PROJECT BACKGROUND PAPER

“TOWARD THE DEVELOPMENT OF A CARIBBEAN REGIONAL ORGANIC WASTE MANAGEMENT SUB-SECTOR”

A GLOBAL ENVIRONMENT FACILITY (GEF)-CARIBBEAN REGIONAL PROJECT:

“DEVELOPMENT OF A CARIBBEAN REGIONAL ORGANIC WASTE CONVERSION SUB-SECTOR TO INCREASE COASTAL RESILIENCE AND CLIMATE CHANGE IMPACTS AND PROTECT FRESH WATER RESOURCES”

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18 MAY 2015
DRAFT 1.0
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1 INTRODUCTION

The overall project goal of the project is to establish and implement a special funding mechanism to support public private partnerships (PPP) for effluent waste to energy projects implementation in the Caribbean Community (CARICOM).

Although waste management was one of the priority areas of the Barbados Programme of Action (BPoA), no elaborated strategy was developed to help guide Small Island Developing States (SIDS) in the implementation of sustainable waste management systems. Consequently, waste management is now emerging as a major concern for SIDS as the consequences become manifest. It is therefore an urgent necessity for SIDS’ waste management experience to be studied, in order to identify approaches that are more socially equitable, less costly to operate, more environmentally friendly and less demanding on the limited land resources. Furthermore, it must be done in manner that will help the islands reduce their vulnerability to water stress.

The majority of regional populations have traditionally depended on environmental and natural resources to make a living, especially through commodities such as sugar and bananas, other agro-based industries, fisheries, minerals and tourism (which now accounts for one in ever four or five jobs in the Caribbean region, for example). This has led to a complex pattern of interaction of people, communities, institutions and industries with the environment, as energy and resources flow from the environment into patterns of human use, and as resulting waste materials flow back into the environment.

Solid and liquid waste management in the region is a mix of managed systems usually deployed in urban centers and tourism facilities and predominantly untreated disposal sometimes in open dumps, and waterways, for the rest of the population. Illegal dumping and littering are common, compared to recycling solid waste, which is practiced at a minimal level. Untreated waste has direct and indirect negative consequences for fresh water resources, tourism and agriculture, and industries, but more importantly, untreated waste affects public health and survival of Caribbean people, particularly the poor.

The region is heavily reliant on the public sector to manage the majority of generated waste, which is an increasing challenge, absent regulations and effective enforcement. To date, an individual waste management effort by either the private sector or the public service has proved
unsustainable and restrictive in promoting integrated sustainable waste management options or developing public private partners. In addition lack of resources or other restrictive means limit potential efforts toward sustainable waste management practices by both sectors. Promoting partnerships between public sector and government through policies, and incentives would open opportunities for greater private sector involvement, job creation, and change in attitude towards sustainable waste management at the regional, sub-regional and national levels.

2 REGIONAL GENERATION AND MANAGEMENT OF WASTE

The management of wastes throughout the Caribbean is marginally effective. As a result, severe damages to coastal ecosystems that should function as buffers against the impacts of climate variability and change, and support the critical tourism industry, have rendered coastal infrastructure and land uses increasingly vulnerable to climate change and sea level rise. Inadequate institutional arrangements, ineffective legislation, lack of monitoring of effluents and emissions, and failure of enforcement mechanisms relating to the management of waste characterize almost all countries in the Caribbean. The weaknesses are not only threatening fresh water resources but also public health.

The most common method of waste disposal in the Caribbean SIDS is landfilling, which is not recommended in the SIDS since land space is limited and there are more sustainable means of waste management. Incineration of solid waste is undertaken on a much smaller scale. Many of the solid waste problems being experienced in the Caribbean stem from packaging materials, disposable food containers, aluminum beverage cans and plastic bags. Population growth, increased urbanization, increase in per capita income and improvements in the standard of living have led to an increase in the purchase of goods that, because of advances in materials science, are now packaged in cheaper, non-biodegradable disposable material. An expansion of the tourism industry and an increase in the number of stop-over and cruise ship tourist arrivals have also resulted in an increase in the quantity of waste generated by the tourism industry.

Solid waste collection coverage in major Caribbean cities varies from 60 per cent to over 90 per cent of the population, with the exception of Haiti where it is much lower. In many Caribbean SIDS domestic waste comprises the largest proportion of total solid waste generated, followed by commercial waste. While waste collection is still inadequate in some countries, the major problem is that current disposal methods are unable to cope with the increasing quantity or the changing composition of the waste.

The composition of the solid waste generated in the Caribbean SIDS continues to change from mostly organic to inorganic material. This presents an additional challenge to solid waste management since these countries are already constrained by limited financial resources, spatial and geographical constraints, and insufficient technical personnel. Coastal and marine pollution caused by wastewater and solid waste is also a major environmental problem. Most of the pollution in the coastal and marine environment comes from land-based sources such as industries, surface runoff from agricultural and urban areas, and garbage that has been dumped in
rivers, streams, drainage gullies and wetlands. Inadequate inland waste water treatment facilities result in discharge at sea of marine generated waste by cruise ships into the Caribbean Sea.

**Solid Waste Disposal** – Many of the landfills in the Caribbean are sited in hazard-prone areas, without any of the necessary hydro-geological investigations. Drains, rivers, streams, wetlands, alleys and land depressions are all used as waste depositories. Many informal dump sites are unauthorized and were created in response to excess demand for waste disposal facilities. As a result, coastal ecosystems have often been contaminated, particularly mangroves and wetlands. In St. Vincent and the Grenadines, for example, lack of siting criteria for dumps has led to floodwaters taking sediments and plastics out to sea and depositing them on reefs. Tourism has also increased the amount of solid waste in the region, due to the massive import of goods to service the industry that generates additional demand for informal and unauthorized waste disposal facilities. Tourism can be harmful to the environment in a variety of ways. Cruise ships sailing through the Caribbean dump waste into the sea; one U.S. Environmental Protection Agency (USEPA) study in 2002 found that a ship carrying 2,000 passengers and 1,000 crew generated the same amount of waste as a small city, producing approximately 210,000 gallons of waste & sewage and 1 million gallons of gray water from showers and drains (per week), additionally about 6lbs (~3kg) of solid waste per person per day, from which only 15-25% is typically discharged on mainland as the ash from incineration is usually discharged at sea.

Wastes are inevitable by-products of biological life, which requires material and energy flows through living organisms. Accordingly, the biosphere has many integrated biodiversity-rich ecosystems in which one creature’s waste often becomes the food for another, facilitating the dispersal and disposal of naturally occurring wastes. Consequently, when ecosystems are in balance, they have a robust capacity to handle the environmental impacts of naturally occurring wastes. However when human behavior dispose more waste than can be handled by the ecosystems, or when the waste is of such composition that it negatively impacts the ecosystem then environmental problem arise, which negatively impact public health and economic well-being. Across the Caribbean of solid waste, waste water, and waste heat all represent wasted resource, that technology could transform into good and services.

If instead of depending on the ecosystems to take care of waste disposal government policy and incentives to foster the deployment of proven waste conversion technologies by private sector, solid and effluent waste could be transformed from a nuisance to a resource. The level of waste generated by Caribbean countries is not readily available as most of the waste data is for Municipal Solid Waste (MSW), effluent waste is not documented with any frequency, but across the region there are in excess of 1000 breweries, distilleries and sewage systems.
2.1 Municipal Solid Waste

In 2005, it was estimated that between 27,000 to 945,000 metric tons of waste was generated in the Caribbean and daily per capita waste ranged from 0.7 to 2.8 kilograms. Coverage of waste collection services in the region’s cities can range from 11 to 100% with a regional average of 80%. The uncollected waste is discarded in open spaces and eventually most of it makes its way to the coast. Given the spatial confines which add to concerns such as population density and competition for land use, these figures reflect a larger challenge.

Solid waste collection coverage in major Caribbean cities varies from 60 per cent to over 90 per cent of the population, with the exception of Haiti where it is much lower. In many Caribbean SIDS domestic waste comprises the largest proportion of total solid waste generated, followed by commercial waste. While waste collection is still inadequate in some countries, the major problem is that current disposal methods are unable to cope with the increasing quantity or the changing composition of the waste.

The composition of the solid waste generated in the Caribbean SIDS continues to change from mostly organic to inorganic material. This presents an additional challenge to solid waste management since these countries are already constrained by limited financial resources, spatial and geographical constraints, and insufficient technical personnel. This explains the dominance of landfills in the Caribbean being the best method of solid waste disposal in regards to scale-efficiency. Limited availability and competing needs for technology and financial resources also leads to a lack of other waste management options (incineration, waste-to-energy generation, composting and recycling) among other approaches.

Nonetheless, the Caribbean reality of solid waste management has slowly evolved considering countries such as Jamaica, Barbados and The Bahamas are developing existing legal and regulatory frameworks and securing funding to improve waste management infrastructure. Also, small islands such as St. Kitts, Dominica and St. Lucia have developed legislation in efforts to improve solid waste management:

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Waste Category (m³)</th>
<th>Household</th>
<th>Commercial</th>
<th>Industrial</th>
<th>Institutional</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antigua and Barbuda</td>
<td>2005</td>
<td></td>
<td>152878</td>
<td>176259</td>
<td>274964</td>
<td></td>
<td>604101</td>
</tr>
<tr>
<td>Bahamas</td>
<td>1998</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4979166</td>
</tr>
<tr>
<td>Barbados</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>365000</td>
</tr>
<tr>
<td>Belize (Western Corridor)</td>
<td>2014</td>
<td></td>
<td>34254</td>
<td>24053</td>
<td>2441</td>
<td></td>
<td>60748</td>
</tr>
<tr>
<td>Dominica</td>
<td>2011</td>
<td></td>
<td>8497176</td>
<td>2099418</td>
<td>826670</td>
<td>541256</td>
<td>12433767</td>
</tr>
</tbody>
</table>
Below are country by country profiles of waste generated in 14 Caribbean countries.
2.1.1 Antigua and Barbuda

Antigua has a population of about 73,661 inhabitants with a per capita waste generation of about 1.75kg/person. Tourism contributes greatly to this quantity of waste generation. Solid waste management in Antigua is centralized under the National Solid Waste Management authority (NSWMA) which manages all phases of solid waste management by disposal in landfill.

The NSWMA provides solid waste management services to 100% of the population with waste collection taking place once a week to daily and twice a day in some areas. Two major challenges that exist in Antigua and Barbuda is that there exists no national solid waste plan and a lack of funding for operational costs remains a weakness. Nonetheless, Antigua’s solid waste regulatory framework can be described as adequate. The strength of the system lies in the high level of organization and stability (Forde et al. 2002).

Presently, private participation in solid waste management system includes the contracting of the Antigua and Barbuda Independent Tourist Promotion Corporation to assist the NSWMA and Central Health Board. Also, some recycling initiatives exist with the recycling of glass that arrives on the island. This scheme recovers about 50% of the glass which would normally enter the waste stream.

2.1.2 The Commonwealth of the Bahamas

Bahamians and visitors tend to generate an estimated 264,000 tons of solid waste annually. Residential waste accounts for 70% of the waste collected and 30% for commercial waste. About 77% of this is generated in New Providence. The situation on more lightly populated islands indicated that the waste generated cannot be transported economical to a regional or central disposal facility therefore unique solutions to waste disposal needs to be considered for each separate island.

On New Providence, waste is disposed of at the Harrold Road Landfill. Some operational and technical problems include poor covering material, minimal compaction of waste and lack of control of the facility among other issues. On the Family Islands, there is a combination of official and unofficial dump sites whereas illegal dumping happens frequently. It is also safe to note that many of these dump sites are located along marshes, sea shores or near water supply fields and future groundwater-supply reserved lands.

The Department of Environmental Health Services (DEHS) provides collection for residential and small businesses through its Waste Management Division. Furthermore, commercial collection is provided by private operators. Some weaknesses of the DEHS include the lack of proper containerization and inadequate equipment management practices. Private contractors are responsible for collection on the Family Islands through contracts with Local Boards.

In the Bahamas, waste minimization is a minimal part of the current solid waste management practices. Nonetheless, re-use programmes tend to be more common than recycling (IDB, n.d.).
2.1.3 Barbados

In Barbados, the Sanitation Service Authority (SSA) is the body responsible for the collection and disposal of solid waste from homes and government agencies. A commercial arm of the SSA services the private sector. Residents benefit from a free collection service at least once a week and twice for densely populated parts of the island. In Bridgetown, collection increases to about 13 times a week as a result of growing commercial activity. Lack of infrastructure and curb-side recycling, along with the issue of illegal dumping are challenges in Barbados. Dumping usually takes place in gullies and remote areas of the island. Nevertheless, the reduction of dumping is compensated as a result of monetary rewards as part of a recycling scheme by the private sector for goods like refrigerators, washing machines and stoves. Mangrove Pond Landfill, one of four government solid waste disposal site receives approximately 1000 tons of garbage daily. It is also safe to mention that there hasn’t been a significant increase in tonnages for domestic waste in recent years. Most waste includes construction and demolition waste, green waste, wood pallets and other recyclables including plastics, glass and metals. Non-sewage waste such as effluent from the paint industry is disposed also of at Mangrove Pond (United Nations, n.d.).

2.1.4 Belize

A waste generation and characterization study was undertaken in four main municipalities in Belize. This included Belize City, San Ignacio/ Santa Elena, San Pedro and the Caye Caulker municipalities. Based on this study it was concluded that the waste generated per day was 1.07kg/cap with a component of 63.8%, 31.8% and 4.5% generated from residential, business/commercial sectors and from institutions respectively. In regards to waste composition, the major component was 33% biodegradable organic material. This consists of wood, yard waste such as leaves and twigs and a large proportion of food scraps. In addition, a percentage of 19% and 16% were noted for both plastics and paper respectively. Consolidating this waste into three categories, the components were 33%, 19% and 48% for biodegradable, non-recyclable and lastly recyclable waste respectively (IDB, 2011).

