Visualizing Solar Energy on Galiano Island:
An Education Plan for the Galiano Learning Centre

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SUMMARY

The Galiano Learning Centre's reliance on solar energy creates an excellent opportunity for educating visitors about the uses of alternative energy. Our project's main goal is to design educational tools that can be utilized by the Galiano Conservancy Association (GCA) as they educate visitors about solar energy. In line with this goal, we propose three educational tools that can be adapted to the GCA's programming needs.

The first component is the installation of a presentation screen inside the classroom building. This screen will display how much energy is being produced and consumed through the solar system. This will be especially useful for visitors to learn through a visual format.

The second tool is an education plan for use by staff. The program will provide visitors with a basic understanding of how solar energy works, an explanation of the GCA's use of solar, exploration of what it means to be off-grid, and will emphasize the link between everyday energy consumption choices and environmental sustainability.

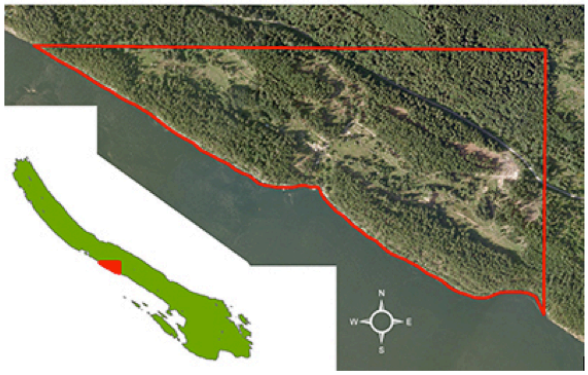
The third tool is the creation of an educational poster to be displayed in the classroom building. The poster will inform visitors about the basics of solar, the off-grid lifestyle, and everyday energy use.

1. INTRODUCTION

Our project addresses the knowledge gap between everyday actions and environmental issues, with specific focus on energy use. We aim to strengthen the personal connection between site visitors and their energy consumption habits. The following report outlines how educational opportunities, highlighting uses of solar energy, and a visual display of energy production and consumption will achieve this goal.

2. BACKGROUND

The GCA has installed an off-grid solar system at the classroom building on the Galiano Learning Centre property. The Learning Centre is a 188-acre property located on the southwest side of Galiano Island (Learning Centre: History, 2016). 18 solar modules located on the roof power the 1200 square foot classroom building (Learning Centre Updates, 2015).



Galiano Learning Centre site. (Learning Centre: History, 2016)

Solar modules on the classroom building at the Galiano Learning Centre property. (Learning Centre Updates, 2015)

The GCA has expressed an intention to provide greater opportunity for the public to learn about solar energy and increase their awareness about energy usage. This report aims to support the existing goals of using the solar system as a demonstration and teaching site about renewable energy, and provide some tangible tools for implementing this vision.

This project aligns with the Galiano Conservancy Association's Mission, in particular point 3:

1) land and marine conservation

2) stewardship and restoration; and

3) environmental education and public awareness

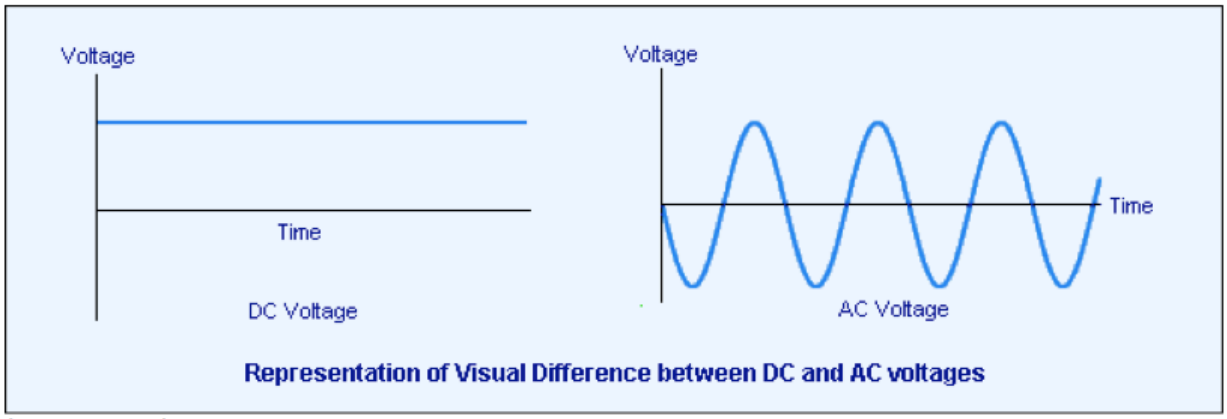
Why Solar Energy?

