INTEGRATED SUSTAINABILITY

Final Report

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

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Prepared for:

UN Climate Technology Centre & Network (CTCN)

CTCN
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INTEGRATED SUSTAINABILITY

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1 INTRODUCTION

The Government of Dominica has established a policy to develop the county's natural energy resources including geothermal, wind and solar. Energy is critical for economic growth of Dominica and access to affordable and reliable energy is essential for public health, education, food production, tourism, manufacturing, water security, and communications services.

The United Nations Environment Programme (UNEP), represented by its Division of Science office at Nairobi, Kenya has, as its operational arm, the Climate Technology Centre and Network (CTCN) of the United Nations Framework Convention on Climate Change (UNFCCC) Technology Mechanism. The CTCN has provided funding to carry out a technical and economic feasibility assessment of solar units and water storage on public buildings in Dominica.

Dominica's Water and Sewerage Act provides for "rooftop catchments", referring to them as "any installation or device suitable for the collection of rainwater on the roof of buildings or dwelling houses". The Dominica Water and Sewerage Company Limited (DOWASCO) is authorized by the government to provide the owner of a privately owned building or residential dwelling with technical or financial assistance towards the installation of rooftop catchments.

As climate change is expected to result in increasing severity of tropical storms and hurricanes that could impact water and power resources in Dominica, the project is also viewed as a way to increase climate resilience and reduce greenhouse gas (GHG) emissions.

This Final Report summarizes the activities carried out by Integrated Sustainability in evaluating the technical and economic feasibility of implementing building-scale solar generation and rainwater harvesting systems. The project included identifying key stakeholders involved in the management of public buildings and stakeholder involvement and analysis was a continuous task throughout this project. This report examines the different scenarios for electricity and water supply/storage and analyses the feasibility of these scenarios considering the buildings capacity of hosting solar generation and water storage units. The report also briefly summarizes our field investigation that included visiting ten (10) public buildings that were selected as representing the various types of public structures.

2 CLIMATE CHANGE IMPACTS

The updated Nationally Determined Contribution (NDC) for Dominica commits to a total reduction of greenhouse gases (GHG) of 39% below 2014 levels by 2025, and a 45% reduction by 2030[1]. Near complete decarbonization is expected in the energy sector, with a 2030 target set for GHG emissions reduction of 98.6% relative to 2014 levels. The greatest driver of the change in the energy sector is the current development of utility-scale renewable energy projects, particularly the development of a 10 MW geothermal powerplant in the Roseau Valley area in Dominica. The project, expected to be completed by 2025, will supply most of the country's electricity demands

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[1] The Commonwealth of Dominica Updated Nationally Determined Contribution. UNFCCC (2022). https://unfccc.int/sites/default/files/2022-07/The%20Commonwealth%20of%20Dominica%20updated%20NDC%20July%204%20%2C.pdf

(2022 peak demand was 16.3 MW[2]), together with approximately 6 MW of hydroelectric power, which has been operational on the island for decade. The geothermal power in the Roseau Valley area exceeds 300 MW, and it is expected the geothermal power capacity will be increased to supply the green industrialization needs on the island, and to export power to neighbouring Caribbean countries.

Even with large-scale projects in place to mitigate the impacts of climate and reduce GHG emissions, small-scale rainwater harvesting, and solar power supply systems can have a significant impact on meeting the country's GHG reduction targets. The project's potential contribution towards the energy sector mitigation goals for emissions reductions, based on the buildings assessed in this project are highlighted in Table A.

Table A. Contribution of Project to GHG Emissions Abatement

	Proposed Solar PV System size	Annual Electricity Usage (MWh)[2]	Annual Solar PV Potential (MWh)[3]	Associated GHG Reduction (Metric Tons CO_2 Equivalent)
Education				
Dominica State College (DSC) - Buildings A, B, C (1)	10 / 10.9	12.5	15.6	11.1
DSC - Carpentry Building	20 / 21.8	24.6	31.2	22.1
DSC - Library	5 / 5.8	6.1	7,.8	5.5
DSC - Building N1	2 / 2.52	2.9	3.1	2.2
DSC - Building N2	3 / 3.3	3.5	4,7	3.3
DSC - Tourism Building	1 / 1.2	1.3	1.6	1.1
DSC - Confucius Classroom	5 / 5.8	6.5	7.8	5.5
DSC - General Studies Building	8 / 9.2	10.2	12.5	8.9
DSC - Creative Caribbean Building	1.5 / 1.6	1.8	2.3	1.7
DSC - Main Building & Office	20 / 21.8	24.4	31.2	22.1
DSC - Jolly's Mini Pharmacy	6 / 6.7	7.2	9.4	6.6
Dominica Community High School (2)	3 / 3.3	3.8	4.7	3.3
Mahaut Primary School (3)	15 / 16.8	17.9	23.4	16.6
Community				
Vieille Case Community Centre (4)	3 / 1.6	1.6	2.5	1.8
Trafalgar Community Centre (5)	2.5 / 2.9	3.2	3.9	2.8
Sineku Resource Centre (6)	0.3 / 0.4	0.3	0.47	0.322
Health				
Mahaut Health and Wellness Centre (3)	6.1 / 6.7	7.4	9.5	6.8
Newtown Health Centre (7)	6.1 / 6.7	37.9	9.5	6.8
Other Sectors				
Roseau Fisheries Complex (8)	57 / 59.6	104.5	89.0	63.1

[2] 2022 Annual Report. Dominica Electricity Services Limited (2022). https://www.domlec.dm/download/2022-annual-report/

[3] Based on electricity generation assumption of 1,562 kWh per kWac

	Proposed Solar PV System size	Annual Electricity Usage (MWh)[2]	Annual Solar PV Potential (MWh)[3]	Associated GHG Reduction (Metric Tons CO_2 Equivalent)
Dominica Meteorological Office (9)	10 / 10.9	23.0	15.6	11.1
All Buildings			**285.9**	**202.7**

COMMUNITIES (#)

1. *Stockfarm*
2. *Roseau*
3. *Mahaut*
4. *Vieille Case*
5. *Trafalgar*
6. *Sineku*
7. *Newtown*
8. *Roseau*
9. *Jimmet*

As highlighted in Table A, the installation of solar PV at all 20 buildings considered would produce an estimated aggregated annual electrical generation potential of 286 MWh/year, equivalent to a reduction of approximately 203 metric tons of CO^2, contributing to the NDC's GHG mitigation target. The solar PV systems will have long-term energy cost savings during normal operation and the energy generation and rainwater harvesting capabilities will be strategically important when electricity and/or water systems are down. Seventeen of the 20 buildings that were assessed can produce more electricity than they have historically consumed, and the capital cost of the solar power systems in those buildings can be offset by the savings in electrical utility costs as well as the value of the excess power discharged to the grid. The autonomous power capability of buildings also has a wider economic value for the overall electrical distribution network, as it frees system capacity for other future users to connect to the grid and delays the need for future network upgrades. Similarly, the rainwater harvesting storage can be used to reduce water demands on the water distribution system during the day.

2.1 Benefits of building power generation and water supply systems

Installing PV solar power generation and rainwater harvesting systems will have economic, environmental, resilience, reliability, and gender balancing benefits.

2.1.1 Economic Benefits

Energy generation and water harvesting systems will have long-term cost savings during normal operation and when electricity and/or water systems are down. Seventeen of the 20 buildings that were assessed could produce more electricity than they require, and the capital cost of the solar power systems are offset by the savings in electrical power costs as well as the value of the excess power generation, where an excess is generated. The autonomous power capability also has a wider economic for the overall electrical distribution network, as it frees system capacity for other future users to connect to the grid and delays the need for future network upgrades.

Table B and Table D highlight the contributions and economic benefits from solar PV installed at the 20 buildings, and Table E presents the assumptions used for the analysis. The total potential PV solar power generation capacity for all 20 buildings combined is 183 kWAC/ 201 kWDC. The estimated solar PV power generation potential for all twenty buildings is 286 MWh annually, and the estimated average annual electrical consumption from all buildings is 300 MWh.