Waste disposal in Belize starts with waste transfer stations. They serve as link between the collection system and the final waste disposal facility which is the Mile 24 George Price Highway which the country’s regional sanitary landfill. At the transfer station, recyclable materials such as PET bottles, aluminum and steel cans are manually sorted out and removed from the facility. Residual waste is then hauled to the regional sanitary landfill.
2.1.5 Dominica

Solid waste collection services benefit between 50 – 70% of the Dominican Population. The per capita waste generation is about 0.91kg/person/day. Solid waste is managed by the Dominica Solid Waste Management Corporation (DSWMC). This body collaborates closely with the Environmental Health Department. Waste is disposed of at two major landfills (Roseau and Portsmouth), neither of which is secure; with the Portsmouth landfill being a little more than an open dump. There are plans to phase out and cap both landfills for a new secure Fond Colet landfill and a Portsmouth area transfer station. Industrial, Commercial and Institutional waste is privately collected usually by the generators themselves.

Due to staffing and financial problems, the island has been unable to achieve full collection coverage. Although the collection service in the capital of Roseau has improved, the south-eastern section of the island remains unserved by the Dominica Solid Waste Management Corporation, giving rise to complaints from a wide section of the community. Another weakness is a major lack of operational funding. Without access the necessary financial and human resources to provide collection services to the entire island, Dominica’s citizens will continue to suffer from insufficient solid waste management (The World Bank, 2003).

Composting of green waste is of great interest by the general public, possibly at the commercial level. The DSWMC is also promoting composting of rural domestic waste in order to reduce the amount of organic waste in landfills (Xavier et al. 2002).

2.1.6 Grenada

The Grenada Solid Waste Management Authority (GSWMA) is responsible for waste management in Grenada. The existing quantity of solid waste generation on the island constitutes to approximately 100 tons per day and about 40,000 per year with a per capita generation of about 0.85kg/person/day. This includes collection from residential, commercial and industrial sources. Biodegradable organic waste accounts for approximately 27.1% of collected waste. Also, 18.4% and 13.6% accounts for plastic and paper waste respectively. Recyclable waste accounts for 31.96% of the waste collected and Non-Recyclable waste (hazardous waste, other organic material such as textiles and other waste remaining) accounted for 37.94%. Currently, recyclables recovery in Grenada is minimal. Solid waste collection services the urban population between 100% in Grenada. (Rothenberger, 2015).

Some existing initiatives in Grenada have led to improved collection coverage and enhanced landfills. A firm legislative system for the management of solid waste and a very good cost recovery system are also some strong points of the solid waste management system in Grenada. Nonetheless, some weaknesses include a lack of responsibility and authority over monitoring as well as a lack of regulations to support solid waste legislation (DaBreo et al. 2002).
2.1.7 **Guyana**

In Guyana, particularly Georgetown, solid waste management is an integral part of the services provided by the municipality and unfortunately a formal system of solid waste separation is not implemented. Furthermore, waste characterization studies show that materials in the waste streams being informally separated only account for 24% of the waste generated. The impact is a result of the diversion of a significant part of the waste stream.

Data has shown that approximately 83,000 tons of waste is currently generated annually in Georgetown alone. Of this 50% is organic waste. The Georgetown Municipality provides collection service to approximately 42,400 households and about 2000 institutions and retail businesses. Commercial and Industrial entities are required to arrange their own waste transport (Urlin, n.d.).

2.1.8 **Jamaica**

The National Solid Waste Management Authority (NSWMA) in Jamaica is mandated to collect solid waste across the island. Yearly, approximately 1.2 million tons of municipal waste is collected across the island. The NSWMA separates the island into four major waste sheds. The percentage coverage of these four waste-sheds is around 76%. A sizeable portion of the solid waste is either recycled or reused. Nonetheless, a portion ends up in the environment, predominantly in waterways and shorelines.

Commercial clients are defined as all nonresidential entities which include schools and educational institutions, government ministries and agencies, penal institutions, manufacturing companies among others. The NSWMA already has plans to expand and diversify its services offered to the public. This will be achieved through collaboration with public and private partnership and include but is not limited to; commercial composting, recycling, scrap metal collection and marketing, waste exchange, hazardous waste storage, incineration and waste to energy (Murray, n.d.).

The waste management sector in Jamaica primarily funded through property taxes. Also, significant improvements have been made in regards to the collaboration with other sectors and partners. Where new development occurs in the municipality it is required that developers plan for the provision of solid waste management, for example. Furthermore, this sector has also seen an increase in the shared and participatory approach to waste management with a number of private sector companies and non-governmental organization evolving (PAHO, 2002).
2.1.9 **St. Kitts and Nevis**

The Solid Waste Management Corporation succeeds at over 95% collection coverage, with services in Basseterre and surrounding urban areas once or twice daily, semi-urban areas twice weekly, and all other areas at least once a week. A past study concluded that the island depends on the private sector for the collection of a bit over 75% of the waste primarily from institutional, industrial and ship-generated sources. Almost 100% of waste reached the landfills. The landfills now receive more waste resulting in a greater need for public knowledge on waste reduction and re-use. The Nevis Solid Waste Management Authority has improved collection practices though disposal remains a problem (The World Bank, 2003).

New development projects have resulted in an enhanced landfill system on both St Kitts and Nevis. With semi-autonomous bodies controlling their solid waste management systems, the per capita waste generation is 2.08 and 1.52 kg/person/day for St Kitts and Nevis respectively.

Presently, no legal or regulatory framework exists for the control of solid waste on either island. Legislation has been drafted but not passed by the governments. There is a degree of high functionality on both islands however; the system in St Kitts’s major weakness is the issue of underfunding. Also, there is a shortage of personnel in the area of solid waste management (Rawlins et al 2002).

2.1.10 **Saint Lucia**

2008 saw the generation of an estimated 80,470 metric tons of waste in St Lucia which translated to a daily per capita waste generation of 1.44 kilograms. 90% of the population benefits from solid waste management services.

The Saint Lucia Solid Waste Management Authority is responsible for the management of solid waste in Saint Lucia. There are currently two disposal sites in Saint Lucia: the Ciceron Waste Disposal Site and the Vieux Fort Solid Waste Disposal Site. The Ciceron Site is soon to be closed and the Vieux Fort Disposal Site upgraded. A modern disposal site that complies with international standards will be built to replace the Ciceron Site. The total volume of waste generated in 1998 was 202,045.5 m³. In 1999, the total volume was 259,884 m³; in 2000, 298,488 m³ and in 2001, the total volume of waste generated was 275,906 m³. Preliminary census results show that 88.4 per cent of households use the garbage trucks/skip as the main method of garbage disposal, followed by burning which is used by 5.1 per cent of households and dumping which accounts for the remaining 1.8 per cent of waste disposal (CARICOM Secretariat, 2004).
2.1.11 St. Vincent and the Grenadines

The Solid Waste Management Unit (SWMU) falls under the Central Water and Sewerage Authority (CWSA) and that in turns falls under the control of the Ministry of Health in Saint Vincent and the Grenadines. This semi-autonomous body has achieved 100% collection coverage on both the main islands as well as in Bequia, Canouan and Union Island in the Grenadines. Private operators provide services to other parts of the grenadines. The SWMU/CWSA provides daily collection services in the capital city, a weekly service to all other areas on St. Vincent, and services twice a week on all of the Grenadines. The SWMU/CWSA also has ensured that over 95% of all waste collected reaches the landfills on St. Vincent, as well as on Bequia and Union Island (The World Bank, 2003). The estimated per capita waste generation is estimated at 0.79 kg/person/day. Development projects in the grenadines have focused on improved to the system used for collection and a solid administrative framework.

The primary strength of the system in St. Vincent and the Grenadines is in the strong cost recovery programme and a solid staff and administration. Furthermore, there exists an institution which permits independent operation. A primary weakness lies in the lack of a solid regulatory framework to aid the basic controlling legislation (Lewis, 2002).

2.1.12 Suriname

Waste management constitutes as a major problem to the government of Suriname. An increase in the consumption of western products along with the expansion of residential areas in Greater Paramaribo has resulted in an increase in per-capita waste generation. The Waste Collection and Disposal Services (VOV) are in charge of waste disposal in Greater Paramaribo however the body is only able to collect an estimated 70% of the waste generated.

In Suriname, it is common practice to dispose of waste through legalized open dumping in addition to other methods such as open burning and sometimes illegal dumping. The primary method of waste disposal is in pits designated as landfills however there are more characteristic of open dumps without a weighing facility. Improper methods continuously contribute to the pollution of water resources and the emission of greenhouse gases.

Currently, there exists no solid waste management program by the government to monitor and manage these waste streams. It is also safe to add there has been no waste characterization study by the government and there exists no exact data about the waste being generated which results in more waste being uncollected. Furthermore, there are no reports on waste quantification and characterization. VOV has made rough calculations using a method of visual measurement. This includes counting the number of incoming trucks at the disposal site and estimating their capacity. It was estimated that about 70,000 tons of residential waste per year and 50,000 ton of crude waste from the commercial and industrial sectors is generated. Collection occurs two times a week in most cases with the technical consideration such as putrefaction rate of waste, weather, the mobile availability and routing necessities.
Admittedly, a great challenge which exists in regards to solid waste management in Suriname is the lack of essential equipment such as weighbridges at disposal sites. In result there is no data on waste composition and generation rate determined by changes in socio-economics status of a particular area.

There exists no formal program for recycling and Suriname relies more heavily on the informal sector for putting programs in place. Plastic material recycling occurs on a small scale (Zuilen, 2006).

2.1.13 Trinidad and Tobago

Waste disposal in Trinidad and Tobago is mandated by the Trinidad and Tobago Solid Waste Management Company Limited (SWMCOL). Collection is done by private companies who are sub-contracted to the various Regional Municipalities. Most of the solid waste collected is disposed of in three major landfills. These locations however pose an ecological threat to the wetland environment or negative effects on underlying aquifers. The daily amount of waste received in these landfills is about 607,700 tons. It is estimated that the average person generates approximately 4lbs or 2.2kg of waste every day (SWMCOL, n.d.).

The existing waste disposal practices moved from the "open dump" concept to a more controlled and sanitary operation. The practice of the burning of waste was reduced considerably, with the increased utilization of cover material on a regular basis as part of new engineering techniques.

In Trinidad, collection systems have shown an improvement in technology that is able to move later volumes of waste from collection to the sites of disposal.

2.2 Waste Water Generation & Treatment

In the Caribbean, facilities for the treatment of waste water are often insufficient and at times absent. As much as 85% of the waste water entering the Caribbean Sea is currently untreated and 51.5% of households across the region are not linked to a sewer connection. Furthermore, only 17% of households in the region are connected to suitable collection and treatment systems. In St Lucia, for example only about 13% of the population is serviced from a sewage system (Caribbean Environment Programme, 2004).

Poor water quality is one of the biggest threats to the reefs that buffer flooding from hurricanes and rising seas, provides protein for a significant portion of the population, and basis for beach tourism. Approaches to the treatment of increased generation of wastewater, includes use of on-site septic tank, soak-away and package treatment systems. In some cases, the tourist sector shares public sewage infrastructure with local communities, which increases the discharge of untreated effluents into the coastal environment.

According to the Caribbean Environmental Health Institute, the Caribbean average water consumption in the hotel sector is 3 to 4 times higher than that of domestic consumers, and according to the Caribbean Tourism Organization, 80 to 90% of the sewage generated across
the region by hotels is disposed of in nearshore coastal waters without adequate treatment. The end result of primary treated and untreated sewage disposal at the nearshore is the continuing build-up of algae on reefs. Similarly, such poor sewage disposal has also resulted in growing levels of eutrophication in many coastal waters near urban areas and harbors throughout the region. Traditionally, emphasis has been on low cost treatment approaches, such as septic systems or sewage outfalls. In the majority of these islands, the tax base has been insufficient to cover the expenditure necessary to establish treatment systems or to develop the infrastructure to facilitate effective sewage septic connections.

TABLE 2: WASTE WATER GENERATION AND ESTIMATED ENERGETIC CONTENT

<table>
<thead>
<tr>
<th>Country</th>
<th>Quantity of Waste Water generated</th>
<th>Quantity of Waste Water Treated</th>
<th>Estimated Amount of Organic Material</th>
<th>Estimated Energy Available (Based on Fuel Cell and CHP Technologies)</th>
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<td>Antigua and Barbuda</td>
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<td>Trinidad &amp; Tobago</td>
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</table>
2.2.1 Antigua and Barbuda

In Antigua and Barbuda, generally waste water is mainly generated from septic tank systems, sewage plants and to lesser extent some small industries such as paint production, distilleries and brewers. The septic tank system is utilized by approximately 65% of the residential and commercial sector. Furthermore, the majority of hotels and some businesses use sewage packaging plants on the island; however, in a past study it was revealed that 88% of these plants are not functioning properly. Ineffective and inefficient sewage disposal systems are therefore a major contributor to marine pollution.

In the country there exists no national sanitation policy and also there are no governing policies for wastewater discharge or proper enforcement systems. Furthermore, there is a lack of adequate domestic handling and holding facilities, waste disposal mechanism for septic tank sludge, and a lack of a central sewer system (Caribbean Environment Programme, 2010).

2.2.2 Commonwealth of the Bahamas

The Bahamas Water and Sewerage Corporation (WSC) is the statutory body responsible for water resources in the country. In the Bahamas, 15.6% of the population has access to sewage collection services and 44% of sewage treatment plants are in poor condition. Recognizing a need for providing water and waste water services on the New Providence Island, WSC directed Chester Engineers in 2008 to advance in a collaborative public/private approach with the developers to provide cost-effective enhanced wastewater treatment. This enables the WSC to continue to serve as the primary public water and wastewater service provider and it is predicted that the number of customers will increase. The facilities will provide wastewater service to 30% of households (90,000 customers) by 2017.

