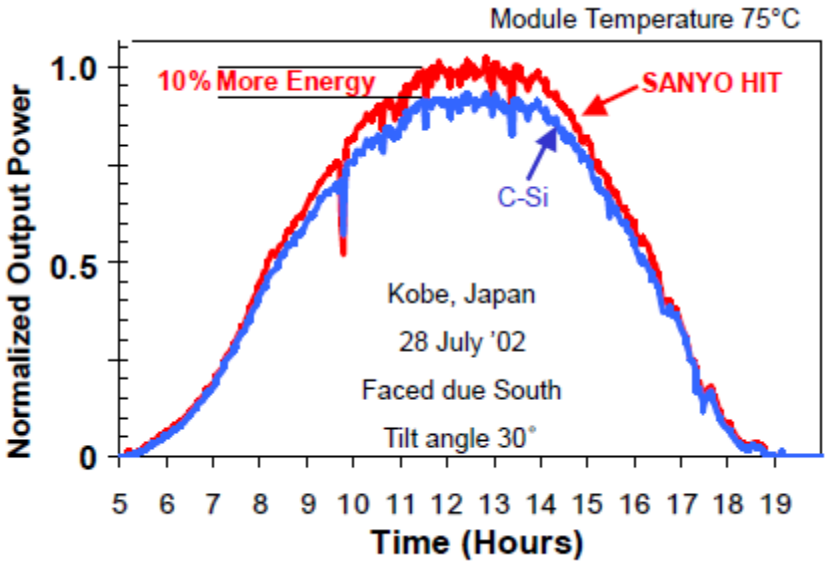

Figure 4. Sanyo temperature graph

2.2.3 Efficiency

The Sanyo Mono-Si HIP-195BA3 solar panel is considered to be one of the more efficient solar panels in the market today. With models up to 15.8 Watts per sq. foot (17% module efficiency), it obtains maximum power within a fixed amount of space making it ideal for grid-connected solar systems. Made of thin mono-crystal silicon surrounded by ultra-thin amorphous silicon layers, the Sanyo Mono-Si HIP-195BA3 solar panel cells are regarded as one of the most efficient in the industry because of their innovative technology that allows it to maintain higher voltages at higher temperatures which naturally results in more power generation with enhanced performance.

2.2.4 Reliability and Durability

The Sanyo Mono-Si HIP-195BA3 solar panel has no moving parts and weigh less than 31 pounds (14 kg). The panels are 100% emission and noise free. Environmental factors such as strong winds and hail have been considered during our research. We found out that Sanyo Mono-Si HIP-195BA3 panels are UL 1703 safety rated for wind, fire and hail. They can withstand 1 inch diameter hailstones at 50 mph and have a Class C fire rating.

2.3 COST

With all the features listed above for the Sanyo Mono-Si HIP-195BA3 solar panel, the cost of the solar panel is considered more expensive than conventional solar panels. From researching several online retailers, we obtained a price of the Sanyo Mono-Si HIP-195BA3 solar panel, with

an area of 1.18m^2, to be around $818.00 US dollars.

The designers of the new Student Union Building are considering using Sanyo Mono-Si HIP-195BA3 solar panels on the roof of the building, as shown by the table below.

Renewable Energy Feasibility for New SUB - Option 1

Total roof area dedicated to solar technologies	2745	m2
Total roof area	5439	m2
% dedicated to solar	50%	

	Sanyo Mono-Si HIP-195BA3	Canadian Solar CS6P 230W	units
Module Efficiency	16.5	14.3	%
Panel Area	1.18	1.6	m2
Rated output	165	144	W/m2
*Potential solar installation	1922	1922	m2
# modules	1629	1201	modules
Array output	356	310	MWh
PV Solar factor	1123	1122	kWh/kW

* Assumes 70% of the available solar area can be occupied (considers access, shade...)

Figure 5. Dedicated roof area for Sanyo solar panels

Assessing the total cost the new Student Union Building will have to spend according to their plan.

