ENERGY SECTOR

1. Solar PV On Grid

SECTOR: ENERGY

TECHNOLOGY: Solar PV On Grid

Introduction

In order for Belize to become a low carbon economy by 2033, one sustainable energy strategy includes the development of Renewable Energy (RE) to shift the energy matrix away from fossil-fuels (especially oil) to alternative renewable energy technologies (GOB-NCCO, 2016).

In order to achieve some of the energy strategies, it is necessary to develop local electricity micro-generation market where small producers, such as individual households, communities, commercial establishments and even small industrial participants, can sell electricity into local distributions systems and the national grid. Hence, the need to develop the solar photovoltaic on-grid systems for the country.

Table A1: Electricity Generation Output by Primary Fuel (2010) in Belize

Primary Fuel Type	MWh	Percentage
Hydro	263,150	45.9
Biomass	80,893	14.1
Imported Electricity	158,589	27.6
Diesel	43,927	7.7
Heavy Fuel Oil (HFO)	18,428	3.2
Natural Gas (NG)	7,008	1.2
Crude Oil	1,711	0.3
Total	**573,706**	**100**

(Source: Tillett, A., Locke, J., Mencias, J., 2012)

Table A1 provides a breakdown of the actual electricity (measured in MWhs) generated from the primary fuel inputs. Approximately 60% of electricity was generated from renewable energy sources, and 27.6% was imported from Mexico. Interestingly, nearly 16% of the total electricity was generated for own use, with the remainder provided by utility sources.

Solar PV has enormous energy potential in many countries in Central America and the Caribbean, and likewise in Belize. Most of Belize, especially the central and northern areas, receives medium to high solar intensity (4.5-5 kWh/m^2/day) that can sustain a reasonably good power generation throughout most of the year (Tillett, *et al*. 2012); GOB-MESTPU, 2015).

Technology characteristics	Solar photovoltaic, or simply photovoltaic (SPV or PV), refers to the technology of using solar cells to convert solar radiation directly into electricity. A solar cell works based on the photovoltaic effect. The photovoltaic effect can be briefly summarized as sunlight striking a semiconductor and causing electrons to be excited due to energy in the sunlight (photons). [1] Solar PV systems can also be classified into two types: (i) On-grid or Grid-connected, which includes those connected to the traditional power grid (ii) Off-grid, those not connected to the grid. Off-grid PV systems can service areas without electricity access, especially in rural settings such as villages or small communities. These systems need storage such as a battery bank and an optional backup generator. Off-grid PV may also be established in a hybrid configuration with other renewal energy technology such as wind and micro-hydropower. Grid-connected PV systems do not require energy storage but instead use an inverter to convert electricity from direct current (DC) to alternating current (AC) and the generated electricity is then fed grid distribution network to consumers. Grid connected PV systems are further classified into two types of applications ─ distributed and centralized. Grid-connected distributed PV systems are installed on residential, commercial or public buildings and generate electricity which is consumed by the customer and the excess is sent/sold to the grid to be consumed by other users. Most distributed systems range between 1-5 kW in power generation. The centralized systems are usually larger and not necessarily on building rooftops but can be designed as solar 'farms', ranging from 10 kW up to a few MW in generating capacity.
Costs, including cost to implement mitigation option	Based on the two major Solar PV companies in Belize, the current price for on-grid Solar PV, including installation range from BZD 4.5-7.0 per Watt. Annual maintenance costs for on-grid systems is approximately 2-5% of system cost. Projected approximate cost to supply and install a unit on-grid residential system is as follows: 2.6 kW On-Grid system: BZ$ 17,500.00 3.13 kW On-Grid system: BZ$ 19,600.00 3.9 kW On-Grid system: BZ$ 23,450.00 4.2 kW On-Grid system: BZ$ 26,600.00 5.2 kW On-Grid system: BZ$ 30,400.00 The above specifications and costs were taken from: http://www.wholesalesolar.com Costs do not include applicable importation taxes of mark-up. It is being recommended that a pilot project be instituted for the installation of ten (10) on-grid solar systems country-wide. The chosen participants will need to show a three (3) year history of monthly electricity bills. The pilot project will seek to compare past electricity bills with ones after the on-grid solar systems are installed.

Cost of not modifying the project	The cost of not doing anything would result in a gradual increase in energy production from non-renewable sources. Note that there is great potential for Solar PV to increase its share in the energy mix and impact on GHG reduction. If the expected Solar PV target of 5 MW (3.4%) to the electricity grid is realized within the next 15 years, and assuming an emissions factor of 0.22 tCO_2 per MWh from CFE (Comisión Federal de Electricidad), this would contribute to a reduction of over 30,000 metric tons of CO_2 annually.
Potential development impacts, benefits	
Economic	Some of the economic benefits for Belize triggered by an increased Grid-connected Solar PV uptake would include: Direct job creation- Installation and maintenance of PV systems would require technical and manual labour, which would increase the workforce for Belize. The utility and regulator would need more technical personnel as well, to monitor and evaluate installations. Even tertiary institutions can benefit from offering technical programs in Solar PV systems Energy security – It is crucial to diversify energy sources for electricity production, especially since a large portion of electricity is obtained from Mexico and may become insecure in the future. Also, a high portion of Belize's electricity is generated through hydropower, which can be compromised from projected increased in extreme drought conditions due to climate change. Solar PV can strategically complement hydropower during dry periods when hydropower generation is generally lower. National Cost savings ─ resulting from reduced imports of total petroleum products and electricity purchases. Reduced Grid Electricity Losses - Grid-connected distributed PV systems allow for reduced losses in the electricity network since the system is installed at the point of use and costs are reduced if mounted on existing structures. Customers with on-grid distributed systems can benefit from a reduced electricity bill or in some cases make a profit by selling back excess power to the grid.
Social	The Growth and Sustainable Development Strategy 2014 – 2017 adopts an integrated, systemic approach for sustainable development and encompasses medium-term economic development, poverty reduction and longer-term sustainable development issues. It is focused on the country's development priorities which creates an enabling environment for investment in technologies required to achieve this goal. Some Social Benefits of an increased Solar PV market include: i) Increased income due to investment in Solar PV systems, employment through installation, maintenance, evaluation and monitoring of systems, and even training programs. ii) Capacity development of locals through training and capacity building in the