The collection and handling of sewage in The Bahamas is a mixture of systems from on-site treatment plants for resorts, to septic tanks in most household and a centralized sewer in parts of Nassau. About 20% of the population benefits from the central sewer system and the remaining have individual septic tanks. Most septic tanks and cesspits do not conform to the building code and in result do no function properly. Hence, contaminants are prone to permeate groundwater (ICF Consulting, n.d.).

Significantly most of the urban sewage collected by the Bahamas Water and Sewerage Corporation is brackish or saline, mainly because of the use of private wells and infiltration, and this means that it is unsuitable for reuse for irrigation purposes. It is therefore appropriate that the treated effluent be returned to a seawater environment, and just such an environment is conveniently located in the subsurface throughout the Bahamas. In a controlled collection system, like a private development, where the wastewater is fresh it can be reused, and this is the recommended procedure.
2.2.3 Barbados

In Barbados, central Bridgetown is serviced by a government operated sewage treatment plant. Most hotels however have privately operated sewage treatment systems. In regards to domestic and commercial properties, methods of disposal vary from environmental sanitary pits to water borne facilities. Disposal from homes is done underground via septic tank, well or earth pit and effluent from existing treatment plants is usually disposed to the sea after a primary treatment. The present capacity to treat or recycle wastewater is limited to the Bridgetown sewerage plant. This has a capacity of about 9000 cubic meters per day. Some hotels treat waste water and reuse it for irrigation purposes (Mwansa et al. n.d.).

The primary sources of land based pollution of the marine environment are Sewage from through flow of septic wells into the near shore region from domestic septic wastewater; Industrial Discharge; Agriculture chemicals and Land runoff; and illegal dumping of garbage.

Technology-related issues that need to be or are being addressed include those such as the use of freshwater resources - devices are available to reduce consumption; wastewater treatment and reuse are also promoted. Additionally, the Government has commenced a project to address sewering of the south and west coasts. The technological need of Barbados with respect to waste water treatment is up to tertiary level treatment technologies; and, with respect to water purification, it is presently limited to filtration and disinfections.

2.2.4 Belize

Belize Water Services currently maintains and operates the sewerage system in the Belmopan, Belize City and San Pedro Town municipalities in Belize. The coverage of these systems is under 100%. In Belize City, 37,500 consumers (roughly 12.5% of the population) benefit from the services and 1,500,000 gallons of sewage are treated per day. In Belmopan City, approximately 7,900 consumers (about 2.6% of the population) are served and 200,000 gallons (equivalent to 760,000 liter or 760 tons – per consumer this is a rate of 96 liter or 25 gallons per day per consumer) are treated per day. Furthermore in the municipality of San Pedro Town 3,400 consumers benefit from these services (1.1% of population) and about 160,000 gallons of sewage are treated per day.

Upcoming projects include a new wastewater collection and treatment system in the Placencia Peninsula, a very important tourist destination, with funding from both the Inter-American Development Bank (IDB) and the Global Environment Facility (GEF). Currently there is no wastewater collection and treatment facility serving this area resulting in residences and businesses providing their own treatment solutions which in result is unsustainable considering the growth in tourism in the area.
2.2.5 **Dominica**

One centralized sewerage system exits in Roseau and two smaller systems at Canefield and Jimmit. In Roseau, sewage after the removal of material and sludge, is collected and disposed of at sea. In the other two existing systems, sewage is collect and disposed of with no treatment about 1000 feet from the shore. In other areas of Dominica, waste water disposal is done by septic tank and soak away systems (Dominica Solid Waste Management, 2002).

2.2.6 **Grenada**

The two systems of wastewater management in Grenada are managed under the National Water and Sewage Authority (NAWASA). The two systems include a sewered system in St. George’s and fall out pipe at the stadium bridge and a sewered system along Grand Anse towards a fall out pipe at Point Salines. These two systems serve about 45% of the households on the island. The households with septic tanks and soakaways are served by tanker trucks and drained into one of the two sewer systems. The emptying of septic tanks occurs about every 2-5 years. These Septic tanks only tend to retain 20% of the backwater. Furthermore, the remaining 55% of the population depend on latrines and cesspit systems.

Households tend to divert the less polluted greywater from kitchen and bathrooms in separate pipes which drain in garden or nearby storm dreams or water bodies.

Wastewater in Grenada is usually not treated prior to being discharged in the sea. It is noted by the NAWASA that a waste water treatment plant is not considered high priory at the moment; the reasons being manly the high investment and operational costs and also space limitations.

2.2.7 **Guyana**

Guyana still faces constant institutional, financial and operational challenges in regards to the progression of access to safe sources of water and sanitation. Also, the quality of water supply is hindered by the deterioration of distribution networks. About 50 to 70 percent of water being used is unaccounted for at a national level and more than 70% in Georgetown itself.

Issues in the water and sanitation sector in Guyana include untreated and poorly treated sewage due to a shortage of wastewater treatment facilities. At present only about 13% of the country’s population has access to sewerage. Currently, the sewage system covers just about 48,000 people living in Georgetown which is 6.6% of the national population. This means that the rest of the population seeks individual solution in the form of cesspit, septic tank or pit latrine. Current sewage disposal practices seem to cause contamination of drinking water sources by fecal matter. The pollution of ground and surface water also presents serious effects on coastal and marine fisheries resources. The discharge of waste from distilleries and surface runoff also contributes to bad water quality (Caribbean Environment Programme, 2010).
2.2.8 Jamaica

The discharge of improperly treated wastewater effluent is one of the main contributors to coastal zone degradation in Jamaica. Mostly major urban areas benefit from sewerage services. 98.9% of households nonetheless have access to water closets and pit latrines which can be considered acceptable. Flush toilet is the main type of facility used by about 64.3% of households. Nonetheless, 42.4% of households are not linked to sewers which signify that soil absorption tends to be the main means of sewage disposal in Jamaica.

In rural areas, sewage is generally no provided with the exception of small housing developments. In rural households, 68% use pit latrines as a form as sanitation.

The largest network of wastewater treatment in Jamaica is comprised of sewage treatment facilities which are around 260 in total. These are owned by the National Water Commission (NWC). Kingston, St Andrew, St. James and St. Catherin account for about 90% of the water handled by the NWC. Within this NWC system, the capacities of plants can range from anything between 0.053 – 52.8 million litres per day (Caribbean Environment Programme, 2010).

2.2.9 St Kitts and Nevis

The population of St Kitts is considerably small. The same can be expressed for the number of industries and commercial activities. Hence the treatment of waste water on the island is to an extent nonexistent. Wastewater disposal is mostly done through a collection system of sewage from houses and places of commercial business. It is then deposited at a designated area at the landfill. Grey water is usually deposited directly to the ocean from houses and excreta deposited to the sewage system. A few businesses recycle waste water for use in washrooms (re-flushing). In regards to industrial waste water, it is usually treated in a system and then deposited via drains to the ocean. Municipal sewage in St Kitts and Nevis is generally stored in septic tanks and sent via conduit soak-away into the ground (United Nations – Waste Activity Information System, n.d.).

2.2.10 St Lucia

There are two sewerage systems in Saint Lucia. The first is a primary sewage collection and disposal system in the city of Castries, which serves approximately 15% of the greater Castries population and covers the business area, and the second is a sewerage system which includes collection, treatment and disposal and is located in Rodney Bay, to the north of the island and serves primarily residential areas and hotels. There is also one sludge and sewage treatment plant at Union. Currently the Rodney Bay treatment system is underutilized, and is running only 40% capacity. In total the plant serves a population of 3000-4000. Treated effluent from the system is discharged via an earth drain to a ravine which leads to the ocean on the East Coast of Saint Lucia (Government of St Lucia, 2010).
2.2.11 St. Vincent and the Grenadines

The wastewater management system in St Vincent and the Grenadines (SVG) was set up to manage only sewage in Kingstown. The majority of Kingstown is connected to an underground sewer system and waste is collected at a central point and pumped out to sea. Biological communities within the oceans have indicated the capability of breaking down and immobilizing the pollutants from the sewage as indicated by studies. In SVG this has proven to be effective. Nonetheless, in the event of outflow lines being damaged, it sometimes seeps and washes inward towards the islands. The majority of households in the rural and suburban SVG dispose of waste through, pit latrines or septic tanks with soak-away. The Public Health Department in SVG is responsible for the monitoring aspect but privately owned companies do the collection and disposal on the island. Grey water is collected by drains. In Kingstown, an existing problem is the grey water from restaurants and other establishments. Grease and other residue get caught up in drains creating a problem with odor and rodents (Culzac-Wilson, 2003).

2.2.12 Suriname

There is little or no waste water treatment in Suriname. Normally, domestic waste water is discharged into the Suriname River or the Saramacca Canal with little or no treatment in septic tanks. In Suriname, there exists a need for stabilization ponds and it can be noted that there is land availability for this. About 86% of the population use septic tanks and the remaining percentage utilize latrines, effluent from which enters the Suriname River via its tribunes.

About 25% of the interior population defecates in rivers which are also used for water supply. Also, the availability of sanitary facilities in the rural population is only accessible to about 44% of the population. It is common for people to use fields, bushes and rivers. On the coast and in Paramaribo, ground water is very high. The standard flowrate of domestic wastewater in the coastal region is estimated at about 0.7 m³/s. As a standard, septic tanks are designed mostly very high and prove inadequate to remove all solid. Also, soak-aways are often not functioning properly and effluent from septic tanks is directly discharged into ditches, canals and open storm drains.

Other domestic sewage, such as sullage as a product of personal washing, laundry and the kitchen enters storm and street drains untreated. There exists a serious financial and economic issue to maintain sanitation services especially in Paramaribo which continues to expand at an uncontrolled rate. There lies a great strain in the absence of a public sewer system. For example the flow of effluent into storm water drains may sometimes cause water back-up during period of heavy rain (US Army Corps of Engineers, 2001).

Some other major concerns in regards to water management and sanitation in Surname include biological, mercury and pesticide contamination as well as saltwater intrusion affecting some of the water supply. Nonetheless, the lack of water policy and water laws constitutes to the largest weakness in regards to the management of water resources.
2.2.13 Trinidad and Tobago

Around 92% of the population of Trinidad and Tobago has access to safe drinking water. The remainder receives water on a weekly schedule. About 30% of the 1.3 million inhabitants have a sewerage connection and 58% utilize soakaways or septic tanks. Also, 10% utilize latrines.

Over the past 50 years there has not been adequate expansion of the central sewerage system to match the population growth and housing developments. The Water and Sewerage Authority (WASA) has established policy where housing developments larger than 40 houses require sewerage and a water treatment plant. Nonetheless to date, WASA’s central sewerage system have not been expanded as anticipated. Effluents from these facilities, which usually contains poorly to untreated sewage, is then often discharged into water courses. Some of these are upstream intakes which in turn pose health and environmental risks and in result increase the cost of potable water treatment. Also, untreated sewage disposal into coastal waters and rivers not only impact the quality of aquatic life but also poses an economic threat to the tourism sector (Sammy, 2011).

2.3 Waste Heat

The regions primary source of energy for most islands in the region is imported liquid petroleum. It is estimated that the CARICOM countries import in excess of 30 million barrels of fuel for the generation of electricity. As shown in Table 4 on page 40 there is some 2500 MW of operating power plants in CARICOM fueled by imported diesel generating significant waste heat.

As pointed out earlier Caribbean countries are with increasing frequency being affected by changing rainfall regimes and water limitation is more frequent. The use of waste heat from power plants represents a major source of energy for purification of contaminated ground water, or desalination of sea water. Coupled with technologies such as spray flash evaporation many islands could develop a new reliable source of potable water under all weather conditions.

3 ENVIRONMENTAL AND HEALTH IMPACTS OF INADEQUATE MANAGEMENT OF WASTE

The management of wastes throughout the Caribbean is marginally effective. As a result, severe damages to coastal ecosystems that should function as buffers against the impacts of climate variability and change have rendered coastal infrastructure and land uses increasingly vulnerable to climate change and sea level rise. Fresh water resources the life blood of islands, is becoming less available, more costly to provide, and the situation is worsening in availability and quality as a result of waste entering waterways and leaching into aquifers, polluting underground water resources. Inadequate institutional arrangements, ineffective legislation, lack of monitoring of
The Caribbean region is rich in renewable water resources accounting for 30% of the world’s total, and the population is increasingly dependent on the supply of freshwater especially in regards to the agriculture and tourism. According to a study done by UNEP the pollution of existing freshwater supply in the region is moderate. The discharge of untreated or partially treated sewage and the intensive use of chemical are the main factor contributing to fresh water pollution.

In many countries wastewater treatment is considerably inadequate. In addition, manufacturing and processing plants including breweries/distilleries and paint manufacturing frequently discharges untreated effluents directly into rivers, or storage of waste in unlined holding ponds. In the larger Caribbean countries such as Jamaica, industrial pollution in particular presents a pressing problem given that the level of industrialization in regards to rum, sugar and petrochemicals. In Jamaica for example, there has been a concern about the discharge of industrial effluent into sinkholes which has resulted in the rapid movement of waste towards nearby ponds and aquifers. Solid waste management presents an issue as well in Jamaica, as unlined waste dumps/landfills allows leachates to infiltrate ground water.

Some critical challenges may include decreasing water per capita due to population increases, deforestation and climate change. Nonetheless a large contributor to the decrease in freshwater quality is the result of untreated sewage and the excessive use of fertilizers and pesticides and pollution from industries. The degradation of water quality of surface and groundwater in the region last 30 years has been significantly due to agriculture and untreated urban and industrial sewage. In agriculture processes, an excessive use of fertilizers has resulted in the growth of Lake Eutrophication.