The sun as a renewable energy source has enormous potential- aside from wind it is the only energy source able to provide enough energy to supply all the energy needed for humanity (Mommsen, 2016). Other energy sources have proven difficult if used at a large scale (Mommsen, 2016). For example, hydroelectricity does not meet the excess demand of electricity worldwide and competes with food security (Mommsen, 2016). In the case of nuclear energy, long-term problems exist (Mommsen, 2016). For instance, the explosion that happened in Chernobyl nuclear power plant and the meltdown that took place Fukushima Daiichi power plant led to radioactive emissions and dislocated local residents, with long-lasting impacts. Oil and gas are carbon intensive (Mommsen, 2016). According to Dworjan (2016), various challenges in building geothermal energy plants also exist as the locations where geothermal activity happens is limited and extraction requires large amounts of water. Thus, the potential available places for construction of a geothermal energy plant are narrow as they must be near water sources. Similarly, potential tidal locations are geographically limited and the extent of its impacts on the marine environment is still unknown (tidalpower.org, 2016).

Solar energy, on the other hand, is an inexhaustible energy source that is pollution free and often noise free (National Geographic Partners LLC, 2016). It can be used to power households such as heating water, charging laptops and powering ovens. It can even be used outside homes in transportation such as cars, airplanes and boats. Solar is versatile and holds a lot of potential. Taking into account the advantages that solar energy can provide, it is important to have an understanding of how it works, enabling us to promote the more sustainable living that the solar system can offer.

How does Solar Energy Work?

Solar energy is produced through photovoltaic cells, or solar modules (solar panels) that absorb sunlight and convert it into direct current (National Geographic, 2016). Photovoltaics facilitate a conversion of energy as electrons are 'excited' into high-energy movement, which is then transferred to an external circuit (Solar Energy, 2013, 170). The direct current (DC) then runs through an inverter that transforms the current into alternating current (AC) (Energy Matters, 2016). While DC flows only in one direction and has a uniform amount of electricity, AC periodically changes its direction and its wave-like motion enables power to be efficiently distributed to places over large distances (Early, 2013). The AC electricity generated by the inverter enables the energy to power appliances such as computers and lamps in offices and homes through common household outlets. However, most digital devices such as smartphones also use DC. These appliances contain a circuit called a "bridge rectifier" that allows the conversion of AC to DC (Early, 2013). The photovoltaic cells mounted on the roof and the inverter are important components of a solar system that transfers energy from the sun into electricity that can be used to power our technological devices.



(Kumar, 2013)

Solar Energy on Galiano Island

The GCA uses an off-grid solar energy system. This means that the DC electricity produced by the solar modules goes into a regulator which controls the charge to the batteries instead of feeding into a main grid shared by neighbours. According to Mommsen (2016),

Galiano Island receives around 2,030 hours of sunlight per year but the solar panels reduce energy production when there is less sunlight (cloudy days, night). When this happens, the centre must rely on the reduced amount of energy produced from the panels, and the energy stored in the battery (Higgs, 2016). Therefore, it becomes extremely important that individuals become considerate of their energy use. Given this limitation, the GCA provides a great opportunity for visitors to learn about a solar energy system and increase their awareness about energy usage in their everyday life.

4. GOALS AND OBJECTIVES

1. Create learning opportunities for site visitors about solar energy systems
    a. Increase the amount of information available at the centre about the GCA's solar system
    b. Create educational activities to engage visitors of all ages

2. Encourage greater awareness about personal energy use habits and resulting environmental impacts
    a. Visualize energy consumption habits through technology, written formats and educational activities

5. DESIGN

The goal of educating visitors about solar energy has been divided into three components. When combined, these three educational tools provide the GCA with a comprehensive tool kit to support the Conservancy's values and goals.

