INTEGRATED SUSTAINABILITY

Financial Analysis Report

Consultancy for Technical and Economic Feasibility of Solar Units and Water Storage on Public Building in Dominica

Contract # UNEP/2022/322 (Umoja #4700023842)

Prepared for:

UN Climate Technology Centre & Network (CTCN)

CTCN
UN Climate Technology Centre & Network

Integrated Sustainability Consultants Ltd.

June 15, 2023

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Any questions concerning the information, or its interpretation should be directed to Nick St-Georges.

Document Revision History

Rev No.	Rev Description	Author	Reviewer	Approver	Rev Date
A	Issued as a Draft	Gregory Hinkson	Nick St-Georges	Nick St-Georges	Jun. 15, 2023

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1 INTRODUCTION

Dominica's Water and Sewerage Act refers to "rooftop catchments" defined as "*any installation or device suitable for the collection of rainwater on the roof of buildings or dwelling houses*" also noting the "*Company may procure and protect land on which it elects to erect, operate and maintain ground catchments for the supply of water*" or they "*may, at the request of the owner or occupier of any building or dwelling house, provide technical and financial assistance towards the installation of rooftop catchments on such building or dwelling house*". This means that rooftop rainwater capture is provided for in the Act and "The Company" (the Dominica Water and Sewerage Company Limited (DOWASCO) and any person duly authorised by DOWASCO may choose to provide technical and financial assistance towards private rainwater capture systems.

In addition to the Water and Sewage Act, Dominica developed the National Water Policy in 2005 to provide guidance on the sustainable management of water resources in the country. This policy outlines several goals, including increasing access to safe drinking water, improving the efficiency of water use, and protecting water resources from pollution and degradation.

This report examines the different scenarios for electricity and water supply/storage and analyzes the feasibility of these scenarios considering the buildings capacity of hosting solar generation and water storage units.

1.1 Water

Rainwater harvesting (RWH) and surface water impoundments in rural settings can often be used for potable water purposes following treatment. The implementation of appropriate non-potable plumbing code provisions and keeping storage reservoirs for such systems isolated through an air gap is frequently implemented to address cross-connection concerns, and private RWH systems are expected to have a beneficial impact on the existing DOWASCO public water system which could be challenged to meet public water demands under climate change influenced drought conditions or after a large storm event such as a hurricane. At the very least, the ability to store and distribute water within a building for non-potable applications (i.e. dual-plumbing systems to supply water for toilet/urinal flushing, laundry and irrigation, for example) would reduce public potable water demands.

The design considerations, for RWH storage systems focused on three (3) main categories:

- Potential tank installation location;
- Cost options associated with each design consideration; and
- Various tank sizes that are available by local suppliers.

Using these design considerations, a variety of water collection system options were generated, that include design drawings (illustrated in Appendix 4 of the "Analysis of Current Electricity & Water Consumption Patterns" report), as well as unit costs (included in Appendix 6 of the same report). Each design option will need to be considered when conducting field verifications to finalize the selection process to match the most appropriate system for each building type.

We suggest that since all the identified sites are commercial in nature that the ideal system for these locations be:

- RWH storage system that include solar systems to charge the pumps, which includes two (2) 1,000-Gal rainwater tanks; or
- gravity fed RWH storage system which includes two (2) 1,000-Gal rainwater tanks.

Table A shows the proposed size of the system for each of the locations and the estimated cost of the system, while Table B reflect the cost of the RWH plus solar panel storage system including the two (2) 1,000-Gal rainwater tanks, and Table C shows the cost of the gravity fed RWH storage system including the two (2) 1,000-Gal rainwater tanks. The Overall Material Costs used to determine the amounts noted in Table B and Table C is shown in Appendix 1.