Table B. Estimated Solar PV Generation from Project and Electricity Consumption of Public Buildings

	Proposed Solar PV System size	Average Annual Generation Potential from Solar PV System (kWh)	Average Annual Electricity Demand (kWh)	Annual PV Electricity Generation Utilization (kWh)	Annual Electricity Required from Utility (kWh)	Annual Excess PV Generation Exported to Utility's Grid (kWh)
	(kWAC/kWDC)	A	B	C = A x 0.60	D = B - C	E = D - C
Education						
Dominica State College (DSC) - Buildings A, B, C	10 / 10.9	15,615	12,528	9,369	3,159	6,246
DSC - Carpentry Building	20 / 21.8	31,230	24,612	18,738	5,874	12,492
DSC - Library	5 / 5.8	7,808	6,048	4,685	1,364	3,123
DSC - Building N1	2 / 2.52	3,123	2,928	1,874	1,054	1,249
DSC - Building N2	3 / 3.3	4,685	3,480	2,811	669	1,874
DSC - Tourism Building	1 / 1.2	1,562	1,260	937	323	625
DSC - Confucius Classroom	5 / 5.8	7,808	6,456	4,685	1,772	3,123
DSC - General Studies Building	8 / 9.2	12,492	10,176	7,495	2,681	4,997
DSC - Creative Caribbean Building	1.5 / 1.6	2,342	1,812	1,405	407	937
DSC - Main Building & Office	20 / 21.8	31,230	24,384	18,738	5,646	12,492
DSC - Jolly's Mini Pharmacy	6 / 6.7	9,369	7,212	5,621	1,591	3,748
Dominica Community High School	3 / 3.3	4,685	3,768	2,811	957	1,874
Mahaut Primary School	15 / 16.8	23,423	17,892	14,054	3,839	9,369
Community						
Vieille Case Community Centre	3 / 1.6	2,498	1,584	1,499	85	999
Trafalgar Community Centre	2.5 / 2.9	3,904	3,204	2,342	862	1,562
Sineku Resource Centre	0.3 / 0.4	468	312	281	31	187
Health						
Mahaut Health and Wellness Centre	6.1 / 6.7	9,525	7,368	5,715	1,653	3,810
Newtown Health Centre	6.1 / 6.7	9,525	37,884	5,715	32,169	3,810
Other Sectors						
Roseau Fisheries Complex	57 / 59.6	89,006	104,520	53,403	51,117	35,602
Dominica Meteorological Office	10 / 10.9	15,615	23,040	9,369	13,671	6,246
Total - All Buildings		**285,911**	**300,468**	**171,546**	**128,922**	**114,364**

Table C. Estimated Economic Costs and Savings from Project

	Proposed Solar PV System size (kWAC/kWDC)	Electricity Bill Without Solar PV System ($ ECD / yr)	Electricity Bill Incl Solar PV Generation ($ ECD / yr)	Savings on Electricity Bill ($ ECD / yr)	PV System Initial Cost Estimate ($ ECD / yr)	Payback Period, Excluding Net Billing Comp (Years)
Education						
Dominica State College (DSC) - Buildings A, B, C	10 / 10.9	$13,272	$3,348	$9,924	$52,920	5
DSC - Carpentry Building	20 / 21.8	$26,076	$6,228	$19,860	$94,365	5
DSC - Library	5 / 5.8	$6,408	$1,440	$4,968	$34,965	7
DSC - Building N1	2 / 2.52	$3,108	$1,116	$1,980	$18,765	9
DSC - Building N2	3 / 3.3	$3,684	$708	$2,976	$22,680	8
DSC - Tourism Building	1 / 1.2	$1,332	$348	$996	$9,450	10
DSC - Confucius Classroom	5 / 5.8	$6,840	$1,872	$4,968	$34,965	7
DSC - General Studies Building	8 / 9.2	$10,788	$2,844	$7,944	$54,945	7
DSC - Creative Caribbean Building	1.5 / 1.6	$1,920	$432	$1,488	$12,555	8
DSC - Main Building & Office	20 / 21.8	$25,836	$5,988	$19,860	$94,365	5
DSC - Jolly's Mini Pharmacy	6 / 6.7	$7,644	$1,680	$5,952	$39,960	7
Dominica Community High School	3 / 3.3	$3,996	$1,020	$2,976	$22,680	8
Mahaut Primary School	15 / 16.8	$18,960	$4,068	$14,892	$22,681	2
Community						
Vieille Case Community Centre	3 / 1.6	$1,680	$96	$1,584	$69,255	13
Trafalgar Community Centre	2.5 / 2.9	$3,396	$912	$2,484	$21,870	9
Sineku Resource Centre	0.3 / 0.4	$336	$36	$300	$3,240	11
Health						
Mahaut Health and Wellness Centre	6.1 / 6.7	$7,812	$1,752	$6,060	$161,460	7
Newtown Health Centre	6.1 / 6.7	$40,140	$34,080	$6,060	$39,960	7
Other Sectors						
Roseau Fisheries Complex	57 / 59.6	$110,748	$54,168	$56,580	$257,580	5
Dominica Meteorological Office	10 / 10.9	$24,408	$14,484	$9,924	$279,990	5
Total - All Buildings	**183.1 / 200.9**	**$318,372**	**$136,608**	**$181,764**	**$1,348,651**	**7 (Average)**

Table D. Economic Benefits Assumptions

Assumption	Unit	Value
DOMLEC Retail Electricity Tariff	EC $/kWh	$1.06[4]
Feed-in Tariff (i.e. value of electricity exported to the grid by RE systems)	EC $/kWh	$0.405
Percentage of Solar PV Generation used for Consumption in Building	%	60

As the power generation potential exceeds consumption during the day, and power consumption occurs during days and times of the day when there is no sunlight, the solar power systems can be connected to the power grid through a reversing electrical meter. When power is more than the building needs generated, it will be transferred to the grid and the building will get credit for the excess. Under conditions where the amount of electricity generated is less than the building needs, or is non-existent, the building can draw power from the grid, without the need for a battery power-storage system.

Assuming an electricity tariff of EC $0.95 per kWh[5], and assuming there is no financial compensation from a feed-in tariff mechanism (i.e. no ability to transfer electricity to the electrical utility grid), the solar PV systems at the twenty buildings assessed would collectively generate about 286 MWh per year, compared to an estimated annual consumption of 300 MWh. The electricity generated by the solar PV systems would result in a savings in electricity worth about EC $181,000 per year, with an estimated total capital cost of about EC $1,350,000. Assuming a financing rate of 5% on the capital purchase, the average payback period would be an average of about 7 years.

If excess electricity can be discharged to the grid through a reversing meter, assuming a feed-in tariff of EC $0.405, the excess electricity could result in an additional economic value of about EC $228,000 per year, or about EC $4.55 million over 20 years.

2.1.2 Resilience and Reliability Benefits

The provision of solar PV power generation with a reversing meter connection to the grid combined with water storage will improve the reliability of service to the buildings and their resilience to major shocks.

As previously noted, seventeen of the twenty public buildings assessed in this study could generate more solar PV electricity than they have historically consumed. With battery storage the buildings

[4] Islands Energy Snapshot. National Renewable Energy Lab (NREL). https://www.nrel.gov/docs/fy15osti/62704.pdf

[5] DOMLEC's electricity tariff was modelled at a rate of ECD $1.06 per kWh (USD $0.39 per kWh), the average tariff charged to all customers for electricity sold by DOMLEC (NREL). This value is distinct from the modeled Feed-in Tariff (FIT) value ($0.405 per kWh), which represents the value of renewable energy exported to the utility's grid.
The electricity tariff was used to estimate the total electricity costs for the public buildings, assuming all of their consumption was supplied by the utility.
The FIT value was used to calculate the savings the solar PV systems will bring to the public buildings from excess electricity exported to the utility's grid, along with savings due to less consumption from the buildings being served by the utility at the electricity tariff.

could be self-sustaining, and with a connection to the grid they could provide a supplemental source of electricity during utility service disruptions.

Similarly, rainwater harvesting, and storage will improve building resiliency and reduce water demands on the distribution system. Even during dry weather, without rainwater replenishment, the building water storage could be topped up at night when network flows are low, improving peak water demand performance later in the day for the distribution system. The installation of solar PV and water storage, combined with the strategic locations of the public buildings across Dominica can significantly reduce the impact of these buildings on electrical and water services, as well as enabling the buildings to remain functional during periods when electrical and/or water services may be disrupted.

This reduction in total dependence on the larger electricity/water networks, while contributing to greater sustainability, is in-line with the Government of Dominica's mission to become a climate-resilient country across multiple sectors. To achieve this, the solar PV and water storage infrastructure will need to also be resilient. The solar panels should be capable of withstanding category 5 hurricane wind speeds (by having an uplift rating exceeding 4,000 Pascals), and installation must be carried out thoroughly to maintain the category 5 rating for the equipment. Likewise, the water storage equipment will need to be adequately protection from damage due to extreme weather conditions (e.g. wind speeds).

2.1.3 Gender Equity Benefits

In the context of this project, an examination of gender needs will need to address the gendered use of the facilities identified, including how water and electricity are used. The assessment of use must be explored through an intersectional lens to include age, disability, and Indigenous people in order to capture as far as possible the needs of men and women of Dominica, in all their diversity.

Given the time and scope of this component of the project, the examination of gendered benefits of the installation of solar power and water storage devices in the public buildings identified can only be explored briefly using the strategic gender need of *access to, and control over resources***.**

> "*Men and women use space differently because they have different responsibilities and experiences. An educational space designed only for girls or women would differ from that designed for boys or men, and space would therefore be utilised differently.*" (Lang, 2010)

In the examination of the use of space, in the context of Dominica, there must be a clear examination of who uses the buildings under consideration for this project. Tertiary level and primary schools, as well as health and community centres are identified under this project. Consideration must therefore be given to safe access. Safe access in the context of use of buildings, include use of bathrooms, physical structures such as ramps, and adequate lighting. According to The Gender Inequality of Risk Study for Dominica (Perch, 2021), people with disabilities make up 5.2% of the population, and 51% of people without educational qualifications. The report also states that access to services remains a challenge for people with disabilities. This project must therefore pay attention to improving such access and including the necessary changes in the infrastructural works necessary for installation of solar power and water storage.

