UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation of Solar Energy as a Renewable Energy Source for the New Student Union Building

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AN INVESTIGATION OF SOLAR ENERGY AS A RENEWABLE ENERGY SOURCE FOR THE NEW STUDENT UNION BUILDING

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ABSTRACT

"An Investigation of Solar Energy as a Renewable Energy Source for the New Student Union Building"

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This report investigates the feasibility and practicality of utilizing solar energy technology as a renewable energy source for the new Student Union Building (SUB) at the University of British Columbia (UBC). A triple-bottom-line assessment was used to access the economic, environmental, and social aspects regarding solar energy. After extensive literary and quantitative/qualitative reviews, the importance of solar energy as a clean energy source has been revealed.

As UBC aims to become a leader in sustainability on campus, solar energy produced through the use of photovoltaic (PV) cells should be considered. Currently, the SUB is connected to UBC's main energy source which is run on natural gas. When natural has is burned, it produces carbon dioxide which has negative effects on the environment. The cost of natural gas will also continue to grow as supplies of natural gas are depleted. Furthermore, there are many social implications involved when using non-renewable energy sources and the use of solar energy can effectively improve the economic, environmental, and social factors of energy use. However, a major challenge that exists with the implementation of a PV system is the initial cost of installation.

This report will include a detailed quantitative analysis of component costs for PV systems. By assessing other factors involved in determining the cost of a PV system, long term economic benefits may exist. The environmental and social aspects are assessed through a qualitative approach. Many environmental and social problems are solved by using solar energy as an alternative energy source. Issues such as pollution, health, and aesthetics can all be improved.

TABLE OF CONTENTS

ABSTRACT…………………………………………………………………………..…..ii

LIST OF ILLUSTRATIONS…...iv

GLOSSARY…………………………………………………………………………….…...v

LIST OF ABBREVIATIONS……………………………………………..…………...vi

1.0 INTRODUCTION………………………………………………………………......1

2.0 SOLAR POWER ECONOMIC ASSESSMENT…………………………………..3

2.1 Initial Cost of the System…………………………………………...…...3

2.1.1 Government Subsidies………………………………………….....3

2.1.2 Component Costs……………………………………………........4

2.1.3 Maintenance Costs……...……………………………………...6

2.2 Life and Payback Times……………………………………………...…..6

2.3 Disposal and Recycling…………………………………………………..7

3.0 ENVIRONMENTAL ASPECTS OF SOLAR ENERGY……………………….…8

3.1 Photovoltaic Cells……………………………………………………….…8

3.2 Reduced Air Pollution…………………………………………………...8

3.3 Land Use……………………………………………………………………9

3.4 Disposal and Recycling………………………………………………….9

4.0 SOCIAL ASPECTS OF SOLAR ENERGY…………………………………...10

4.1 Visual Impact of Photovoltaic Cells…………………………………10

4.2 Health Benefits…………………………………………………………11

4.3 Educational Benefits…………………………………………………11

4.4 Job Opportunities………………………………………………………11

5.0 CONCLUSION…………………………………………………………………12

REFERENCES……………………………………………………………………..13

LIST OF ILLUSTRATIONS

Figure 1. The components used for harnessing solar energy……………………………...1
Figure 2. Retail Module Price Index for a PV system…………………………………….5
Figure 3. Payback time for a PV system………………………………………………..6
Figure 4. PV cells integrated into the design of a building………………………………10

GLOSSARY

Grid-Connected: The solar power generating system is connected to the city’s power lines and adds power to these lines when not all the power is being consumed

Grid Parity: The point at which alternative means of generating electricity is equal in cost or cheaper than grid power.

LIST OF ABBREVIATIONS

BIPV	Building Integrated Photovoltaics
kWh	Kilowatt-hour, a unit of energy. Although watts (W) appear in the unit, the multiplication by hours (h) gives an energy unit.
PV	Photovoltaic
SUB	Student Union Building
UBC	University of British Columbia

1.0 INTRODUCTION

Conventional energy sources based on oil have proven to be drivers of economic progress, but at the same time damaging to the environment and human health [1]. Since these sources are also depleting, renewable and clean energy sources need to begin to make a substantial contribution. Post secondary institutions need to play a big part in awareness, help develop solutions for this major issue and be a model for for the rest of society to make a change. With that in mind, the University of British Columbia's new Student Union Building should incorporate as many renewable sources of energy as possible.

This report will use the triple-bottom-line assessment of social, environmental and economic characteristics of solar power generation. Solar power generation works by using an array of photovoltaic materials, commonly silicon, that exhibit the photoelectric effect. This works by absorbing photons from sunlight and releasing electrons, which can be collected as an energy source [2]. The figure below depicts this process along with the components in such a system [3].

