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Solar Energy A Solution To Reduce Jaguar Building's Carbon Footprint And Increase Energy Efficiency And Sufficiency At The University Of Belize In Times Of Climate Change.

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ABSTRACT: *Despite ongoing efforts to improve energy efficiency in the workplace, the world's growing reliance on the Internet is leading to a rapid increase in greenhouse gas emissions. The Jaguar building located at the Belmopan campus of the University of Belize encloses one of the biggest concentrations of computers, servers, networking equipments and cooling systems of all the university which make it a high energy consumer. The building's carbon footprint can be considerably reduced by using solar energy, a growing trend in the world today, and is particularly applicable to Belize where climate conditions are positive for many types of renewable energy. At the same time the building would become the perfect shelter, capable of provide its own electricity in emergencies like floods and hurricanes that in recent years are more frequent and harmful as a result of the climate change and phenomenon El Niño. The purpose of this paper is to present how solar energy can cover all needs for the building, making it self-sufficient in case of emergencies, reducing energy cost, and promoting environmental awareness in our students. The university can take the lead in identifying sustainable ways through which energy efficiency and sufficiency can be attained to help the nation to be better prepared for future climate change impacts. The University of Belize is able to provide an environment for determining what can be later applied to other organizations in the country to reduce their carbon footprint and possibly reducing energy costs, but at the same time help the community and the country to adapt and effectively respond to the new challenges that the climate change imposes.*

KEYWORDS: *solar energy, carbon footprint, resilience, University of Belize.*

I. INTRODUCTION

Solar energy is the technology used to harness the sun's energy and make it useable (National Geographic). More and more people and companies are using, investing and researching on all available renewable sources of energy capable of produce a small, but significant and growing percent of the global energy demand. Every day it is more common to find photovoltaic cells, or solar panels, on things like spacecraft, rooftops, and handheld calculators. The cells are made of semiconductor materials like those found in computer chips. When sunlight hits the cells, it knocks electrons loose from their atoms. As the electrons flow through the cell, they generate electricity (National Geographic).Solar energy is lauded as an inexhaustible fuel source that is pollution and often noise free. The technology is also versatile. For example, solar cells generate energy for far-out places like satellites in Earth's orbit as easily as they can power downtown buildings, information technology (IT) servers as part of green server farms and futuristic cars, etc. Energy can also be stored in batteries for later use and this can be especially useful when facing climate phenomena like hurricanes and floods to provide electricity to radios, lights and shelters. Solar energy doesn't work at night without a storage device such as a battery, and cloudy weather can make the technology unreliable during the day. Solar technologies are also very expensive and require a lot of land area to collect the sun's energy at rates useful to lots of people. Solar energy does not cause pollution; however, solar collectors and other associated equipment / machines are manufactured in factories that in turn cause some pollution.

II. PHOTOVOLTAIC PANELS SOLAR STATION AT THE UB CAMPUS.

The University of Belize is a national, autonomous and multi-location institution committed to excellence in higher education; research and service for national development (University of Belize). On August 2012, The University of Belize was handed over a multi-million dollar project for introduction of clean energy by a solar electricity generation system. The facility is located at the Belmopan campus of the University of Belize (UB) and was funded under the grant aid for environment and climate change program by the Japanese International Cooperation Agency (Jica). Completion of the project took about a year and BZ$20 Million (Office of Public Information, 2011). Approximately 2.04 acres of land were made available for the operations of this cutting-edge technology using photovoltaic (PV) panels (Office of Public Information, 2011).

The project's install capacity is about four hundred and eighty kilowatt peak and basically it has two thousand six hundred and sixty four solar panels that are rated at 180 watts per module and it's all designed to withstand a category three storm.

Fig 1: *Photovoltaic panels from the University of Belize's solar energy station* (Polanco, 2012).

According to Mr. Herman Charlesworth, Sub-Consultant for Nippon-Koei Co. Ltd, in an interview on August 16, 2012, explained: "This project here it has been running since August third in the testing phase and it has generated two thousand kilowatt hour daily; if you were using diesel plant, you will be using a hundred and thirty gallons of diesel for that same period to generate the same amount of electricity." (Polanco, 2012).
Solar panels absorb the sunlight and convert it to electrical energy. The panels are linked to five boxes and the energy is collected in a collector box and sent to the control room. The system is designed to convert direct current into alternating current which passes through the Belize Electricity Limited (BEL) grid and into homes as a form of clean, renewable energy. An important detail is that the energy is not stored. It will go directly from the connection box to the control house then from the control house it will be step up from the transformer to the 11K (11,000 volts) switch gate and straight into BEL grid. Government of Belize (GOB) will also transfer the ownership and management of the photovoltaic system to UB free of cost after a period of 10 years. The Ministry of Works and UB will maintain the equipment, with necessary assistance from BEL and other related organizations (Office of Public Information, 2011).