Table A. Estimated Costs per site

Building ID	Storage Type	Size of System	Estimated Costs ($ECD)
Education			
Dominica State College	Rubber tank above ground	N/A	Nil
Dominica Community High School	Rubber tanks at ground level	Two (2) 1,000 Gal Rainwater tanks powered by solar panels	$ 16,977
Mahaut Primary School	Rubber tank above ground	Two (2) 1,000-Gal Rainwater tanks gravity fed	$ 11,484
Community			
Vieille Case Community Centre	Rubber tank at roof	Two (2) 1,000 Gal Rainwater tanks powered by solar panels	$ 16,977
Trafalgar Community Centre	Rubber tank at Roof	Two (2) 1,000 Gal Rainwater tanks powered by solar panels	$ 16,977
Sineku Resource Centre	Rubber tanks at ground level	Two (2) 1,000 Gal Rainwater tanks powered by solar panels	$ 16,977
Health			
Mahaut Health and Wellness Centre	Rubber tank above ground	Two (2) 1,000-Gal Rainwater tanks gravity fed	$ 15,765

Building ID	Storage Type	Size of System	Estimated Costs ($ECD)
Education			
Newtown Health Centre	Rubber tank above ground	Two (2) 1,000 Gal Rainwater tanks powered by solar panels	$ 16,977
Other Sectors			
Roseau Fisheries Complex	Rubber tank above ground	Two (2) 1,000 Gal Rainwater tanks powered by solar panels	$ 16,977
Dominica Meteorological Office	Rubber tank above ground	Two (2) 1,000-Gal Rainwater tanks gravity fed	$ 11,484

Table B. RWH Storage System With Solar

Quantity	Description of Item	Costs ($ECD) Not incl. VAT
2	1,000-gallon Plastics Rainwater tank	$4,000.00
2	Delivery of Plastic Rainwater tank	$560.00
1	Reinforced cast-in-place 6'x6'x6" slab	$4,340.00
1	4" marl fill, 6'x6'x4"	$97.39
1	Electrical components for Solar Option 1	$1,175.00
1	12V 250Ah rechargeable battery set	$1,400.00
1	450W Solar panel, incl. hardware	$700.00
1	RWH Plumbing fittings	$550.00
1	Hurricane straps	$155.00
2	Installation for standard concrete pad set-up	$4,000.00
	Sub-Total	$16,977.39
	O&M estimated on a 5-year term	$4,300.00
	TOTAL	**$21,277.39**

Notes:

This cost assumes that no structural upgrades were deemed necessary to the building.

Table C. RWH Storage System

Quantity	Description of Item	Costs ($ECD) Not incl. VAT
2	1,000-gallon Plastics Rainwater tank	$4,000.00
2	Delivery of Plastic Rainwater tank	$560.00
2	Reinforced cast-in-place 6'x6'x6" slab	$2,170.00
2	4" marl fill, 6'x6'x4"	$48.70
1	RWH Plumbing fittings	$550.00
1	Hurricane straps	$155.00
2	Installation for standard concrete pad set-up	$4,000.00
	Sub-Total	$11,483.70
	O&M estimated on a 5-year term	$4,300.00
	TOTAL	**$15,783.70**

Notes:

This cost assumes that no structural upgrades were deemed necessary to the building.

By using RWH systems on certain Government buildings, Dominica has the potential to reduce the amount of water consumed by the network with its potential resulting cost savings. Water collected through RWH can be used for many non-potable purposes, such as landscape irrigation and irrigation for agricultural purposes, washing clothes, toilet reservoirs and flushing, washing of vehicles and extinguishing of fires. It can also be used as an additional water source wherever water is scarce and needed, such as in the case of any disruption in the water distribution network or during natural disasters such as hurricanes. RWH can also assist in stormwater management by preventing or reducing surface runoff and flooding during heavy rainfall. As noted in Section 3.3 – Water Storage Analysis of the "Analysis of Current Electricity & Water Consumption Patterns" report, it was difficult to determine how much water is currently used for non-potable use, such as irrigation, and if each building would not use rainwater for laundry or flushing toilets, this leaves the primary use for RWH to be for irrigation purposes solely. The cost savings would therefore relate to the cost of the amount of potable water that could be saved by using RWH for irrigation.

1.2 Solar System

Due to many factors including high solar irradiance levels, high cost of utility power, and the generally declining cost of solar equipment, solar photovoltaic (PV) systems provide one of the best solutions for reducing the electricity costs of the buildings that have been assessed. When coupled with battery storage, solar PV systems can potentially provide additional value streams including further energy cost savings and backup power. Solar PV installations have been proposed for all sites.

Solar PV systems were sized for each site based on the general conditions stated in Dominica Electricity Services Limited's (DOMLEC's) Distributed Renewable Energy Policy (2016, version 2.00). This document indicates that the allowed capacity of distributed generation (DG) systems of 150kW and lower is limited to the average monthly consumption for the past 12-months divided by 150 and multiplied by 1.5.