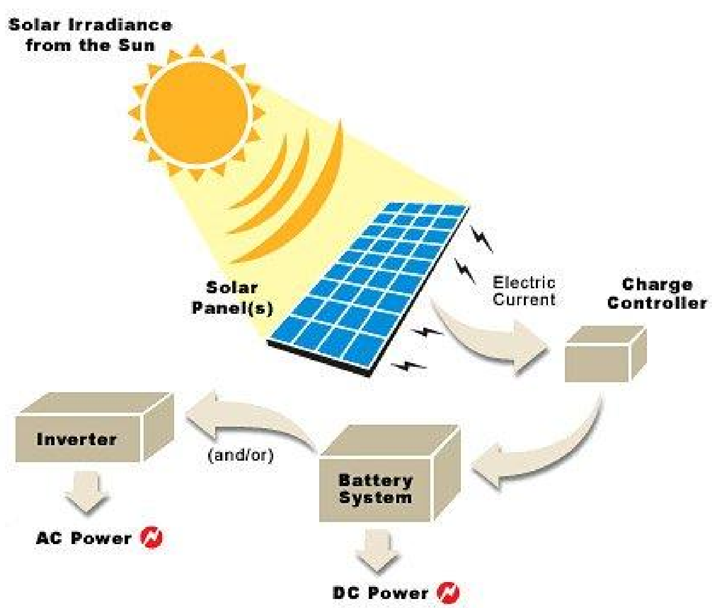

Figure 1: The components used for harnessing solar energy
Source: www.homesolarinfo.com

After researching the three columns of this triple-bottom-line assessment, a recommendation will be made to the contractors of the new SUB at UBC of whether or not to implement solar power generation. This recommendation will be made purely on secondary research sources and it is suggested that further research as well as primary sources be used to confirm or deny this recommendation.

2.0 SOLAR POWER ECONOMIC ASSESSMENT

The main factor today that is greatly inhibiting the growth of solar power generation is the current cost of installation and maintenance of these systems. Fortunately, as technology continues to increase at a fast rate, the costs associated with solar power generation systems continue to drop [4].

Even though Vancouver climate does not provide the optimal environment for solar power generation, implementation of these systems is still valuable and can still provide economic benefits in the long-term. In the specific case of the new SUB at the University of British Columbia, a lot of pressure is being placed on creating a sustainable major node on campus. The economic assessment of implementing solar power generation at the SUB will be broken down into the following components: initial cost of the purchase, government subsidies and the projected payback time for this system. Since it is known that the new SUB will incorporate solar power, this section aims to quantify the possible economic benefits or set-backs of doing so.

2.1 Initial Cost of the System

When developing a cost estimate for a solar power generation system there are numerous factors that needed to be taken into account. These include the type of solar module used, climate where system will be installed, size of the installation, subsidies in place by government and the current price of the modules (which changes month to month) [4]. Evaluating each of these factors along with the variables that these factors rely on will provide the economic baseline for the feasibility of such a system at the new SUB.

2.1.1 Government Subsidies

Throughout the world there are many different types of subsidies and benefits provided by the government in order to promote residential installation of solar power generating systems. As mentioned earlier, using Germany as a case study provides great insight into the potential of solar energy when the costs associated are greatly reduced by the government. The payback time for these systems can also be reduced when the government forces electric providers to buy back energy from grid-connected* solar power systems that produce excess energy at above cost.

In British Columbia, there are limited subsidies in place for such systems, which directly attributes to the limited solar generation in BC. Currently, the only reduction in initial costs is for solar water heating systems in residential areas [5]. This minimal rebate provides very little incentive for installing such systems. Therefore, current government incentives are not significant enough for the average person to be able to afford these systems. In relation to the new SUB, the initial cost of implementing the system without subsidies should not be a barrier to implementing this technology.

2.1.2 Component Costs

Referring to figure 1 in the introduction of this report, it can be seen that a PV system is comprised of the following components: a module, charge controller, inverter and battery. Many cost estimations are focused on the module cost, which is the most expensive component. With the costs of the other components improving only slightly over time, improvements in technology can drastically reduce the cost of the module, which accounts for roughly 50% of the total system initial cost.

Knowing that the new SUB will be using solar powers sourced from the United States, the American solar price index can be used to estimate the cost of this installation. Fortunately, this price index includes the complete system integration, including all components as well as installation costs [4]. The graph below outlines the decrease in solar power systems over the last 9 years.

