The Efficacy of Implementing a Photovoltaic System at 1400 Lemarchant St.

ENVS 3502

Environmental Problem Solving II

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April 10, 2018

DALHOUSIE UNIVERSITY

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Executive Summary

In this study we conducted a cost benefit analysis of an installation of photovoltaic panels on a house located at 1400 Lemarchant St. We calculated the available suitable rooftop space on the house, determined it to be 27m^2, and found we could fit 12 photovoltaic panels on the roof. After selecting a brand of photovoltaic panel to use for the study (GoGreenSolar.com DIY Solar Install Kit), we calculated how much energy would be produced per day, given the location of the house and the amount of sunlight it would receive, as well as the electricity producing properties of the chosen panel. We multiplied the daily energy production by 365 to determine the yearly energy production. We then calculated the amount of money the photovoltaic panels would produce per year by multiplying the yearly surplus energy production by Nova Scotia Power's General Tariff. We then calculated the time it would take to buy-back the photovoltaic system by dividing the total system cost by the yearly amount of money saved. (8674/854=10.16 Years) The buyback time was calculated to be approximately 10 years. Given the associated costs, we determined that the installation of a photovoltaic panel system at 1400 Lemarchant St would be a good way to increase the amount of renewable energy that is produced on Dalhousie campus. In addition to reducing Dalhousie's carbon footprint, we feel that the system can serve as a financially viable example of how other university campuses can make an effort to include more sources of renewable energy. The system also serves to provide a highly visible display of clean energy which can positively influence students, and create discussion about 'green' energy.

We recommend that Dalhousie implements our suggested photovoltaic system at 1400 Lemarchant St, as well as perform a similar analysis on other Dalhousie campus buildings to determine their suitability for hosting a photovoltaic panel-based energy system.

1. Introduction

Universities are showing a transition from conventional energy towards solar power. The campus has a similar climate to that of Dalhousie, which shows that solar energy is a smart option here as well. University of Toronto is taking a loan of over a quarter million dollars to install solar panels on the campus (Going Greener..., 2010). The investment shows that they will be able to pay off the solar panels within 11 years, and start to make profit afterwards (Going Greener..., 2010). The project is perceived as a positive because eventually the solar panels will start to save the university money on energy costs, as well as reducing the university's carbon footprint. With the incentive of saving the university money, it can also help against environmental degradation.

There are other projects at a smaller scale than the one at University of Toronto, which would be more in line with the project for Dalhousie. Private homes in Germany and France are beginning to add solar panels to their home that are independent of a grid system, where the photovoltaic systems only supply energy to the single home (Mundo-Hernández, de Celis Alonso, Hernández-Álvarez, & de Celis-Carrillo, 2014). Another option is to implement solar panels on a home that will feed into a grid system (Mundo-Hernández et al., 2014). These private homes in the EU receive subsidies for installing solar panels on their roofs which also creates a stronger financial incentive to invest (Mundo-Hernández et al., 2014).

There are also other options for institutions to move away from conventional energy. Butte College, in Oroville, California is a grid positive college, where all of the school's energy is supplied via 25,000 solar panels (Baker, 2016). Other schools, such as Northwest University, fundraise money in order to buy solar panels for the university, and others buy all of their school's energy supply from off site renewable sources (Baker, 2016). The point of this project however, is to put an emphasis on Dalhousie switching towards more sustainable investments on campus that will help offset energy costs and help the environment. As opposed to buying solar power from other companies, or fundraising money in order to have solar panels, we believe that the school should be investing in their own photovoltaic solar panels in order to eventually save money for the school and then improve their carbon footprint.

The purpose of this project is to provide a cost benefit analysis of implementing photovoltaic solar panels on the Dalhousie owned building at 1400 LeMarchant Street. Similar to other projects, this analysis wishes to see Dalhousie improve their carbon footprint. The goal of the cost benefit analysis, is to show how transitioning to renewable energy can financially benefit the university. If the project shows greater savings for the university, we hope to see a greater commitment to renewable energy at Dalhousie University in the future.

This project wants to consider photovoltaic solar panels because they are the best source of renewable energy for the building at 1400 LeMarchant Street. Once the solar panels are built, they produce 0 carbon emissions as well as no noise while producing electricity (Lo Piano & Mayumi, 2017).The quiet energy source makes it ideal to place on a small building. The photovoltaic system also has a 30 year lifespan, making it an extremely reliable product (Lo Piano & Mayumi, 2017). Since the system has such a long lifespan, it is a safe investment. Once the system dies, elements in the photovoltaic system can be recycled for further use, making it an extremely ‘green’ product.