Table D provides a proposed solar PV sizing summary for each facility. Some sites have been earmarked for solar PV systems only, while other sites have been earmarked for both solar PV and battery storage systems. Where possible, the maximum allowable solar PV system have been determined based on the usable roof space at each facility.

In addition to proposed solar PV systems, battery storage sizes are also estimated, including their costs for installations at each site in Table D. Appendix 3 of the "Analysis of Current Electricity and Water Consumption Patterns" report provides potential layouts of the solar PV arrays that could be installed at these sites.

Table D. Solar PV & Battery Storage System Capacities and Costs

Building ID	Average Monthly Electricity Usage (kWh)	Maximum Permitted Solar PV System Size (kWac)	Proposed Solar PV System Size (kWac/kWdc)	Solar Panels Required (420W panels)	Battery Storage System Size (kWac/kWh)	Estimated Cost ($ECD)
Education						
Dominica State College – Buildings A, B, C	1,044	10.4	10 / 10.9	26	N/A	$52,920
Dominica State College – Carpentry Building	2,051	20.5	20 / 21.8	52	N/A	$94,365
Dominica State College – Library	504	5	5 / 5.8	14	N/A	$34,965
Dominica State College – Building N1	244	2.4	2 / 2.52	6	N/A	$18,765
Dominica State College – Building N2	290	2.9	3 / 3.3	8	N/A	$22,680
Dominica State College – Tourism Building	105	1.1	1 / 1.2	3	N/A	$9,450
Dominica State College –	538	5.4	5 / 5.8	14	N/A	$34,965

Building ID	Average Monthly Electricity Usage (kWh)	Maximum Permitted Solar PV System Size (kWac)	Proposed Solar PV System Size (kWac/kWdc)	Solar Panels Required (420W panels)	Battery Storage System Size (kWac/kWh)	Estimated Cost ($ECD)
Confucius Classroom						
Dominica State College – General Studies Building	848	8.5	8 / 9.2	22	N/A	$54,945
Dominica State College – Creative Caribbean Building	151	1.5	1.5 / 1.6	4	N/A	$12,555
Dominica State College – Main Building & Office	2,032	20.3	20 / 21.8	52	N/A	$94,365
Dominica State College – Jolly's Mini Pharmacy	601	6	6 / 6.7	16	N/A	$39,960
Dominica Community High School	314	3.1	3 / 3.3	8	N/A	$22,680
Mahaut Primary School	1,491	14.9	15 / 16.8		N/A	$81,675
Community						
Vieille Case Community Centre	132	1.3	3 / 1.6	4	6 / 11.4	$69,255
Trafalgar Community Centre	267	2.7	2.5 / 2.9	7	N/A	$21,870
Sineku Resource Centre	26	0.3	0.3 / 0.4	1	N/A	$3,240
Health						
Mahaut Health and Wellness Centre	614	6.1	6.1 / 6.7	16	30-Oct	$161,460
Newtown Health Centre	3,157	31.6	6.1 / 6.7	16	N/A	$39,960
Other Sectors						

Building ID	Average Monthly Electricity Usage (kWh)	Maximum Permitted Solar PV System Size (kWac)	Proposed Solar PV System Size (kWac/kWdc)	Solar Panels Required (420W panels)	Battery Storage System Size (kWac/kWh)	Estimated Cost ($ECD)
Roseau Fisheries Complex	8,710	87.1	57 / 59.6	142	N/A	$257,580
Dominica Meteorological Office	1,920	19.2	10 / 10.9	26	20 / 68	$279,990

2 PROPOSED SOLAR PV MONITORING

Monitoring of a solar PV system is an important aspect of system operation that allows for the verification of system performance, identification of technical issues and defects, and determination of economic return on the investment. Best practice dictates that system monitoring should be available both at the site of the installation and remotely. Many manufacturers of PV equipment provide monitoring features that allow users to view equipment status, electrical parameters and statistics, and on-site weather conditions.

A solar PV system monitoring system should provide the following information to users:

- Real time AC and DC electrical characteristics, including power, energy, voltage, current, frequency, power factor, inverter status, fault codes and diagnostics;
- DC earth fault monitoring at the inverter input;
- Where a meteorological station is installed information on solar irradiance, ambient air temperature, back of module temperature, wind speed, and wind direction should be provided;
- Where battery storage is installed information on battery voltage, temperature, state of charge, state of health, and charge/discharge cycles should also be provided.

