UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation Into Photovoltaic Technology For The New Student Union Building

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AN INVESTIGATION INTO PHOTOVOLTAIC TECHNOLOGY FOR THE NEW STUDENT UNIONION BUILDING

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ABSTRACT

"AN INVESTIGATION INTO PHOTOVOLTAIC TECHNOLOGY FOR THE NEW STUDENT UNION BUIDING"

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Nowadays, majority of the researches are focused on finding renewable and environmentally friendly energy sources. Photovoltaic technology is a power generation method which converts sunlight into electricity. Although most of the sunlight's energy is dissipated into heat, sunlight is still a reliable and a safe energy source, comparing to the limited fossil fuel. The energy generated from the sunlight is renewable and constant, which is ideal for a sustainable environment.

Photovoltaic technology is based on the electronic device - the photovoltaic cell. A photovoltaic cell converts sunlight into electrical energy directly. By utilizing panels of photovoltaic cells, enormous amount of energy can be generated with zero emission. Generally, a single photovoltaic panel has a long lifetime of 20 to 25 years. The main drawback of photovoltaic technology is the high manufacturing cost and the waste disposal issue. However, as the technology advances in the future, the manufacturing cost is expected to decrease. The reduction in cost will increase the production of photovoltaic panels. Employment and demands for photovoltaic panels will also increase within the photovoltaic industry as a result. Despite the cost and disposal issue, photovoltaic technology is effective in the long run.

To determine the feasibility of implementing photovoltaic technology in the new Student Union Building, the three main aspects of the triple bottom line assessment are taken into account. The triple bottom line assessment captures the economical, the social, and the environmental aspects of photovoltaic technology. Overall, it is ideal for the Alma Mater Society to implement photovoltaic technology into the new Student Union Building.

GLOSSARY

Conversion efficiency of a PV cell:

The percentage of photovoltaic energy that can be converted into electrical energy.

Photovoltaic effect:

A process in which sunlight is converted into electricity

Photovoltaic cell:

A device that converts sunlight directly into electricity by creating a certain voltage in the cell that exposes to electro-magnetic radiation.

Photovoltaic panel:

A block of interconnecting photovoltaic cells

Semi-conductor:

A material that has certain amount of electrical or heat conductivity. Semi-conductors are neither metal nor insulators as the material does not fully conduct or insulate.

LIST OF ABBREVIATIONS

AMS:	Alma Mater Society
CO_2	Carbon Dioxide
CPU:	Control Processing Unit
KWhr:	Kilo-Watt-hour
PV:	Photovoltaic
SUB:	Student Union Building
UBC:	University of British Columbia
W_p	Peak Watt

LIST OF ILLUSTRATIONS

1.0 INTRODUCTION

Using PV cell is a great way of preserving the ecosystem because PV energy is sustainable and inherently obtainable. Therefore, replacing current conventional energy system with renewable photovoltaic energy is crucial since the current main energy source is harmful to the environment. However, to begin using PV generated power as a main source of energy is a challenge. Installing PV panels is one obstacle as panels must be directed to face the light source as much as possible at all times. The second obstacle is the availability of high sunlight intensity due to shading. If the AMS invests in photovoltaic technology, UBC will set a good example of using environmental friendly energy source. This report is a triple bottom line assessment which evaluates the economical, the social, and the environmental aspects of photovoltaic technology for the new SUB.

2.0 COST ANALYSIS OF ENERGY SOURCES

Travis Bradford, the president of Prometheus Institute, stated that the cost of silicon-based PV cells will drop by $1.50 per watt from 2007 to 2010 [11]. Nevertheless, PV cells are still expensive, compared to traditional energy systems in terms of implementation. However, this should not prevent PV technology from being a feasible solution to the global warming crisis. The subsequent paragraphs clarify in detail why PV technology is a sustainable alternative.

In the future, conventional fuels will become expensive. Many reasons cause rise on the value of conventional energy sources. Firstly, more renewable sources are joining the market at the moment. Secondly, fuel manufacturing has declined worldwide. Nonetheless, as the demand for conventional energy is still above average, market prices for conventional fuels carry on to swing upward. Thirdly, more consumers start to comprehend environmental significance of switching from conventional to renewable energy sources. Lastly, the rise of photovoltaic energy conversion efficiencies causes PV cell to be economical (See **Table 1**).

Type	Conversion efficiency (%)	Collection Method	Approx. Cost per peak Watt
Amorphous Silicon	4-7	Direct solar	$2.75 /Wp
Single crystal silicon	9-17	Direct solar	$4.07 / Wp
Polycrystalline TF	10 – 15	Direct solar	$3.80 /Wp
Multijunction PV*	21 – 34	Direct (space) and focused beam	Above $10 / Wp

Table 1: Photovoltaic Cell Efficiencies
Source: Wilson, J.R., & Burgh, G., Energizing Our Future, 2008, p.254

Michael G. Rogol, a MIT graduate, expects that PV energy will turn out to be the main electricity source in 2015 [4]. Ultimately, PV cells are more economical than conventional sources because PV cells need less maintenance. More essentially, we need

renewable source to substitute conventional energy in order to safeguard our children and the planet's future.