The consideration of gender issues in the context of these buildings, must be approached considering several areas:

Architectural Theory:

Architectural theory analyses the influence of gender on the planning, construction, and use of buildings. This requires knowledge of gender issues in general, and an analysis of the immediate working context. Consideration must also be given to the level of gender awareness in legislation, governing, planning, and building. Building administration also needs to be gender-sensitive and ensure that any redesign consider differentiated user needs as well as community health and safety.

Sustainable Development:

The 2030 agenda[6], serves as a guide to sustainable development in all areas. This approach highlights the need to address both environmental and gender issues in all development planning. However, in addressing the gender issues in the context of this project it must be recognised that "*strategic planning as the most crucial planning level for integrating gender perspective into spatial planning*" (Larsson, 2006), and therefore, gender considerations must begin at the very conceptualisation of a project, and integrated at levels of strategic planning, project implementation and monitoring and evaluation.

Safety:

In the conceptualisation and construction of buildings and their use, safety considerations can include lighting, location of access doors, and location of bathroom facilities, to name a few. In the case of educational buildings under consideration in this project, issues of risk mitigation around gender-based violence must be integrated in the planning. Additional safety issues for consideration under this project can be access for the elderly and people with disabilities.

Health and Sanitation:

A very practical and targeted gender issue in health and sanitation is the special hygiene needs of women and girls regarding menstruation. Access and use of water, as well as privacy needs must be vital considerations. The access for women and girls with disabilities, as well as any unique customs of the indigenous population around menstruation must be given consideration.

The integration of gender considerations at every level of a project, requires that specific questions be asked at every level from project planning, throughout implementation, and in the monitoring and evaluation process. Developing checklists at every stage of the process is a good practice approach.

Table E outlines general considerations when seeking to develop gender checklists in the context of this project.

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[6] UN. Goal 17: Revitalize the global partnership for sustainable development. https://www.un.org/sustainabledevelopment/globalpartnerships/?gclid=Cj0KCQjwilOmBhDjARIsAP6YhSUYtiXHdtVZO30LiL0DfrrzaSU_-NxP2RafRpWD8igM4QWePXuPQ4AaAqr3EALw_wcB

Table E. General Considerations for Gender Checklists

Areas of Consideration for Checklists			
Architectural Theory	**Sustainable Development**	**Safety**	**Health & Sanitation**
- Ramps - Width of corridors and stairs - Location of bathroom facilities - Lighting at entries and exits, in corridors, - Gender awareness in building codes and legislation	- Gender awareness in planning and project implementation - Gender knowledge in project teams - Public administration requirements and accountabilities	- Proximity of male to female facilities - Risk mitigation for GBV/sexual violence - Lighting in critical areas that can be at risk for acts of crime and violence	- Menstrual hygiene needs - Lactating rooms - Cultural or religious needs of the indigenous population

While there are questions that will apply to all buildings, it is important to examine the needs of users of specific buildings, and therefore developing a checklist for each type of building is useful in ensuring that the needs of all users, of every type of building is met.

The tables below are simple examples of the kinds of checklists that could be developed for the different buildings under consideration. These checklists are not exhaustive, and the number and kinds of questions to be asked will depend on the level of construction to be undertaken for the installation of the solar panels and water storage facilities. Anticipating the work to be undertaken and taking the time to include consideration of gender (target needs of women, men, PWDs, the elderly and other vulnerable groups) at the beginning of the process, would ensure that improved access to services for a wider cross-section of the population.

In developing the checklists for educational buildings, the primary user populations would be student and teachers, and parents may be considered secondary users. Consideration must be given to the fact that schools are sometimes used as shelters for displaced people following the impact of a natural event such as a hurricane (Perch, 2021).

Table F. Gender Inclusivity Checklist for Educational Buildings

EDUCATIONAL BUILDINGS	Yes	No	Notes
Is there wheelchair access to the campus?			
Is there wheelchair access to lecture halls?			
Is there wheelchair access to administrative spaces?			
Are there designated bathrooms for wheelchairs and people with other disabilities for both students and staff?			

EDUCATIONAL BUILDINGS	Yes	No	Notes
Are there breast-pumping spaces for staff and students?			
Is there adequate lighting in critical areas, particularly around bathrooms?			
Are corridors wide enough for wheelchairs and fitted with handrails?			
Can people with disabilities access designated areas for recreation, crafts, assembly hall, conference rooms?			

Users of Health Centres are largely all members of the community (service area). Of critical importance is the understanding that the elderly and people with disabilities often face health challenges and are likely to the more frequent users of these facilities. Pregnant women, and new mothers must also be given significant considerations.

Table G. Gender Inclusivity Checklist for Health Centres

HEALTH CENTRES	Yes	No	Notes
Are there wheelchair access/ramps to the facility?			
Is there wheelchair access to examination rooms, labs, other special services areas such as training rooms for pre-natal sessions?			
Are there designated pumping stations with adequate water supply and lighting for lactating mothers?			
Are there changing rooms with adequate water supply and lighting for women with babies?			
Are waiting rooms designed to ease of movement for wheelchairs and elderly people?			
Is there adequate water storage capacity to address all health services, as well as general health and sanitation needs (e.g., pipes, water coolers, etc)?			

Community Centres, like Health Centres, generally serve a designated geographic community. The critical difference is activities. Community Centres are most likely to be used for larger gatherings and discussions, training, and social events. Like schools, community centres are also used as shelters for displaced people.

Table H. Gender Inclusivity Checklist for Community Centres

COMMUNITY CENTRES	Yes	No	Notes
Is there adequate lighting in the areas of stairs, ramps, and bathrooms?			
Are meeting and training rooms adequate in size and location for wheelchair access?			
Is there wheelchair access to training rooms, conference rooms and bathrooms?			
Are elevators adequate for wheelchair access in multi-level buildings?			
Is there adequate parking for people with disabilities?			
Are parking spaces and external walkways well-lit?			
Are there any special requirements for cultural events by the Kalinago population or other religious functions?			

2.1.3.1 Gender Equity Benefits

It is essential to consider gender-specific implications when planning and implementing infrastructure projects related to electricity and water. It is important that decision-making (As well as policymaking) prioritize inclusivity and gender equality in efforts to improve infrastructure and basic services. Measures to ensuring equitable access to energy and water is important to the overall development and empowerment of both men and women as well as other groups. The Government of Dominica has committed to increase the country's usage of renewable energy to 100% from its' current 30% (generated from hydro) by developing and utilising geothermal energy sources (Government of Dominica, 2022).

As in any society, the gendered relevance of having reliable electricity and water is significant in Dominica. Access to reliable power and water can directly impact both men and women, but the implications may differ based on gender roles, responsibilities, and societal norms. In the context of Dominica this can also be nuanced by age, ability, geography as well as ethnicity. Dominica's indigenous community requires consideration. For example, the Kalinago population (the indigenous group of Dominica) live experiences the highest poverty rate of any group at 49.8% and reside in the more rural areas of the country. This has implications on their ability to access and utilise these resources (Perch, 2021). Here are some ways in which reliable electricity and water can be of particular importance for different genders in Dominica:

1. **Economic Opportunities and Income Generation:**

Access to reliable electricity can promote economic activities and income-generating opportunities. Women are often engaged in small-scale businesses, and access to electricity can enable them to run businesses more efficiently including operating stores, selling goods, or running food stalls. While the generation of solar PV electricity and the storage of water for public buildings is not expected to directly benefit such enterprises, the overall benefit associated with load reductions and making utility sources of power and water more generally available is expected to benefit small businesses. In addition, public buildings also provide community support in times of crisis and also provide critical services including possible business continuity services that aid small businesses. While women may account for 15% of registered farmers, many operate in the agriculture sector informally and their ability to access water can be impacted due to travel and transporting water to remote areas and household duties (UN Women, 2021).

2. Household Responsibilities:

Women, especially in traditional roles, are often responsible for managing households including cooking, cleaning, and childcare. Reliable electricity is crucial for household tasks that involve electrical appliances, making these roles more manageable and efficient. Adequate water supply is also essential to these roles. As women continue to carry out these roles in the public space including as users of public buildings and the related services, consideration of their differentiated needs including care for children and babies may need to be considered. Access to the building and services, particularly multi-floor buildings, can be facilitated by continuous energy supply that feeds elevators, escalators, and other technology. This continuous energy supply could be powered by renewable energy sources such as rooftop photovoltaics while adapting energy efficient technologies into the measures.