2.1 Feed-in Tariff

According to the Distributed Renewable Energy Generation Interconnection Policy, published by the Dominica Electricity Services Limited (Domlec), the company will encourage and promote renewable and clean generation sources including Photovoltaic, Hydro, Wind, Fuel Cells, or Microturbines (under 250kW in unit size) and renewable fuels including biogas and landfill-gas. According to The Renewable Energy Industry in CARIFORUM Countries, published by Caribbean Export, for Dominica, the Independent Power producers negotiate selling rate with Domlec and the regulator for PV systems. Net billing is utilized using the standard customer rate and the Feed-in Tariff, often referred to as 'FiT', to be set by the regulator. FiT is estimated to be around $ECD 0.405 per KWh.

In order to make an investment into solar photovoltaic panels worthwhile with lower paybacks it is advisable to look into the FiT. The FiT obliges the energy company (DOMLEC) to pay the owner of a solar PV system a price (per kWh) for the energy that they sell/export back to the grid.

The solar PV Feed-in Tariff has been designed to recognise the financial commitment of the solar PV system owner through a guaranteed repayment on their investment; in most cases a competitive return over and above what the system costs to install and in recognition of the contribution made to lowering the country's dependence on imported fossil fuels and lowering overall carbon dioxide emissions.

The solar PV generation tariff guarantees a fixed payment based on the size of solar PV system that is installed and the amount of power (measured in kWh) that the solar PV system is capable of generating.

One of the main debates under the FiT constraints is what tariff to use. It is evident that the higher the FiT payment, the shorter the payback period will be. It is therefore suggested that a small sized solar PV installation will generally receive the highest tariff. For larger PV systems, the tariff begins to reduce and becomes less attractive but nevertheless can still provide a reasonable rate of return. The size of system designed for a building is also closely related to the number of panels able to be placed on the roof. The key objective is to design a PV system to generate as much as possible of the building's electricity requirement, reducing the owner or occupier's dependency on grid electricity and utility bills.

Traditionally, grid connections rely on a generating plant (fossil fuel) connected to an electric power transmission system followed by a distribution network to domestic, commercial, and industrial energy users. That connection has now evolved into having a split generating source, it no longer relies purely on a generating plant but now also relies on renewable energy plants (Wind, Hydro, Solar or other).

2.2 Cost Analysis Considerations

The cost analysis of the solar PV systems in this report takes into consideration and evaluate the following information:

- Capital cost of materials;
- Labour to install such panels;
- VAT on labour & materials;
- Yearly estimated maintenance fee;
- Estimated inverter replacement (once every 20-years;)
- Decrease in solar panel efficiency;
- Feed-in Tariff rate; and
- Savings made on electricity bill, based upon electricity price per kWh.

2.3 System Options and Selection

Multiple system options have been designed and simulated based upon the parameters of the building and roof structure for the sites as noted in this Report. The ten (10) sites noted in this report, covering twenty (20) buildings provide a good representation for the estimated one hundred (100) public buildings which can be outfitted with solar PV system, and as such, we have chosen to conduct a financial analysis on the larger building included in the ten (10) sites. This information can be used at scale to compare to other buildings.

Table D lists the configuration of proposed solar PV systems selected for the Dominica State College – Carpentry Building and the Dominica State College – Main Building & Office with the proposed PV of 20 kWac/21.8kWdc. Both systems are designed to provide their higher produced energy output. As illustrated in Appendix 3 of the "Analysis of Current Electricity & Water Consumption Patterns" report, the roof area on the Dominica State College – Carpentry Building and the Dominica State College – Main Building & Office allows for uninterrupted placing of panels with no apertures/roof structures prohibiting the design layout of the panel.

The selected system for the Dominica State College – Carpentry Building and the Dominica State College – Main Building & Office are a fifty-two (52) 420Wp monocrystalline panel system with a total power output of 20kWp, producing an average annual estimated energy output of 31,230kWh.