Because photovoltaic solar panels require low maintenance, people are continuing to buy into this product, leading to more efficient and improved options (Lo Piano & Mayumi, 2017). Photovoltaic energy systems are now using recycled elements from older systems, therefore the energy cost of producing these systems are becoming much lower (Lo Piano & Mayumi, 2017). With lower energy costs for production, the systems are becoming cheaper (Lo Piano & Mayumi, 2017). The cost benefit analysis sees the decrease in price for these systems as a positive, as it will hopefully allow Dalhousie to take on larger projects in the future.

2. Methods

For this study, we followed the generic steps of the U.S. Department of Energy's guide for planning a home solar electric system. It involves investigating the current energy efficiency of the house, examining the rooftop to look at available space, and examining the options for implementing the system (Planning a Home..., n.d.). From there we examined the total cost of the system and the energy it would generate to determine how long it would take to buy it back.

In order to determine the amount of electricity generated by implementing a photovoltaic system at 1400 Lemarchant Street, we first needed to calculate the amount of rooftop space that we could use on the house. 1400 Lemarchant has a large area tilted towards the morning sunlight that is available for use. On the right hand side of the roof there is a peak which would not allow for panels to be implemented. To measure the space available, a combination of measurements were used. Roof height was calculated by measuring the side of the house from the peak to where the roof ended. Length and width were measured in ArcGIS using Halifax Regional Municipality's building outline layer, as we did not have access to the roof (Building Outlines, n.d.). Then the rooftop space was calculated as the surface area of the hypotenuse of a right angle triangular prism.

After determining the amount of available space, we decided on a photovoltaic panel to examine. It needed to fit on the roof, and also be available at a reasonable price point. We selected the 3120 Watt (3kW) DIY Solar Install Kit w/Microinverters from GoGreenSolar.com (3120 Watt..., n.d.). It fits on the rooftop, and costs $8,674 with a 15.8% efficiency.

Calculating the amount of energy generated was accomplished using solar insolation data from Natural Resources Canada (2017). Solar insolation across the province averaged out to be 3.92kWh/m^2/day, at an angle of 45°. This was combined with the efficiency of the panel, and the amount of space used to determine the yearly energy generation at 1400 Lemarchant according to equation 1. Electricity generation was multiplied by Nova Scotia Power's General tariff (14¢) to determine the amount of money that would be saved in the year (Large General Tariff, 2017b). The buyback time of the photovoltaic system was then calculated by dividing the system costs by the yearly money generation. The energy generation was then compared to the previous years data. The energy generation and the buyback time were used to determine if it was worth implementing photovoltaic energy at 1400 Lemarchant Street.

$$(1)\ \ Daily\ Insolation\ *\ Efficiency\ *\ Available\ Area\ *\ 365\ =\ Energy\ Generated/year$$

Limitations

Implementing photovoltaic solar panels will face some limitations. The largest limitation that the solar panels face is that they are only able to produce energy from being exposed to sunlight. Due to the requirement of sunlight, it is impossible to account the exact amount of energy these solar panels will produce. The Dalhousie building faces some of these limitations. The front side of the roof faces the east and is exposed to the sun rising. The back side of the roof however, faces the west and is exposed to less sunlight due to trees in the surrounding. Because the building receives some shading from trees and it is impossible to fully predict the weather, the house will face the limitation of not knowing exactly how much energy it will produce from sunlight. Due to the potential shading from trees, it is not possible to fully predict the insolation, and thus we used NRCAN's data as an estimate (Natural Resources Canada, 2017).

The required elements for photovoltaic solar panels is another limitation that the project faces. Photovoltaic solar panels require some rare elements. Rare elements such as tellurium, indium, and germanium are required for the manufacturing process of these solar panels (Fthenakis, 2009). The abundance for tellurium is extremely difficult for predict since it is produced as a by-product (Bustamante & Gaustad, 2009). 90% of this element is created as a by-product of copper (Bustamante & Gaustad, 2009). Therefore, manufacturing photovoltaic solar panels will depend on the demand for other materials. As well, long-term historical patterns are usually unavailable for new technologies such as photovoltaic solar panels (Bustamante & Gaustad, 2009). These issues of uncertainty add to the limits of this product's availability long term if Dalhousie decides to take on other projects with photovoltaic energy.