2.1 Battery storage for solar energy or backup system for emergencies.
The solar plant at the UB campus was designed to directly feed the BEL grid and because of that no energy is stored for later use.
The argument against battery storage can be made on both an economic and an environmental basis:

- **Economically,** the cost of battery storage generally outweighs any savings from storing your own electricity. The costs of wiring, controls and installation it is also important. The cost of having and running this battery will be more than just buying electricity from the grid and then there is the impact of the manufacture or relatively short-life batteries (Center for Alternative technology).
- **Environmentally,** the argument is two-fold: First, the production of batteries requires energy and involves hazardous substances such as lead and acid. A lot of the material can be recycled, but there is still an environmental impact that should be avoided if possible. Second, if excess renewable energy is fed into the grid then it can replace electricity from fossil fuel power stations - this renewable electricity means that somewhere else a power station needs to burn less fuel. This is especially relevant in the case of PV panels as these produce electricity during peak demand time (middle of the day) when the dirtiest coal power stations are often used to produce peak electricity (Center for Alternative technology).

Similarly, arguments in favor of a battery storage system for the university can be made. The University lacks a backup power system for emergencies or especial circumstances. This means that the network infrastructure, servers and other equipments are vulnerable to damages and with them the services provided by the network infrastructure. A simple electrical failure like a brownout can take down the whole network, which then will require several minutes for servers and equipments to restore services, internet and connectivity in general. This makes clear the importance of protecting these expensive IT equipments, the data they store and the services they provide. This is a cost-effective power protection that could also be used in case of other types of emergencies to provide energy as an off-grid system. Of course, this will require a suitable proposal that meets the University's needs and at the same time including additional functionalities like providing emergency energy services for lights and other essentials with sufficient battery life. The university is cognizant of the fact that no elec-

trical backup system is in place and this is a liability for the organization that should be fixed.
When deciding on an electrical backup system, many factors go into selecting the right solution. Consider the following (42U):

- **Topology**
- **Type of Power Rating** - How much load, in volt-amperes (VA), does the uninterrupted power supply (UPS) need to carry? Equipment nameplate ratings only tell part of the story.
- **Form Factor** - Freestanding or rack-mounted
- **Availability features** - Do you need redundant deployment architectures, hot-swappable components, extended battery runtime, easy battery management, or remote monitoring?
- **Scalability & modularity** - Is the system able to grow with your company's needs?
- **Software and communications**
- **Available Services & associated costs** - Who will maintain the UPS and how frequently does it need to be serviced? Is a service plan required? How much are replacement batteries?

A well-thought-out power protection solution not only helps keep your mission-critical systems online, it can be an important tool in managing the overall quality of your power system (42U).

III. JAGUAR BUILDING PRESET CONDITIONS AND USE.

UB's main campus is located in the capital city, Belmopan. The Jaguar building is one of the newest constructions on the Belmopan campus. It hosts the Information and Communications Technology (ICT) Department and Department of Information Technology; in addition it includes an auditorium, 6 student's labs plus a chemistry lab and several offices and service rooms. This building encloses one of the biggest concentrations of computers, servers, networking equipments and cooling systems of all the University which makes it a high energy consumer. The building's carbon footprint can be considerably reduced by using solar energy, a growing trend in the world today, and is particularly applicable to Belize where climate conditions are positive for many types of renewable energy. Of course, there are other areas that must be taken in consideration in order to reduce the carbon footprint, examples of these are: Waste management, water consumption and even the amount of paper use by students, faculty and staff. The focus on this paper will be in how the use of a renewable source of energy along with the reduction on the power consumption contributes to minimize the Jaguar building's carbon footprint.

Fig 2: *Jaguar Building at the Belmopan Campus.*

An average desktop computer uses between 60 and 300 Watts. It is very difficult to know exactly how much computers use on average because there are so many different hardware configurations. The computer power supply is not an accurate way to measure energy use because the power supply output is advertised as the max amount of watts a power supply can output. The electricity usage of a computer also heavily depends on the video card; a high end video card can use a lot of power. It can be estimated that an average modern desktop PC will use approximately 100 watts of power an hour, not including the display screen (EnergyUseCalculator.com). The cost to the University to operate a typical computer and monitor workstation is roughly 130 watts of power an hour in a conservative approximation to the real value that is unknown. The Jaguar building has a total of 147 computers therefore the power consumption will be in the order of 20 kilowatts. Adding to this value the electricity required to keep lights, ACs, servers and others devices running, it is a plausible assumption that the current solar station could cover a big part if not all of the Jaguar building's energy requirements.