Design 1 - Presentation Screen

Purpose:

Educate visitors by describing and displaying the site's energy production and usage.

Reasoning:

Installing a screen that would display information about solar production would create a valuable resource for site visitors to learn about the advantages of solar energy. It would help illustrate the value in utilizing solar energy as a resource and disconnecting from the grid. One potential benefit concerns a commonly held misconception about solar power- that it is not produced during cloudy days. Installing a screen would visualize the power created on cloudy days, and help visitors understand that solar power can be created throughout the whole year, not only during the summer. A detailed visualization of the amount of power produced in the past would demonstrate when solar power is most effective. Installing a screen would help accomplish the goal of educating visitors about solar energy, with the purpose of increasing understanding of the utility of solar energy.

Components:

The display screen would show the following:

- Total energy being produced
- How much energy is being consumed currently
- Average energy usage per year
- Historical energy usage per month

Possible vendor/example:

Solar Fox is the highest rated display screen provider on the market. The SOLARFOX® SF-100 SERIES display screen can visualize historic usage and current energy production. Display screens are customizable (Solarfox, 2016).

LARGE DISPLAYS FOR INDOOR USE

SOLARFOX® SF-100 SERIES

applications

The SF-100 series is designed for installation indoors. Who relies on cost-optimized functionality associated with the new model SF-100 an unbeatable offer for beginners. The displays can be operated up to 10 hours per day or be switched on and off via a timer function.

product scope

- LED display
- integrated control computer SC-100 with software
- 15 ° Tilting Wall Mount
- Cables and accessories
- Internet connection (LAN)
- Online management
- custom content and information

Solarfox display screen. (Solarfox SF-100 Series, 2016)

Solarfox display screen. (Solarfox SF-100 Series, 2016)

Cost:

Display and accessories - $825 USD

Software license - $239 USD

Shipping from Germany - $110-170 USD

Dimensions:

- Comes in both 24" and 32".
    - 24" consumes 20-24 watts.
    - 32" consumes 38 watts. (Solarfox SF-100 Series, 2016)
- Energy consumption per year (8 hour per work day).
    - 24": 44.7 kWh
    - 32": 66.9 kWh
- Power supply for both is 120/230 V

Conclusion:

Installing a display screen would increase awareness of education opportunities about the benefits of solar energy. It is possible that some members of the conservancy would feel uncomfortable about installing a piece of technology in the centre of the building. It could be argued that in installing the screen, the atmosphere of connection to the natural environment that the conservancy is attempting to foster would be lost.

We would argue the benefits of installing this screen would outweigh the potential costs. Visitors to the centre could take the knowledge they learned from seeing a visual of how much energy everyday appliances consume, and apply it to their daily lives. This would accomplish the goal of educating visitors on how to reduce their energy consumption. The screen would be small in size, and placed in an inconspicuous area of the room, ensuring that visitors would not be distracted from the natural beauty of the conservancy.

Design 2 - Solar Literacy Education Program

Program Purpose:

Create opportunities for engaging with solar energy education in an interactive format.

Goal:

Education opportunities should inform site visitors about solar energy systems and increase personal awareness about energy use habits.

Inquiry-Based Pedagogy:

"Environmental Inquiry," is a pedagogical method developed through the *Dr. Jackman Institute of Child Study* at the University of Toronto that places natural curiosity at the centre of the learning process and is driven by student's questions and ideas (Chiarotto, 2011, 6). We recommend a similar curiosity-based approach to knowledge sharing in GCA programming. This approach would emphasize clear connections between the information shared, and what this means for program participants and site visitors for their own lives, and within the greater context of our changing planet. See Appendix A for more information about Environmental Inquiry.

Inquiry-based learning. (Chiarotto, 6)

Guiding Questions:

- What do we know about solar energy?
- How do we use energy in our daily lives?
- What connections can we draw between our energy use and environmental impact?