1 Sanyo Mono-Si HIP-195BA3 solar panel = 1.18m^2

Potential solar installation = 1922m^2

Cost of 1 Sanyo Mono-Si HIP-195BA3 panel = $818.00

Number of solar panels needed to reach potential = 1629 panels

Total Cost = $1,332,522

2.4 ASSESSMENT

The Sanyo Mono-Si HIP-195BA3 photovoltaic is an efficient, user-friendly, easy-to-install, and reliable solar panel. The efficiency of the Sanyo Mono-Si HIP-195BA3 is at 17%, which is considered quite high. It can withstand extreme weather and one of its unique features is its

ability to increase power generation when exposed to high temperatures. However, it is considered a medium to high-end solar panel, priced at almost $820 per panel.

3.0 CANADIAN SOLAR CS6P 230

3.1 OVERVIEW

CS6 series from Canadian Solar uses 156 x 156 mm, 6" high-efficiency polycrystalline silicon cells, typically 180-200 micron thick. The module output ranges from 160 W to 300 W. CS6P is a robust solar module with 60 solar cells. These modules can be used for on-grid solar applications. The meticulous design and production techniques ensure a high-yield, long-term performance for every module, with a module efficiency of over 14.3 % on the 230 watt version which is the one being considered for the new SUB.

3.2 FEATURES

The Canadian Solar CS6P 230P panel incorporates a unique 100% UMG Si technology cell construction. The panel is Polycrystalline, which is considerably cheaper to manufacture compared to Monocrystalline panels, but it has an overall lower efficiency than the former. It also has special aluminum frame design that offers exceptional mechanical strength to withstand severe wind and snow loads, and enables easy mounting on both long and short sides of the frame.

It has an advanced EVA encapsulation system for enhanced module protection. High transparency, low-iron tempered glass maximizes light transmission and impact resistance. The panels also have strong frames module, passing mechanical load test of 5400 Pa to withstand heavier snow load and extreme weather conditions. The panel has a weight of 20 kg. This system has a 100% free emission and quiet operation.

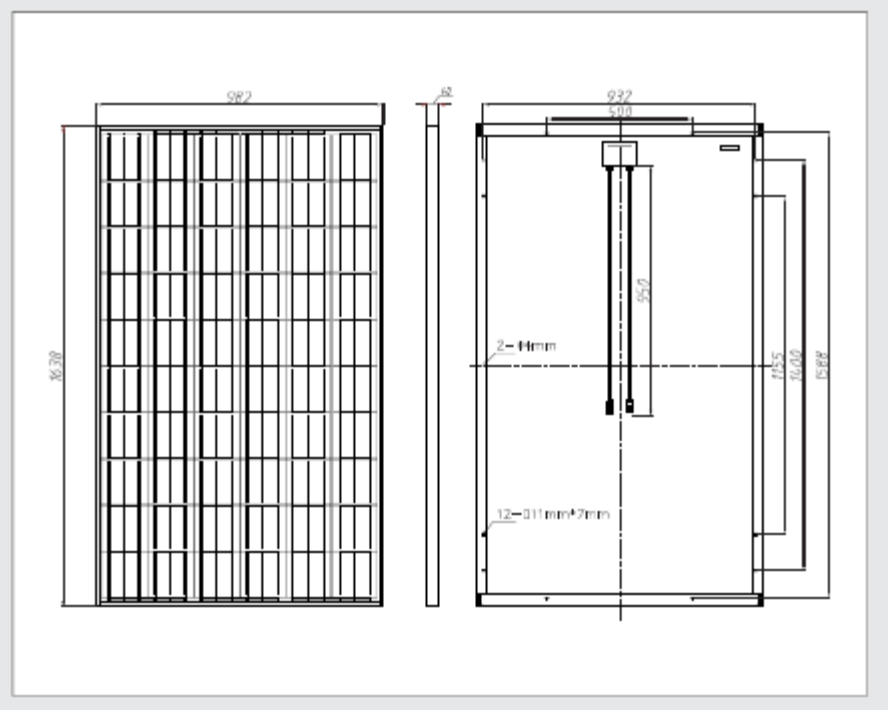

Figure 6. Canadian solar panel dimensions

Below is a detailed table the designers of the new Student Union Building sent us, introducing some of the specifications of the Canadian Solar CS6P 230P.