3. Results

In order to conduct our cost-benefit analysis we needed to look 1400 LeMarchant street's energy use and costs in the last year. After looking at both the physical measurements of each photovoltaic panel and the total available rooftop area (27m^2) it was calculated that we can fit 12 photovoltaic panels on the roof.

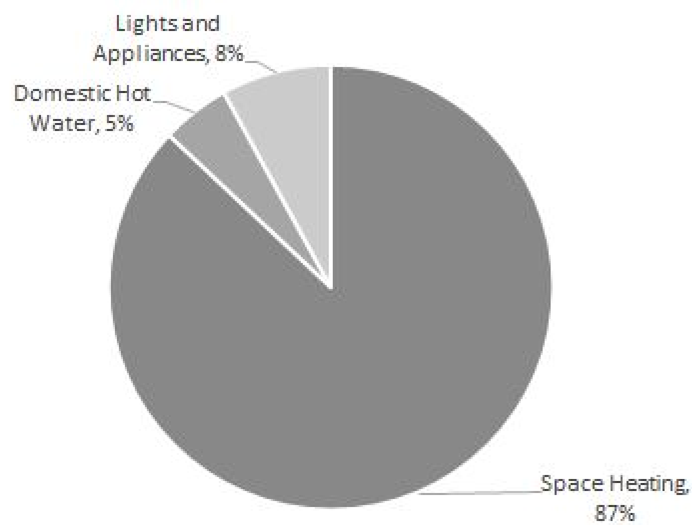

Figure 1 Types of energy usage at 1400 Lemarchant Street in 2017 (Data from Dalhousie Sustainability Office, 2018).

We also obtained data from the Office of Sustainability about their energy uses (Figure 1).The majority of the energy use at 1400 Lemarchant is used for space heating (Figure 1).

Table 1 1400 LeMarchant Energy use and costs from 2011- 2017 (Data from Dalhousie Sustainability Office, 2018).

Year	Yearly Average Consumption (kWh)	Yearly Average Cost
2011-2016	5526.5	$952.33
2017	3,853	$587

Once this was found, equation 1 was used to determine the energy generation of the the 12 photovoltaic panels. In 2017, 1400 LeMarchant street consumed about 3,853 kWh of energy (Table 1). With the implementation of the 12 photovoltaic panels it was calculated that about 6,107 kWh of energy would be produced per year (Figure 2).

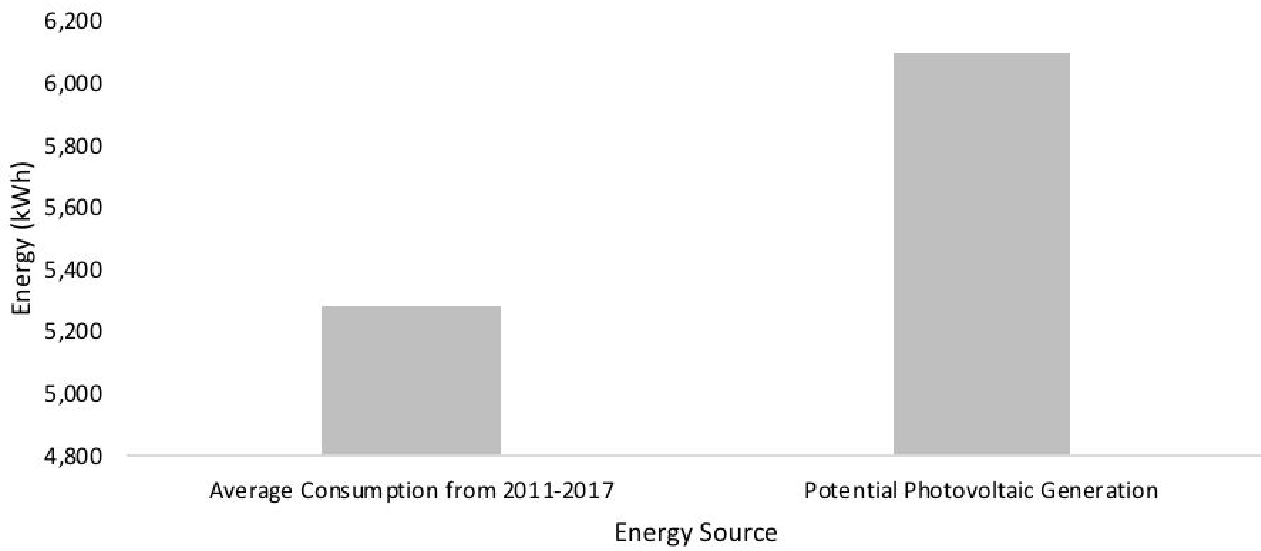

Figure 2 Energy consumption at 1400 Lemarchant from 2011-2017 compared to the potential energy generation of a photovoltaic system per year at the same location. Data collected from Dalhousie Sustainability Office, 2018.

