UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into Generating Renewable Energy for New Student Union Building Using Solar Cells

Muhammad Usman Rizwan, Malihsa Haddadi, Vincent Wirasaputra, Chris Esposito

University of British Columbia

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Muhammad Usman Rizwan
Malihsa Haddadi
Vincent Wirasaputra
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Abstract

This report investigates one renewable energy source for the new SUB. This source needed to be on site and able to power at least 20% on the new SUB's energy needs. A budget was not given but different cost options were explored within the energy source. The energy source discussed is crystalline photovoltaic cells.

After a triple bottom line assessment the conclusion was that these solar cells are a viable option to produce the necessary power for the SUB. Economically we found solar cell system to be affordable and found that it will pay off. Socially, the benefits far outweigh the consequences. The largest negative effect is the use of hazardous chemicals but as long as the production and disposal processes are done properly this is not a risk to society. The benefits include opportunities for developing awareness of green technology and creating "green" oriented jobs. With this technology on the roof of the SUB workshops, info sessions and classes could be held for the community and students to further our knowledge of this environmental friendly technology. Green jobs are jobs that promote environmental solutions to problems. These jobs for solar cells include the production, installation, and maintenance of the cells. Environmentally solar cells are drastically better than fossil fuel. They reduce the CO_2 emission by 50 times. The weather conditions in Vancouver will provide enough solar energy to power the SUB as long as a proper storage unit is installed as well. Also the cells can be recycled and reused. The silicon can be extracted and the other metal components can be melted down as well.

In conclusion, crystalline photovoltaic cells are an economically, socially, and environmentally viable option for the SUB to meet LEED platinum standards, and more importantly provide and system for the SUB to independently create its own power without having negative impacts on society and the environment.

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Glossary

Photovoltaic: The technology of the conversion of sunlight into electricity

Reactive Power (kVarh): Kilovolt Amps Reactive Hours is the power that cannot be converted by equipments

Rate Rider: The rate rider is applied to the total of energy, demand, and reactive power charges, before taxes and levies

Innovative Clean Energy Fund Levy: It is applied to the total charge of energy, demand, reactive power, and rate rider charges, before taxes;
It is collected to support the new energy of technologies that can solve the problems in BC and other provinces.

List of Abbreviations

SUB – Student Union Building

FLEED - Leadership in Energy and Environmental Design

kWh - Kilowatt Hour

PST – Provincial Sales Tax

PV - Photovoltaic

GW - Gigawatts

CO_2 - Carbon Dioxide

STE - Solar Thermal Energy

1.0 INTRODUCTION

Most of the energy sources we use today are from fossil fuels that will not last forever. A renewable natural source is one that can be replaced naturally. We can reduce the level of greenhouse gas emissions by using alternative renewable energy sources. In addition to water and wind, the sun is an example of a renewable energy source.

When harnessing the solar energy for thermal energy the technology is called Solar Thermal Energy (STE). We can also use solar energy to make electricity using Photo Voltaic (PV) systems. This report focuses on the photovoltaic control of solar energy for the new SUB. Photovoltaic devices use semiconducting materials such as silicon to convert sunlight directly into electricity. The triple bottom line assessment of PV system is conducted and the report is broken down into three sections: Economical, Social and Environmental.

2.0 Economical Analysis

A solar system is analyzed as a potential renewable energy source for the new SUB in order to help it achieve LEED platinum rating. In this section economical analysis is done and we have computed the cost and revenue generated by proposed solar system if it would be installed at the new SUB roof. The requirement of renewable energy source must be known before the energy system is analyzed economically.

2.1 RENEWABLE SYSTEM REQUIREMENT

The requirements of solar systems for the new SUB are the following:

1. The system must be within the budget of the new SUB
2. The system must not affect the health of the users
3. The lifetime of solar panels must be between 20 and 25 years
4. The system must be suit to the design of the new SUB building by architecture
5. The energy produced from solar system must be at least 20 % of SUB total energy requirements to get LEED Platinum.
6. The system should be economical in the long run and ideally should help generate some revenue

2.2 Calculations

There are five steps to select the right solar panel system: New Sub Power Requirement Analysis, the Sun Radiation Energy Calculations, the Area of the Solar Array Required and Available, the Selection and the Initial Cost of Solar Panels