Another element to have in consideration is that the building is not open at night and only a small portion of all network equipments and servers are working after light hours and no more solar energy can be obtained from the grid. Sadly the University of Belize does not count with an accurate calculation of the power consumption of the different buildings, departments or areas inside the campus. This information will be really important in order to implement energy saving campaigns that target specific areas in order to reduce the energy use, save money and reduce its carbon footprint. A request for this information was sent from the department of IT to Physical Plant, but at the time this article was written the information was not available.

3.1 Reducing carbon footprint and increasing energy efficiency and sufficiency.

Climate Change and Global Warming are the names given by scientists for the gradual increase in temperature of the Earth's surface that has worsened since the industrial revolution. Over the past two decades the effect has become more marked. Considerable evidence exists that most of this warming has been caused by human activities, which affect the chemical composition of the atmosphere through a buildup of greenhouse gases (GHG) (World Nuclear Association, 2011).There are many different electrical generation methods, each having advantages and disadvantages with respect to operational cost, environmental impact, and other factors. In relation to GHG emissions, each generation method produces GHGs in varying quantities through construction, operation (including fuel supply activities), and decommissioning (World Nuclear Association, 2011).

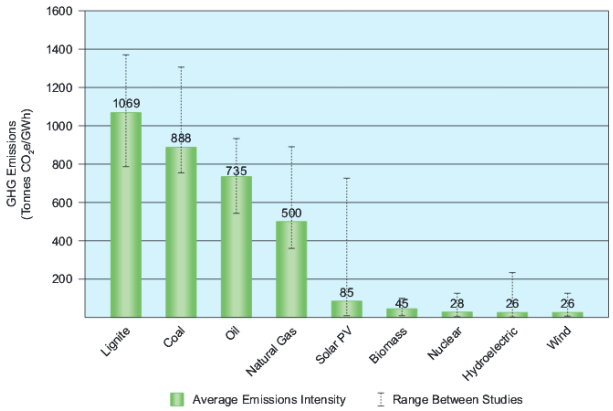

Fig 3: *Lifecycle GHG Emissions Intensity of Electricity Generation Methods* (World Nuclear Association, 2011).

Lifecycle GHG emissions for the different electricity generation methods are provided in Figure 3. The figure shows that solar photovoltaic lifecycle intensity is significantly lower than fossil fuel which in recent years as the technology and manufacturing processes has become more efficient; the lifecycle emissions of solar photovoltaic panels will continue to decrease (World Nuclear Association, 2011). If GHG emissions are taken into consideration as a big part of the UB's carbon footprint, having a solar panels compound inside the University is definitely an advantage. Notwithstanding that after two years of operation, the University has not been receiving any direct benefit from the energy nor the revenues generated by the solar panels located on its campus, but this project has considerably reduced Belize's carbon footprint. University officials are cognizant of the fact that the UB should be receiving benefits from this project, which in 8 years will be owned and managed by the University with the help of the Ministry of Works and the necessary assistance from BEL and other related organizations (Office of Public Information, 2011).To reduce the carbon footprint; the Jaguar building and the University must implement a plan in order to educate students, faculty and staff in ways of saving energy, and also by a regular inspection of the power consumption in the different areas to increase energy efficiency which will benefit the finances of the University. Take as an example the 17-inch flat panel monitors model E170Sc that the University has in labs and other areas. This model has a typical and maximum power consumption of 17 and 25 watts respectively and the power use in sleep mode is less than a 1 Watt which offers one of the highest environmental standards at a great value (DELL, 2010).

Assume that the 15 minutes between classes on a computer's lab a monitor is in sleep mode. Considering a maximum of 7 classes in the day and in between 15 minutes break, this represents up to 90 minutes of sleep mode in one day. Labs are normally used from Monday to Thursday which means 360 minutes in the week and in a 4 week month a total of 24 hours of sleep mode. Taking into consideration only the 4 labs that the Jaguar building has on the first floor, each with 21 desktops, the monitors' power consumption in sleep mode will be in the order of 2KWatt in a month. This is a considerable amount of energy that could be saved if students just turn off the flat panel monitors when the class is finished and if lecturers enforce this simple rule.