Program Components & Plan:

The educational program is built on a series of questions for site visitors. Each question is intended to encourage participants to think about the topic, and facilitate conversation and discussion. The following plan is intended not as a strict script, but as a template for educational activities. The template highlights areas perceived as significant to a solar education program, and provides a format that can be adapted to specific GCA programming needs.

1. Introduction

The Galiano Conservancy Association classroom building is off-grid and powered by solar energy.

Q: What does this mean?

- Encourage audience participation: thoughts, knowledge about solar energy, and what it means to be off the grid. Based on responses, gauge group understanding of alternative energy.

Q: Who knows how their home is powered?

In BC, almost all houses are connected to the power grid. This means that power is generated at facilities across the province and transported through lines and cables to power homes and buildings in cities, towns, and villages in all parts of the province.

- Did you know? There are over 18,000 km of lines and underwater cables and 100,000 wood poles in BC that connect power sources to those relying on the grid for energy (BC Hydro, 2016).
- 70-80% of the province's energy consumed in Lower Mainland, while most of energy is produced in the north and southern interior of the province (BC Hydro, 2016). This means energy travels a long way to turn on the lights in your kitchen.
- In BC, energy is produced in a variety of different ways to power electricity in all the homes (and apartment buildings, stores, hospitals, skating rinks...) connected to the grid. The main source of energy in BC comes from water.

- Hydroelectric dams generate almost 90% of the province's electricity, supplying more than 1.9 million residential, commercial, and industrial users (BC Hydro, 2016).
- Power also comes from bio-mass, wind, diesel, and solar... (EnergyBC, 2012).

In an off-grid system, power comes from a source chosen for a specific purpose. At the GCA, the board chose to power the classroom using energy from the sun.

- While a hydroelectric dam requires building huge infrastructure, disrupting an ecosystem, solar can be easily transformed into energy with very little impact on the planet.

Q: Does anyone know how solar energy works?

Solar energy hits the modules mounted on the roof, where sunlight is converted into energy. Sunlight makes electrons move around, that flow of electrons is electricity. This electricity is converted into a form that then powers our lights, refrigerator, computers... (Union of Concerned Scientists, 2015).

2. Tour

When describing the system, take everyone outside to see the solar modules on the roof, show them where the battery is located, and if possible (group size dependant), visit the basement when discussing the inverter.

- Emphasize: everything needed to create power and electricity takes place on-site through the technology they can see.
- Return to classroom where presentation screen is located.
- Briefly describe the technology screen capabilities and information sharing. Check how much power is being used at the time.

3. Activities

Q: Why do you think we chose solar energy/ an off grid system?

- A key benefit of an off grid solar system is that the users of electricity become more conscious of energy consumption, as you can easily see how your actions draw energy.

Q: Do you know how much energy you use in a day?

Q: What are some actions that require electricity/ energy? (Briefly)

Q: What happens if you use a lot of energy in an on-grid system? Off-grid?

- Off-grid: have to stop consuming energy or else you will run out, or damage the battery. In contrast, in an on-grid system you can keep drawing energy without clearly seeing the impacts of your actions.

Activity 1: Daily Energy Use

Ask visitors to think through a day in their life. Note each time they use electricity in an average day.

- For example: Wake up using an alarm clock, turn on the lights, plug in the toaster for breakfast...
    - Younger age group: walk students through as a group, while recording responses on a whiteboard for all to see.
    - Older age group: divide into teams, challenge each group to think of as many daily energy uses as possible, report back and record responses on whiteboard.

Activity 2: Energy Use Quiz

Using some of the items mentioned in Activity 1, explore how much each appliance uses. See Appendix B for an example list of products and their energy usage.

- Younger age group: provide group with options, and ask which do you think uses more energy? Another option is to order a series of items from least to most energy use.
- Older age group: encourage them to guess energy use of certain appliances.

Activity Recap: return to the list of uses of electricity in the day; facilitate a group discussion about ways to reduce our energy use on an everyday basis.