The lack of environmental education increases the impact of these effects. In some instances due to the lack of solid waste collection systems in the region, many people see it fit to dispose of waste in drainage channels, mangrove swamps and alongside river bends. This practice results in the pollution of freshwater systems such as rivers and streams and eventually to the coastal waters. Poor disposal of solid waste results in the leaching of harmful contaminants into ground water resulting in the degradation of critical wetlands and/or coastal ecosystems. In Jamaica, leachate entering groundwater is a result of indiscriminate solid waste disposal and unlined dumps.

Also noteworthy, is the effect of improper disposal of waste on the propagation of diseases in the region. This is due to the progressive degradation environment’s natural ability to cleanse water pollutants and pathogens. The greatest threat to public health is from sewage related pollution and stagnant polluted water. This consists of water rich in nutrients that carry pathogenic microorganisms such as viruses and bacteria in the excreta of the population (UNEP, n.d.).

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1 Duncan
2 UNEP study
3 Source – Duncan paper
The most common method of waste disposal in the Caribbean SIDS is landfilling, which is not recommended in the SIDS since land space is limited. Incineration of solid waste is undertaken on a much smaller scale. Many of the solid waste problems being experienced in the Caribbean stem from packaging materials, disposable food containers, aluminum beverage cans and plastic bags. Population growth, increased urbanization, increase in per capita income and improvements in the standard of living have led to an increase in the purchase of goods that, because of advances in materials science, are now packaged in cheaper, non-biodegradable disposable material. An expansion of the tourism industry and an increase in the number of stopover and cruise ship tourist arrivals have also resulted in an increase in the quantity of waste generated by the tourism industry, which requires increased waste management capacity in the region.

Coastal and marine pollution particularly in the capital cities harbors, is caused by wastewater and solid waste is a major environmental problem. Most of the pollution in the coastal and marine environment comes from land-based sources such as sewage, industries, surface runoff from agricultural and urban areas, and garbage that has been dumped in rivers, streams, drainage gullies and wetlands.

Poor water quality is one of the biggest threats to the reefs that buffer flooding from hurricanes and rising seas, provide food security and the foundation of the tourism industry. Trends in the Caribbean include increased generation of wastewater, mostly on-site septic tank, soak-away and package treatment systems. In some cases, the tourist sector shares public sewage infrastructure with local communities, which increases the discharge of untreated effluents into the coastal environment. According to the Caribbean Environmental Health Institute, the Caribbean average water consumption in the hotel sector is 3 to 4 times higher than that of domestic consumers, and according to the Caribbean Tourism Organization, 80 to 90% of the sewage generated across the region by hotels is disposed of in nearshore coastal waters without adequate treatment.4

The end result of primary treated and untreated sewage disposal at the nearshore is the continuing build-up of algae on reefs. Similarly, such poor sewage disposal has also resulted in growing levels of eutrophication in many coastal waters near urban areas and harbors throughout the region. Traditionally, emphasis has been on low cost treatment approaches, such as septic systems or sewage outfalls. In the majority of these islands, the tax base has been insufficient to cover the expenditure necessary to establish treatment systems or to develop the infrastructure to facilitate effective sewage septic connections.

Coral reefs help protect coastlines, which include coastal communities, hotels and other investments, from storms. Researchers at Stanford University in California say the stony substance secreted by millions of tiny animals minimizes the force of sea waves and helps protect an estimated 200 million people in islands and coastal states from storms and rising sea levels. In a 2014 Stanford University scientists estimated that up to 60 per cent of coral reefs around the world have been wiped out, adding that things could be getting worse in the

4 Source – Duncan
Caribbean\(^5\). Other studies have shown that the region may have lost 80 per cent of its coral reefs. Heavy reliance on tourism by the Caribbean islands is said to be hastening the demise of the ecosystems. If this trend is allowed to continue the value of the Caribbean Sea as premier tourism destination will not be long if our governments do not act in a comprehensive matter to protect it, which means significant increase in actions for protecting the quality of the Caribbean Sea.

### 4 CARIBBEAN ENERGY SECTOR OVERVIEW

#### 4.1 General Overview

The quality of life of a population is directly proportional to the availability of energy, the efficiency that it is used to generate goods and services, and its environmental consequences. Imported petroleum is the dominant source of energy and imports account for an average of 12 per cent of regional imports. In response, several countries have drafted a number of national energy policies, strategies and action plans. Unfortunately, countries are not generating enough money to finance implementation of these policies and plans, in the absence of available donor support. Invariably, what happens is that the policies exist as paper, like so many policies, lacking the resources to implement and enforce. In March 2013, the CARICOM Energy Policy was approved by the Forty-First Special Meeting of the Council for Trade and Economic Development. The policy was developed to coordinate and expedite the increased use of renewable energy and energy efficiency and chart a new, climate-compatible development path that harnesses indigenous renewable energy resources, maximizes energy use, minimizes environmental damage, and spurs economic growth and innovation.

Many Caribbean islands are facing a very difficult energy situation. They are facing the challenges of affordable energy services, energy security and climate change mitigation and adaptation simultaneously. High oil prices and uncertain availability pose a major challenge for islands, security of supply is tied to proportion of mechanism through which energy is imported and financed. We do not know how high prices will go and when they will increase, there is too much volatility and this is evident in the negative impacts on small- and medium-sized businesses. Energy diversification and increased energy efficiency therefore becomes critical, and countries must look to seeing how they can diversify their economies. Questions such as, what should be the essence of such a guiding policy? Should we approach as individual countries, or regionally? And how could the Caribbean Single Market and Economy (CSME) be used as an effective mechanism for this purpose? Efforts to increase the proportion of electricity generation from RE becomes more important in the above context. Other major challenges can be summarized as follows:

- High electricity tariffs and generation costs represent a burden for the economy, private households and local companies;

\(^5\) Stanford University 2014 Study
• The financial status of some utilities is weak due to high diesel generation costs and technical and commercial efficiency losses;
• Low energy efficiency in buildings, appliances, industrial processes and technical and commercial grid losses results in power cuts and load shedding;
• Frequent power cuts have led to the installation of private diesel generators;
• National access rate to modern energy services remains at low levels on some islands;
• The available RE&EE potentials remain largely untapped;
• Increasing extreme weather events impact infrastructure and energy planning.

Energy access to modern and reliable energy services is not a significant issue in most of the Caribbean islands. CARICOM member states have universal or near-universal access to electricity, except for Belize, Guyana, Haiti, and Suriname. The dispersed rural populations in these countries are the main reason for their lower electrification rates despite their government efforts to deal with the issue. However, their rural electrification strategies often include the use of renewables to supply electricity to the rural populations. Cuba and the Dominican Republic have also significant rates of electricity access with 97 percent and 95 percent, respectively.

The energy sector is the most critical sector for the vast majority of small island states, and represents the major source of economic vulnerability. Sustainable development of these small island states is not possible without the existence of a highly integrated energy sector that not only has minimal dependence on external sources, but also synergistic linkages with waste management, water supply, agriculture, tourism, transportation, and general employment. In a number of Caribbean SIDS, the increased dependence on direct heating and cooking from biomass for domestic energy has resulted in accelerated de-vegetation, increased soil erosion, loss of biodiversity, and reduced availability of fresh water resources. As with fossil fuels, current biomass usage is inefficient.
With the exception of Trinidad and Tobago and to a lesser extent Barbados and Belize, all the countries in the region depend on the importation of fossil fuels to meet more than 90 per cent of commercial and industrial energy demand. The cost of fuel imports requires a significant percentage of foreign exchange earnings. In some cases, the cost of fuel imports is greater than the value of total exports of the country. It is estimated that some 85 per cent of all electric power in the Caribbean is still generated with liquid fuel. Overall, across the region, approximately 85 per cent of the population has access to electricity. The region’s consumption of petroleum fuel has increased from slightly over 116 million barrels in 1985, costing the region USD 530 million, to over 76 million barrels in 2011, costing more than seventeen times the 1985 costs (more than USD 9 billion). The increase in consumption is driven by the expansion in population and economic growth. Clearly, a key goal of any sustainable development strategy has to be reduction of the present high cost of energy services, relative to the value of Caribbean exports of goods and services so that the countries can compete in the global economy.

Out of 38 SIDS, only six (6) utilities are privatized, the majority (5) in the Caribbean, and one in the Pacific. In the Caribbean, privatization of regional electric utilities is motivated by budgetary pressure and a desire to attract private capital, and is promoted as a means to reduce government funding of the sector, to improve reliability, inefficiencies, and to reduce the cost of power. The list of privately held utilities includes Barbados, St. Lucia, Dominica, Jamaica, and Grenada. The list of public-owned utilities includes Antigua and Barbuda, Bahamas, Trinidad and Tobago, St. Kitts and Nevis, St. Vincent and the Grenadines, and Guyana. Most of the utilities are
monopolies, and in the case of Barbados, under current Barbados law, only the government-owned Barbados Light and Power Company (BLPC) is allowed to sell power to the general public. In Dominica, the privately-owned DOMLEC is the only entity that can sell power.

Grenada Electricity Services Ltd. (GRENLEC), a private-public owned utility company, holds a monopoly on the generation, transmission and distribution of electricity, and provides electricity to the islands of Grenada, Petite Martinique, and Carriacou. Virtually all of Grenada’s electricity is generated with diesel. The Electricity Supply Ordinance of 1961 provides GRENLEC with exclusive license for the generation, transmission, distribution and sale of electricity for a period of 80 years. A new Electricity Supply Act in 1994, reaffirmed GRENLEC’s market dominating position and granted it a monopoly until December 31, 2073 (Inter-American Development Bank – Caribbean Dev Trends, 2015).

With regard to regulation of the energy sector, the majority of the utilities are guided by Acts and Laws, where they exist, dealing with environmental protection and energy. Due to small scale, distance between islands and grids, distribution difficulties, and small markets, it is difficult to regulate the electricity sector similar to large economies. There are also frequent power cuts and blackouts. As noted, a number of countries suffer from unreliable supply that makes many businesses and households have to invest in stand-by generators which increase fuel consumption and are less efficient than large plants. These distinctions may make it difficult to apply international best practices in regulating water and energy infrastructure and utility services in small island countries. Regulatory practices developed for large countries and small landlocked countries can be excessive or expensive when applied to small island countries (Asian Development Bank, 2008).

Regulation is limited in the majority of islands, including the eastern Caribbean countries that are now looking at putting in place a regional regulatory authority. With support from the World Bank, the OECS plans to establish and operationalize a regional approach to the development of the electricity sector in participating countries, by supporting the establishment of the Eastern Caribbean Regulatory Authority (ECERA) (The World Bank, 2011). In the past 5-10 years, a number of Caribbean countries have put regulatory frameworks in place that outlines the legal requirements to be met and attendant policies, strategies, action plans, standards and guidelines.

Research on the regulatory experience in the Caribbean region show the structure of the industry and the regulatory arrangements are generally characterized by:

- Existence of vertical monopolies;
- Existence of 20-50 year exclusive licenses;
- Regulatory and oversight procedures which, with only few exceptions, are not open to public scrutiny;
- Very few tariffs are incentive based, and;
- Most utilities have cost-plus tariffs which guarantee a rate of return on capital (Binger, 2009).
Given that both public-owned or the privatized utilities remain dependent on imported petroleum fuels and neither are providing sustainable and/or reliable energy services at prices that allow the countries to be economically competitive, there is need to assess how the electric utility should best be structured so that it can provide the foundation for the blue-green economy, and which is consistent with the overall imperative of sustainable development, including the threats from climate change.

Few countries have regulatory capacity, therefore, if Governments with support of international agencies are encouraging privatization, then there is need to ensure that regulations are put in place prior to privatizing in order to make sure that the country’s well-being and development of a blue-green economy is not undone by the nature of the privatization. Examples where this has happened before include Dominica, which, despite its high hydro resources, has one of the highest prices of power in the region.

To facilitate the process of translating intentions into action, the CARICOM Secretariat developed the Caribbean Sustainable Energy Roadmap and Strategy (C-SERMS), designed to build on existing regional efforts and to provide CARICOM Member States with a coherent strategy for transitioning to sustainable energy. CARICOM members face a number of challenges in pursuit of energy security, poverty reduction, and building resilience to climate change including high and volatile oil prices; inadequate policies and regulations; inadequate promotion and investment in renewable energy and energy efficiency; lack of financing and technology transfer. The recently approved regional energy policy and the C-SERMS is intended to address a number of critical issues facing the regional energy sector.

4.2 Usage of Petroleum Fuel

The Caribbean region is heavily dependent on fossil fuel combustion, with petroleum products accounting for an estimated 93 per cent of commercial energy consumption. The islands of the Caribbean are predominantly net energy importers as shown below, with the exception of Trinidad and Tobago. Major imports of energy sources range from gasoline and diesel for transportation uses, and fuel oil for power generation and shipping, jet fuel for aviation, and Liquid Petroleum Gas (LPG) for domestic and some commercial applications. Meeting energy demand in CARICOM, in 2011, required the importation of more than 76 million barrels of petroleum fuels.