2.4 Economic Analysis

The estimated cost for the selected system for the Dominica State College – Carpentry Building and the Dominica State College – Main Building & Office is approximately ECS$95,400; this figure includes the total estimated cost for the technology, delivery, installation, and other extras with VAT. We have modelled that funding for these two (2) systems would be through 100% equity financing. The Government of Dominica may be able to obtain grant or low interest funding to cover some or all of the costs of the installation of the solar PV systems on these buildings.

Further analysis on investment and payback is displayed in Figure A and Figure B. It can be observed that the payback period is in 9 - 10 years in which the system is operating and obtaining the FiT. The income generated from the FiT accumulates to ECD$103,700 over the 20-years. Conservative savings on electricity bills at a rate of ECD$0.10 per kWh, amounts to approximately ECS$57,900 over the 20-years on each installation, based on the net production of electricity. The FiT is assumed to be fixed during the 20-year period. These figures also takes into consideration any additional cash flow payments throughout the 20-year scheme, i.e. maintenance for cleaning the panels and inverter replacement once every 20 years.

Figure A. Cash Flows Pay Back Period (20-years)

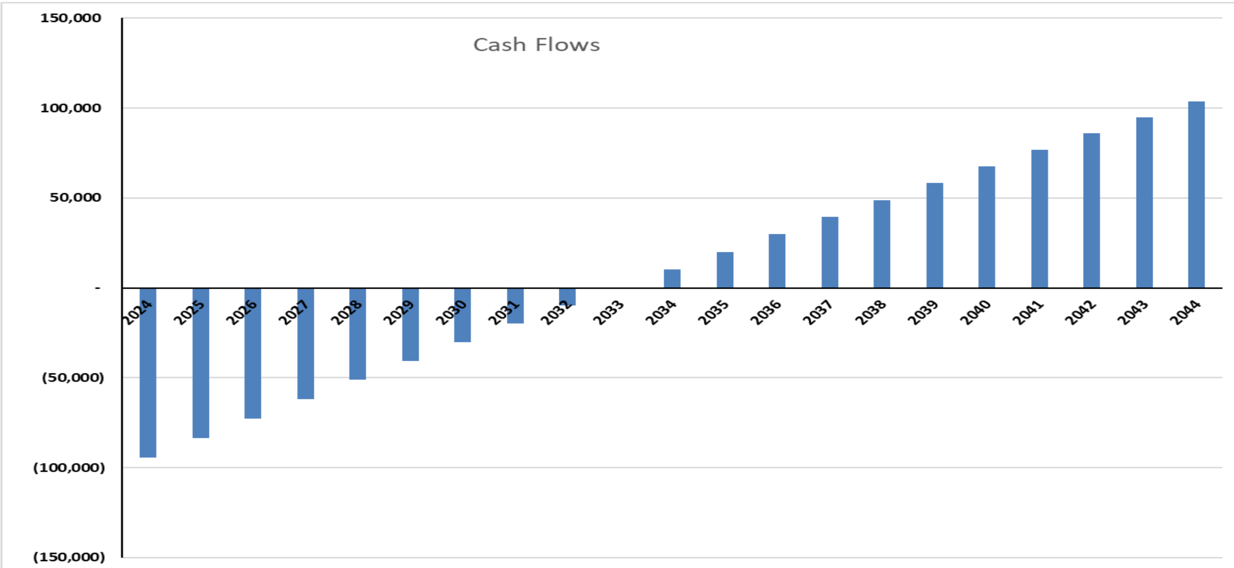
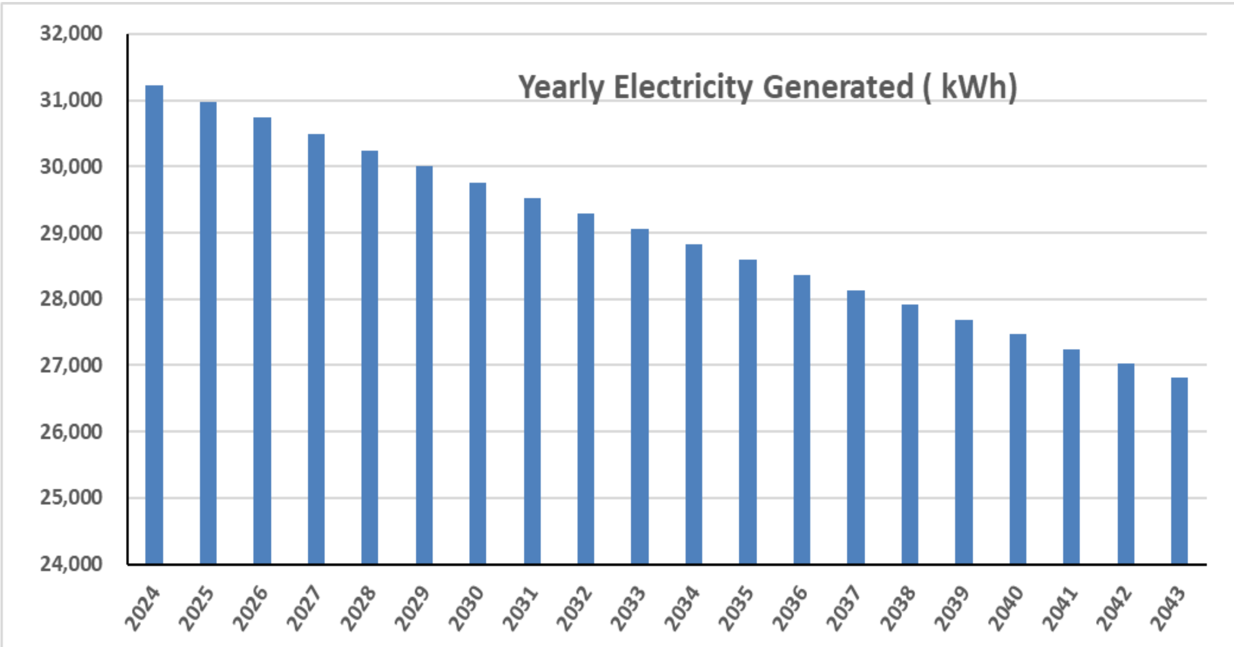