	installation, use and maintenance of solar technologies.
Environmental	Solar PV is a clean technology and has the following additional environmental benefits: (i) Grid connected-distributed PV systems that are roof-mounted and do not require additional land usage for its installation. (ii) Solar PV systems are considered 'closed' systems and hence require no fuel or any inputs during operation and electricity production. It also does not contaminate water. (iii) Solar PV systems cause no noise or vibration and hence considered environmentally friendly. (iv) Predictions are that upwards of 80% of the bulk material in solar panels will be recyclable; recycling of solar panels is already economically viable.
Current Status	According to a 2013 initial draft proposal by the Public Utilities Commission (PUC), the CAP for Non-firm Renewable generation sources will probably be about 10% of peak demand, so using 2012 as a baseline, this would be about 8.2 MW for wind and solar power generation combined. Given that the total allowed is 8.2 MW (2012), then a possible allocation could be affected as follows: Solar Home Systems/Distributed Domestic – 1.5 MW (0 to 5 kW_p); Distributed Commercial Systems – 1.7 MW (5 to 75 kW_p); Others – 5 MW (75 kW_p systems and greater). As electricity demand increase, these allocations would certainly expand. On implementation of the Caps it would mean that developer installations would be approved on a first come first serve basis, with time limits being imposed for System installations for implementation. Net-metering and Distributed Generation can commence as soon as regulations are in effect. [2] Currently, Belize is seeing a rise in the purchase and use of Solar PV systems, for both grid-connected and off-grid use. Two major Solar PV companies in the central corridor of Belize have installed an average of 140 kW annually over the past three years, almost equally split between on-grid and off-grid. One company has done over 40 installations with most installations averaging 5 kW for each system, mostly off-grid, while the other has done twice as much on-grid installations as off-grid. Belize also boasts a 480 kW solar farm located in the capital Belmopan at the University of Belize (UB) campus, courtesy of the Japanese government (JICA). This system has been producing approximately 590 MWh of electricity annually since 2012 and the system is tied to the grid.
Barriers	Based on the Castalia Consultant report on Belize Renewable Energy (RE) and Electricity (EE) Sustainable Energy study, some of the barriers of Solar PV on-grid uptake include:

	- Information Barriers-lack of investment-grade resources and information so that customers can be convinced that this is a viable investment. - Regulatory Barriers-regulations concerning sale of excess electricity to the grid (net-metering) still unresolved. - Financial Barriers-limited investment interest leading to high interest rates, few financial incentives such as lower taxes and import duty. - Technical Barriers-Few skilled persons can install and maintain Solar PV systems, limited familiarity with grid interconnection of intermittent RE. Additionally, the current stock of meters used in Belize cannot support net-metering. - No net meter legislation for Solar PV On-grid electricity generation and purchase. - Sole electricity distributor in Belize not keen on having their profit margin reduced because some customers will accumulate credits from solar PV On-grid electricity generation. - Initial or capital costs
Acceptability to local stakeholders	Private and commercial stakeholders are willing to implement this technology – especially since it promises a reduction in monthly electricity bills.
Endorsement by experts	The Public Utilities Commission (PUC) requested proposals to establish electricity generation and/or supply facilities that will satisfy public demand for electricity in Belize for the next 15 years. Through this process the PUC, with the support of the utility company Belize Electricity Limited (BEL) and GOB, aim to add up to 60 MW of dispatch able capacity, and 15 MW of variable capacity to the National Electricity System, over the next 15 years. According to Ministry of Energy and PUC sources, it is anticipated that approximately 5 MW of variable capacity will be reserved or allocated for Solar energy generation. Belize' s 2020 target is to achieve at least 80% electricity production from renewable sources and to become a net exporter of electricity by the end of the decade.
Timeframe	Time frame to install – 3 months. Time frame for pilot test is 12 months.
Institutional capacity	For the pilot tests, the required institutional capacity can be met by the existing local solar companies. However, as solar grows, there will be need for increased institutional capacity in the form of trained personnel to install and maintain. Since 2010 in the United States, the number of people working in the solar industry more than doubled and the cost of solar systems fell by 70%. [1]
Adequacy for current climate	Without the net metering legislation in place, the suitability of on-grid solar systems in minimal. Additionally, the following elements are required: Acceptance by the public and private sector that Solar PV is a proven technology and that it is a financially viable alternative. Policies formulated and promulgated by GOB and PUC allowing for net-metering.

	Reduction in procurement costs of the components via lower import duties and other taxes. Greater numbers of technicians with the capacity to assess, provide advice, and install the systems. Willingness on the part of BEL to purchase power from private suppliers.
Size of beneficiaries group	On-Grid solar systems can provide significant benefits to large cross section of the population. Opportunity for the private sector to become net suppliers of renewable energy to the national grid.

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Net Metering Options Draft Proposal – PUC

www.prosolarltd.com