In recent years, the Caribbean countries have been negatively impacted by both the volatility and higher global oil prices that is frustrating economic development and employment generation. Had it not been for the PetroCaribe Agreement with Venezuela, the existing socio-economic situation would be a lot worse in some countries. In an effort to reduce the economic and social impacts of petroleum imports in 2005, Caribbean countries entered into an agreement – the PetroCaribe Alliance - with the government of Venezuela, to purchase oil on conditions of preferential payment.
Within the framework of the 2005 PetroCaribe Alliance, Venezuela supplies crude oil and petroleum products on concessional terms. The majority of Caribbean states have already joined the alliance, although Barbados is yet to do so. PetroCaribe only deals with state entities, whereby Caribbean nations import petroleum products under preferential terms allowing them to pay 60 percent of the cost while financing the rest with long-term, low-interest loans. Participating nations can also pay a portion in goods and services. Also, under the agreement, the Caribbean countries are expected to replace privately run storage and distribution facilities with a state-run counter-part for the Venezuelan-owned PDVSA (Binger, 2009).

5 AGRICULTURE AND FOOD PRODUCTION

The vast majority of the regional population is to some extent dependent on the natural resources for their livelihood. However, the limited resources base for production, and ineffective use, results in the region importing an estimated 90 percent of food. The region has limited food security in many ways similar to energy and is very dependent on imports. While agricultural products and food dominate exports they also dominate the region’s imports. In 2013, the Caribbean had an astronomically high annual food import bill of USD 4.75 billion.

In 2013, Jamaica 138.9 %, Grenada 115%, St Kitts-Nevis 104.9%, Antigua and Barbuda 92.9% and Barbados 92% had the highest debt-to-GDP ratio. At the lower end of the unsustainable high debt-to-GDP ratio are Guyana 63.9%, Dominica 74.95, Belize 75.5%, and St Vincent and the Grenadines 76.4% (source IMF and World Bank).

It should be noted that in the case of Haiti, while its debt-to-GDP ratio is low (21.3%), it has the highest rate of poverty at 77% of its population. Other countries with high levels of poverty are: Belize 41.3%, Grenada 37.7%, Guyana 36.1%, and St Vincent and the Grenadines 30.2%.
6 FRESH WATER RESOURCES IN CARIBBEAN ISLANDS

With growing awareness of fresh water deficits across the Caribbean due to changing climate, population and economic growth, water is an increasing limited resource and access will become more costly. Reduction in fresh water availability is not unique to the Caribbean according to the United Nations the world could suffer a 40 percent shortfall in water in just 15 years unless countries dramatically change their use of the resource, according to the United Nations Report. Many underground water reserves are already running low, while rainfall patterns are predicted to become more erratic with climate change.

As the world's population grows to an expected 9 billion by 2050, more groundwater will be needed for farming, industry and personal consumption. The report predicts global water demand will increase 55 percent by 2050, while reserves dwindle. If current usage trends don't change, the world will have only 60 percent of the water it needs in 2030, the report said (United Nations, 2015). This would have significant negative impacts on the Caribbean as food prices would increase, and imports food provides estimated 90 percent of its food the region’s consumption. Increased water stress would require additional use of electrical energy to desalinate and distribute potable water. Already the Caribbean has had to install more than a hundred desalination plants.

Freshwater drawn from the groundwater source requires 0.14–0.24 kWh/m³ (0.5–0.9 kJ/kg) for a pumping head of 100–200 ft. Conventional treatment of surface waters to potable quality requires 0.36 kWh/m³ (1.3 kJ/kg) (Gude, 2011). The cost of freshwater supply through conventional treatment is around $0.25/m³ (Gude, 2011). For Caribbean island states the alternative to fresh water from rainfall is reverse osmosis systems (RO). Energy consumption for a RO system is very dependent on size, it is estimated 100 cubic meter (m³)/day uses about 350 kWh approximately 3.5 kWh per Tonne of fresh water. A 500 cubic meter plant/day uses about 1400 kWh approximately 2.8 kWh per Tonne.

It is therefore critical that Caribbean islands states, particularly those that are already water stressed and have high cost electricity to take action to protect existing fresh water sources. The major threat to ground water resources quality, the major source of fresh water in the Caribbean Islands, is contamination from waste. Across the region effluent waste from agro-industries, sewage facilities, breweries, distilleries, along with water closets are the major threat to fresh water resources.

The value for renewable internal freshwater resources per capita (cubic meters) in Caribbean small states was 55,494 as of 2011. At current population levels, the available water supply in some of the Caribbean SIDS is significantly below the international limit of 1,000 m³ per capita per year below which a country is classified as ‘water scarce’. This limit places Antigua and Barbuda (800 m³ per capita), Barbados (301 m³ per capita), and St Kitts and Nevis (621 m³ per capita) in the category of water-scarce countries. The situation is critical in the low limestone islands of the Eastern Caribbean, where rainfall seasonality is very pronounced. In islands such as Anguilla, Antigua and Barbuda, Grenada, and Barbados, more than 65 per cent of total annual rainfall may be recorded in the wet season from June to December. In Barbados, groundwater
recharge is restricted to the three wettest months of the year, with only 15–30 per cent of annual rainfall reaching the aquifers. Much of the rainfall in the region is strongly associated with the genesis and passage of easterly waves, tropical depressions and storms, thus, changes in the occurrence of these events will have an impact on the water supply of many Caribbean countries.

Within the Caribbean, freshwater is a priority issue, albeit with different priority weights. Freshwater resources are vital for meeting basic needs and inadequate protection of the quality and quantity can set important limits to sustainable development. Despite literature reports that Latin America and the Caribbean Region is “rich in renewable water resources with more than 30 per cent of the world’s total” in most Caribbean islands (with Dominica and Jamaica as exceptions), rainfall is the sole source of freshwater, with several islands depending on the use of desalination water. The goal of reducing by half, the proportion of people without sustainable access to safe drinking water is a major challenge for Caribbean countries, as huge investments are needed to meet Millennium Development Goal (MDG) targets. Rapid urbanization, improved sanitation and health practices in rural areas, and persistent growth in tourism and in industrialization, have significantly increased the demand on freshwater resources.

Deforestation and the encroachment on protected areas of watersheds have resulted in significant changes in the water-retention capacity of the soil. Climate variability has been associated with serious droughts and water shortages, sometimes over extended periods. Deterioration and malfunction of the municipal water supply, poor maintenance and weak attempts at rehabilitation of irrigation distribution systems have created added problems in water resources management.

Degradation of upland watersheds, pollution from waste and chemical run-off from agriculture are the major factors determining the future quantity and quality of available potable water. The rapid growth of the tourism industry, which is estimated to account for 40 per cent of regional GDP, is also impacting water resources in most islands. Water consumption in the tourism industry is reported to be five or ten times higher than other residential uses, and growing populations are placing huge demands on the islands’ water. Many small islands no longer have any freshwater available from what were once freshwater ecosystems. Fresh ground water resources are being exhausted, polluted or degraded by salt-water intrusion or polluted by waste (UNEP, 2002).

Meanwhile, the region’s agriculture sector, already besieged by economic forces both local and international, will find it very difficult adapting to the impacts of climate change. The vast majority of agricultural production across the region is rain-fed. The projected reduction in precipitation would have a serious impact on food security and exports. The impact of climate change on agriculture is linked to its effects on water resources. In addition, changes in patterns of rainfall will increase crop vulnerability to certain diseases. In the case of bananas, that are highly water dependent (demanding 1,300-1,800 mm of water per year), adequate water supply is required to produce larger fruit size, and the lack of water is associated with the onset of Black Sigatoka disease. In the case of sugar cane, an increase in atmospheric carbon dioxide concentrations could cause a reduction in sugar cane yields.
Ensuring access to freshwater will become increasingly challenging for Caribbean countries as global temperatures and sea levels continue to rise. The Inter-Governmental Panel on Climate Change (IPCC) reports that water resources will be affected negatively; as models predict that the region’s annual precipitation could decrease by about five percent during the period to 2050, and by about seven percent by 2080 (UNFCCC, 2002). In the Caribbean, for example, a number of countries are already utilizing desalination processes for the production of potable water. Today, rising levels of wastes and pollutants accentuate such challenges. Consequently, effective management of water resources and watersheds is critical to the sustainability of development in the region.

7 DEVELOPMENT OF WASTE TO ENERGY TECHNOLOGIES

The consumption habits of the people of the Caribbean region are major contributing factors to the growing waste problem. Local landfill capacities will not be able to facilitate the waste at current rate for much longer in most cases. It is also suitable to consider that for many of the small island nations in the region, land is a limiting resource. As stated before, the waste issue also has an impact on the ecosystems and public health. A possible solution is to recycle waste for energy generation. As an energy source, energy from waste has a number of potential advantages beyond its renewable content such as its non-intermittent characteristic, energy security and the various potential energy outputs. Energy generated from waste can convert the waste to energy within a plant. This can be electricity and heat, or to ‘transportable’ energy-rich supplies such as substitute (synthetic) natural gas for injection into the grid or used as transport fuels. Also, simple chemicals could be used to make new materials.

Waste-to-energy technologies convert waste matter into fuel of various forms to be used for energy supply. Necessary feedstock can include municipal waste, agricultural waste, industrial waste and even gases such as methane naturally produced in landfills. The type of technology used for this conversion of waste to energy includes physical methods, thermal methods and biological methods.
7.1 Thermal Technology

Combusting waste is primary and historically used to reduce the volume of solid waste. Incineration technology is described as the controlled combustion of waste incorporating heat recovery in order to produce steam that in turn produces power through steam turbines. After pretreatment, municipal solid waste is fed to a boiler where high pressure steam is used to produce power. This is indirect generation with an overall efficiency of 15-27%. Processes such as pyrolysis and gasification produce a combustible syngas (synthetic/substitute gas) which can either be used to raise steam or by a more innovative means is cleaned up for the direct generation in a gas turbine or engines. This provides for better energy generating efficiency. The main difference is that they use less oxygen than traditional incineration. Syngas has a calorific value and therefore can be used as a fuel to generate electricity or steam or as a chemical feedstock in the petrochemical and refining industries. The calorific value is a factor of input waste composition. This gasification and pyrolysis process can be narrowed down to four stages (Friends of the Earth, 2009):

1. The feedstock may be in the form of derived fuel or mixed waste that has been processed through some type of recycling facility to remove recyclables and materials of no calorific value.
2. Waste is heated in a low-oxygen atmosphere to produce residue (gas, oils, char)
4. Scrubbed gas is used to generate electricity or heat through the use of combined heat and power (CHP)

Advantages of these waste-to-energy technologies as opposed to traditional mass-burn incineration include:

1. The use of less oxygen may produce fewer emissions.
2. Plants are made up of small units which are removable as the volume and composition of waste streams change. They are also quicker to build.
3. The product produced is more useful as it can be used for fuel of feedstock in other applications.
4. Syngas is a more energy efficient energy generation route.

7.2 Biological Waste Treatment Systems

The purpose of biological waste treatment is to convert dissolved and colloidal pollutants to cell mass, water, and gases. However, many times cell growth is too small to collect by any particle method. Microorganisms create an increased demand for oxygen when they are discharged from a treatment plant to a body of water. The challenge is to gather the cells into aggregates or flocks large enough to collect by filtration or sedimentation, systems used to do this includes (Bungaym 1992):
7.2.1 Trickling Filters:

There are several different types of trickling filters but all are based on the same basic principles. There must be a period when drainage is good so air can percolate into the matrix. Organisms attach themselves to the solid medium and get their nutrients from the liquid and oxygen from the air.

7.2.2 Activated Sludge:

Activated sludge units are usually rectangular tanks when constructed on site, while fabricated supplier units are likely to be circular. In both designs, the feed enters a zone that is aerated with air bubbles and liquid in good contact. The aeration could be evenly distributed throughout the tank, tapered or stepped, depending on the process demand.

7.2.3 Lagoons:

Sunlight is used to promote photosynthesis so these units are usually rich in oxygen at the surface or top. However, deep lagoons may be anaerobic at the bottom. Most lagoons have no added mixing and rely mostly on wind, diffusion, flow and the sinking or floating of microorganisms for mixing. Deflectors and baffles may be used to distribute flow through ineffective, stagnant regions. A raceway design is the most reliable method to encourage plug flow.

7.2.4 Mechanical Biological Treatment (MBT)

A mechanical biological treatment system is a type of waste processing facility that combines a sorting facility with a form of biological treatment such as composting or anaerobic digestion. MBT plants are designed to process mixed household waste as well as commercial and industrial wastes.

MBT is also sometimes termed BMT – biological mechanical treatment – however this simply refers to the order of processing, i.e. the biological phase of the system precedes the mechanical sorting.

7.3 Anaerobic Fermentation

Anaerobic fermentation is a collection of processes by which microorganisms break down biodegradable material in the absence of oxygen. The process is used for industrial or domestic purposes to manage waste and/or to produce fuels. Much of the fermentation used industrially to produce food and drink products, as well as home fermentation, uses anaerobic digestion. Anaerobic fermentation occurs naturally in some soils and in lake and oceanic basin sediments, where it is usually referred to as "anaerobic activity". This is the source of marsh gas methane.
The digestion process begins with bacterial hydrolysis of the input materials. Insoluble organic polymers, such as carbohydrates, are broken down to soluble derivatives that become available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. These bacteria convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Finally, methanogens convert these products to methane and carbon dioxide. The methanogenic bacteria populations play an indispensable role in anaerobic wastewater treatments.

It is used as part of the process to treat biodegradable waste and sewage sludge. As part of an integrated waste management system, anaerobic digestion reduces the emission of landfill gas into the atmosphere. Anaerobic digesters can also be fed with purpose-grown energy crops, such as sorghum and millet and other grasses. Anaerobic fermentation is widely used as a source of renewable energy. The process produces a biogas, consisting of methane, carbon dioxide and traces of other ‘contaminant’ gases (hydrogen sulfide). This biogas can be used directly as fuel, in combined heat and power gas engines or upgraded to natural gas-quality bio-methane. The nutrient-rich effluent produced can be dried and used as very valuable fertilizer.

With changing attitude recognizing waste as a resource, and new technological approaches which have lowered capital costs, anaerobic digestion has in recent years received increased attention among governments in a number of countries.