2.2.1 Power Requirement Analysis

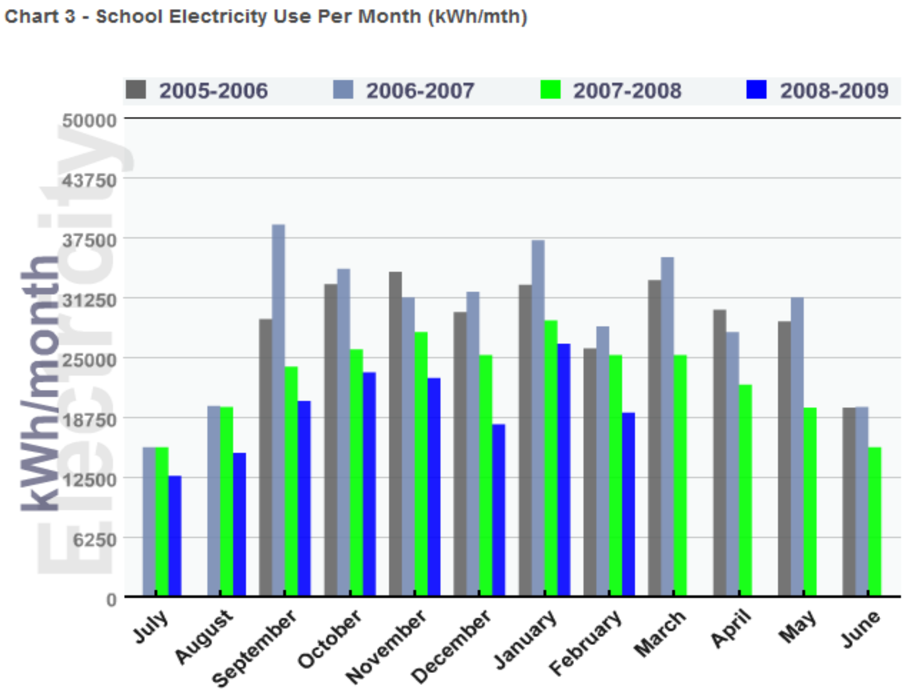

Figure 1: the Electricity Use per month at old SUB [1]

Analyzing the power consumption of the old SUB is the first step of power analysis because it can be used to approximate the amount of energy that will be required for the new SUB. As it is shown in Figure 1, according to the U-Sustainability website, the energy consumption at the old SUB in 2008-2009 was 228,500 kWh [1].

We expect as the new SUB is going to be bigger than old SUB it would require more energy but since there will be better lighting and more energy efficient appliances the energy consumption would stay the same. Also it is evident in the graph that energy requirements are going down year by year therefore energy required in later years should be less than what it is in the present for that building. *Energy Required For the new SUB = 228,500 kWh/year*

20% of that energy for LEED Platinum = 57,700 kWh/year

2.2.2 Sun's Radiated Energy Analysis

We have used the data from Forest Canada website in order to get amount of energy Vancouver region receives from the Sun (See Figure 2). The light blue area is Vancouver Region which receives about 2.1 $\frac{kWh}{day.meter^2}$. [2]