3. Health and Hygiene:

Access to clean water is essential for maintaining proper hygiene and health. Women, who are often the primary caregivers, have a significant role in maintaining the health of their families. Clean water can help prevent waterborne diseases and reduce the burden of caring for sick family members. The use of sanitation and hygiene facilities in public buildings including educational facilities relies on both access to water and electricity including energy to pump water to the buildings.

Reliable electricity is also crucial for powering medical facilities and ensuring proper healthcare services, which can significantly impact women's health during pregnancy, childbirth, and other medical needs.

4. Education and Empowerment:

Access to reliable electricity can improve educational opportunities and consistent and resilient supply can be critical to education uptake, access to information and leveraging knowledge as an asset.

5. Safety and Security:

Women face safety and security risks in many societies, particularly at night but also during the day. GBV is fairly common in the Caribbean and is well known to take place in public spaces. Reliable electricity can provide better lighting in public spaces reducing the vulnerability of women to violence and accidents. This is true for women, girl, persons with disabilities as well as indigenous boys and girls.

3 POLICY AND REGULATORY ANALYSIS

3.1 Supporting Frameworks

There may be several technical, financial, and policy and regulatory limiting factors for the development of solar photovoltaic (PV) energy and rainwater harvesting on public buildings In the Commonwealth of Dominica.

3.1.1 Technological Framework

Technological advancements in the following building-scale solar generation and water capture systems have improved their efficiency and cost-effectiveness:

- **Solar Generation Systems**: Photovoltaic (PV) systems are commonly used for solar energy generation throughout the Caribbean, converting sunlight into electricity, which can be used on-site, stored onsite in batteries, or directed into the grid.
- **Solar Water Heating Systems**: Solar water heaters are increasingly utilized for domestic and commercial application to reduce the dependence on electric water heating.
- **Rainwater Harvesting Systems**: Rainwater harvesting systems are valuable both as a source of water to augment or off-set domestic distributed water supplies as well as for storage of domestic water during dry weather to reduce peak water demand impacts on the community water distribution system. Following screening and filtration, water collected through rainwater harvesting can be used for a wide range of non-potable water applications including irrigation, toilet and urinal flushing, showering, laundry, and general cleaning. If intended for potable water a higher degree of filtration and effective disinfection is required, as well as careful consideration of the potential for contamination from surfaces and materials the rainwater comes into contact with during collection, storage and distribution. As about 85 percent of domestic and commercial water demands can be met by a non-potable water supply, point-of-use treatment for potable uses, rather than treating all the water to a potable standard, is expected to be more sustainable.

3.1.2 Implementation Challenges

Technical Challenges: The area available for solar panel deployment on roof-tops, and shading from roof-top structures, vegetation and adjacent buildings is a key limiting factor in determining power generation potentials. Similarly, the surface area available for rainwater collection, the potential for contamination of collection surfaces, and the amount of water that can be stored are key limitations for rainwater harvesting.

Building Structure: Some older public buildings in Dominica may not be structurally adequate to attach PV panels in a manner suitable to withstand hurricane winds, or to modify for rainwater collection or bear the weight of a water storage tank. The cost of structural modifications may affect the economics or may not be practically possible, but, regardless, may require additional resources and planning to overcome.

Maintenance and Operation: Both solar PV systems and rainwater harvesting infrastructure require regular routine maintenance to ensure their optimal performance. Without proper maintenance, these systems may not achieve their intended benefits. However, the availability of skilled personnel with appropriate operations and maintenance training and may be a limiting factor in the context of public buildings.

Regulatory and Guidance: As further discussed in section 3.1.4 below, there is currently no plumbing code in place to facilitate non-potable water distribution systems within buildings, or regulatory governance enabling the distribution of non-potable water in Dominica.

The implementation of using purple pipe to signify the use of reclaimed non-potable water is practiced in many areas around the world, including the Caribbean such as Barbados. The source of the reclaimed water is often from a wastewater treatment plant and can be blended with rainwater capture for non-potable use such as irrigation, toilets and even laundry. Dual plumbing codes have been developed to provide standards and guidance for the installation of these non-potable water distribution systems. This policy framework is needed in Dominica to utilize more reclaimed water and place less of a demand on the potable water distribution system that is expensive to produce and maintain, especially with high non-revenue water (NRW) leaks in the system.

Awareness and Education: A significant barrier to the implementation and use of solar generation and rainwater water collection systems can be the lack of knowledge and guidance available to assist public officials, policymakers, and stakeholders in deploying these systems. Conducting awareness campaigns, educational programs, and workshops can help disseminate information about the benefits (e.g. climate change mitigation, adaptation and improved electrical and water network performance), feasibility, financial viability and long-term direct and indirect cost savings associated with these technologies. In carrying out awareness campaigns, educational programmes as well as workshops to disseminate information, gender-sensitive and inclusive approaches are critical. This means that the approaches to the format and content of the information as well as how it is disseminated should take gender into consideration including the differentiated needs and interests of men, women, young people, the elderly, Persons with Disabilities, and Indigenous People. Moreover, ideally content and should be developed that acknowledges these diverse groups and some of the specific needs they have in deploying these systems and as users of the buildings identified. Additionally, accessibility of content is important in terms of the imagery and language used (avoiding gender-based stereotypes and biases), as well as trying to ensure some content is accessible to the hearing and sight-impaired and also uses Kalinago language where possible.

3.1.3 Financial Framework

In considering the financial framework, it is essential to consider the initial investment, maintenance costs, payback periods, and revenue generation potential over the life of the systems. Financing options, such as government programs, loans, grants, or partnerships, can help overcome direct cost barriers, as can electricity metering policies that enable reversing meters and provide for tariff premiums for sustainable power generation.

The financial framework for solar generation and rainwater capture and storage systems in Dominica, includes the following:

Initial Capital Investment Cost: Because of the long pay-back periods, upfront capital investment is a key barrier to the widespread adoption of solar PV systems and rainwater harvesting infrastructure. This is particularly true for rainwater harvesting systems as the true utility cost of supplying water is seldom reflected in the unit cost or the water obtained from a public water distribution system. The cost of installing solar panels and setting up rainwater harvesting systems can be substantial, which may deter public buildings from implementing these technologies.

Financing and Funding: Access to financing and funding options can be a significant limitation for public buildings seeking to implement solar PV and rainwater harvesting. There is currently limited availability of financial subsidies such as grants, capital subsidies, and loans specifically targeted at renewable energy and water conservation projects, restricting the financial feasibility of such initiatives.

3.1.4 Policy and Legal Framework

Dominica

Dominica has made significant progress in developing its legal framework to support renewable energy, including solar generation and water capture systems. The legal framework for solar generation and water capture systems in Dominica include regulations related to permits, licensing, interconnection, and safety standards. Additionally, the dissemination of information regarding incentives, subsidies, or tax benefits provided by the government for renewable energy installations is crucial.

In relation to rainwater capture, there is currently no plumbing code in place to facilitate non-potable water distribution systems within or between buildings, or regulatory governance enabling the distribution of non-potable water in Dominica. From an implementation perspective there is also no qualified or certified individuals with experience in installing and maintaining such plumbing systems.

The government owned Dominica Water and Sewerage Company Limited (DOWASCO) is responsible for providing water supply and sewage services to residents and businesses in Dominica. It is responsible for sourcing, treating, and distributing potable (drinking) water to households and businesses across the island including maintaining the water infrastructure, such as reservoirs, treatment plants, and distribution networks, to ensure a consistent and safe water supply.

The property owner is responsible for plumbing maintenance, inadequacies and modification or upgrades. DOWASCO advises that each household should have adequate storage of potable water to last 24 hours, but the collection, management and storage of rainwater is left to the prerogative and preferences of the property owner. One example of a private sector rainwater harvesting initiative in conjunction with buildings in Dominica is the Londonderry Livestock Facility which installed a 90.9 m3 capacity ferro-cement tank in addition to five 4.6 m3 capacity tanks on various buildings (Cherry-Fevrier, 2014).

Caribbean RWH Experience

Early historical rudimentary RWH practices have improved with the introduction of simple technologies and a better understanding of water quality standards requirements to protect public health. Although RWH is a simple and low-cost means of water supply which is characteristically easy to install and maintain, with the expansion of central municipal water services, the practice of implementing RWH has declined in the Caribbean. Many countries haven't included RWH in their integrated water resources management (IWRM) plans and/or water polices, resulting in relatively little commitment to invest in RWH practice in many islands. This is also attributed to lack of awareness, requisite skills and knowledge among citizens and their governments (Caribbean Environmental Health Institute. 2006).

Other parts of the Caribbean have considerable experience with rainwater harvesting and could serve as a good starting resource for formally considering such systems for Dominica including Grenada and Anguilla.

In Grenada landslides and sedimentation from heavy rains caused problems to the water distribution network, highlighting vulnerability of the community to extreme water-scarcity in a post-disaster environment. As a consequence, a national RWH program was established through consultation with of key public and private sector stakeholder institutions, and select communities, as well as national workshops. The Grenada program became the basis for a regional Integrated Water Resources Management (IWRM) program stated "to contribute to the conservation of the water resources of the Caribbean through adoption of sustainable water management and conservation technologies".