Figure A charts the yearly payback over the 20-year FiT scheme. The income generated from the PV system will be repaying the initial capital cost of the system for the first 9-years. Over the 20-year analysed timeframe, the system will have saved carbon dioxide emissions being produced from grid electricity. Figure B shows the effect of the gradual reduction in efficiency of the system over the 20-years. The first year's total electricity generation at 31,230kWh reducing to 26,810kWh in year 20.

Figure B. Yearly Electricity Production



Further analysis for the remaining fifteen (15) sites where there is a solar PV system without battery storage, show similar pattern of cash flows, and electricity generated with payback periods between 9 – 11 years, based on the estimated FiT.

In the case of the selected sites with both a Solar PV system and Battery storage, we have determined the estimated cost for the selected system for the Mahout Health and Wellness Centre is approximately ECDS$161,500 with the proposed PV system of 6.1 kWac/6.7kWdc with 10 kWAc/30 kWh batteries. Again, these figures includes the total estimated cost for the technology, delivery, installation, batteries, and other extras with VAT. It should be noted that the proposed PV system for the Newtown Health Centre in similar in size but without the batteries and the estimated cost of that system is approximately ECD$40,000, roughly one quarter of the cost of the same sized system with the batteries.

Further analysis on investment and payback for this solar PV system with batteries is displayed in Figure C. In the case of the solar PV system with batteries, the payback period is in excess of 20 years, when the Fit is considered. Figure D shows the actual annual electricity production vs the electricity generated by the solar PV system. Based on the selected system for the Mahout Health and Wellness Centre, the system is designed to generate more electricity than what is consumed therefore this site can technically operate "off-grid", potentially saving the annual electricity costs. With average annual electricity production from this system at the Mahout Health and Wellness Centre being approximately ECD$3,900 per year, at the current electric tariff rates, the payback period for this system will still be in excess of 20 years.