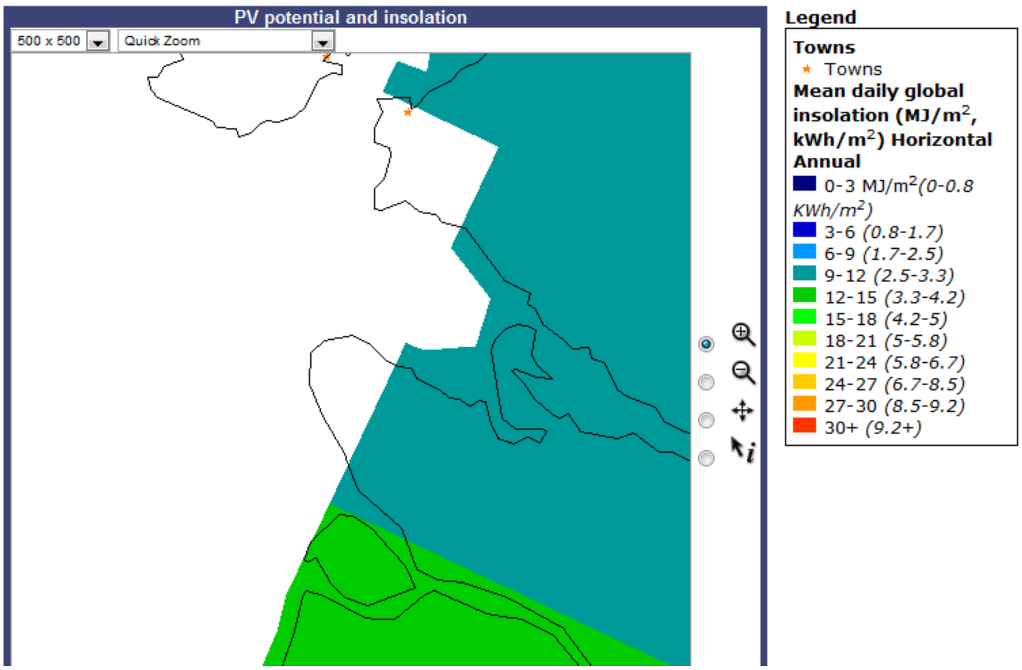

Figure 2: The Photovoltaic potential (kWh/kW) in Lower Mainland [2]

The total radiation energy per year can be calculated as

$$2.1 \frac{kWh}{m^2\, day} * 365 \, {}^{days}/_{year} = 776.5 \, {}^{kWh}/_{m^2}$$

2.2.3 The Area of the Solar Array Required

According to the SEED website, the total area of the new SUB is 250,000ft^2,[3] which gives 50,000ft^2 (4651.25m^2) for each floor since the building will have 5 floors. To calculate the available area for solar arrays, we need to calculate the renewable energy source that must produce at least 20% to get the LEED Platinum: 288,500 kWh per year * 0.2 = 57,700 kWh per year. And, the energy efficiency of solar panel is about 15%

therefore $776.5 \, {}^{kWh}/_{m^2\,year} * 0.15 = 116.5 \, {}^{kWh}/_{m^2\,year}$

Thus, the total area available for solar arrays is

$\boldsymbol{Area} = \frac{\mathbf{57{,}700}\boldsymbol{kW}\mathbf{h}}{\mathbf{116.5}\frac{\boldsymbol{kW}\mathbf{h}}{\boldsymbol{m}^{\mathbf{2}}}} = \mathbf{495.4}\boldsymbol{m}^{\mathbf{2}}$, which is 10.65 % of the total area of the roof top .

Therefore given that solar cells will be 15% efficient in converting energy and given that SUB will get 2.1 kWh/day.meter^2. Solar cells will need area of 495.4 meter square.

2.2.4 The Selection of Solar Panels

The picture below is also from Forest Canada and shows the amount of yearly sunlight Vancouver region gets. From the picture it is evident that Vancouver gets about 1100 hours per year and 2.74 hours per day.[2]