Renewable Energy Feasibility for New SUB - Option 1

Total roof area dedicated to solar technologies	2745	m2
Total roof area	5439	m2
% dedicated to solar	50%	

	Canadian Solar CS6P 230W	**units**
Module Efficiency	14.3	%
Panel Area	1.6	m2
Rated output	144	W/m2
*Potential solar installation	1922	m2
# modules	1201	modules
Array output	310	MWh
PV Solar factor	1122	kWh/kW

* Assumes 70% of the available solar area can be occupied (considers access, shade...)

Option 1 Annual Electricity	1,844
PV % of total demand	17%

Figure 7. Canadian solar panel energy plan for new SUB

Warranty and performance

The manufacturer provides a 6 year product warranty (which include materials and workmanship), it also guarantees module power output as follows:

10-year 90% power output assurance
25-year 80% power output assurance

3.3 COST

The cost per Canadian Solar CS6P 230 panel is $518.00, which is significantly lower than other panels of its kind. This provides a cost-effective solution to the implementation of Solar energy to the SUB. Using the potential solar installation area and calculating the amount of panels needed to cover the roof area we came up with the following estimates for the Canadian Solar CS6P 230 panel:

1 Canadian Solar CS6P 230- solar panel = 1.6m2
Potential solar installation = 1922m2
Cost of 1 Canadian Solar CS6P 230- solar panel = $518.00
Number of solar panels needed to reach potential = 1201 panels
Total Cost = $622,118

3.4 ASSESSMENT

CS6-230P panels from Canadian Solar have a relatively high efficiency of 14.3 % and are one of the most cost-effective panels found in our research. They exhibit a high Watt rating of 230 W per panel, which is among similar panels, more over the company itself has been certified for ISO:TS16949 (The automotive quality management system) in module production since 2003 and for ISO17025 qualified manufacturer owned testing lab, it also fully complies to IEC, TUV, UL testing standards.

After a thorough and extensive research the Canadian solar panel proves to be a good candidate for the new renewable energy source for the SUB for its cost-effective energy production and the company's performance assurance which will ensure a proper functioning of the panels throughout its lifetime.

4.0 MAINTENANCE

Both panel options will exhibit similar maintenance and operation procedures, some of which include:

Regular inspection to keep modules clear of snow, bird droppings, seeds, pollen, leaves, branches, dust and dirt spots. Given a sufficient tilt (at least 15o), it is not generally necessary to clean the modules (rainfall will have a self-cleaning effect). When there is a noticeable build-up of soiling deposits on the module surface, the PV array should be washed using water without cleaning agents and a gentle cleaning implement (a sponge), during the cool of the day. Dirt must never be scraped or rubbed away when dry, as this will cause micro-scratches that will affect the performance of the device. If snow is present, a brush with soft bristles can be used to clean the surface of the module.

Periodical inspection of the system is recommended to make sure all wiring and supports stay intact. Electrical or mechanical inspection or maintenance should always be performed by a licensed, authorized professional to avoid hazards of electric shock or injury.

5.0 TRIPLE BOTTOM LINE ASSESSMENT

5.1 SOCIAL

Sustainability has been UBC's main design factor for the new SUB, and as such UBC is trying to promote sustainability amongst their community with initiatives and programs around campus. Some examples of this initiative are projects like the Sustainable Initiative Campaign, the North America's Greenest Building, UBC Sustainable Sport Center and in our case for this project: the new SUB , which will feature the highest levels of sustainable building design and will serve as a model for future developments on UBC and around the world.