*This term and all subsequent terms will be found on the glossary on p.iv

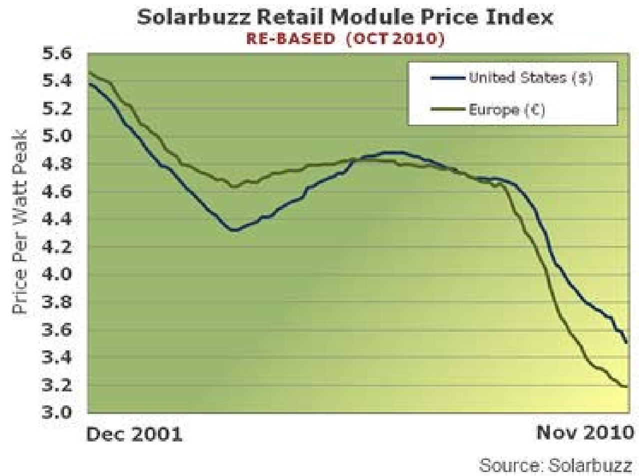

Figure 2: Retail Module Price Index for a PV system
Source: www.solarbuzz.com

Assuming that the scale of the UBC SUB will be between a commercial and industrial venture, initial costs can be averaged from these two current industry costs. Without detailed information on the proposed system, it will be assumed that the system to be installed at the SUB will generate 100 kW. This assumption may be high but will allow for a conservative estimate.

The current costs for commercial and industrial solar systems can be found in the chart below [4]. As mentioned above, the cost for the new SUB can be found by interpolating by system size. Price reductions for increased system size can mostly be attributed to bulk purchase price reduction [4].

System Scale	***Cost for System in Sunny Climate ($/kWh)***	***Cost for System in Cloudy Climate ($/kWh)***
Commercial	~0.22	~0.49
Industrial	~0.17	~0.38
UBC SUB Interpolated Costs	~0.21	~0.47

Knowing that Vancouver has a cloudy climate, this price model can help estimate the projected cost of a new solar system at the new SUB. Continuing with the assumption that a 100 kW system would be installed, it can be predicted that the cost for the complete system and installation would be about $800,000. This estimated cost does not include possible subsidies or incentives that the university could attain.

2.1.3 Maintenance Costs

The maintenance costs of solar power systems are a fraction of the total cost. On a residential scale, maintenance costs are about $2,000 for the lifetime of the panels. Scaling this average cost up to the SUB, it can be expected that an additional $50,000-$100,000 would be needed for solar panel maintenance.

2.2 Life and Payback Times

The average lifetime of silicon PV system is in excess of 20 years. Over these 20+ years, the generating capability of these systems will decrease by 20% maximum [4]. As mentioned earlier, the lifetime of these systems continue to increase as related technologies improve. The overall decision many clients face when determining if installing a PV generating system will be worth it in the long run comes down to this lifetime and the corresponding payback time. Usually, if the payback time exceeds the lifetime, the process would not go forward. The graph below shows the varying payback times associated with a cloudy climate and a varying discount rate [4].

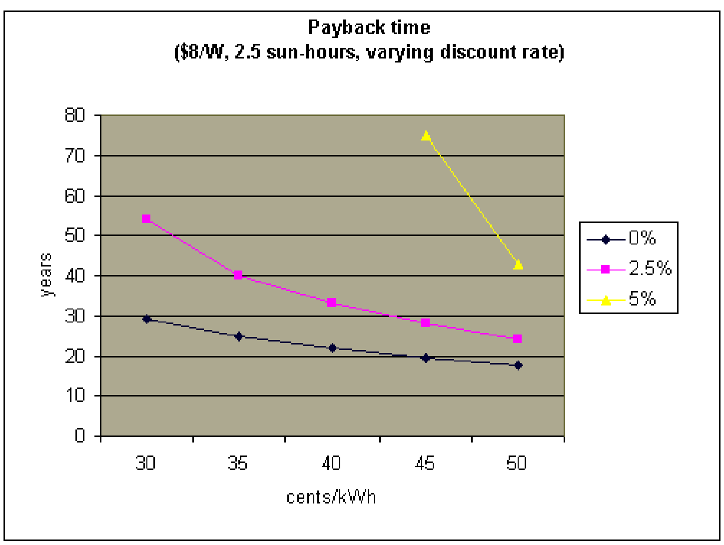

Figure 3: Payback time for a PV system
Source: www.solarbuzz.com

This graph confirms that large improvements in technology are needed for these systems to be cost effective. Although the payback time for systems installed in sunny climates are much lower, there is no guarantee that the system will save the owner money in the long run. It is also very difficult to accurately estimate a payback time without case specific data and supplier information.