Additional energy savings can be realized if rather than leaving computer on standby they are turn off when not in use. Especially on weekends and after classes when labs are closed and still all computers are left on standby thereby consuming power from the grid. If simple energy saving tips are applied and enforced through education and programs, the Jaguar building and the University will significantly reduce its energy use. Some of those simple tips that have been proven to have a considerable impact in lowering electrical bills are:

[1] Turn the monitor and PC off when not in use.
[2] Regulate room temperature and turn off ACs when not necessary.
[3] Turn lights off when leaving classroom or offices.
[4] Use natural light when possible.

Of course, this needs to be part of a joint work between University, GOB and partners. A good way to start would be setting meters in different areas with the purpose of measuring power consumption and use this information to generate strategies that could keep the University in a consistent path to reduce its carbon footprint.
The University of Belize is able to provide an environment for determining what could be later applied to other organizations in the country to reduce their carbon footprint and possibly reducing energy costs, but at the same time help the community and the country to adapt and effectively respond to the new challenges that climate change imposes.

IV. SOLAR ENERGY, CLIMATE CHANGE RESILENCE AND JAGUAR BUILDING'S ROLE.

In recent years climate emergencies have been more frequent and harmful as a result of the climate change and the phenomenon known as El Niño (Carrington, Goldenberg, & Readfearn, 2014) in the region. Being prepared became a priority, especially at this time where it has been proven that climate change could be irreversible (theguardian.com, 2014) and it is time to create strategies that allow people and countries to adapt and live under the present conditions while continuing to function at an acceptable level. Climate change resilience is definitely one of the goals of the National Emergency Management Organization (NEMO). NEMO coordinates preparedness, disaster response, and is also reasonable for hurricane forecasts, tracking, and survival instructions which are a crucial function in a small country like Belize that is already feeling the effects of climate change. NEMO website offers relevant information in case of different emergencies and especially for hurricanes there is a list of available shelters in the different areas of the country (NEMO, 2014). The University is not included on the 2013 national hurricane list for the Cayo District (NEMO, 2013), but if it is taken in consideration the impact of having a shelter like the Jaguar building which is strategically located near to a renewable source of energy, there is a strong combination of positive factors: a building that is in good condition and also, a source of energy that could provide electricity during emergencies.

To make this possible, the University, GoB and partners will need to collaborate on a cost-effective power protection strategy, which provides emergency power for systems immediately when the main supply is cut, thereby preventing data loss and helping to prevent damage to today's sensitive electronic gear, but at the same time being able to store energy from the solar panels or the grid during the day so it can be used during at nighttime, or when the electricity grid is down to power lights, radios and others, in case of emergencies. If an alternative power source such as a generator is available to offer a more redundant system, the installed battery capacity will provide sufficient power to keep systems and utilities running until the secondary supply is brought online. The proposal should take into consideration all these elements to ensure its scalability not only for a future growth of the organization, but as a way to adapt the University infrastructure to serve in case of national emergencies to protect human lives and their own resources so the University will continue functioning and at the same time providing a vital service to the community.

Some of the basic areas that this proposal must cover but not the only ones are:

- Assessment and maintenance of the infrastructure in place.
- Reduce the power consumption throughout the University; enforce environmental strategies and energy saving tips.
- The University should be able to feed from both the solar system and the BEL grid, to ensure redundancy.
- Identify and establish the features of the power protection strategy for the ICT department, Jaguar building and University.
- Scale the infrastructure to provide energy during emergencies in response to the impact of climate change.
- A power management plan that allows the University to continue functioning, minimize negative effects and maintain the ability to respond to changing conditions.

Working on this proposal will also open new research opportunities for UB lecturers who will have the opportu-

nity to apply their expertise to benefit their own community and work place. At the same time students will have the opportunity to participate in the process from which they will get real hands-on experiences and explore topics like renewable sources of energy, engineering, climate change and others.

V. CONCLUSIONS

The University can take the lead in identifying sustainable ways through which energy efficiency and sufficiency can be attained to help the nation to be better prepared for future climate change impacts. Reducing the carbon footprint can be achieved but not exclusively with use solar energy or any other form of renewable energy. It requires the cooperation of all to take actions against the incorrect use of the natural resources available. In the case of the Jaguar building is a compromise to decrease its power consumption and promote environmental awareness between students, faculty and staff. Solar energy and the correct power protection strategy can help to reduce Jaguar building's carbon footprint and increase energy efficiency and sufficiency at the University of Belize. At the same time, these resources will play an important role in case of emergencies, where they can transform the University in a shelter to help the nation to plan, face and adapt to the challenges that the climate change imposes minimizing negative effects and maintaining the ability to respond to changing conditions.

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