Special Programme for Adaptation to Climate Change (SPACC)
Implementation of Adaptation Measures in Coastal Zones

TECHNICAL NOTE
5C/SPACC-12-05-01 (15 May, 2012)

Implementation of adaptation measures to address the absence of fresh water and coastal vulnerabilities in Bequia, St. Vincent and the Grenadines

The Special Program for Adaptation to Climate Change (SPACC) pilot project *"Implementation of adaptation measures to address the absence of fresh water and coastal vulnerabilities in Bequia, St. Vincent and the Grenadines"*, was implemented in Bequia, Saint Vincent and the Grenadines by the World Bank, acting as the implementing agency for the Global Environment Fund (GEF), and the Caribbean Community Climate Change Centre (CCCCC), acting as the executing agency.

Background

Bequia is the largest of the Grenadines islands, approximately 7 square miles in size, with a population of 4,874 (1991 census). Due to its size and geology, the island has no surface water and no known underground source. Approximately 30% of the island is covered with scrub vegetation of no market significance. The livelihood of the people of Bequia is tied to the surrounding coastal sea. Most natives are fisher folks or sailors. Given the absence of surface water and the calciferous nature of the soil, fresh water resource is a major issue for Bequia.

Bequia's need for water

Bequia's very limited water resources are being threatened by climate change. For people living in Bequia it is clear that dry spells are becoming unusually long, or that the pattern of the rainy season has changed. Water availability to key critical ecosystems is at greater risk as the limited water available is tapped or harvested by households due to the rain water supply systems that no longer meet their water needs. At present, there is no water distribution system in the island of Bequia. Each household has traditionally solved its water supply needs by building individual rain collection systems. It is indicated that up to 30% of the construction cost of a house in Bequia is allocated to the rain harvesting system.

The community and climate change

Of particular concern is the Paget Farms community (Figure 1) where the least wealthy population of the island lives. The entire community relies exclusively on rain water harvesting as the source of potable domestic water. In fact, many of the households in the Paget Farms community, the population targeted by this pilot, are equipped with underground storage that fill during the rainy season. The others utilize one or more glass reinforced plastic tanks that do not always satisfy their needs throughout the season and water supplies have sometimes had to be supplemented by purchase of water transported by barge from Kingstown.

Figure 1: Paget Farm community in Bequia, with Fisheries Complex in the foreground

Current trends in precipitation confirm what Global Circulation Models predict: there are longer periods of drought, followed by shorter, more intense precipitation events. Moreover, sea level rise is threatening coastal aquifers through saline intrusion. Both factors are already threatening water supply stability for already stressed populations, which in turn leads to over-exploitation of aquifers and natural resources, endangering the fragile ecosystems and associated biodiversity.

The project: building a carbon neutral reverse osmosis desalination plant

The pilot project in Bequia was aimed at exploring an integrated, sustainable solution to face these challenges: the combination of a renewable, carbon-free energy generation source (photovoltaic system), with a reverse osmosis desalination plant whose input is inexhaustible sea water.

The low-maintenance renewable energy source offsets the high energy demand of the plant by providing all the energy required plus some excess energy for the island, with the additional revenue generated covering operation and maintenance costs.

This combination has been proven to be both technically and economically viable, and showcases a robust, sustainable approach to the issue, with a very strong replication potential elsewhere in the Caribbean, where similar zones are suffering similar stress.

Figure 2: Hangar at Bequia Airport with solar panels installed on the roof

The photovoltaic system

A renewable energy (photovoltaic) system was installed on the roof of the hangar at the Bequia Airport and connected to the national VINLEC grid, and is monitored via an installed meter. A power purchase agreement will be reached with VINLEC

in order that all energy required for the operation of the desalination plant, will be guaranteed, while surplus electrical energy is transmitted to the island's grid to allow for expansion, but also to reduce energy production, operation, and maintenance costs.
An internet link has been provided to enable monitoring of the output of the system at http://www.sunnyportal.com/Templates/PublicPageOverview.aspx?page=f1ab5fb0-5daa-42a1-a0ac-e633037bc282&plant=274e4d44-ffec-4a07-ac98-bb2717d7a868&splang=en-US

The desalination plant

The desalination plant has been built to specifications to enable provision of water for about 1,000 inhabitants, the projected population of Paget Farms by 2018, while working at approximately 65% of its full capacity.
The water distribution system includes a permeate tank of 16,000 liters capacity, installed immediately after the desalination plant, plus a water storage and distribution tank of 90,000 liters capacity[1].

Figure 3: Exterior and interior view of the containerized SWRO plant installed in Bequia

The desalinated water will be pumped from the permeate tank to the larger storage tank, then gravity-fed into the distribution system. In order to facilitate distribution, the storage tank is located at an elevation of 150 meters above sea level, high enough for a gravity water distribution system to be functional. This location, near the top of the hill, is also close enough to the neighboring community, thereby enabling future expansion.
The benefits of this activity range from health and economic development benefits, production of clean renewable energy and reliable water supply to poor areas.