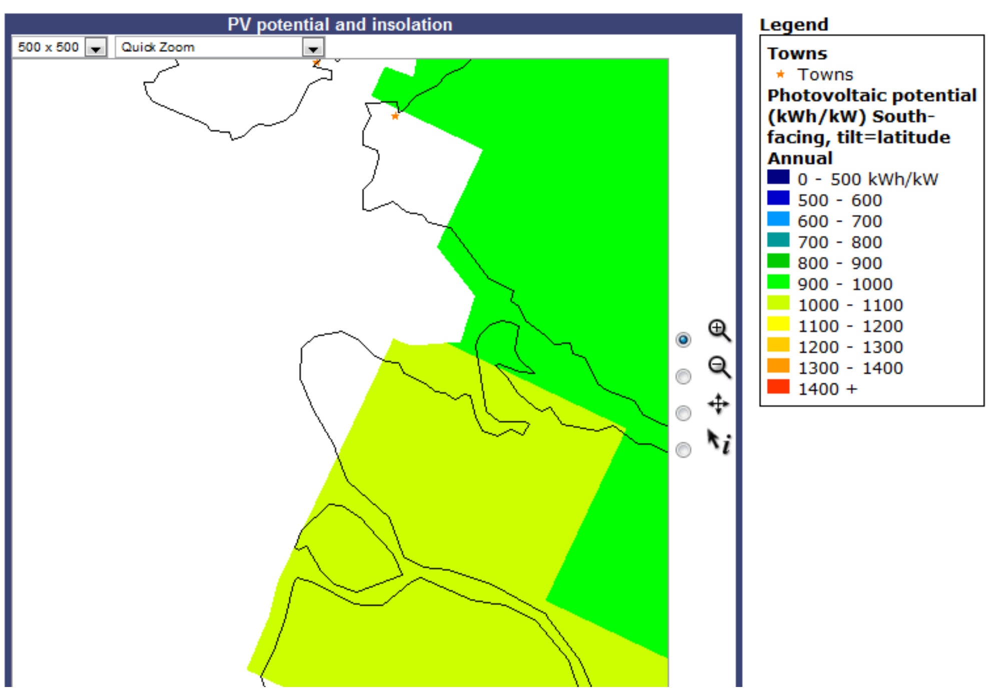

Figure 3: The mean amount of sunshine in lower mainland per year [2]

According to Solar Tech US website, the price of Canadian Solar- 200 W panel is $585 per panel [4] and the area of the panel is 1.61m^2 (Solar Tech US). To make sure that the chosen solar panel can generate energy that is equal to or higher than 57,700 kWh per year, we need to calculate the total number of solar panels that we will need which is

$$\frac{495.4\ m^2}{1.61m^2} * 1\ panel = 308\ panels$$

Then, the power generated from all the solar panels is

$$308 \text{ panels} * 200\ {}^{W}/_{panel} = 61.6\ kW$$

And, the total energy that can be generated from solar panel in a year is

$$61.6 \text{ kW} * 2.74\ {}^{hr}/_{day} * 365\ {}^{days}/_{year} = 61{,}606.16 \text{ kWh per year}$$

As can be seen in the calculations our proposed solar panel system will produce about 62,000 kWh per year, though new SUB power requirements should be about 58,000 kWh per year. As a result system would produce more energy than it consumes annually. In order to deal with this excess energy, a system needs to be in place to store this energy for other needed times or sell it to BC Hydro.

2.2.5 The Initial Cost of Solar Panels

Since this type of solar panels manages to generate more energy than we have expected, we recommend to purchase 200 Watt, Area = 1.61 meter square type of panels.
The total initial cost of Canadian Solar Panel is

$$\$585/_{panel} * 308 \text{ panels} = \$180{,}180$$

which is only 0.17% of the total budget of the new SUB ($ 103 million).

2.3 Comparison with BC Hydro Utility Charges

This section calculates the amount of money UBC need to pay if the UBC decides to use electricity from BC Hydro.
To show the system will be economically viable in the long run, the calculation is done below. The cost breakdown of a business bill can be seen in Figure 4.

General Service (Commercial): 35 kW and Over for 1 month	
Retail stores, medium industry, manufacturing, schools, office buildings, supermarkets. Demand is 35 kW or over and a demand meter is usually installed. Schedules 1200, 1201, 1210, 1211 of the Electric Tariff.	
Basic Charge:	17.16 cents per day
Demand Charge:	First 35 kW for NIL
	Next 115 kW at $4.18 per kW
	All additional kW at $8.02 per kW
Energy Charge:	First 14,800 kWh $0.0816 per kWh
	All additional kWh $0.0393 per kWh
Discounts:	1.5% on entire bill if customer's electricity is metered at primary potential.
	$0.25 per kW if customer supplies transformation from a primary to a secondary potential.
	If a customer is entitled to both discounts the 1.5% discount is applied first.
Minimum Charge:	50% of the highest maximum demand charge billed in any month within an on-peak period (1 November to 31 March inclusive) during the preceding 11 months.
Rate Rider:	4.0% Rate Rider applied to all charges, before taxes and levies

Figure 4: The commercial Rate of BC Hydro [5]

Assume that the power consumption is $\frac{228500\ kWh}{12\ month}$ = **19041 kWh** per month and, then

The total cost of basic and energy charge is

The basic charge = $0.1716 per day * 31 days per month = **$ 5.32**

The first energy usage cost is $\frac{\$0.0816}{kWh}$* 14800 kWh = **$ 1207.68**

The second energy usage cost = $\frac{\$0.0393}{kWh}$ * (19041 – 14800) kWh = **$ 166.67**

The total charge = $1,379.67

Then, if the new SUB uses more than 35 kWh in a certain period, it will be charged with demand charge. In this calculation, we assume that the solar panels produce $\frac{19401\ kW}{230\ Watts}$ = 83 kW in a certain period. Thus,

The demand charge = 0*35 kW + (83-35) kW * $4.18 per kWh = **$ 200.64**

Then the cost of reactive power can be done by adding all the energy and demand charge and multiplying the results with 0.04.