2.1 CHALLENGES OF PHOTOVOLTAIC CELLS

Challenges associated to the growth of PV cell are discussed below.

Achieving high energy efficiency in PV cells is one of the hardest challenges. A group of German scientists argues that a new PV cell has been established and has a 41.1 per cent efficiency rate [5]. Though the new PV cell is currently the most efficient of all other PV cells manmade, more research is still required to drop the cost of the new PV cell.

PV cell is temperature dependent. Various materials exhibit different temperature dependencies. Generally, higher temperature reduces a PV cell's total efficiency [13]. Nevertheless, researchers have been looking for a way to remove the dependencies at the moment. For example, it is possible to achieve this by using multi-layers and thin coating.

The government's determination on research and eagerness to substitute conventional sources with renewable energies play a major role on the growth of PV cell. For instance, the U.S government approved the Nanotechnology Research and Development Act in 2003. Consequently, Nanotechnology has been thriving since then [9]. The development of nanotechnology eventually leads to the fabrication of more dependable and efficient PV cells. The government's input and contribution on researching renewable energy sources definitely have vast influence on the development of PV cells.

Even though PV technology has more benefits over traditional energy generation methods, PV cells also have their drawbacks. The initial cost of PV cells is still high compared to conventional energy sources. However, scientists expect that the cost of PV cells will reach the cost of fossil fuels by 2013. Substituting conventional energy sources with PV energy sources will benefit the future generations.

3.0 SOCIAL CONSEQUENCES OF CONVERTING PHOTOVOLTAIC POWER

Using PV technology is an ideal solution to the economical and the social issues within the society. The issues include the need to increase public awareness on sustainable energy, and the lack of social inequality and employment. In addition to this, there are also some limitations to the PV technology.

3.1 EFFECT ON SUSTAINABILITY

PV technology is under-developed in North America since the cost of using PV generated energy is still higher than the cost of fossil fuel generated electricity. Due to the low population and the utilization of other feasible energy sources, the Canadian society is unfamiliar with PV technology. Currently, the government is aiming to increase the usage of this technology by allowing owners of PV panels to sell their generated electricity back to the power company at a higher price. Although this method is favorable to some of the owners, it will not raise the public awareness of using sustainable energy sources. People sell their electricity because they are attracted to the financial benefits. In order to establish a sustainable environment, UBC should demonstrate the effectiveness of PV technology. This can be achieved by installing PV panels into the new SUB. The installation will increase the students' understanding in PV technology and sustainability. Their knowledge will spread among different communities. Eventually, more people will be aware of this technology.

3.2 EFFECT OF SOCIAL INEQUALITY

Sunlight is a universal energy source because everyone has access to it. PV technology can potentially reduce the gap between the rich and the poor countries. Instead of competing with other countries for non renewable energy sources, developing countries can use PV cells to generate electricity. It is ideal for developing countries to adapt PV technology since PV panels have lower power requirements on infrastructures. Also, the panels are easy to produce and maintain. The main challenge of developing PV technology is the price competition of high purity silicon wafers. Many researchers proved that silicon wafer has high energy efficiency. However, most of the silicon wafers are sold to CPU manufacturers because they are willing to pay a lot of money. In order for PV manufactures to achieve maximum efficiency on their PV panels, high purity silicon or other materials such as Cadmium must be used. Due to the rarity and high cost of the manufacturing materials, the price of PV panels increases significantly. Currently, PV panels are affordable to the upper and the middle classes. As PV technology improves, the cost should decrease.

3.2 EFFECT ON EMPLOYMENT

PV technology is not heavily developed in North America. However, if PV technology has more recognition from the public, the employment rate will increase among the PV industry. Job opportunities will be dependent on the manufacturing, the marketing, the maintenance, and the recycling of PV panels. As the manufacturing cost decreases, demands in PV panels will raise. In addition to this, this demand will be an assist in developing a new sector of skills within the PV industry.

3.3 EFFECT ON PUBLIC HEALTH

The electromagnetic field produced by PV panels poses a potential risk to human health. Researchers discovered that there are negative effects associated with electromagnetic fields. A research done by Good Company highlights that "the magnetic fields created by alternating current electric systems" are able to "induce a current in the human body large enough to cause muscle and nerve stimulation that can result in headaches and pains [7]." Many PV panels generate direction currents, which do not fluctuate over time or induce electromagnetic field. However, many electrical appliances require alternating current. In order to supply sufficient power, the electricity generated by the PV panels has to be converted in the form of alternating current. The conversion can be accomplished by connecting the PV panels to several power inverters. In the Good Company's report, it states that the electromagnetic field produced by one single inverter is 50% less than the International Commission's requirement on the Non-Ionizing Radiation Protection Exposure Guideline [7]. Since PV panels are usually installed on the roof, people are at safe distances away from them. Therefore, the electromagnetic effect on human health is minimal to none.