A study in Angulla (Tiwar1, 2021) assessed the presence of indicator coliform bacteria in water collected from rainwater harvesting systems in 86 homes and associated health risk to the consumer in Anguilla. The majority of the samples collected contained sufficient levels of bacteria to be a health concern, particularly as a majority of the households were found to be drinking the rainwater without any treatment and had a history of at least one episode of gastroenteritis-like illness during the previous year, concluding the water poses a potential health risk to the consumers and requires proper treatment for consumption.

The Rainwater Harvesting Knowledge Network Forum held in Saint Lucia from 21-23 October in 2014, shared knowledge, research, and good practices for the purpose of providing decision-makers with adequate models of RWH systems that promote access to safe water supply. Key findings of the forum included:

- RWH systems should be designed for the people who are using them, especially women and vulnerable groups;
- RHW awareness programs are needed, particularly aimed at schools, to distribute local knowledge on rainwater management;
- RWH projects need to factor in the various stakeholders, such as technical professionals, businesspeople, and politicians, who all have different objectives;
- RWH programs need to be coordinated by a lead regional agency that takes ownership and has the legitimacy to champion advocacy and implementation of RWH initiatives;

- Policy leaders in the Ministries of Finance and politicians, in general, need to become more aware of RWH systems and their use;
- It is very important to reach out to and consult with consumer groups, households, the Ministry of Gender Affairs, Village Councils, and the main users of RWH at the planning stage;
- A work plan should be produced that identifies the key things that can be done and implemented on a step-by-step basis is necessary. This should be underpinned by research, making use of new information, and leveraging social media and other telecommunications tools;
- Incremental implementation of RWH systems should be considered on a sector-by-sector basis, for example, beginning with the hotel sector, and focusing on the areas where most returns can be obtained. Emphasis should be placed on the revenue savings from RWH systems to households or communities, and not only storage; and
- RWH Policy issues need to be developed alongside an enabling environment for implementation of the policies.

Speakers at the forum highlighted the key reasons for investing in RWH, which included "longer dry seasons and reductions in the length of the rainy season, resulting in changing rainfall patterns and more frequent occurrences of drought (due to climate change), particularly when water demand exceeds supply. (Cherry-Fevrier, 2014).

Importance of Practical Regulations and Standards

Inconsistent or complex regulations can impede the implementation of solar generation and water capture systems. Streamlining the permitting process, reducing bureaucracy, and providing clear guidelines for interconnection and safety standards can facilitate the adoption of these technologies.

In addition to streamlining processes, policies must seek to address gender both as cross-cutting theme and a unit of analysis. "*While not many policies or strategies are gender blind in DMI, there are still not as many that are gender responsive and even for those that are sensitive, one observation is that they do not often consider how weaknesses in the sector contribute to the poor performance of other sectors and vice-versa*" (SAEDI, 2021). An approach to policy development, which seeks to address issues such as age, ethnicity, educational levels, disabilities, and religion, and their intersection with gender, serves to ensure that policies and legislation are having the desired positive impacts.

3.2 SOLUTIONS

3.2.1 Multi-Faceted Approach

The successful implementation of a program to encourage PV solar power and rainwater harvesting and storage systems requires a multi-faceted approach involving government support, public-private partnerships, capacity building, and awareness campaigns. This requires a combination of financial incentives, supportive policies, capacity building, and public awareness, to encourage and accelerate the development of solar photovoltaic energy and rainwater harvesting infrastructure on public buildings.

3.2.2 Technical Support

Grid Integration Challenges: Technical infrastructure limitations and grid stability concerns may make the integration of solar generation systems into the existing electrical grid infrastructure challenging. Upgrades to the grid infrastructure and implementing grid codes and standards that accommodate renewable energy sources are expected to be required and are crucial to facilitate integration. The grid infrastructure must be equipped to accept surplus energy contributions during daylight hours. Implementing or updating grid interconnection standards can help manage technical challenges associated with surplus energy sale, such as voltage regulation and grid stability.

Grid Stability and Management: Ensuring grid stability and managing the impact on the grid of multiple renewable energy source contributions will likely require appropriate upgrades or modifications to the grid management system currently being used. Investing in advanced grid management technologies, such as smart grids, energy storage systems, and demand response mechanisms, can mitigate the challenges associated with integrating surplus energy into the grid.

Building Assessment: Thorough on-site assessments are required to identify the best-suited locations for solar panels and rainwater collection systems, considering factors like available space, shading, and sunlight exposure. These should include additional building assessments to identify necessary renovations or modifications required to ensure structural integrity to accommodate solar PV panels or rainwater harvesting systems and to ensure that structural modifications adhere to safety standards and building codes. If inadequate space is available on-site, suitable government owned lands should be considered to install solar and tie it into the grid.

Expert Engagement: Solar PV and rainwater harvesting experts should be engaged in the design and installation of these systems to ensure they are optimized for the specific needs of each public building. The experts can provide training and capacity-building programs to public building staff who will operate and maintain the systems or establish contracts with qualified maintenance service providers. Organize workshops, seminars, or training programs to disseminate knowledge and build capacity among stakeholders regarding the installation, operation, and maintenance of these technologies. The experts given the responsibility for the selection and installation of the solar PV and rainwater harvesting systems should also be responsible for the development of maintenance plans and operating protocols, including establishing regular maintenance inspections, cleaning, and repairs, to ensure the longevity and efficiency of solar PV and rainwater harvesting systems.

Public Awareness: Launch public awareness campaigns to educate decision-makers, building owners, and the general public about the benefits and feasibility of solar PV and rainwater harvesting.

3.2.3 Capital Investment Financial Support

Financing capital costs can be a significant obstacle to adopting. Limited access to affordable loans or financing options can hinder the widespread adoption of these technologies. Encouraging financial institutions to offer favourable loan terms or establishing dedicated funds for renewable energy projects can address this barrier.

Some of the financing mechanisms include:

Grants and Incentives: The Government of Dominica, in collaboration with international partners, could provide grants and incentives to promote renewable energy adoption solar PV and rainwater harvesting initiatives. These incentives may include tax credits, duty exemptions, or subsidized financing options including grants or concessional funding.

Dominica's Climate Resilience Execution Agency for Dominica (CREAD): CREAD facilitates access to climate financing, including funding for renewable energy projects. It supports project development, capacity building, and investment facilitation.

Renewable Energy Fund: The Renewable Energy Fund, administered by the Dominica Social Security, provides financial assistance for renewable energy projects. It offers concessional loans, grants, and equity financing for eligible initiatives.

Exploring innovative financing mechanisms, such as green bonds or crowdfunding platforms, may also help to overcome this barrier. Encourage public-private partnerships to share the investment burden and leverage private sector expertise and resources. Establish dedicated funds or financing mechanisms that cater specifically to renewable energy and water conservation projects in public buildings.

3.2.4 Changes to Net Metering Policies

Implementing or revising net metering policies can enable energy surplus producers to sell excess electricity back to the grid. Net metering allows for a fair compensation mechanism and promotes the economic viability of solar generation systems. Reviewing and enhancing existing net metering regulations can encourage more participation. Net metering also has the advantage of eliminating the need for significant on-site battery storage. This is a substantial reduction of the expected cast for a fully autonomous power generation system, as battery storage costs are about 40% of the solar PV system cost.

Power Purchase Agreements (PPAs): A power purchase agreement between surplus energy producers and utility companies is a crucial requirement for the sale of excess electricity. Encouraging the development of standardized PPAs and providing support for negotiations can help manage the barriers associated with surplus energy sales.

Changes to Policy and Regulations: A favourable environment for renewable energy projects can be fostered by streamlining associated permitting processes, establishing clear guidelines for interconnection procedures, and updating regulations to reflect advancements in technology. Clear and supportive policies and regulations need to be formulated that facilitate the adoption of solar PV and rainwater harvesting on public buildings, including streamlined permitting processes and simplified approval procedures.

Financial Incentives: Introduce financial incentives such as feed-in tariffs, tax credits, or rebates to encourage public buildings to invest in renewable energy and water conservation technologies.

4 CAPACITY BUILDING AND DISSEMINATION OF RESULTS

Gender awareness, and therefore gender expertise in the project team, is a significant component of any project, as it allows for a clearing understanding of implementation would serve to improve how men and women benefit from project activities, as well as reduce levels of inequalities in the communities where interventions are taking place. The use of gender as a unit of analysis at this stage, must address who benefits from the project, and who needs to get information. Dissemination of results will only be impactful it is understood by the intended recipient.