2.3 Disposal and Recycling

Although there are a large amount of benefits from solar power generation during its operational life, at the end of PV cell's life there can be many negative effects on the environment if these materials are not recycled or disposed of properly. This will be described in more detail in the environmental section. In terms of costs, most solar panel manufacturers and distributors cover the costs of recycling these materials because they can be reused to make new PV cells [6]. Knowing that disposal and recycling costs can be avoided, these costs will not factor into the assessment of a solar system at the new SUB.

Overall, the total expected cost of integrating a solar power generating system at the new SUB can be estimated to be about $900,000. Once again, this estimate is fairly conservative based on the assumptions stated above.

6.0 ENVIRONMENTAL ASPECTS OF SOLAR ENERGY

A renewable energy source to be considered for the new Student Union Building at UBC is solar energy. Conventional energy sources such as fossil fuels are being used extensively around the world and they release greenhouse gas emissions, carcinogens and carbon dioxide into the atmosphere. These pollutants contribute to changes in the environment such as the depletion of the ozone layer, climate change, smog, and acid rain [7]. The current SUB is connected to UBC's main energy source which is run on natural gas, a fossil fuel. Natural gas is a non-renewable energy source and as the supply of natural gas decreases, the price will increase. Although using natural gas is better than other fossil fuels such as coal and oil, it still releases carbon dioxide when it is burned. Carbon dioxide is a greenhouse gas and should be limited as much as possible. One way that we can lessen our dependence on natural gas is by using other sustainable, self-contained technologies such as photovoltaic cells which can be implemented into the design of a building.

3.1 Photovoltaic Cells

Solar energy is produced by using photovoltaic cells and they are one of the most promising renewable energy technologies [8]. The sun is an inexhaustible resource which is available around the world and supplies the earth each day with enough energy for 27 years [9]. Instead of creating energy from fossil fuels, it is possible to utilize even a small amount of the abundant energy from the sun. A very important application of photovoltaic cells is in the design of a building. It is the most viable form of renewable energy for use in an urban setting such as UBC's campus [10].

3.2 Reduced Air Pollution

According to [11], designing clean sources of energy has become one of the most important tasks given to science and technology. In a place like the UBC's SUB, it is important to use clean energy sources since it is very feasible and beneficial. One of the main advantages of using solar energy is that it does not produce any air emissions or waste products. This helps to reduce the amount of greenhouse gases and toxic emissions in the atmosphere [12]. Greenhouse gases and toxic emissions from conventional sources of energy are very harmful to the environment and cause acid rain, the depletion of the ozone layer, and climate change [7]. The only greenhouse gases that are related to solar energy are the ones produced during the manufacturing of solar devices. However, the amount of greenhouse gases produced is insignificant compared to the greenhouse gases produced by using other conventional energy sources [12]. According to [10], solar energy is considered an almost absolutely clean and safe energy source. Switching to a clean alternative source of energy such as solar energy is a great way to help reduce the air pollution created on campus.

3.3 Land Use

Implementing photovoltaic cells for electrical power in the new Student Union Building will not require any extra land use and actually reduces the amount of land use for energy supply [13]. The photovoltaic panels can be mounted on roofs or walls and can be completely integrated with the design of a building. This solar energy system is self-sufficient and can work in a single building setting. Therefore, it is not connected to larger power plants or power lines and the amount of transmission lines connected to a building is reduced [12].

3.4 Disposal and Recycling

An environmental issue with solar systems is the disposal of PV cells. Although a majority of companies offer a recycling program for their PV cells, some of the discarded PV cells can still end up in landfills. Some of the materials used to make PV cells are very toxic and dangerous. If discarded improperly, chemicals and toxins such as mercury can permeate into groundwater supplies [9]. Therefore, the proper disposal and recycling of PV cells must be used to prevent the pollution of the environment.

7.0 SOCIAL ASPECTS OF SOLAR ENERGY

The implementation of photovoltaic cells to utilize solar energy for the new SUB has many social benefits. Universities are a place of research and technology and should be updated with current beneficial technology. UBC aims to be a leader in campus sustainability and using renewable energy sources are very important for the image of the campus. There is campus and community pride surrounding the exposure of sustainable buildings and using solar energy is the most viable source of renewable energy [10].