kVarh = $ (200.64+166.67+1207.68+5.32+19041) * 0.04 = **$824.85**

The rest of charges are calculated as follows:

Rate of Rider = $(200.64 +166.67 + 1207.68+ 5.32+19041 +824.85) *0.04 = **$857.85**

ICEFL = $(200.64+166.67+1207.68+5.32+19041+824.85+857.85)*0.004 = **$ 89.22**

PST = 0.12 * (200.64+166.67+1207.68+5.32+19041+824.85+857.85+89.22) **= $2,676.49**

The total cost of one month = $(1,379.67+200.64+824.85+857.85+89.22+2676.49) **= $ 8705.21.**

The total amount of money paid to BC Hydro in 25 years = $(8705.21 * 12) *25 years **= $2,611,563.6.**

The amount of money saved by solar panels = $2,611,563.6 * 20% = $522,312.72

The monthly bill is lower than the initial cost of the panels. However, in the long run, solar panels will save $522,312.72 to UBC. Therefore solar panels will out perform the conventional BC Hydro bill.

3.0 Social Analysis

We need to change our relationship with energy since we cannot live without it. The goal to use renewable energy is to produce more energy in the new SUB than is used. We need to develop alternative energy supplies and reuse waste energy. Solar energy is one of the alternatives to realize this goal.

3.1 Community Engagement

The process of using solar energy on campus can be based on emerging concept of interactive social research. This creates opportunities for UBC student to take leadership roles, to interact and engage in different processes such as: focus groups, expert workshops, community meeting and more. It can involve the research users in the creation of useful knowledge. For example, the involvement of APSC 261 students in this project is one of the public knowledge engaged. The development of renewable energy in the new SUB will also brings a world-class education and development on campus.

3.2 Safety Issues

The most significant health and safety hazards are associated with the use of hazardous chemicals in the manufacturing phase of the solar cell. Improper disposal of solar panels at the end of their useful life also presents an environmental, health and safety concern.

Firefighter vulnerability to electrical and casualty hazards when fighting a fire involving PV modules has to be taken into consideration in the construction of the new SUB in addition to the risks related with live electricity. In the event of a fire, it is theoretically possible for hazardous fumes to be released and inhalation of these fumes could pose a risk to human health.

Other building regulations have to be examined in construction such as: strength of roof (increased weight loading), effect of wind lift on PV modules and roof supports, safe installation of solar PV systems and safe maintenance of solar PV systems at height.

3.3 Visual Impacts

Because solar panels are generally large with highly geometric and sometimes highly reflective surfaces, solar energy facilities may create visual impacts. Aesthetic issues are highly subjective. However this impact to the landscape can be avoided by proper sitting of solar panels in a building. [6]

3.4 Creating Green Jobs

Introducing net positive energy buildings on campus will set new grounds and lead the way for others.

Many people in BC had assumed that premier Campbell would announce new measure to create green jobs. However the Campbell government recently turned down profitable alternative energy investment by letting BC Hydro cap and rejects 14,000 GW/h of potential clean power, private money investment. The province could have had 6 times as much private investment in renewable energy as we are going to get now and 6 times as many jobs as a result. [7]

Since the journey to net positive energy has already taken place in other countries in the world, it is logical that our government might try the same. Jobs in renewable energy are expanding worldwide (See Figure 5 below). The solar energy has provided an estimated number of 663,000 green jobs worldwide in 2006.[7]