Reasoning & Conclusion:

In planning an education project around solar energy, there are many different ways to interpret the task. As a group, our first realization after choosing the topic was that we ourselves possessed only very basic knowledge of how solar power actually works. From this perspective, we identified a primary goal of the education program as contributing to solar literacy. What exactly does an off-grid solar system mean, and how does it work? In conversation with those involved in the solar project at the GCA and other solar installations on Galiano Island, we identified a key reason for choosing to have an off-grid solar system was as a means of educating visitors about energy use and creating greater awareness about personal energy choices. This proposed education plan integrates these two observations with the aim of educating visitors about the basics of solar energy, and highlighting how this system can help us better connect our actions and energy choices to the larger environmental picture.

Design 3 - Educational Poster

Purpose:

Provide opportunities to understand how a solar system works and why it is important. Pictures and diagrams are used in order to make the information easy to understand, and accessible to all site visitors.

Written Content:

The poster itself is given in a separate PDF format. The content below only shows the written parts of the poster with proper citations.

Poster Script:

Solar Energy on Galiano Island

Why solar energy? (National Geographic Partners LLC, 2016)

- Renewable energy source that can provide enough energy for all humanity
- Pollution free
- Can generate energy from places far away… even from satellites in Earth orbits

Issues with other energy sources (Mommsen, 2016)

- Oil and gas: energy intensive
- Hydro: does not meet excess demand of electricity worldwide and competes with food security
- Nuclear: long- term uncertainties exist
- Geothermal: there are limited locations to build plants. Geothermal also requires large amounts of water for its extraction
- Tidal: limited locations and uncertain effects on marine environment (tidalpower.co.uk, 2016)

How solar energy systems work

- Solar energy is produced through photovoltaic cells, or solar modules (solar panel).
- These cells convert light (photons) into electricity (voltage) by absorbing sunlight and enabling electrons to flow through the material (RenewableEnergyWorld.com, 2016).
- These produced electrons of direct electricity (DC) flow into a solar inverter that converts DC electricity into alternating current (AC) (Energy Matters, 2016). The AC current generated by an inverter to enable energy use for appliances such as computers and lamps.
- In the case of on-grid solar system, the surplus of energy produced by a solar panel goes to the electricity main grid. Often, electric companies measure the electricity fed to the grid by individual residences and provide credit on their bills (Energy Matters, 2016).

Solar energy system on Galiano Island

- Galiano island receives around 2030 hours of sunlight per year (Mommsen, 2016)
- The Galiano Learning center uses an off-grid solar energy system. This means that the DC electricity produced by the solar module goes into a regulator that controls the charge to the batteries (Energy Matters, 2016).
- The battery stores energy so that electricity can be used during the night or on cloudy days when a module may or does not absorb any sunlight (Energy Matters, 2016).

Living Off-grid? (Vannini and Taggart, 2014)

- Living off-grid means living in a place disconnected to broad infrastructure such as large electricity networks and natural gas.
- It is different from on-grid system where power, heat and water flow any time when they are needed no matter the weather condition.

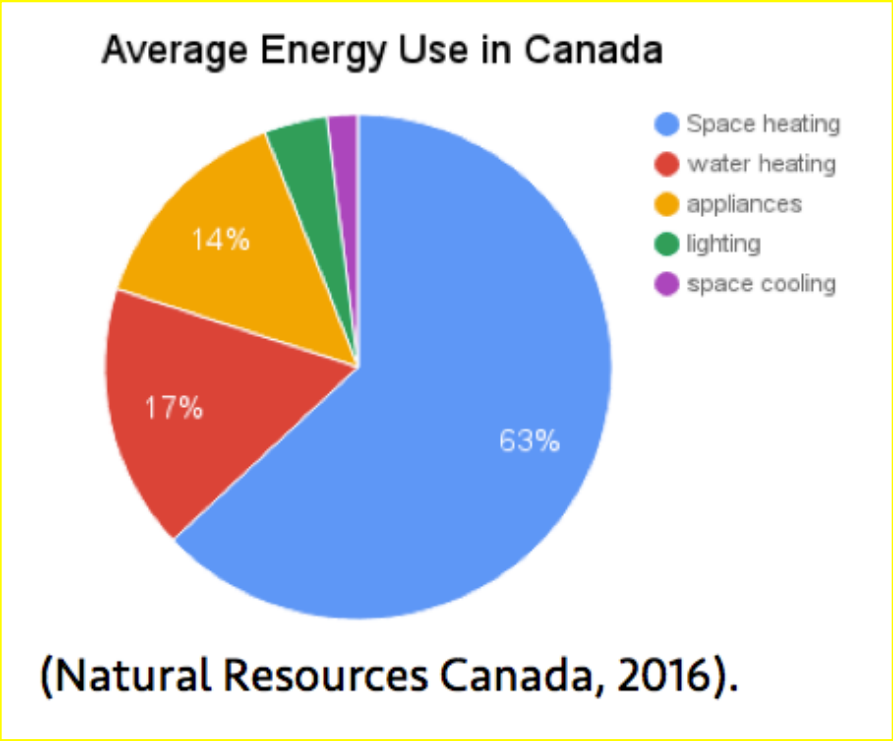
- Off-grid living demands that individuals take care of power, heat, and water and alternate their living habits depending on the weather condition and resource availability.
- In an off-grid system, individuals should understand how their energy system works, and if there is a problem, why it is not working as it should.
- The off-grid lifestyle allows one to lead a simple way of life that requires more ethical and sustainable consumption.