Specific details

Substantive installation of the SWRO plant was completed on 25th July 2011. Commissioning was conducted immediately afterwards, simultaneously with training of operators over the period

[1] This water storage and distribution tank will be located at an elevation of 450 feet above sea level, in a site selected to provide water supply by gravity feed to Paget Farm and surrounding communities. It is equivalent to the expected water consumption of the area served during a twenty-four hour period.

26th to 28th July 2011. It has been operational since, producing 34,560 gallons over a twenty-four test period while consuming 568.8 kwh of electrical energy. It was manufactured by FLOWTRONEX PSI Inc, ITT Corporation Company of Dallas, Texas, USA, through a procurement and installation contract with Caribbean Water Treatment Limited of St. John's Antigua. Three residents of the Paget Farms community were trained as operators.
Installation of the Photovoltaic system rated at 70 kW was completed by mid October 2011, and it was commissioned shortly afterwards. This was facilitated through a Procurement and Installation contract awarded to the Joint Venture of Grenada Solar Power of St. George's Antigua and Juwi Solar Power GmbH of Woerrstadt, Germany.

Institutional arrangements

The project has been executed by the Caribbean Community Climate Change Centre, utilizing a Grant provided by The World Bank, with GEF resources, on behalf of the Commonwealth of Dominica, Saint Lucia and Saint Vincent and the Grenadines.
Project management of the Bequia renewable energy-powered desalination system was provided by the CCCCC in Belize. The counterpart in Saint Vincent and the Grenadines was the Ministry of Health, Wellness and the Environment (MoHE), who appointed a focal point who acted as National Technical Coordinator.
From its inception, project management engaged with the Central Water and Sewage Authority (CSWA) and the electricity utility company (VINLEC). Through this partnership, specifications of the water distribution system and the general parameters for the desalination plant were designed in collaboration with CWSA engineers, while the technical details and installation support for the PV system was provided by VINLEC.
The equipment (both the desalination plant and the PV panels) are the property of the MoHE. A power purchase agreement is expected to be formalized between VINLEC and MoHE. This agreement has not yet been reached since it would be the first of its kind in the island; and the terms of the agreement need to ensure that all parties' concerns are addressed.
The desalination plant will be operated by CWSA. The company will introduce a water fee to the community. This rate of this fee has not yet been decided, and its institutionalization goes beyond CWSA and MoHE's attributions. This has been another source of delay in the final completion of the project.

Lessons learned and recommendations

The approximately one thousand residents of The Paget Farms community who previously depended on an unreliable supply of water derived from rain water harvesting are the immediate beneficiaries of this pilot project.
The renewable energy supply installed to provide electricity for the operation of the plant guarantees clean and environmentally safe source of power, but also generates a surplus that allows expanded provision of services to this and neighbouring communities.
Revenue can be generated through sales of bottled water (from the plant). This opportunity exists because Bequia is a sail-boat tourist destination, and this plant allows for local water supply that could replace supplies previously imported from Kingstown.
An important lesson learned was that institutional arrangements for the management and operations should be finalized very early during project execution; this would enable a seamless

and short period of transition between the procurement and installation of the components of the system and handing-over to the responsible authority or agency. This would also enable more effective technical supervision, greater quality assurance of the project during implementation, and help to establish ownership of the facility.

Certain policy decisions, such as introduction and collection of a water tariff in Bequia, were required for the sustainability of this pilot after "SPACC" and "Other Sources" of financial investments expired. Such policy changes or decisions were beyond the mandate of the Executing Agency, but within the purview of the local authorities, whether public or private sector. Stakeholders' response to a "willingness to pay" survey can contribute to such decisions.

The Government of St. Vincent and the Grenadines utilized the SPACC investments to leverage complementary funds from other international donours in order to install the remaining components of the system.

In this case the remaining components required to provide potable piped water to the yards of the entire and neighbouring community included the additional pipes, valves, and meters for the water distribution system. Similar co-financing approaches may be the way to go for countries who wish to extend the benefits of projects to a wider community.

Reverse osmosis is a proven technology that is increasingly utilized in coastal communities where fresh water supply is unavailable. Models like that installed in Bequia, can be scaled up in size and output to meet the demand of much larger communities.

The pilot demonstrated convincingly that the utilization of renewable energy for reverse osmosis desalination plants to make them sustainable is economically feasible and viable.