4.0 ENVIRONMENTAL ANALYSIS OF PHOTOVOLTAIC TECHNOLOGY

Out of all the environmental problems on Earth, global warming is the most critical one. The negative impacts of global warming are observed in all parts of the world. The main contributors of global warming are carbon dioxide emissions and fossil fuel burning. The main concerns of continuous fossil fuel burning are "acid rain, soil damage, and human respiratory ailments [8]." The supply of fossil fuel is limited and the consumption rate is high. Undoubtedly, the Earth is deteriorating at an alarming rate, and the future will be at risk if we rely on the natural resources. In order to reduce the large amount of fossil fuel consumption, a reliable and environmental friendly energy source is required. Photovoltaic technology is a sustainable energy source which is capable of reducing the carbon emission. The energy generated from PV panels is renewable and safe to the environment.

4.1 OPERATION OF PHOTOVOLTAIC PANELS

PV panel is the main component of a PV system, and it operates on the Photovoltaic effect. Simply put, the Photovoltaic effect is the process of converting sunlight into electricity. In the PV system, a battery is required for storing the electricity generated by the PV panel. No pollution, greenhouse gas, or noise is produce during the operations of PV panels. In addition to this, the installation of PV panels on rooftops "eliminates the problem of finding the required space for [PV] panel placement [3]." The space gained from using PV panels will allow sufficient green areas to coexist with the new SUB. PV panels installed on the roof of any typical homes "would prevent 3.3 tons of coal from being burned, 8.5 tons of CO_2 from enhancing the greenhouse effect [8]."

Shading is a problem related to the operation of PV panels, which arises when a soft or hard source reduces the intensity of sunlight absorbed by the panels. Soft sources such as trees and surrounding buildings are objects which overshadow the PV panel. Hard sources such as leaves are objects that are directly touching the surfaces of PV panels [6]. Although PV panels are capable of sensing lights in cloudy weather, it operates more efficiently on sunny days. In order to obtain maximum power output, it is recommended to install PV panels in an open area of maximum sunlight exposure. Installing panels on the rooftop and the windows of the new SUB would be ideal.

4.2 PRODUCTION OF PHOVOLTAIC PANELS

Although the operation of PV panels produces no emission or radioactive waste, the manufacturing process of the panels contributes to greenhouse gas production. In addition to this, the toxic materials such as lead, mercury and cadmium are required in the manufacturing process. In particular, crystalline silicon is one of the most expensive PV materials because its production requires high energy consumption and extracts a large amount of waste. Many North America and European countries enforces the strict law, which govern how toxic waste and chemicals can be used and disposed. However, majority of the PV manufacturers are located in developing countries where the laws are more tolerant. Therefore, it is possible that companies will reduce the manufacturing cost by disposing the toxic waste into surrounding rivers or farmland [2]. Fortunately, the "manufacture of solar cells produces far fewer air pollutants than conventional fossil fuel technologies [12]." Nowadays, more universities and PV developers are looking into the safety and the efficiency aspects of the production process. After spending 16 years in perfecting the PV technology, the company, Sampath, has developed glass coating PV

panel, in which its manufacturing process is a “low waste process with less than 2% of the materials used in production needing to be recycled [1].”

4.3 LIFETIME OF PHOTOVOLTAIC PANELS

The approximate lifetime of a PV panel is 20 to 25 years. As PV technology advances, more developers are producing PV panels which can withstand extreme temperatures and harsh weather conditions for a longer period of time. As the durability increases, the maintenance of PV panels will decrease. The myth that PV panels require more energy to manufacture than they can produce was refuted as early as the 1970s [8]. Depending on the type of PV silicon, the payback period can range from 1 to 5 years. Moreover, the energy that a single PV panel generates in its lifetime “can be used to produce more PV [panels] identical to it [8].” Overall, the benefits of operating the PV panels over the approximate lifetime period will outweigh the drawbacks. As of now, the implementation of PV technologies into our ecosystem is one of the most sustainable solutions to the Earth’s environmental problems.

5.0 CONCLUSION

After evaluating the photovoltaic technology using the triple-bottom-line assessment, we suggest that PV panels should be implemented and considered for the new SUB. Our evaluation takes into account of the economical, the social, and the environmental aspects of photovoltaic technology. Although PV panels have a high manufacturing cost, the lifetime of the panels is much longer than other energy sources. In the long run, the energy produced by the PV panels will overcome the energy required to manufacture them. In addition to this, the operation of PV panels produces zero emission, which creates a greener campus environment for the university. Implementing photovoltaic technology into the new SUB also increases the public awareness of sustainability. After comparing the environmental and social benefits with the economical cost, it is beneficial for the new SUB to utilize photovoltaic technology.

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