> *"The people angle of climate change is relevant, "Age, level of education and socio-economic status are intervening variables in the level of concern about climate change. While the whole population should be targeted, special efforts should be used to pitch the messages of climate change to women, persons with low educational levels and the elderly in the public education programme" (UNDP-JCCCP, 2016)* (SAEDI, 2021)

The overall purpose of the project is to define technical and economic feasibility of solar PV units and water storage of public buildings in Dominica. This is intended to contribute towards the project's outcome to increase climate resilience in Dominica and reduce greenhouse gas emissions from fossil fuel dependence, by assessing the viability of installing solar PV units and water storage on public buildings. Key outputs and results from the project are captured in two separate reports:

1. Analysis of current electricity and Water Consumption Patterns in Public Buildings Throughout Dominica; and
2. Financial Analysis Report.

This section summarizes the key findings of both reports with respect to the dissemination of key results and takeaways to stakeholder groups.

4.1 Current Electricity and Water Consumption Patterns in Public Buildings Throughout Dominica

A site visit and detailed assessment was carried out for each of the twenty selected buildings listed in Table I to determine how solar panels and rainwater storage could be implemented at each building. This included assessments of the building orientation to the path of the sun, roof slope and area, potential locations for water storage, inspection of storage rooms, determining the electricity and water service entry locations to the buildings and a review of any existing backup electricity generation and/or water storage systems.

4.1.1 Electrical Assessment

With respect to electrical services, all the buildings were in good condition, with most of the buildings constructed within the last 5 years. The roof conditions were good to very good at most buildings, with the main exception of three: 1) Dominica State College Main Building & Office; 2) Vieille Case Community Centre; and 3) Trafalgar Community Centre. All three buildings had concrete roofs that were in a deteriorated condition (although the latter two facilities also had concrete roods in very good condition). Apart from N1 and N2 buildings at the Dominica State, the electrical power service into the buildings was also generally very good and functioning, Backup power generation was only available for some Dominica State College Buildings, and present, but not yet installed, at Trafalgar Community Centre and Roseau Fisheries Complex.

Table I. Solar/Electrical Site Assessment Summary

Building ID	Electrical Connection Type	Standby Generator? (Y/N)	Standby Generator Capacity (kVA)	Roof Condition	Electrical Services Condition	Recommended Renewable Energy System
Education						
DSC – Buildings A, B, C	Three-Phase	N	N/A	Very Good	Very Good	Solar PV only
DSC – Carpentry Building	Three-Phase	N	N/A	Good	Good	Solar PV only
DSC – Library	Three-Phase	N	N/A	Very Good	Very Good	Solar PV only
DSC – Building N1	Three-Phase	N	N/A	Very Good	Poor	Solar PV only
Dominica State College - Building N2	Three-Phase	N	N/A	Very Good	Poor	Solar PV only
DSC - Tourism Building	Single-Phase	Y	52 kVA	Good	Good	Solar PV only
DSC - Confucius Classroom	Single-Phase	Y	52 kVA	Good	Good	Solar PV only
DSC - General Studies Building	Single-Phase	Y	52 kVA	Good	Good	Solar PV only
DSC - Creative Caribbean Building	Single-Phase	N	N/A	Good	Good	Solar PV only
DSC - Main Building & Office	Single-Phase	Y	52 kVA	Poor	Good	Solar PV only
DSC - Jolly's Mini Pharmacy	Single-Phase	Y	52 kVA	Good	Good	Solar PV only
Dominica Community High School	Single-Phase	Y	5.5 kVA	Good	Good	Solar PV only
Mahaut Primary School	Three-Phase	N	N/A	Good	Good	Solar PV only
Community						
Vieille Case Community Centre	Three-Phase	N	N/A	Concrete Roof: Good Aluminum Roof: Very Good	Very Good	Solar PV and battery storage
Trafalgar Community Centre	Single-Phase	Y – Not yet installed	12 kVA	Concrete Roof: Poor Aluminum Roof: Good	Good	Solar PV only
Sineku Resource Centre	Single-Phase	N	N/A	Good	Good	Solar PV only
Health						
Mahaut Health and Wellness Centre	Single-Phase	N	N/A	Very	Very good	Solar PV and battery storage

Building ID	Electrical Connection Type	Standby Generator? (Y/N)	Standby Generator Capacity (kVA)	Roof Condition	Electrical Services Condition	Recommended Renewable Energy System
Newtown Health Centre	Three-Phase	N – Generator to be installed in coming weeks	TBD	Very good	Very good	Solar PV only
Other Sectors						
Roseau Fisheries Complex	Three-Phase	Y – Generator on site, but not yet installed	310 kVA	Very good	Very good	Solar PV only
Dominica Meteorological Office	Three-Phase	Y	N/A	Very good	Very good	Solar PV and battery storage

4.1.2 Water Storage Assessment

The water storage assessment recorded the location of water capture/storage units (if any existed), type of system, capacity, size, operation, maintenance needs and water usage data. Additionally, potential health risks (due to water quality issues, mosquito proliferation, etc.) related to the water collection systems and the storage vessel's anticipated endurance against climate events was noted. Half of the buildings that were assessed had existing water storage systems, with half of those located on the roof and the other half located on the ground at the base of the building. All water storage tanks were made of rubber. The water capture systems were all deemed to be capable of operating under hazardous conditions and design recommendations were mostly centred around the facilities having capabilities for both a rainwater storage system utilizing a gravity-fed circulation system and a rainwater storage system using a pump powered by a solar panel. The water storage condition for each site visited with storage tanks is highlighted in Table J.

4.1.1 Solar PV Recommendations

The electricity consumption and general conditions at each public building were assessed to verify the solar PV solutions developed through this assessment were in-line with DOMLEC's distributed Renewable Energy Policy. This policy allows for distribution generation systems below 150 kW based on the average monthly consumption of the buildings for the past 12 months divided by 150, then multiplied by 1.5.

The monthly consumption for each building was determined to identify the maximum permitted size of solar PV on each building. Then the available roof space was considered to determine the feasible solar PV system size for each building. Additionally, 3 buildings were deemed best suited for battery storage – Mahaut Health & Wellness Centre, the Dominica Meteorological Office, and the Vieille Case Community Centre and an additional analysis was carried out to determine the recommended battery storage system size for these buildings. Full details of the recommended solar PV and battery storage solutions and their estimated cost for building is provided in Table K.

Recommendations were also provided for the installation of resilient solar PV systems, based on the guidance contained in the report, "Solar Under Storm Part II: Select Best Practices for Resilient Roof-Mount PV Systems with Hurricane Exposure", which include:

- Require installation of PV modules only in wind Zones 1 and 2 for pitched-roof systems;
- Adopt minimum mechanical attachment specifications;
- Use top-down clamps that do not retain more than one module per clamp to avoid cascading failures;
- Require vibration-resistant fasteners;
- Ensure QA/QC during installation;
- Avoid self-tapping screws for structural loading in the design;
- Verify racking vendor meets recommended analysis and minimum mechanical attachment scheme;

Table J. Water Storage Summary

Building ID	Storage Type	Location of Storage	Is System Scalable?	How Sustainable is Building?	Can Water Capture System Operate Under Hazardous Conditions?	Any Design Recommendations?
Education						
Dominica State College	Rubber tank above ground	Ground setup	Y	Many buildings form campus and most not sustainable.	Yes, certain buildings act as an emergency shelter prior, during or after a natural hazard.	The college has a storage tank with a capacity of 15,000 imp gal. Most structures have timber roofs which makes them vulnerable.
Dominica Community High School	Rubber tanks at ground (existing, Nos.-6)	Ground setup	Y	New extension has concrete roof so additional tanks can be installed at roof level	Yes, this school was newly refurbished under BNTF 9. The new refurbishments enabled the school to be resilient in case of natural hazards.	Both a rainwater storage system utilizing a gravity fed circulation system and a rainwater storage system utilizing a pump powered by a solar panel can be utilized on this site.
Mahaut Primary School	Rubber tank above ground	Roof setup	Y	Sustainable	Yes, this school is newly built with design considerations to make it less vulnerable and more resistant to natural hazards. It was constructed in 2022.	Both a rainwater storage system utilizing a gravity fed circulation system and a rainwater storage system utilizing a pump powered by a solar panel can be utilized on this site.
Community						
Vieille Case Community Centre	Rubber tank at roof	Roof setup	Y	Building commissioned in 2021. Concrete roof exists so units can be placed there. No roof sealant applied, and cracking observed.	Yes, this community centre was newly constructed in 2021, with design considerations to make it less vulnerable and resistant to natural hazards.	Both a rainwater storage system utilizing a gravity fed circulation system and a rainwater storage system utilizing a pump powered by a solar panel can be utilized on this site.
Trafalgar Community Centre	Rubber tank at Roof	Roof setup	Y	Building commissioned in 2021. Concrete roof exists so units can be placed there. No roof sealant applied, and cracking observed	Yes, this community centre was newly constructed in 2021, with design considerations to make it less vulnerable and resistant to natural hazards.	Both a rainwater storage system utilizing a gravity fed circulation system and a rainwater storage system utilizing a pump powered by a solar panel can be utilized on this site.
Sineku Resource Centre	Rubber tanks at ground level (existing, Nos.-2)	Ground setup with cable fastening	Y	Building renovations done in 2021. Sufficient lands available to increase tanks. Resizing of pump maybe required.	Yes, however this structure has a timber roof.	Both a rainwater storage system utilizing a gravity fed circulation system and a rainwater storage system utilizing a pump powered by a solar panel can be utilized on this site.