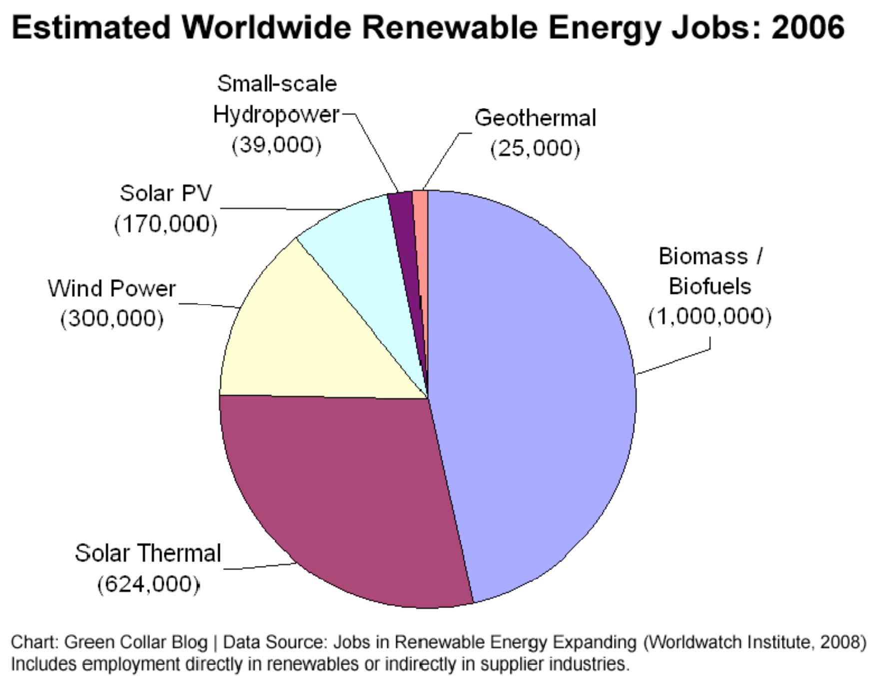

Figure 5: Estimated Worldwide Renewable Energy Jobs: 2006 [7]

With the new Ontario FIT program, the province is attracting over $9 billion of new private money for alternative energy technology investment and with expectations that up to 50,000 new green economy jobs will be created. [7]

The European Union is the world leader in the development of renewable energy with already 700 000 jobs and an annual turnover of 91 billion Euros. (See Figure 6 below)

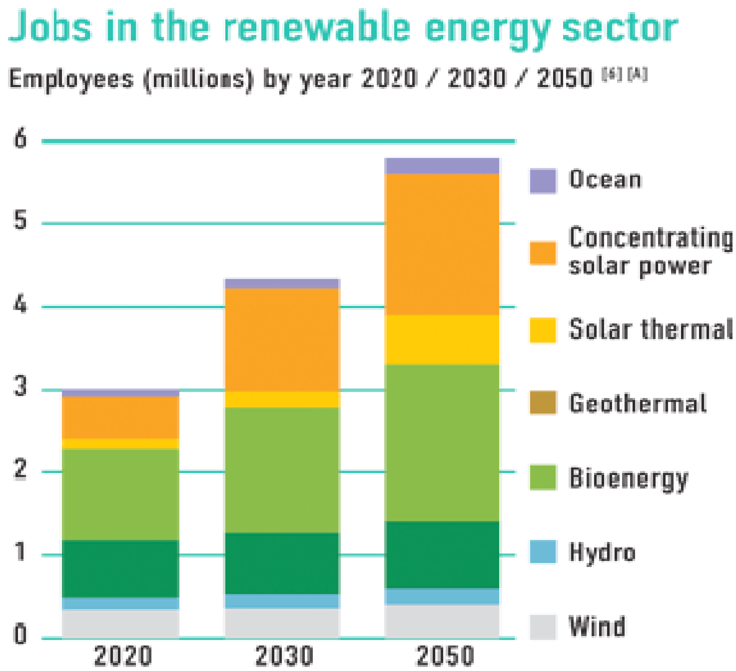

Figure 6: Jobs in the renewable energy sector [7]

One of the countries that are leading in expanding renewable energy jobs is Germany. Their statics shows (See Figure 7 below) that at the end of 2008, approximately 280,000 people in Germany were employed in planning and designing, installing and operating plant and systems. The number of jobs has therefore quadrupled since 1998 and rose by 30,000 in 2008 alone. Due to worldwide demand for renewable energy, the industry expects to give more than 500,000 people in Germany employment in 2020. [8]