7.3.1 Biogas Fuel Cells

A fuel cell is basically electrolyte medium, sandwiched between positive and negative electrodes that result in chemical reactions producing electrical energy. To generate electricity, outside air flows through piping into the fuel cell, entering at the cathode. Upon contact with the negatively charged cathode, oxygen atoms in the incoming air acquire extra electrons, thus becoming ions that diffuse through the electrolyte medium. The oxygen ions travel towards the positively charged anode, where they react with the hydrogen in the fuel entering the cell at the anode, shedding extra electrons that travel out of the fuel cell as electricity, along with water from the reaction between oxygen and water.

A major benefit of biogas-powered fuel cells for energy production in small Caribbean states is the ability to transform a waste stream directly into base-load electricity at relatively small scale through distributed generating systems to offset grid purchases. Fuel cells have very high fuel conversion efficient and produce more electricity per unit of fuel consumed than combustion technologies and zero emissions. The exhaust of a fuel cell is Fuel Cells boost net output of electricity by a minimum of 60%, compare at: Reciprocating engines (CHP) 30%, Turbine engines 40% and Fuel Cells at 60% efficiency roughly 750 degrees Fahrenheit (398,8°C). The water is released in high temperature exhaust air, and can be used for refrigeration or absorption cooling or provide hot water for buildings. Waste heat can also be fed back into biogas digesters to maintain heat or support faster material breakdown.
7.4 Waste Heat Utilization for Desalination

In the industrial sector, energy efficiency is of great importance. In order to improve energy efficiency, the focus on reducing the energy consumed by the equipment used in manufacturing processes like boilers, furnaces, motors, etc., and sometimes a shift in process techniques. An additional option to increase energy efficiency is to capture and reuse waste heat that is intrinsic to all thermal processes. In the processing industry, as much as 20 to 50% of energy consumed is lost as waste heat in the form of hot exhaust gases and from cooling water as well as though conduction, convection and radiation from the surface of hot equipment and product streams. Sources of heat waste are available in offices as well, for example from heating or ventilation systems.

Three factors need to be taken into account in regards to waste heat recovery:

1.) Source of waste heat has to be accessible
2.) Recovery technology proven
3.) Use for recovered energy

### TABLE 3: WASTE TO ENERGY TECHNOLOGIES (BCS, INCORPORATED, 2008)

<table>
<thead>
<tr>
<th>Temperature Range</th>
<th>Examples of Sources</th>
<th>Advantages</th>
<th>Typical Recovery Technologies/Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;650°C</td>
<td>Nickel refining furnace</td>
<td>High quality energy, available for a diverse range of end uses with varying temperature requirements</td>
<td>Combustion air preheat</td>
</tr>
<tr>
<td></td>
<td>Steel electric arc furnace</td>
<td></td>
<td>Steam generation for process heating or for mechanical/electrical work</td>
</tr>
<tr>
<td></td>
<td>Basic oxygen furnace</td>
<td></td>
<td>Furnace load preheating</td>
</tr>
<tr>
<td></td>
<td>Aluminum reverberator Furnace</td>
<td></td>
<td>Transfer to med-low temperature processes</td>
</tr>
<tr>
<td></td>
<td>Copper refining furnace</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steel heating furnace</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Copper reverberator furnace</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hydrogen plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Glass melting furnace</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coke oven</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iron cupola</td>
<td></td>
<td></td>
</tr>
<tr>
<td>230-650°C</td>
<td>Steam boiler exhaust</td>
<td>More compatible with heat exchanger materials</td>
<td>Combustion air preheat</td>
</tr>
<tr>
<td></td>
<td>Gas turbine exhaust</td>
<td>Practical for power generation</td>
<td>Steam/power generation</td>
</tr>
<tr>
<td></td>
<td>Reciprocating engine exhaust</td>
<td></td>
<td>Organic Rankine cycle for power generation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Furnace load preheating, feed water preheating</td>
</tr>
</tbody>
</table>
Temperature Range | Examples of Sources                                      | Advantages                                                                 | Typical Technologies/Methods                      |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heat treating furnace</td>
<td></td>
<td>Transfer to low-temperature processes</td>
</tr>
<tr>
<td></td>
<td>Drying &amp; baking ovens</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cement kiln</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;230°C</td>
<td>Exhaust gases exiting recovery devices in gas-fired</td>
<td>Large quantities of low-temperature heat contained in numerous product</td>
<td>Space heating</td>
</tr>
<tr>
<td></td>
<td>boilers, ethylene furnaces, etc.</td>
<td>streams</td>
<td>Domestic water heating</td>
</tr>
<tr>
<td></td>
<td>Process steam condensate</td>
<td></td>
<td>Upgrading via a heat pump to increase for end use</td>
</tr>
<tr>
<td></td>
<td>Cooling water from furnace doors, annealing furnaces,</td>
<td></td>
<td>Organic Rankine cycle</td>
</tr>
<tr>
<td></td>
<td>air conditioning and refrigeration condensers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drying, baking, and curing ovens</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hot processed liquids/solids</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As shown in Table 4 on page 40 the Caribbean region has some 2500 MW of installed thermal electricity generating capacity. The majorities of these generating plants are located in close proximity to the ocean, and consequently represent a significant source of potential energy for increasing the availability of fresh water. Water stressed countries such as Antigua and Barbuda, Anguilla, Curacao, Aruba, Bahamas, Barbados, Virgin Islands, could derive increased fresh water supply using the waste heat from their power facilities to significantly increase potable energy availability. For countries that are already depending on salt water to provide potable water the technological choice has been reverse osmosis. Reverse osmosis has electrical energy requirements.

As power is generated from imported diesel fuel, reverse osmosis facility expenditure of additional foreign exchange and has a significantly higher carbon foot print compared to waste heat systems. Energy consumption for a RO system is very dependent on size, it is estimated 100 cubic meter (m$^3$)/day uses about 350kWh approximately 3,5 kWh per Tonne of fresh water. A 500 cubic meter plant/day uses about 1400 kWh approximately 2,8 kWh per Tonne. Freshwater drawn from the groundwater source requires 0.14– 0.24 kWh/m$^3$ (0.5–0.9 kJ/kg) for a pumping head of 100–200 ft. Conventional treatment of surface waters to potable quality requires 0.36 kWh/m$^3$ (1.3 kJ/kg) (Gude, 2011) . The cost of freshwater supply through conventional treatment is around $0.25/m$^3$ (Gude, 2011).

In addition to potentially improving availability of potable water through use of waste heat, such a facility would provide a source of water that is less vulnerable to weather related natural
disasters. Public private partnerships between power companies and water companies would be
developed in each country and prefeasibility studies would be prepared. These prefeasibility
studies will be used to promote the opportunity and for procuring financing for the portfolio of
projects across the region.

**TABLE 4: CARICOM MEMBER COUNTRIES ELECTRIC POWER GENERATION INSTALLED
CAPACITY**

<table>
<thead>
<tr>
<th>Country</th>
<th>Company</th>
<th>Year</th>
<th>Installed Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fossil Fuel</td>
</tr>
<tr>
<td>Anguilla</td>
<td>ANGLEC</td>
<td>2013</td>
<td>27</td>
</tr>
<tr>
<td>Antigua and Barbuda</td>
<td>APUA</td>
<td>2014</td>
<td>122</td>
</tr>
<tr>
<td>The Bahamas</td>
<td>BEC</td>
<td>2014</td>
<td>500</td>
</tr>
<tr>
<td>Belize</td>
<td>BEL</td>
<td>2014</td>
<td>92</td>
</tr>
<tr>
<td>Bermuda</td>
<td>BELCO</td>
<td>2014</td>
<td>190</td>
</tr>
<tr>
<td>Barbados</td>
<td>BLPC</td>
<td>2014</td>
<td>240</td>
</tr>
<tr>
<td>British Virgin Islands</td>
<td>BVIEC</td>
<td>2014</td>
<td>39</td>
</tr>
<tr>
<td>Cayman Islands</td>
<td>CUC</td>
<td>2014</td>
<td>131</td>
</tr>
<tr>
<td>Dominica</td>
<td>DOMLEC</td>
<td>2014</td>
<td>20</td>
</tr>
<tr>
<td>Suriname</td>
<td>EBS</td>
<td>2013</td>
<td>191</td>
</tr>
<tr>
<td>Haiti</td>
<td>EDH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Bahamas</td>
<td>GBPC</td>
<td>2014</td>
<td>98</td>
</tr>
<tr>
<td>Guyana</td>
<td>GPL</td>
<td></td>
<td>174</td>
</tr>
<tr>
<td>Grenada</td>
<td>GRENLEC</td>
<td>2013</td>
<td>52</td>
</tr>
<tr>
<td>Jamaica</td>
<td>JPSCO</td>
<td>2014</td>
<td>833</td>
</tr>
<tr>
<td>Saint Lucia</td>
<td>LUCELEC</td>
<td>2014</td>
<td>89</td>
</tr>
<tr>
<td>Montserrat</td>
<td>MUL</td>
<td>2014</td>
<td>6.4</td>
</tr>
<tr>
<td>Nevis</td>
<td>NEVLEC</td>
<td>2010</td>
<td>14</td>
</tr>
<tr>
<td>Trinidad &amp; Tobago</td>
<td>TRINITY POWER &amp;</td>
<td>2013</td>
<td>1668</td>
</tr>
<tr>
<td></td>
<td>POWERGEN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turks &amp; Caicos</td>
<td>FORTIS TCI</td>
<td>2014</td>
<td>75</td>
</tr>
<tr>
<td>St. Kitts and Nevis</td>
<td>ST. KITTS</td>
<td>2009</td>
<td>28</td>
</tr>
<tr>
<td>St. Vincent and the Grenadines</td>
<td>VINLEC</td>
<td>2013</td>
<td>53</td>
</tr>
</tbody>
</table>
8 IMPACTS OF CHANGING CLIMATE ON CARIBBEAN ISLANDS

According the latest report on the anticipated impacts of climate change on small islands by the IPCC the Caribbean can expect changes in weather resulting in increases water stresses, rising sea levels and increased potential for coastal erosion, increased daily averages temperature are among the future impacts (UNFCCC, 2002). Caribbean countries are now giving increased attention to how best to reduce their vulnerability to these impacts.

Waste plays a very critical role in how Caribbean countries can address climate change vulnerability and innovative ways to build resilience. Pollution from the source identified above has adversely affected Caribbean coastal ecosystem, such as sea-grass, mangroves, tidal flats, and coral reefs. This is contributing to increase coastal erosion and negatively impacting resilience and increasing vulnerability to climate change impacts, as without healthy coastal ecosystems, impacts such as coastal erosion including beaches which are critical to the tourism industry, flooding, and salinization of coastal aquifers will be worsened.

Given the need for islands states to mainstream adaptation to climate change and the identified weaknesses with the current dominant approach of disposal to handle waste there is a need for the islands to assess if there are better suited approaches where there is financial sustainability, greater access, and increased resilience to the impacts of climate change through outcomes such as increased availability of fresh water, local source of fertilizer, and development of low carbon energy sector.

Communities as part of these efforts to build resilience to the impacts of climate change meaning the existing attitudes of SIDS population, which consider waste as a nuisance to be disposed of to that recognizing it as a resource, a radically altered perspective. One of the challenges in restructuring mindset of Caribbean population to seeing waste as a resource is on the ground demonstration of viable activity, and that requires innovative management and integration with other sectors of the economy.

There is increasing evidence of public health and ecosystem impacts of inappropriate waste management. Destruction of natural resources arising from current waste management practices is a result of poor waste management practices leading to pollution of groundwater resources and coastal waters, with associated degradation of critical ecosystems, such as coral reefs, sea grass beds, mangroves and coastal zones, and negative impacts on human health. The limited availability of land is a critical constraint for disposal options for waste management in SIDS, and is thus a driving force for the adoption of the integrated waste management paradigm.
9 DESCRIPTION OF PROPOSED REGIONAL PROJECT

As stated earlier there is no significant utilization of waste beyond metal and plastic picking usually at the dump site in the CARICOM countries. Consequently there is limited technology experience in waste conversion across the region. At various time there has been interest in waste to energy and each country has received several proposal for projects to generate power from solid waste. However to date there is no project. The situation with waste water is essentially the same and waste heat is not yet considered as a resource in the region.

The proposed project will focus on organic waste and waste heat for the production of energy and potable water respectively. Organic waste in the form of waste effluent and solids will be converted via anaerobic fermentation to generate substitute fuel for power generation or transportation, along with fertilizer. The focus on organic waste as priority for development of public private partnerships is based on:

1. availability of proven technology to convert organic waste and waste heat into fuels, or energy services like desalination of salt water, or purification of contaminated fresh water;
2. growing interest by private sector in reducing energy cost in operations or for business diversification;
3. improves water security in response to the growing challenges with fresh water availability for the region;
4. significant opportunity for employment generation;
5. project opportunities are numerous, which will make for significant aggregation and enhanced private sector interest and improved chances for project financing.

The primary focus of Public Private Partnerships (PPPs) reflects in addition to the above reality, the wide range in scale of the potential organic waste to energy project opportunities, ranging from dairies to breweries, and sewage treatment facility to desalinization plants across the region. For private sector companies who are direct purchasers of electricity or users of process heat successful implementation will improve competiveness and profitability of the enterprise.

The secondary focus on waste heat reflect the vast unrecognized potential of thermal energy from industry and power generation facilities to contribute to the increasing need for reliable potable water.

Component (1): Strengthening Research and Information Network

The focus on capacity building is intended to increase availability of information and the generation of knowledge to bring about an evolution in thinking among a critical mass of planner and decision makers in the public and private sector, and the population with regards as waste being a resources rather than a nuisance. Increasing knowledge through strengthening of national
research and information networking will provide the foundation for effective capacity building in utilization of organic waste and the development of SME.