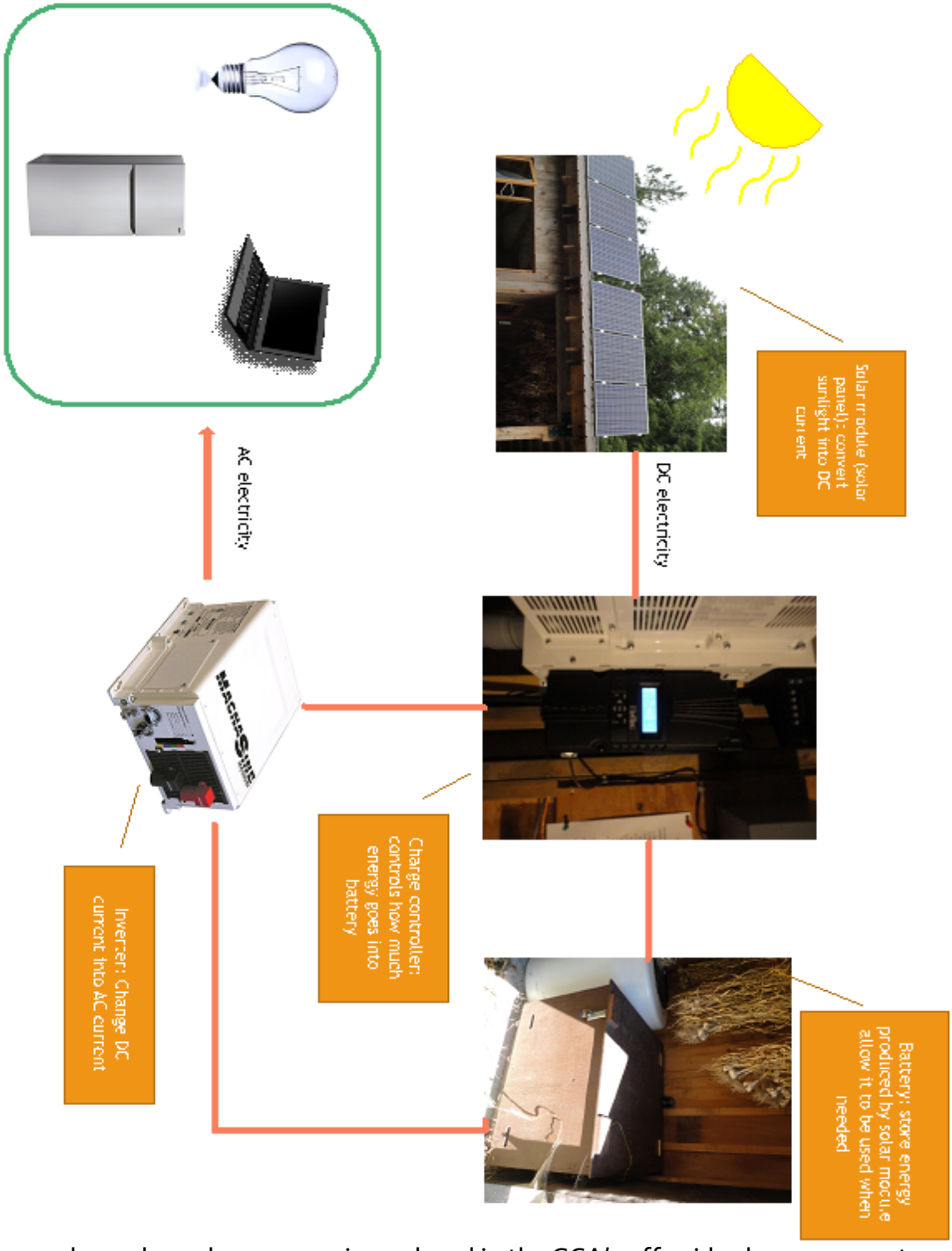
Living off-grid means that one should be careful of daily electricity usage. The following table shows how much energy different electricity appliances consume (Toronto Hydro, 2016; Higgs, 2016). It uses unit of power (watt) which measures the rate at which energy is consumed at a specific moment when turned on (Union of Concerned Scientists, 2016). For example, using a LED light consumes 10 to 12 watts of energy at any moment it is turned on.