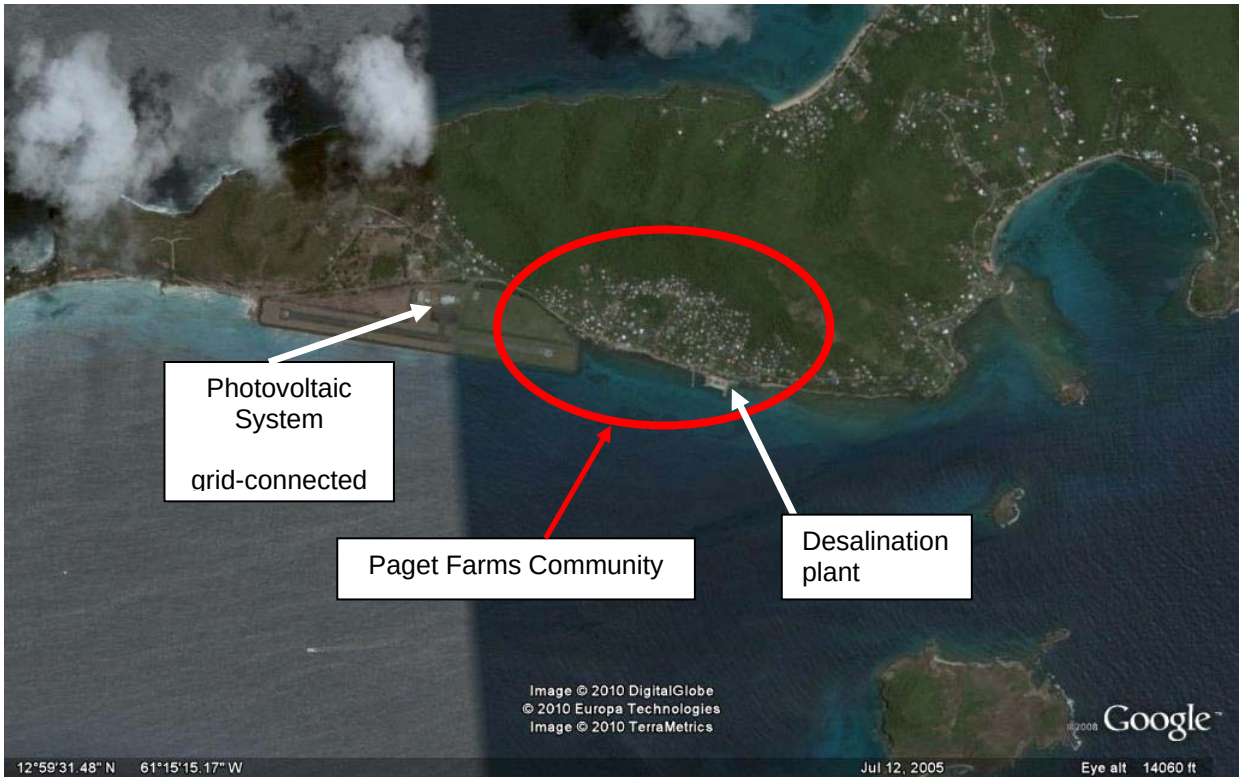

Figure 4: Map of Paget Farms community, showing approximate locations of SWRO plant, water storage tank, and PV system (for illustration purposes)

Technical specifications of the system

Sea Water Reverse Osmosis (Desalinization) plant

Type:	Reverse osmosis with pretreatment and energy recovery
Population to be served:	902 inhabitants in 200 households at 100 liters/person/day
Output design:	5.5 cubic meters per hour
Energy demand (per year):	78,000 kWh
Processed water storage tank:	16 cubic meters
Type of installation:	mounted inside a container, remotely monitored.

Water Distribution system

Main water distribution tank:	90 cubic meters
Pump to main tank:	5.5 KW
High pressure pipelines:	2,438 meters
Medium pressure lines:	6,456 meters

Photovoltaic System

Nominal Power:	70 kW
Rated Output:	130,000 kWh/year
Type of installation:	330 standard panels mounted on roof of the Bequia hangar. Remote monitoring.

Water quality

Tests were conducted on the effluent of the SWRO Plant, with results recorded as follows:

Parameter	Standards	Results
Turbidity	5 NTU	0.34
pH	6.5 – 8.5	6.8
Iron	0.3 mg/l	0 mg/l
Nitrate	10 mg/l	1.8 mg/l
Conductivity	<1000 ms/cm for sea water	507 ms/cm
Salinity	3 – 5 % typical sea water	2.44 %
Total Coliform	Nil/100 ml	Nil
Fecal Coliform	Nil/100 ml	Nil

The results indicate that the quality of the water produced by the plant was well above the WHO standard in all the parameters measured.

Final costs

Costs for the procurement and installation of the system as installed is valued at about eight hundred and nineteen thousand, one hundred ninety five dollars, United States currency. Additional details are described in the table below.

Item	Source of Funds (US currency)		
	SPACC	**Other**	**Total**
Design, preparation, & supervision costs	37,750.00	18,000.00	55,750.00
Geotechnical Survey & Analysis		5,230.00	5,230.00
Grundfos centrifugal pump		4,643.39	4,643.39
SWRO Plant	275,500.00	6,400.56	281,900.56
Permeate tank		10,014.75	10,014.75
Pump, mains, and main distribution line installation		46,706.41	46,706.41
Storage tank	19,500.00		19,500.00
Tank containment structure and Fence		80,706.11	80,706.11
Spares & consumables for the Plant		35,450.00	35,450.00
70 kW Photovoltaic System	305,043.00		305,043.00
Feasibility Analysis of the system		10,000.00	10,000.00
Total Project Investment in Bequia	***637,793.00***	***217,151.22***	***854,944.22***

Note: Older versions of this document contain an error in the calculated total cost of the installation. (Corrected 16th September 2014).