Figure C. Cash Flows Pay Back Period (20-years)

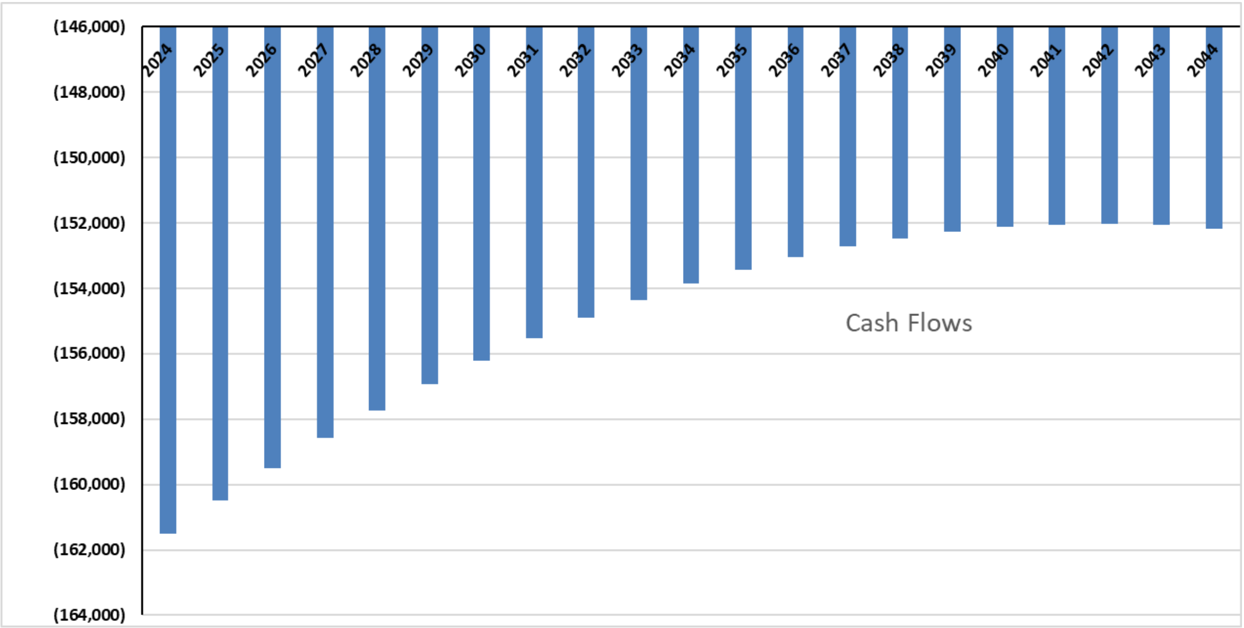
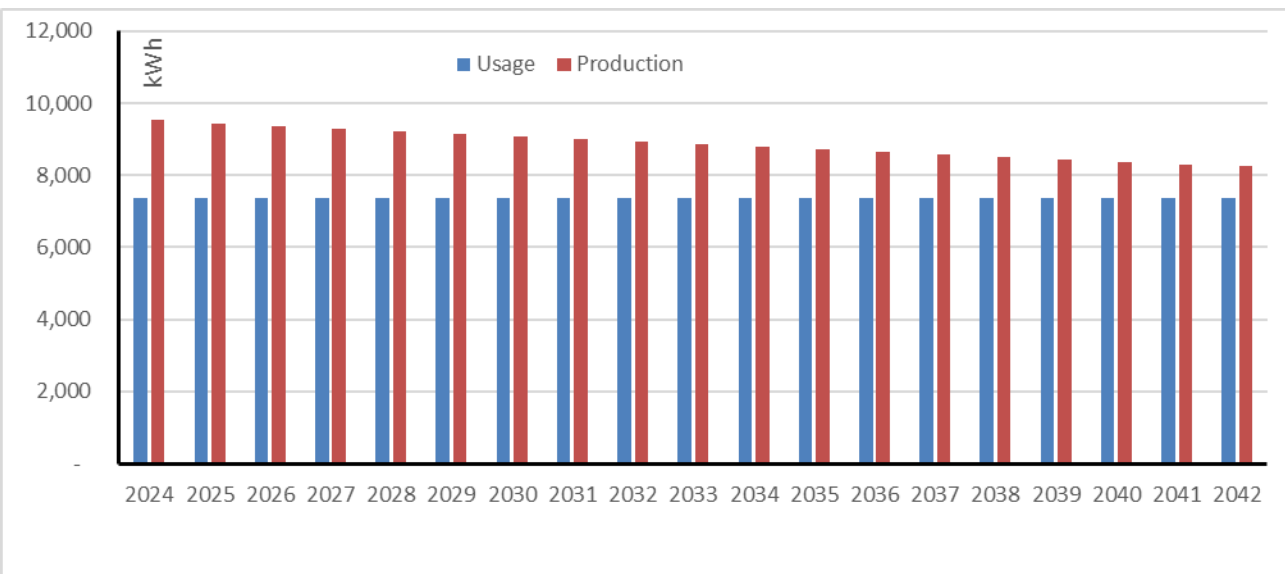


Figure D. Production versus Usage (20-years)



3 CONCLUSION, SUMMARY OF RESULTS

This report has highlighted the technical and economic issues pertaining to the sizing and specifying of solar photovoltaic systems onto existing domestic commercial structures. Twenty (20) PV systems have been designed and discussed for ten (10) locations with the objective of providing a clear understanding of all the constraints and technical issues surrounding the installation of PV technology, before committing to a 20-year investment.