Organic waste in solid form is generated in many ways ranging from household to markets to Highway maintenance and farming; similarly effluent organic waste is generated by households, businesses, industry and farms. Distilleries, breweries generate significant point source of waste and are usually private owned; there will be significant early focus on developing local technical capacity to assess the potential feasibility of the various sources and location of organic waste that could become viable projects. The research results from this component will provide the potential candidates for prefeasibility studies in Component 2.

Priority on getting research results is to support speedy development of feasible projects through PPP to demonstrate proven applications. Based on the provision of these tangible evidence across the region with different scale and government could use policy levers to support private sector investment in the new sector. The technology for converting organic effluent and biomass into fuel, as noted above is well developed and it is anticipated that once there is increased understanding of the economic attractiveness, and the technology many breweries and distilleries will adopt. Despite the high BOD impact of sewage when dumped into rivers and lakes and coastal waters, organic effluents (sewage, vinasse, etc) are in reality more than 90 percent water, and the best practices for anaerobic fermentation to treat effluents incorporate supplemental organic material (grass, yard cutting, market waste) to increase the quantify of fermentable material and maximize fuel production. Designing and operating such anaerobic fermentation systems require trained technicians, and this has been an obstacle to wide scale adaptation. Hands on training will be provided through the Biomass Research Centre being established by the Government of Belize (GOB), 5Cs and the University of Belize (UB). The information and knowledge networking will be facilitated by the CCREEE which is being established as a regional renewable energy and energy efficiency organization, supported by the UNIDO, GOA, SIDS DOCK and CARICOM.

Capacity building will take place at the national levels – through training workshops organized in collaboration with public and private sector entities including research and rural development organizations, government agencies responsible for agriculture, energy water and sewage, and industry, national development bank. In additional to getting participants more informed about the opportunity of the establishment of SME in waste to energy, and the benefits to certain businesses the workshop will bring both private and public sector together, with waste to energy professionals in order to try and catalyze a core community of interest in each country. This core will be critical and is to provide the foundation for the design and implementation of projects, the goals of capacity building activities will be to:

1) improve the capacity for project formulation, implementation and evaluation
2) develop capacity across all sectors, through appropriate programmes of formal and informal training, education and public awareness
3) overcome reluctance to share and publicize information and create a culture of collaboration and information-sharing between agencies, departments, institutions and SIDS regions
Identification research projects—the majority of CARICOM countries have through their SIDS DOCK National Coordinators submitted an estimated USD 67.3 Million (}

References


“DEVELOPMENT OF A CARIBBEAN REGIONAL ORGANIC WASTE CONVERSION SUB-SECTOR TO INCREASE COASTAL RESILIENCE AND CLIMATE CHANGE IMPACTS AND PROTECT FRESH WATER RESOURCES”


Mwansa, R., Alleyne, S., Moore, W., Catwell, S., (n.d.) “Treated wastewater reuse scheme in Barbados”. [online] Available at: https://www.oas.org/dsd/publications/Unit/oea59e/ch37.htm


“DEVELOPMENT OF A CARIBBEAN REGIONAL ORGANIC WASTE CONVERSION SUB-SECTOR TO INCREASE COASTAL RESILIENCE AND CLIMATE CHANGE IMPACTS AND PROTECT FRESH WATER RESOURCES”


“DEVELOPMENT OF A CARIBBEAN REGIONAL ORGANIC WASTE CONVERSION SUB-SECTOR TO INCREASE COASTAL RESILIENCE AND CLIMATE CHANGE IMPACTS AND PROTECT FRESH WATER RESOURCES”
ANNEX A) in indicative projects in waste to energy, which will represent the starting pipeline for research and prefeasibility studies, countries can submit additional project ideas any time during the project period for assistance. A review will be conducted to identify and rank projects for research, prefeasibility studies for each country. Based on the results of the review and ranking, projects priority will be determined and assigned. After each review an updated project portfolio document will be prepared to test private capital attractiveness.

Component (2): Pre- and Feasibility Studies and Business Plan Preparation

The projects in each participating country will be determined based on the results of the process outlined in Component (1). It is proposed that in each country a minimum of two organic waste streams be identified for research. The waste stream identified will be based on criteria developed by the Project Steering Committee that incorporates the following:

- Confirmed resources quantities
- Ownership and Accessibility of the resource
- Technological systems validation
- Does project represent scale-up, replication, or new system

During the life of the project there will be semi-annual review of projects to determine potential feasibility and document readiness.

Component (3): Pilot Facilities -- GEF Co-financing for Each Country Pilot Facility

Implementation of commercial pilot facilities to demonstrate technology and build confidence are considered essential as both part of capacity building and creating the enabling environment for the development of PPP for nationwide implementation of viable waste to energy project opportunities. The successful wind energy project in Cabo Verde has shown conclusively demonstration and public education provide the foundation for national scale implementation. Public education to increase awareness will be driven by successful pilots. The policy drivers needed to support scale of successful commercial pilots to national implementation will be informed to a significant extent by the pilot’s results. And equally important successful pilots reduced the level of perceived risk and make future private sector investment more likely.

Technology options include combustion, gasification and anaerobic digestion. Cost-effective scale for combustion requires waste volumes of at least 300 metric tons per day. Assuming typical waste volumes of 1 to 2 kilograms per capita, this implies a minimum island population of 150,000 to 300,000 for combustion to be cost-effective. Gasification and anaerobic digestion may be cost-effective on smaller islands, however. Waste-to-energy technologies typically have high operation and maintenance costs in the neighborhood of 10 cents per kWh which have to be considered along with the capital costs of installed facilities. Nonetheless, such technologies should often be cost-competitive as many islands face electricity costs of 35 cents per kWh or

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6 Henderson Dissertation
higher. A key driver for the choice of island waste-to-energy systems can be the cost of transportation and distances.

As UNIDO process of industrialization has shown helping to reduce the level of risk and provide technical assistance is critical to development of new industries. Addressing the risk in waste to energy nut conducting local research, building capacity through training and knowledge networks and implementation of commercial pilot where the investor financial risk is shared is considered a proven approach. Involvement of local financing organization such as a national and regional development bank will help increase confidence that the perceived risk are being addressed and position those organization to provide financing for expansion and well as taking through loan project risks.

The perceived risk could also be addressed through policy actions such as government giving tax break and holidays on the investment in these projects –this has proven very successful in the introduction of solar water heater in Barbados.

10 PROJECT JUSTIFICATION

The dominant approach to waste management by regional governments has been construction of dumps/landfill or sewage systems. The high external indebtedness of the majority of Caribbean countries means that there’s limited financial resource available for investment and lots of competition for those funds. The result is that financing for waste management projects is loan financed to be repaid through taxation as there is no income stream associated with the disposal approach to waste management. Current waste management whether for solid or liquid effluent represents an ongoing major cause of declining environmental quality, and requires continual financing and are therefore not a preferred option for sustainable waste management in the future.

Coral reefs help protect coastlines, which include coastal communities, hotels and other investments, from storms. Studies have shown that the region may have lost 80 per cent of its coral reefs. Heavy reliance on tourism by the Caribbean islands is said to be hastening the demise of the ecosystems. The value of the Caribbean Sea will not long be attractive if our governments do not immediate intensify their national and regional actions to protect it.
10.1 Changing a Destructive Nuisance into a Renewable Resource

Thermal and biological conversion technologies applied to the management of waste provide an alternative to the conventional disposal approach, and generates income by producing local source of fuel and fertilizers, which allows for *off the books* financing. In addition to generating income a technology lead approach also help reduce imports of fuel and fertilizers, contributing positively to balance of trade, while helping to protect the critical environmental resources.

With increasing cost, waste volumes, and negative environmental impacts for improper collection and disposal alternatives that minimizes collection and disposal, needs to be given attention in conjunction with technologies that convert organic waste in substitute for imports. Based on the composition of solid waste arrival at sorting stations, landfills, dump site across the region it is estimated that organic material such as food waste, yard cutting and market waste represent about a third by weight of solid waste material.

If communities would implement separation as source and separate collection of fermentable organic material for use as raw material for waste to energy project, or as supplemental inputs into waste effluent (distillery waste, brewers waste water and sewage systems), there would be potential for new community level enterprises.

**Table 5: Quantities of Solid Waste and Energy Estimates⁷**

<table>
<thead>
<tr>
<th>Country</th>
<th>Quantity of Solid Waste to Landfills (Tonnes/Year)</th>
<th>Composition %</th>
<th>Amount of Organic Material (Tonnes/Year)</th>
<th>Estimated Energy Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antigua and Barbuda</td>
<td>49,984</td>
<td>50</td>
<td>24,992</td>
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<tr>
<td>The Commonwealth of the Bahamas</td>
<td>176,204</td>
<td>50</td>
<td>88,102</td>
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<td>Barbados</td>
<td>152,107</td>
<td>50</td>
<td>76,053</td>
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<td>Belize</td>
<td>186,612</td>
<td>50</td>
<td>93,306</td>
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<td>Dominica</td>
<td>39,605</td>
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<td>19,802</td>
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<td>Guyana</td>
<td>402,716</td>
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<td>201,358</td>
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<td>Grenada</td>
<td>60,002</td>
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<td>30,001</td>
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<tr>
<td>Jamaica</td>
<td>1581,830</td>
<td>50</td>
<td>790,915</td>
<td></td>
</tr>
</tbody>
</table>

⁷ Waste estimation based on mid values from different Caribbean Waste Studies. The numbers are not scientifically proven and are only assumptions which may vary accordingly in single countries. Assumption: 1.5 kg Waste production per day per person. 50% is Organic Waste (Studies show between 40% to 60% and 10%-15% plastic waste)
The approach to solid and liquid effluent pursued is to treat both as independent and have separate rather than integrated solution that would minimize investments and yield co-benefits such as fresh water resources, improved coastal environment, coastal fisheries catch, base-load power for the grid. As shown in Table 5 above separation of organic material at source, and separate collection for processing and usage as supplemental organic matter for waste to energy project that uses biomass in vegetative form or as effluents would provide the economic argument for different thinking that would help communities better manage waste, protect water resources, and develop local enterprises generating fuel and/or power.

The goal of the GEF funded effort is the implementation in pilot countries of viable projects utilizing organic waste (solid and effluent) with raw material coming from farms, markets, agro-processing facilities, distilleries/breweries, sewage facilities, or combinations. The proposed GEF project would do this through capacity building, support for studies and business plan, and grant to co-finance commercial scale demonstration facilities. Benefits from a successful integrated waste conversion approach will significantly reduce volumes of waste going to dumps and land fill, reduce water pollution, reduce cases of ill health and create local employment.

While the conversion technologies provide options for alternate more socio-economically beneficial and more environmentally sound there are challenges to the deployment the technology posed by small volume of waste stream by the small communities. The choice of public private partnerships to formulate, finance and implement the projects is intended to minimize risks and get community participation. The public sector principal will realize co-benefits such as reduced public health risk, improvement in coastal environmental quality, protection of fresh water resources, and employment creation.

The focus on private public partners is intended to address the series of challenges to the development of viable waste to energy enterprises in SIDS and the increasing need to improve management, including:

<table>
<thead>
<tr>
<th>Country</th>
<th>Quantity of Solid Waste to Landfills (Tonnes/Year)</th>
<th>Composition %</th>
<th>Amount of Organic Material (Tonnes/Year)</th>
<th>Estimated Energy Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Kitts and Nevis</td>
<td>30,091</td>
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<td>15,046</td>
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</tr>
<tr>
<td>Saint Lucia</td>
<td>95,136</td>
<td>50</td>
<td>47,568</td>
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<tr>
<td>St. Vincent and the Grenadines</td>
<td>56,393</td>
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<td>28,196</td>
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<tr>
<td>Suriname</td>
<td>310,348</td>
<td>50</td>
<td>155,174</td>
<td></td>
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<tr>
<td>Trinidad &amp; Tobago</td>
<td>670,094</td>
<td>50</td>
<td>335,047</td>
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</tbody>
</table>
Limited financial resources available from the public sector are resulting in an unfortunate lack of waste management services. For example, only a few SIDS are able to afford the investment in sanitary landfill or adequate sanitation and sewage treatment facilities, which are the generally accepted methods of proper waste management.

As government revenues become more limited, new approaches such as privatization of waste management services are now being instituted. One consequence is that poor communities continue to have less than effective systems of waste management, and often their only options are either to dispose of waste by burning or to dump it in drainage systems.

Inadequate handling of waste problems in SIDS translates into concern of impacts on freshwater resources and in the coastal zone. Freshwater resources and coastal zone areas are vital to the welfare of SIDS. SIDS in general have limited availability of freshwater resources; the importance of the coastal area stems from its being the major location of economic activity (industry and tourism in particular), and also home to the vast majority of the population.

Improper waste management represents a growing public health threat. In addition these coastal areas are rich in biodiversity and are highly productive ecosystems critical to the food security of SIDS.

There is a lack of appropriate legal instruments in some cases; in others there is inadequate enactment and a lack of enforcement, or both. In addition to this, there is a lack of enforcement capacity as well as judicial awareness in most SIDS.

Governments, the private sector, NGOs and local communities do not collaborate adequately on waste management decisions.

Many SIDS are parties to international conventions and protocols that mandate the acceptance of imported waste. In some SIDS, ship- and airplane-generated waste (both solid and liquid) constitutes a significant proportion of the total waste stream requiring management. However, air and sea waste management facilities in most SIDS are inadequate and constitute potential threats to the environment and risks to public health. In addition there is a lack of harmonization of regulations and procedures across regions. It is also clear that SIDS lack effective capacity and mechanisms for the safe management of hazardous waste (agro-chemical, nuclear, persistent organic pollutants (POP’s), heavy metals, etc.).