There would be a surplus of energy approximating on average 820 kWh annually. In 2017, 1400 LeMarchant street spent $739 on the energy bill. With the 12 photovoltaic panels implemented 1400 LeMarchant street would be generating $854 annually. If the system was implemented before 2017, it would have generated $115 for Dalhousie.

The buyback time of these photovoltaic panels is approximately 10 years, if none of the money is used to fund the electricity bill. After that, these panels would be generating, on average, 92% of the building's electricity costs every year. If every year is more similar to 2017 than the average, the system would be generating 115% of the required energy.

4. Discussion

We found that implementing a photovoltaic system at 1400 Lemarchant Street could be a viable way to increase renewable energy use at Dalhousie University. While this would not decrease energy usage, it would be from a source that reduces carbon emissions (Sims, Rogner & Gregory, 2003). Implementing this system would actually exceed the energy requirements of the building, allowing the university to sell the energy back using Nova Scotia Power's net metering program (Enhanced Net Metering, 2017a).

The buyback time for our system is approximately 10 years. This is consistent with many other payback times in Canada (How solar panel cost..., n.d.). In addition, the system has the potential to generate beyond the requirements of the house (Figure 2). The system's electricity generation can be used to supply energy for the three main usages of the house (Figure 1).

This building is also located in a central area on campus. Due to its central location, it can influence the campus's stance on renewable energy. Studies show that perception of green energy can be influenced if the individual is surrounded by renewable projects (Smerecnik & Andersen, 2011). Public viewpoints can greatly influence the implementation of renewable energy (West, Bailey, & Winter, 2010). With students being exposed to green energy on campus, it allows for a greater chance of viewing green growth as a positive. If younger generations see 'green' growth as a positive, lower carbon emissions can become an even more important objective in the future.

A study examined historic energy prices in Germany, looking to determine the effect of renewables on national electricity prices (Dilling, Jung & Karl, 2016). They found that renewables had actually reduced overall prices by 5.29ct/kWh. This shows that implementing renewables can affect outside the microcosm of the university. While Halifax does not have the same focus on renewables that Germany does, it is an interesting prospect to consider, that doing something positive for oneself and the environment can also positively affect one's neighbours.

Our study shows that Dalhousie should implement photovoltaic panels at 1400 Lemarchant. They are a fiscally responsible way of continuing to add renewable energy sources to the universities Studley Campus. They are also highly visible, generating discussion and hopefully improving opinions on renewables. A potential future study could be to examine public perceptions pre- and post-photovoltaic implementation, from in front of 1400 Lemarchant Street.

5. Conclusion

Based on our cost-benefit analysis, we would recommend the implementation of these photovoltaic solar panels. We also recommend that a similar analysis be performed on other buildings. Our project can be extrapolated to other larger buildings within limitations, some buildings that come to mind are the Dalhousie Arts Centre and the Life Science Centre. It is also recommended that Dalhousie University allocates a fund that focuses on implementing renewable energy sources such as wind and solar energy. Even though fossil fuels will continue to play a role in our energy needs for decades to come, we can reduce that dependency and create a diverse mix of energy resources (Solar for Community..., n.d.). Already having this fund and renewable energy sources in place on campus, will help with divesting Dalhousie University's dependency on fossil fuels. This fund would also be used for research on other buildings on campus. The carbon footprints of each building on campus needs to be calculated as well as determining if the suitability of renewable energy sources on those buildings can be implemented. Once this is done, facilities management and the Dalhousie Sustainability Office can then determine which buildings are the most suitable in providing energy to itself and potentially, those buildings surrounding it. With the research already found, it will be easier to facilitate the installment of renewable energy sources such as photovoltaic solar panels and/or wind energy. More research needs to be done to determine exactly what buildings are using the most energy, and what can be done to limit this

6. Acknowledgements

In conducting our research, we would like to thank our professor Dr. Amy Mui, and teaching mentor Britany Barber for their guidance throughout this project. We would also like to thank Rochelle Owen, Director of the Office of Sustainability for providing us with data and helping us to determine a location to conduct our cost-benefit analysis. We would also like to acknowledge that 1400 Lemarchant Street is in Mi’kma’ki, the ancestral and unceded territory of the Mi’kmaq People.

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