Products	Energy consumption
Iphone Charging	**5 watts**
LED light	**10~12 watts**
Laptop	**45 watts**
Old fashioned lightbulb	**60 watts**
Desktop	**150~300 watts**
Refrigerator	**500-750 watts**
Coffee maker	**600-1200 watts**
Water heating	**1500 watts**

(Toronto Hydro, 2016; Higgs, 2016)

The chart below shows the average residential energy use of Canadians by activity (Natural Resources Canada, 2016).





The diagram above shows how energy is produced in the GCA's off-grid solar energy system (Energy Matters, 2016).

Conclusion:

Providing a poster that utilizes pictures and diagrams would allow people to understand about a solar energy system in an easy way. In designing this report, we have noticed that many people are not aware of the various advantages a solar energy system can provide and how it functions. Staying few days within an off-grid energy system in Galiano Learning Center, we have also identified that an off-grid energy system can provide people with an opportunity to increase their awareness of energy usage in their everyday life. Thus, the poster was constructed in an effort to explain about solar energy in general, and how energy is produced within the system. It also provides a specific definition of living off-grid and a useful comparison of everyday objects and how much energy each one consumes. A poster can visually convey the information we hope to offer through short phrases, diagrams, charts and images in an effective way.

ACKNOWLEDGEMENTS

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APPENDICES

Appendix A

Environmental Inquiry

The Natural Curiosity Handbook is an environmental education resource focussed on incorporating inquiry-based learning in the classroom setting (Natural Curiosity Handbook). Chiarotto states, "The current environmental crisis can serve to remind us about the purpose of education: To develop knowledgeable and responsible citizens who are committed to the well-being of their communities and to the world at large" (3). This aligns well with the Galiano Conservancy Association Mission and this project in particular. While the handbook is oriented towards classroom learning, it could prove a useful pedagogical resource for education programming at the GLC. The handbook outlines the learning principles at the base of the Environmental Inquiry framework (Chiarotto, 6):

- Experiential Learning
- Integrated Learning
- Stewardship

This handbook could be a valuable resource as a theoretical underpinning to education programming. In addition to learning principles, Natural Curiosity offers activity examples, demonstrating how theory translates into practice. The handbook is available for free online.

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Appendix B

Standard appliances/ technology Energy Consumption (Watts)

Products	Energy consumption
Iphone Charging	**5 watts**
LED light	**10~12 watts**
Laptop	**45 watts**
Old fashioned lightbulb	**60 watts**
Desktop	**150~300 watts**
Refrigerator	**500-750 watts**
Coffee maker	**600-1200 watts**
Water heating	**1500 watts**

Toronto Hydro. (2016). Appliance Usage Chart. *Toronto hydro*. Retrieved from http://www.torontohydro.com/sites/electricsystem/residential/yourbilloverview/Pages/ApplianceChart.aspx