Building ID	Storage Type	Location of Storage	Is System Scalable?	How Sustainable is Building?	Can Water Capture System Operate Under Hazardous Conditions?	Any Design Recommendations?
Health						
Mahaut Health and Wellness Centre	Rubber tank above ground	Ground setup	N	Same design as Mahaut Health Center	Yes, this health centre was newly constructed in 2021, with design considerations to make it less vulnerable and resistant to natural hazards.	Both a rainwater storage system utilizing a gravity fed circulation system and a rainwater storage system utilizing a pump powered by a solar panel can be utilized on this site.
Newtown Health Centre	Rubber tank above ground	Ground setup	N	Leaks on roof existing	Yes, this health centre was newly constructed in 2021, with design considerations to make it less vulnerable and resistant to natural hazards.	Both a rainwater storage system utilizing a gravity fed circulation system and a rainwater storage system utilizing a pump powered by a solar panel can be utilized on this site.
Other Sectors						
Roseau Fisheries Complex	Rubber tank above ground	Roof setup	Y	Sustainable	Yes, this building was rehabilitated and upgraded in 2022, with design considerations to make it less vulnerable and resistant to natural hazards.	Both a rainwater storage system utilizing a gravity fed circulation system and a rainwater storage system utilizing a pump powered by a solar panel can be utilized on this site.
Dominica Meteorological Office	Rubber tank above ground	Roof setup	Y	Sustainable	Yes, this building was recently built and appears to meet recent code changes with many sustainable features (e.g., concrete roof).	There is existing water storage on the roof, however, this can be augmented and in addition inclusion of PV system. Sufficient roof space exists to house these systems.

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

Building ID	Average Electricity Usage (kWh/mo)	Maximum Permitted Solar PV System Size (kWac)	Proposed Solar PV System Size (kWAC/kWDC)	Solar Panels Required (420W)	Battery Storage System Size (kWAC/kWh)	Estimated Cost (USD)
Education						
DSC – Buildings A, B, C	1,044	10.4	10 / 10.9	26	N/A	$19,600
DSC – Carpentry Building	2,051	20.5	20 / 21.8	52	N/A	$34,950
DSC – Library	504	5	5 / 5.8	14	N/A	$12,950
DSC – Building N1	244	2.4	2 / 2.52	6	N/A	$6,950
DSC – Building N2	290	2.9	3 / 3.3	8	N/A	$8,400
DSC – Tourism Building	105	1.1	1 / 1.2	3	N/A	$3,500
DSC – Confucius Classroom	538	5.4	5 / 5.8	14	N/A	$12,950
DSC – General Studies	848	8.5	8 / 9.2	22	N/A	$20,350
DSC – Creative Caribbean	151	1.5	1.5 / 1.6	4	N/A	$4,650
DSC – Main Building &	2,032	20.3	20 / 21.8	52	N/A	$34.950
DSC – Jolly's Mini Pharmacy	601	6	6 / 6.7	16	N/A	$14,800
Dominica Community High	314	3.1	3 / 3.3	8	N/A	$8,400
Mahaut Primary School	1,491	14.9	15 / 16.8		N/A	$30,250
Community						
Vieille Case Community	132	1.3	3 / 1.6	4	6 / 11.4	$25,650
Trafalgar Community	267	2.7	2.5 / 2.9	7	N/A	$8,100
Sineku Resource Centre	26	0.3	0.3 / 0.4	1	N/A	$1,200
Health						
Mahaut Health and Wellness Centre	614	6.1	6.1 / 6.7	16	10 / 30	$59,800
Newtown Health Centre	3,157	31.6	6.1 / 6.7	16	N/A	$14,800
Other Sectors						
Roseau Fisheries Complex	8,710	87.1	57 / 59.6	142	N/A	$95,400
Dominica Meteorological Office	1,920	19.2	10 / 10.9	26	20 / 68	$103,700

- Install positively retained wind deflector with vibration-resistant solution;
- Specify high load (target 5,400Pa front load rating) PV modules; and
- Require structural engineering in accordance with ASCE 7 and site conditions, with sealed calculations for wind forces, reactions, and attachment design.

Recommendations for monitoring the solar PV systems were also detailed to verify system performance, identify technical issues and defects, and determine the economic return on investment. Solar PV monitoring systems were strongly recommended for the installations, with monitoring systems capable of displaying 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; and
- Where battery storage is installed information on battery voltage, temperature, state of charge, state of health, and charge/discharge cycles should also be provided.

4.1.2 Rainwater Harvesting - Collection and Storage Recommendations

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

- Potential tank installation locations;
- Cost options associated with each design consideration; and
- Storage volume options.

Using the above design considerations, a variety of water collection system options were produced including conceptual design drawings and unit costs (included in Appendix 4 and 6 respectively of the "Analysis of Current Electricity & Water Consumption Patterns" report).

Although Table D in the "Analysis of Current Electricity & Water Consumption Patterns" report outlines the recommended potable water storage for each public building that we visited, it is difficult to determine how much of the building water is used for potable versus non-potable uses. However, it is assumed the primary use is for irrigation purposes. During our field visits we attempted to determine how much water was used for irrigation and this information is illustrated in Table L. However, most Stakeholders were unsure as to how much irrigation water was used. Consequently, water use information is sparse and requires further investigation.

Table L. Estimated Amount of Irrigation Water Needed at Each Public Building

Building ID	Irrigation Water Needed (gpd)
Trafalgar Community Centre	TBD
Dominica Community High School	500
Newtown Health Centre	TBD
Mahaut Health Centre	TBD
Roseau Fisheries Complex	TBD
Dominica State College	TBD
Mahaut Primary School	TBD
Dominica Meteorological Office	TBD
Vieille Case Community Centre	TBD
Sineku Resource Centre	TBD

Other than for the Dominica Community High School we were not able to obtain information on irrigation water use. Regardless, a variety of design options, including drawings, with varying storage volumes are provided in Appendix 4 of the "Analysis of Current Electricity & Water Consumption Patterns" report.

The core recommendations for rainwater collection and storage system maintenance include:

- Establish a rainwater harvesting best practices guidance document specific to the conditions in Dominica including information on collection, first-flush diversion, debris screening, treatment requirements for intended water uses, back-flow and cross-connection prevention, storage, and maintenance.
- Establish basic design principles for surface collection materials, treatment and risk management with respect to intended water uses.
- Establish a collection of resource documents for use by operations and maintenance personnel to review including information including standard operating procedures;
- Establish a recommended maintenance management system to maintain technical information and specifications on all physical assets (pumps, tanks, etc) including when purchased, supplier information, the physical location of each asset, performance specifications, capacities, installation details and service records;
- Establish a system of digital work orders that can be signed as completed by clients and are logged under each asset;
- Provide a means of work order requests (a way to raise issues and log response time) from clients and stakeholders;
- Provide scheduling and alerts for service visits;
- Provide a digital checklist for such service visits;
- Record and display data collected in the field in visual formats;
- Provide a troubleshooting guide for service providers and clients; and
- Provide a single point of communication between all parties.

Additionally, maintenance guidelines should include:

- Cleaning or replacing water filter(s);
- Verification of water quality in tank (free chlorine and bacteria detect/non detect test);
- Pump maintenance (as per vendor recommendations);
- Update of a computerized maintenance management system (CMMS) that water system has been serviced and is in good condition; and
- On-going trouble shooting and issue response by provider.

4.2 Summary of Financial Analysis Report

The Financial Analysis Report assessed the financial feasibility of the recommended solar PV and water storage solutions, including recommendations on good practices for the implementation of the systems, as well as possible financing schemes and business models.

4.2.1 Water

The design considerations, for rainwater harvesting (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 from local suppliers.

For all buildings, the recommended water capture system consisted of the following:

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

The proposed storage tank size and estimated cost for each building is provided in Table M and the cost of a storage tank plus solar panel (including the two (2) 1,000 gallon rainwater tanks) is shown in Table N. Table O provides the costs of the gravity-fed RWH including the two (2) 1,000-gallon rainwater tanks.

Table M. 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
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 N. Rainwater Harvesting 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 O. Rainwater Harvesting 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 rainwater harvesting 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. The collected rainwater can be used for many non-potable purposes including landscape irrigation, laundry, toilet and urinal flushing, vehicle and surface washing and fire suppression. The storage tanks can also be topped up with potable water during dry weather to reduce demands on the water distribution network during dry weather and serve as an additional water source wherever water is scarce including any disruption in the water distribution network or during natural disasters such as hurricanes. The non-potable purposes identified here are gendered in some ways including who is likely to play these roles in terms of the staff in the building as well as any maintenance activities which are likely to still be dominated by men as is landscape irrigation, vehicle, and surface washing suppression. Laundry as well as toilet/urinal flushing are likely to involve if not be dominated by female staff and information on the benefits as well as the use of these technologies needs to engage all of these potential users and workers.