4.1 Visual Impact of Photovoltaic Cells

The physical appearance of a building is significant to its users and the environment that surrounds it. Modern and sustainable design is very important for new buildings on UBC's campus. Photovoltaic cells can be used in a visually appealing way and they also help to supply energy to a building. By using photovoltaic cells, there is a positive aesthetic impact on modern buildings. Architects have discovered that solar panels can be used to enhance the appearance of a building, and also advertise the use of solar energy. These PV cells can be integrated into the design of a building (BIPV) and can be used as architectural elements (See Figure 4). [13] The photovoltaic panels can be integrated into the design of a building by being mounted on roofs or walls. They are also physically attractive due to their flat, glossy appearance. As a result, the use of photovoltaic cells will not hinder the appearance of the new SUB. It will actually be beneficial to its appearance while simultaneously generating electricity.

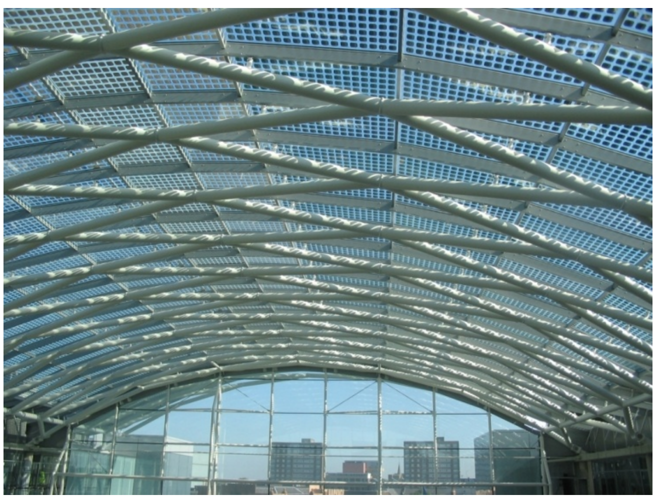

Figure 4: PV cells integrated into the design of a building
Source: www.pv-tech.org

4.2 Health Benefits

Using solar technology such as photovoltaic cells reduces the amount of air pollution and as a result, is beneficial to the health of students and campus users. Conventional energy sources such as the burning of fossil fuels releases harmful toxins into the environment. [12] This directly affects our health by polluting the air we breathe. Photovoltaic systems do not create gas or liquid pollutants, or radioactive substances [11].

Another health benefit to using solar energy is that it is completely silent [10]. A reason for this is because there are no moving parts [11]. In an urban setting, it is important to reduce the amount of noise pollution we create, especially with other buildings on campus that contribute to noise pollution. The reduction of noise is beneficial to student health and provides a better learning environment.

4.3 Educational Benefits

Universities have a strong influence on the public and can promote the idea of sustainability and alternative energy sources. Solar systems assist in encouraging alternatives to saving energy by the building owners, promoters, and users [12]. Installing photovoltaic cells in the new SUB can benefit the public by educating them about clean energy sources and the possibility of incorporating this technology into their homes. This green technology will also be presented to students and can be used to promote awareness of renewable energy sources. By building the new SUB with sustainability in mind, UBC can exhibit the technology and design of the new SUB to the world.

4.4 Job Opportunities

Another social benefit to implementing solar energy in the new SUB is the increase in job opportunities in the solar energy field [12]. Job opportunities will be generated for the manufacturing, construction, and operational phases of a solar system. Solar energy will contribute to an increase of jobs in almost all sectors of industrial production and service. An example of this is the development of different industries for the production of solar energy converters and solar energy equipment. [13] In addition, the job opportunities that will be created in the construction and operational phases are local and will employ members of the community.

8.0 CONCLUSION

After conducting a triple-bottom-line assessment for solar power generation at the new SUB at the University of British Columbia, it is recommended that such a system be implemented. Despite the high costs of such a system, the non-ideal climate for this technology and the inability to guarantee cost savings in the long-term, the social and environmental benefits far outweigh the minimal economic set-back for the school. The students at UBC are being released into the world with the capability to make positive changes in terms of dependence on non-renewable sources.

By implementing a clean energy source such as solar energy in the new SUB, UBC can educate the public of alternative energy resources. The awareness created can positively influence and motivate individuals to consider renewable energy sources in their own homes. This change in energy generation and consumption will have a positive social and environmental impact.

The use of fossil fuels should be limited as renewable energy technologies become more advanced and efficient. A major benefit of using a solar energy system is that there is no pollution created while it is operating. Sustainable development and design is crucial to preserving our natural environment. It is important to work towards a sustainable future with clean, renewable energy sources dominating the energy markets. Through the implementation of a solar energy system in the new SUB, the environmental and social issues with conventional energy sources can be minimized.

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