Increased private sector participation has been widely accepted as a way to improve service delivery. However, limited contract management skills and private sector capacity result increasingly in privatization approaches that are inappropriate, and can compromise the access of poor, rural and isolated communities to (Integrated Waste Management (IWM). In addition, restricted financial resources and capacity limitations in SIDS for effective privatization have led to outcomes that have failed to meet expectations. Paramount among these unmet expectations is
equity of access for the poorer segments of the populations. Future public-private partnerships to support waste management should ensure that there is equitable participation of the local private sector and civil society and that poor communities are not discriminated against.

The close linkage between increasing urbanization, changing patterns of consumption and decreasing self-sufficiency in food and energy, the onset of climate change requires different approaches by the public sector to the management of waste. Growing population densities are overloading waste management systems. Increased access to water-based sanitary systems and a concomitant increase in domestic waste water generation has strained freshwater resources both in terms of quality and quantity.

Additionally, the absence of proper sewage treatment systems has significantly increased the quantities of water-borne and sediment-rich nutrient loads in the near-shore and aquatic environment, threatening critical ecosystems. The pollution of groundwater and surface water resources in SIDS and in coastal areas by physical processes, chemical and biological waste, and saltwater contamination and intrusion constitutes a critical health and environmental issue, particularly in smaller islands and coral atolls. Tourism is an important economic factor, but places additional stress on waste management. Ultimately it could help destroy the very ecosystems on which it depends.

11 ONGOING ORGANIC WASTE 2 ENERGY INITIATIVES

As noted in Section 7, there have been significant advances in technology for converting various types of waste into energy services and products to support agriculture. There is also increasing interest in waste management and waste to energy as an option to promote sustainable management. At the January 2015, IRENA Assembly the following donors expressed interest:

- The French Energy Management Agency, Ademe, expressed interest in assisting the development of waste-to-energy systems for islands in the context of the Martinique event.
- The German Environment Agency, BMUB, has traditionally placed a lower priority on waste-to-energy systems than on other renewable energy technologies but could consider some assistance to waste-to-energy projects on islands that enhance environmental sustainability.

Based on the characteristics of the waste, two systems will be prioritized for this project. The first will be organic waste and the second waste heat from power plants. All projects will directly or indirectly improve both energy and water security in the participating countries. Ongoing initiatives related to the development of SME project in waste to energy include the following:

- Regional Biomass assessment being done by the GIZ
- Prefeasibility study ongoing for Saint Lucia by the CCCCC/GIZ
“DEVELOPMENT OF A CARIBBEAN REGIONAL ORGANIC WASTE CONVERSION SUB-SECTOR TO INCREASE COASTAL RESILIENCE AND CLIMATE CHANGE IMPACTS AND PROTECT FRESH WATER RESOURCES”

- Regional indicative project pipeline of waste to energy projects SIDS DOCK
- Establishment of research facility CCC/GIZ/GOB
- Development of ESCOs – GEF ESD 5 Country project

Add the industrialization aspect from UNIDO

12 BUDGET

Based on the projected participation of six countries the request to the GEF will be in the region of USD 3.00 million or $500k per country, this would require matching funds of at least USD 6.0 million, for a total project budget of USD 9.0 million. The majority of co-financing would be investment in the pilot plants. Funding for the pilot would be a blended package consisting of some grants (EU, GEF, GIZ, JICA, USAID), private capital and loan financing based on offtake agreement for the project products such as energy and fertilizer. Potential sources of project loan financing are kfw Bank (Germany), Nordfund (Norway), IADB/CDB and Kazakhstan Sovereign Wealth Fund.

Expected costs are as follows:

Component (1): Strengthening Research and Information Network (Capacity building – including strengthening of research):
Total: USD 900,000.00

Component (2): Pre- and Feasibility Studies and Business Plan Preparation (Pre- and Feasibility Studies and Business Plan; Based on doing one feasibility and one prefeasibility study per country for a budget of about USD 50,000 per country):
Total: USD 300,000.00

Component (3): Pilot Facilities -- GEF Co-financing for Each Country of USD 300,000.00:
Total: USD 1.8 Mio.

13 PARTNERS

- Caribbean Community Climate Change Centre
- Caribbean Regional Health Agency (TBC)
- Climate Technology and Climate Network (TBC)
- SIDS DOCK
- United Nations Industrial Development Organization
- International Renewable Energy Agency (TBC)
14 METHODOLOGY AND NEXT STEPS

The preparation of the document will be coordinated by the project partners based on the proposed timetable:

- Preparing TOR for the Regional Meeting Background Paper: May 2015
- Preparation of Meeting Concept Paper: May 2015
- Preparation of TOR for regional project background paper: May 2015
- Preparation of the Project identification Form (PIF) and submission to the GEF along with request for GEF PPG: May 2015
- Regional Consultations: May – July 2015

Starting with the preparation of the draft meeting concept paper, the proposed regional project ideas will be developed through a series of consultations with national stakeholders such as department of sanitation, municipalities, and private sector companies involved in organic material processing or disposal, and ministries of energy.

The regional consultations which will be conducted electronically supplemented with strategic visits is intended to gauge level of interest, identify potential meeting participants and project stakeholders, identify potential private sector leaders, and identify opportunities to expand the regional waste to energy indicative project pipeline.

- Preparation and circulation of draft regional project concept paper: July/August 2015
- Finalization of Draft Project Background Paper: September 2015
- Regional Waste 2 Energy Meeting: November 2015

Two representatives from each interested country (we expect a minimum of 6 countries), the GEF focal point and the energy specialist. Based on the responses to the background paper and the agreements from the regional meeting to which the representatives from each interested country will be invited the project document will be prepared and submitted to member for validation and the GEF through the GEF Implementing agency (UNIDO)

- Finalization of Proposal: December 2015

**Table 6: Proposed time schedule**

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<td>Regional Consultations</td>
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“DEVELOPMENT OF A CARIBBEAN REGIONAL ORGANIC WASTE CONVERSION SUB-SECTOR TO INCREASE COASTAL RESILIENCE AND CLIMATE CHANGE IMPACTS AND PROTECT FRESH WATER RESOURCES”

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“DEVELOPMENT OF A CARIBBEAN REGIONAL ORGANIC WASTE CONVERSION SUB-SECTOR TO INCREASE COASTAL RESILIENCE AND CLIMATE CHANGE IMPACTS AND PROTECT FRESH WATER RESOURCES”


ANNEX A

SIDSDOCK CARIBBEAN REGION WASTE-TO-ENERGY (WTE) INDICATIVE PROJECT PIPELINE

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>PROJECT TITLE</th>
<th>ESTIMATED PROJECT COST (USD)</th>
<th>FINANCING REQUIRED (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANTIGUA &amp; BARBUDA</td>
<td>Integrated Bioenergy and Food Production: The project pre-feasibility has been completed for this project that would establish of approximately 500 acres of grain sorghum on the island of Barbuda that would be used to produce broiler meat, and the waste produced would be used to generate biogas fuel which would displace diesel for power generation. Diesel fuel is now transferred by boat in drums to the island and consequently the cost of electricity is very costly for the population, who depend primarily of fishing and subsistence agriculture for livelihood.</td>
<td>5,400,000</td>
<td>5,400,000</td>
</tr>
<tr>
<td>BAHAMAS (COMMONWEALTH OF)</td>
<td>Feasibility Study for Establishment of a Solid Waste-to-Energy Facility on New Providence: The island of New Providence generates in excess of 1,000 tons, per day, of solid waste, dominated by packaging material, enough raw material to export in excess of 20MW of firm power to the grid from a waste-to-energy facility. The feasibility study will determine the best system to use and relative cost benefits to aid government decision making in developing a public/private partnership to implement the project if proved feasible.</td>
<td>250,000</td>
<td>250,000</td>
</tr>
<tr>
<td>BELIZE</td>
<td>Feasibility Study on Distributed Generation to Generate Base Load Power for Grid Connection: Community waste-to-energy projects; the dispersed nature of Belizian communities is resulting in solid waste management becoming a major challenge for local government, resulting in high cost of collection and transport over long distances to the nearest landfill. Feasibility studies will identify systems that are operational at the scale of 500-</td>
<td>30,000</td>
<td>30,000</td>
</tr>
<tr>
<td>COUNTRY</td>
<td>PROJECT TITLE</td>
<td>ESTIMATED PROJECT COST (USD)</td>
<td>FINANCING REQUIRED (USD)</td>
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<tr>
<td><strong>BELIZE</strong></td>
<td>2000 residences than can generate reliable base load power for grid connection.</td>
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<td></td>
</tr>
<tr>
<td><strong>BELIZE</strong></td>
<td><strong>Belize Biogas from Wastewater and Manure:</strong> The Government of Belize and SIDSDOCK are developing an anaerobic digestion/biogas project at the waste water facility in San Pedro Ambergris Caye. The project will use livestock manure from Spanish Lookout. The developers plan to negotiate a PPA with Belize Water Services Limited (BWSL). The project will produce biogas for electricity, fertilizer resulting from the sludge by product for sale to local farmers and carbon offsets for sale in the carbon market.</td>
<td>3,000,000</td>
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<tr>
<td><strong>BELIZE</strong></td>
<td><strong>Demonstration Project for a Low Energy Waste Water Treatment System:</strong> The majority of small communities in island states do not have waste water treatment systems. Waste water generated in households and institutions is disposed of usually by septic treatment systems. Increasing the use of the septic systems are proving to be a major source of subsurface fresh water pollution, and coastal environmental degradation. Alternate waste water system modular in design that uses active biofilms for the decomposition of organic matter, requiring significantly less energy input than the conventional sewage systems, and with significant less pollution footprint than septic systems will be demonstrated to provide evidence of feasibility, comparative energy requirement and potential contribution to water resource availability as part of climate change adaptation.</td>
<td>150,000</td>
<td>150,000</td>
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<td>DOMINICAN REPUBLIC</td>
<td>Commercial demonstration project for sea water desalination -- project is to provide potable water, using the waste heat from the power plant as the primary energy source. Waste heat from power plants is major non-utilized energy resources in the SIDS, and could be used to improve availability of potable water, as projection are for island states will be become increasingly fresh water stressed and will have to depend increasingly on desalination and water harvesting, and recycling of waste water.</td>
<td>1,000,000</td>
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<tr>
<td>GRENADE</td>
<td>Waste-to-Energy Feasibility Study: The mountainous topography of the country presents major challengers for the collection and disposal of solid waste. The current situation is resulting in pollution of the coastal area and deteriorating air quality for communities located in proximity to the facility. Current volumes of waste indicate feasibility for a 2-3 MW base load facility</td>
<td>55,000</td>
<td>55,000</td>
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<tr>
<td>JAMAICA</td>
<td>Feasibility study for waste to energy system for the production or a minimum of 30 MW from the solid waste facility: The Riverton City solid waste facility handles in excess of 1000 tons per day of mixed solid waste, comprised of solid waste collected from households, businesses, institutions, and from cleaning of streets and highways. The solid waste disposal facility is located some 2 miles for the major sewage treatment which is being expanded to treat some 60 million gallons of waste water per day. The feasibility study will determine the best option for maximizing the use of these resources for the production of base load power to lessen dependence on diesel fuel</td>
<td>280,000</td>
<td>0</td>
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<tr>
<td>REGIONAL</td>
<td>Technical Assistance for Preparation of Pre-Feasibility and Feasibility Studies: Project involving Technical Assistance to Caribbean Governments to evaluate the potential viability of waste-to-energy projects as an alternative to the ongoing social, environmental and financially</td>
<td>1,200,000</td>
<td>1,000,000</td>
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</table>
costly disposal that is now the case in most countries. Due to limited land availability, growing population and increased importation of goods, many SIDS are facing problems with the management of the various forms of waste, ranging from municipal, sewage, medical, to agro-industrial waste. In far too many cases, there is improper disposal of waste. Improper disposal of waste is a major source of coastal zone pollution and a growing threat to critical marine ecosystems which are already experiencing growing stress from increasing temperatures, and pollution. The potential projects to be evaluated include:

- Utilization of rum distillery waste
- Conversion of sewage
- Conversion of municipal solid waste and other available biomass resources into energy

Evaluation and per-feasibility studies will be conducted in partnership with technology providers. Projects identified as potentially feasible will be developed through private-public partnerships and the funds provided would be refunded to support development of other projects.

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<td>SAINT LUCIA</td>
<td>Sewage Waste to Energy: Project is intended to produce fuel from a combination of sewage and biomass from markets and other sources to provide 1 MW of base load power and 3 MW of thermal heat for cooling of commercial buildings in downtown Castries</td>
<td>7.000.000</td>
<td>Pre-feasibility Study On-going</td>
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<td>SAINT LUCIA</td>
<td>Solid Waste to Energy: aim is to implement a project that requires no subsidy from tipping fees to produce base load power to the grid. It is estimated that some 10 MW of power could be generated by the project from the waste at the Castries solid waste facility</td>
<td>25.000.000</td>
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<td>SAINT LUCIA</td>
<td>Waste Heat to Power Project: The base load of the country is 40 MW and based on waste heat recovery system there is potential for a project to recover up to 4</td>
<td>21.000.000</td>
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</tbody>
</table>
MW of base load power. Prefeasibility has shown power from such a project at US$0.21 per kWh

SAINT VINCENT AND THE GRENADINES

**Sewage and biomass property waste to Energy:**
The new Argyle International airport is being established as a low carbon facility. Energy for lighting and cooling will be provided with a 100 kw PV system, and other RE combination including biogas. Based on preliminary assessment there is enough inlay materials in the airport that could potentially produce enough biogas for 0.5 MW electricity for 8,300 operational hours per year.

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<td>3,000,000</td>
<td>TOR for prefeasibility study being prepared</td>
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