The analysis process included modelling several PV panel sizes and technologies along with inverter size options for each building or for each block within a building. The modelling mechanism takes influence from each building's orientation, roof tilt, size of availability roof area and any shading that impacts upon the roof. Each PV and inverter option that was simulated obtains a yearly output of electricity and the number of panels required to achieve different output levels. The selection of the 'best fit' PV system was based upon the annual kilowatt/hour output to cost ratio. The case studies analysed in the document are subjected to individual constraints, either with roof space, appropriate orientation, roof tilt or their location.

4 CLOSURE

Integrated Sustainability would like to thank the CTCN for the opportunity to work on this project and for your support. We trust that this report meets your needs and expectations. If you have any questions, please contact the undersigned at any time.

Sincerely,

Gregory Hinkson
Finance Specialist

Appendix 1 – Overall Material Costs

Description of Item	Costs ($ECD) Not incl. VAT	Costs ($ECD) incl. VAT
Plastic Rainwater Tanks		
800-gallon Plastics Rainwater tank	$1,652.17	$1,900.00
1,000-gallon Plastics Rainwater tank	$2,000.00	$2,300.00
Delivery Costs		
Delivery of Plastic Rainwater tank	$280.00	$322.00
Concrete Base		
4 – 3' x 3' x 6" precast slabs	$2,480.00	$2,852.00
Reinforced cast-in-place 6'x6'x6" slab	$1,085.00	$1,247.75
Reinforced cast-in-place 12'x12'x6" slab	$2,095.00	$2,409.25
Concrete block, 6'x6'x6"	$139.13	$160.00
Reinforced cast-in-place 1.5'x1.5'x6" slab	$230.00	$264.50
4" marl fill, 6'x6'x4"	$24.35	$28.00
4" marl fill, 12'x12'x4"	$48.70	$18.35
Pumps		
Standard 1HP, 110V pump	$870.00	$1,000.50
Other Items		
RWH Plumbing fittings	$550.00	$632.50
Filter	$124.00	$142.60
Pressure Tank	$240.00	$276.00
Electrical components for standard 1 HP pump	$310.00	$356.50
Electrical components for Solar Option 1	$1,175.00	$1,351.25
Electrical components for Solar Option 2	$1,700.00	$1,955.00
Earthworks to build a small earth dam	$6,510.00	$7,486.50
Hurricane straps	$155.00	$178.25
12V 250Ah rechargeable battery set	$1,400.00	$1,610.00
450W Solar panel, incl. hardware	$700.00	$805.00
Supply and install four steel piles	$23,500.00	$27,025.00
5.5 m tall wood truss structure	$7,750.00	$8,912.50
5.5 m tall steel truss structure	$34,800.00	$40,020.00
5.5 m tall concrete structure	$131,750.00	$151,512.50

Description of Item	Costs ($ECD) Not incl. VAT	Costs ($ECD) incl. VAT
Engineering Services		
Structural assessment of building and roof	$6,500.00	$7,475.00
Structural design of 5.5m tall wood structure	$4,800.00	$5,520.00
Structural design of 5.5m tall steel structure	$6,300.00	$7,245.00
Structural design of 5.5m tall reinforced concrete structure	$4,650.00	$5,347.50
Geotechnical assessment	$40,000.00	$46,000.00
Installation Costs		
Installation for standard concrete pad set-up	$2,000.00	$2,300.00
Installation for solar and concrete pad set-up	$3,800.00	$4,370.00
Installation for tank on top of a structure	$3,700.00	$4,255.00
Operation and Maintenance		
O&M estimated on a 5-year term	$4,300.00	$4,945.00

Notes:

Value Added Tax (VAT) in Dominica is 15%

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