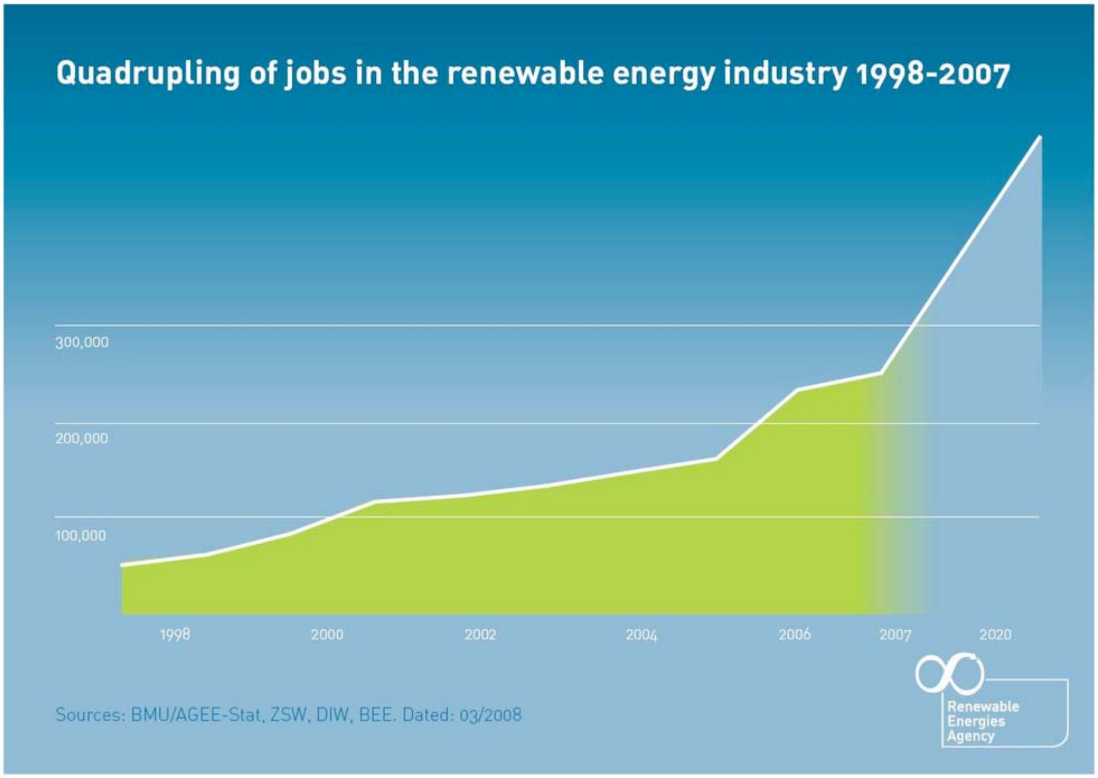

Figure 7: Quadrupling of jobs in the renewable energy industry (Germany) [8]

Considering such great examples, our provincial government should inspire the development of renewable energy to create jobs in our community. The new SUB design is aiming to achieve LEED Platinum status as a building and it can become a symbol that encourages the development of renewable energy in our province. Installing solar panels for the SUB can pursuit sustainability in our community by setting an example in the development.

3.5 Conclusion

The environmental, health and safety concerns for solar panels are minimal and limited. With valid regulation set up by authorities in manufacturing and operating phase, dangers to workers and the public can be minimized. Further, the benefits of photovoltaic outweighs risks concerning with fossil fuel technologies. While nature is giving us all of the resources, we need to be sensible enough to use them.

4.0 Environmental Analysis

Crystalline photovoltaic cells have both positive and negative effects on the environment. When analyzing the cells to see if the net effect is positive or negative there are three major categories to consider, emissions, recyclability and impacts of efficiency and geographical location.

4.1 Emissions

During the production on photovoltaic cells CO_2 are released into the atmosphere, whether it is from the transportation of material or emissions from a production factory it still has a carbon footprint. Although, throughout a cell's life time it only creates pollution while being produced, where as other means of energy such as burning fossil fuels produce CO_2 the whole time you are creating energy. A photovoltaic cell contributes 20g CO_2/kWh into the environment compared to fossil fuels contributing 500 – 1000g CO_2/kWh depending on which fuel is being burnt.[9] This is up to 50 times less emission by switching to crystalline photovoltaic cells.

4.2 Recyclability

To recycle a crystalline photovoltaic cell you need to separate all of its components and then recycle each part appropriately. The whole process from separating to recycling each part is shown in a flow chart in Figure 8. [10]