4.2.2 Solar PV Systems

The estimated costs of the solar PV system and battery storage system (where applicable) have already been provided in Table H. Solar PV & Battery Storage System Capacities and Costs. Additionally, 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 on each building.

4.2.3 Feed-in Tariff and Economic Analysis

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 cost analysis of solar PV systems took into consideration eight key variables:

- Capital cost of materials;
- Labour to install panels;
- VAT on labour & materials;
- Yearly estimated maintenance fee;
- Estimated inverter replacement (once every 20-years;)
- Solar panel efficiency and changes with time;
- Feed-in Tariff rate; and
- Electricity savings based upon ECD $0.405 per kWh.

As an example, a financial analysis was carried out for two buildings – the Dominica Stage College Carpentry Building and Dominica Stage College Main Building and Office. The analysis on these buildings is scalable to other buildings.

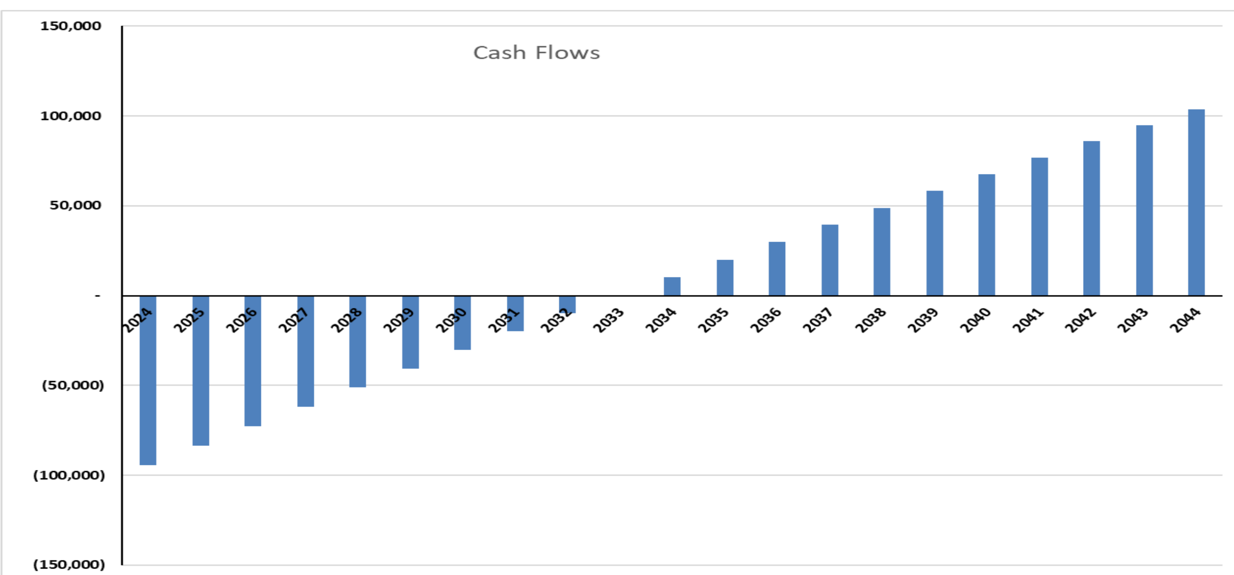
The estimated cost for the selected system for the Dominica State College – Carpentry Building and the Dominica State College – Main Building & Office is approximately ECS $95,400; this figure includes the total estimated cost for the technology, delivery, installation, and other extras with VAT. We 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 take 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 presents 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.

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.

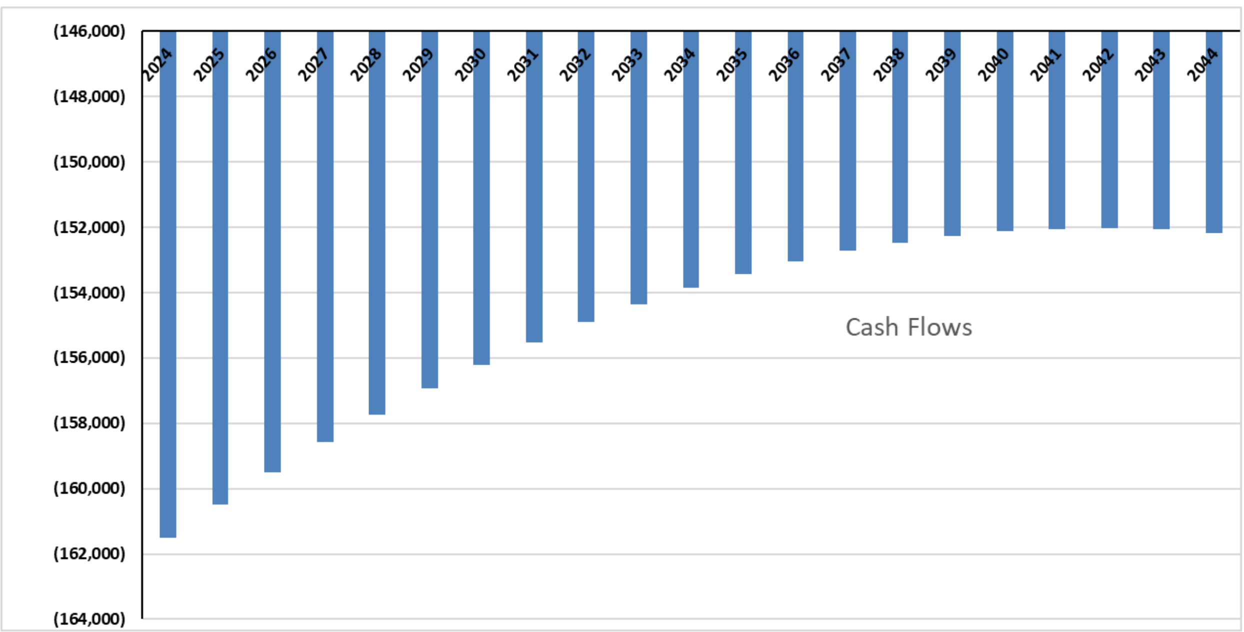
Figure A. Cash Flows Pay Back Period (20-years)



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$161,500 with the proposed PV system of 6.1 kWAC/6.7kWDC with 10 kWAC/30 kWh batteries. Again, these figures include the total estimated cost for the technology, delivery, installation, batteries, and other extras with VAT. It should be noted that the proposed PV system for the Newtown Health Centre in similar in size but without the batteries and the estimated cost of that system is approximately ECD$ 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 B. In the case of the solar PV system with batteries, the payback period is in excess of 20 years, when the Fit is considered. 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 B. Cash Flows Pay Back Period (20-years)



Overall, the Financial Analysis Report 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.

5 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,

Troy D. Vassos, Ph.D. FEC P.Eng.,
Technical Director & Team Leader, Integrated Sustainability

6 REFERENCES:

- Caribbean Environmental Health Institute. 2006. A Programme for Promoting Rainwater Harvesting in the Caribbean Region. https://carpha.org/saintlucia/Rain/Rainwater%20Harvesting%20Toolbox/Media/Print/ProgrammePromoteRWH.pdf
- CARICOM Energy Policy - "Renewable Energy Roadmap for CARICOM Member States" (2018): https://energy.caricom.org/wp-content/uploads/2019/08/RE_Roadmap_June2018.pdf
- Cherry-Fevrrier, Norma. 2014. Overview of regional-level RWH efforts in the Caribbean: A summary of past and current initiatives. Proceedings of the Rainwater Harvesting Knowledge Network Forum held in Saint Lucia from 21-23 October in 2014. https://drupal.caricom.org/sites/default/files/13338-final_rwh_rapporteurs_report.pdf
- Dominica Electricity Power Sector Reform Project: https://www.worldbank.org/en/results/2018/01/25/dominica-electricity-power-sector-reform-project
- Dominica National Energy Policy: http://www.caricomenergy.org/files/Dominica%20National%20Energy%20Policy%202007.pdf
- Dominica Geothermal Development Company (DGDC): http://www.dgdc.dm/
- Dominica Climate Resilience Execution Agency for Dominica (CREAD): https://creadominica.org/
- Dominica Social Security: Renewable Energy Fund: https://www.dominicassa.dm/investments/energy-fund
- International Renewable Energy Agency (IRENA) - "Renewable Energy Market Analysis: Caribbean" (2019): https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jul/IRENA_RE_Caribbean_2019_summary.pdf
- The World Bank - "Unlocking Dominica's Growth Potential: A Pathway to Sustainable Development" (2017): http://documents.worldbank.org/curated/en/126641509759674851/pdf/Unlocking-Dominica-s-growth-potential-a-pathway-to-sustainable-development.pdf

Tiwari, Birendra. 2021. Bacterial Analysis of Roof-harvested Rainwater and their Implications to Public Health in the Caribbean Island of Anguilla. Nepal Medical Collage Journal. 23(1):66-71.

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