In terms of operation , solar panels have zero emissions and also exhibit a quiet operation which will not disrupt the everyday activities that happen at the SUB. The panels will also give the roof of the building a more aesthetic look, which will be appealing to the community and will raise awareness for sustainable development not only on campus but around the world. With the use of solar panels, the public will feel comfortable entering and interacting with a building which not only has the state of the art technology for sustainability but also highly efficient and is helping the environment.

5.2 ECONOMICAL

When considering a solar electrical system, cost must be a major factor to take into account. While solar energy is much more environmentally friendly than other forms of electrical generation such as coal, it is considered more expensive. This is one of the key reasons why solar panels are not as common as non-renewable energy sources. The other reason is environmental factors, which we will discuss in the environmental assessment of solar panels.

Through our research, we found that the average photovoltaic system costs $95 per square foot and generates 10.6 watts for the same area. A two-Kilowatt system solar system, generally retails for roughly US$45000 and is only enough to supply half of a typical American household's energy needs. As you can see, although advancements have been made in solar panels each year, the price to purchase and install are still considerably expensive.

We must also consider the maintenance cost of solar panels. Although solar panels are often guaranteed for 10 to 20 years, which is the case for the Sanyo Mono-Si HIP-195BA3, certain parts like the solar panel's power output needs to be checked every few months and the panels need be cleaned to avoid dust accumulating. These cost around $200 to $1000 per year.

5.3 ENVIRONMENTAL

When compared with the fossil fuels, one of the traditional forms of electricity generation, the most persuading advantage of solar energy is non-polluting feature. Solar energy does not raise

concerns in producing pollutions when generating electricity. It is an excellent alternative energy resource because it actively contributes to reduce the harmful greenhouse emissions. Solar energy comes from the sun and the way to obtain it does not involve contaminants. It is also silent and does not make any noise that might otherwise have a negative impact on human and animals. Solar energy and harnessing it through solar panels represents clean energies, it protects the environment by reducing pollution with each watt of power it generates.

However, solar energy does have a disadvantage when compared to fossil fuels, it depends on sunlight to generate electricity. Solar panels are only benefited to the buildings they support if it is exposed to sufficient sunlight. Locations that experience frequent overcast or rain are not ideal areas to install solar panels as they are not able to generate electricity for the building. Therefore when considering to install solar panels, extensive research is required to analyze the buildings sunlight exposure throughout the year in order to benefit from solar energy.

6.0 CONCLUSION AND RECOMMENDATIONS

The two options explored in this report exhibit both advantages and disadvantages in their design and operation. While both have an emission free and quiet operation, their features differ in terms of cost and performance. The Sanyo Mono-Si HIP-195BA3 solar panel has the highest efficiency of both systems (17% compared to 14.3% of the Canadian solar system), while the Canadian solar CS6 -230P is the cheapest of the two options ($540 compared to $818 for the Sanyo panel). The choice should be made in terms of the capital available for development and the desired efficiency that the building should operate at. Because the two panel options have different sizes, another important decision factor will be the amount of space that will actually be present on the roof of the new building. One will be preferred over the other depending on which one fits best the space available for installation and leaves the least amount of unused space on the roof. The designers should also take into account the sunlight exposure that their location will have and should also design so as to expose the roof of the building to as much sunlight as possible for higher performance.

According to the charts provided by the designers, by implementing one of these options about 300 MWh of electrical power will be produced, which will completely take care of the Lighting load of the building, also the heat generated by the panels will be able to take care of some of the space heating by running water pipes under the panels.

The solar energy options for the SUB showed by this two PV panels proves to be an effective pollution-free system that should be highly considered for the new SUB. Their excellent energy conversion from solar energy and their smooth and quiet operation will have little effect in the daily activities that occur in the building. The implementation of one of these technologies will raise the awareness of the public to the importance of sustainable development in building design and will also put UBC as one of the leaders for this kind of environmentally-friendly development.

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