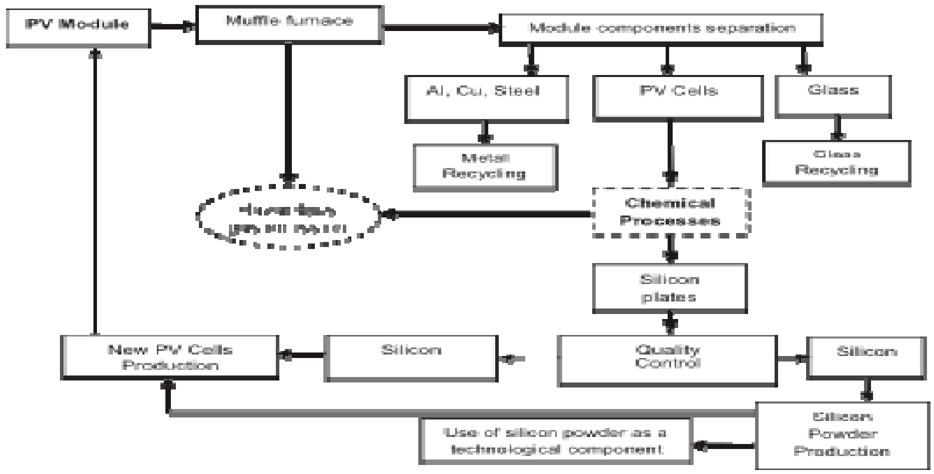

Figure 8 – Flow chart of the recycling process of crystalline PV cells [10]

The main element to be recycled in a photovoltaic cell is the silicon. To do this the cell is put through a chemical etching process to separate the silicon. A diagram is shown in Figure 9.[10]

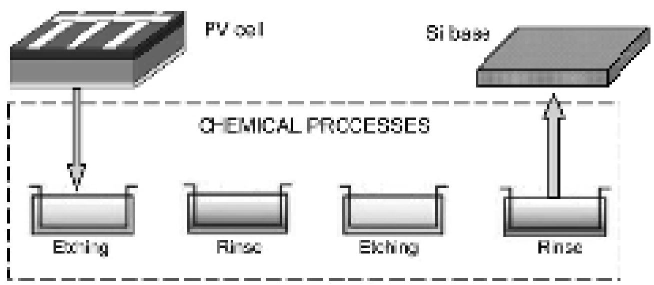

Figure 9 – Diagram of etching process to remove silicon [10]

The efficiency of the etching, to recover pure silicon, depends largely and on the additives in which the manufacture used. [10] The recovered silicon can now be used to produce more solar panels or used in other applications.

4.3 Impacts of Efficiency and Geographical Location

The efficiency of a cell plays a huge role on the power output of the cells because there is a limited amount of energy coming from the sun. The higher the efficiency of the cell, the more power that can be harnessed from the sun and turned into electricity. The average efficiency of a crystalline photovoltaic cell is 12 – 15% depending on the model and the age of the cell. [11] Most companies will also offer a guarantee of 90% output for 10 years and 80% output for 25 years.

In Vancouver our average annual energy from the sun is 11.98 MJ / m^2 Day.[12] This is an average over the whole year with more coming in the summer and less in the winter so for this to be completely practical you also need a proper storage unit to hold the excess electricity from the summer and use it in the winter. 11.98 MJ is equal to 3.328 kWh. Therefore:

$$(3.328\ \text{kWh/m}^2 \ast \text{day})(1393.5\ \text{m}^2)(365\ \text{day})(15\%) = 253{,}906.85\ \text{kWh}$$

There is 253,906.85 kWh of electricity generated over the year on average. This is enough power for the new SUB for the whole year if we are able to store the electricity and have an average year for energy from the sun.

4.4 Environmental Conclusion

Overall crystalline photovoltaic cells have a net positive effect on the environment compared to the conventional ways of generating electricity today. They have much lower CO_2 emissions, can be recycled and are capable of powering the new SUB with our environmental conditions.

5.0 CONCLUSION

Solar System is beneficial in terms of social, economical, and environmental aspects compare to other energy courses. From social aspects, the chance of getting illness from the solar panel is very low that people do not have to worry about their health and surroundings. Moreover, this energy system will soon replace fossil fuel technology since the fossil fuels will be depleted in the near future. The benefits of solar panels in environment are the system has lower CO_2 emissions and the panels can be recycled after 25 years. Finally, the solar panel does not only meet the requirement of getting LEED Platinum, but is also able to generate the electricity at the new SUB during winter after collecting all solar energy into the batteries. In addition, it can generates profits to the Student Union’s Budget by selling batteries that have excess electricity to the local utility companies; as a result, the profits can be used to pay maintenance fee for solar panels. Thus, we concluded that the solar energy system is very suitable renewable energy system in the new SUB.

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