LIMITS AND POTENTIAL OF WASTE-TO-ENERGY SYSTEMS IN THE CARIBBEAN

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ABSTRACT

Waste accumulation is an issue of particular concern in many Caribbean cities and communities. The lack of information on waste management performance and techniques in the region, and the need to improve energy security in order to ensure economic and social prosperity are the main drivers of waste management practices for energy generation. This article describes the current condition of waste management in the Caribbean, highlighting the challenges and opportunities for energy generation and improved energy efficiency via waste-to-energy technologies using waste as feedstock.

1. INTRODUCTION

How much waste is collected everyday in the Caribbean countries? What is the impact of waste on the environment? How can the Caribbean region transform its waste-related problems into socio-economic and environmental benefits?

The accumulation and improper management, treatment and disposal of waste pose a serious threat to environmental quality and public health in many cities and communities of the Caribbean. These threats are exacerbated by the lack of awareness regarding the environmental impact of waste and deficient systems for proper waste management and disposal. Specific challenges include: a propensity of low-density collection points; high operating costs of traditional waste collection and treatment systems; small economies that limit the viability of recycling or alternative waste treatment systems; and limited land availability for sanitary landfill activities due to competing land uses. These conditions lead to improper design and siting of non-sanitary landfills, often in close proximity to groundwater aquifers, which create aesthetic and odor nuisances, increased health risks and climate change effects caused by gaseous emissions. The situation is worsened by the lack of information about municipal, industrial, and hazardous waste generation, limited financial and human resources, ineffective policy frameworks and poor planning capacity.

The region's heavy dependence on fossil fuels for electricity generation represents an additional threat; not only to the environment and to social cohesion, but also to national and regional energy security and macro-economic resilience. In this regard, public policy and public-private partnerships, among others, are essential ingredients of an integrated waste management strategy.

Waste-to-energy systems (WtE) offer a novel and effective response to manage waste and energy issues such as pollution prevention, the protection of drinking water resources, energy generation and increased energy efficiency. Efficient waste-to-energy generation also has the potential to improve environmental health while creating better social and economic conditions by providing new jobs; triggering the growth of small industries and environmental services; and lowering waste collection and treatment costs. WtE technologies have the potential to become an effective response to current challenges facing the Caribbean region with regard to pollution, public health and the economy.

2. THE CONCEPT OF WASTE AND WASTE-TO-ENERGY

The concept of waste is usually associated with Municipal Solid Waste (MSW)[1], industrial hazardous waste, or wastewater. For the purpose of this research paper, we will define *waste* as *the material components, energy or substances formed and disposed of as a result of industrial, services, and recreational and/or residential human activities that have lost their value or functionality and, either directly or indirectly, impact the natural environment (soil, water and air compartments of the natural world) and impede socio-economic development*.

This broader definition acknowledges the fact that waste is unequivocally linked to energy considering that every product ever manufactured requires a certain amount of basic materials and energy for its extraction, manufacture and transport. It also recognizes the fact that adequate waste management techniques result in recovering large quantities of materials or chemicals without losing their economic value in tandem with the highest possible energy recovery (in some cases expressed as energy savings).

The term *Waste-to-Energy*[2] is used to describe a set of alternatives to collect, treat and dispose of waste in a manner consistent with the basic principles of integrated waste management such as Re-duce, Re-use and Re-cycle with a specific focus on Recovery. This concept refers to energy recovery or savings, which should not be confused with the purpose of recycling. In some cases recycling can lead to high energy intensive or net negative energy balance activities with the aim of reaching a high level or quality of marketable products. In contrast to what is generally perceived solely as the combustion of municipal solid waste to generate electricity and heat in a power plant, waste-to-energy entails dealing with a wide variety of waste categories (e.g., conversion of waste and leachate water, and forest and agricultural waste, to organic waste in recycling and disposal facilities); using a much wider range of conversion routes into a diversity of energy carriers (e.g., biogas, electricity, or bio-fuels).

[1] MSW is in general waste that is produced by the household, but can also include commercial and industrial waste that is similar in nature to household waste.
[2] Definition extracted and adapted from: Cradle to Cradle: Remaking the Way We Make Things by William McDonough (Author), Michael Braungart (Author). North Point Press, First Edition 2002.

3. ENERGY DEMAND IN THE CARIBBEAN

Energy is essential for developing and maintaining a modern society. In the Caribbean region, there are two main drivers affecting the demand for reliable and affordable energy services: 1) sustained population growth, and the consequent need to augment economic activities where energy is indispensable, and 2) the ever increasing challenge of energy security affected by the volatile international crude oil market, which leads to expensive petroleum derived fuels such as jet fuel, diesel, fuel oil, or gasoline, combined with increased competition to access basic energy resources for power generation and transport fuels. Table 1 below lists key demographic and energy sector characteristics for the Caribbean OAS Member States.

Table 1. Overview of the Energy Statistics of Caribbean Basin OAS Member States [3] [4]

Country	Approx. Population	GDP (US$-nominal) per cap.	Utility	Gen. Capacity (MW)	Primary Energy consumption for electricity production (TJ)			Average Elec. Rate (US$/ kWh)
					Petroleum	Hydro	Total	
Antigua & Barbuda	69,108	13,092	APUA^	61.4	100	.	100*	0.35
Bahamas	303,770	19,781	GBP†	140	100	.	1,810*	0.22
Barbados	280,946	13,605	The Barbados Light & Power Company Limited	240	20,046	.	.	0.3
Belize	300,000	4,098	Belize electricity Limited, CFE and BECOL	52	516	395		0.22
Dominica	78,000	4,333	DOMLEC	24	429	135	564	0.45
Dominican Republic	9,904,000	4,147	Haina (private) Itabo (private) Hydroelectricity (public) Independent Power Producers (IPPs) (private) Unión Fenosa (private) CEPP (private) Transcontinental Capital Corp. (private) Monte Rio (private) AES (private) Metaldom (private) Laesa (private)	3,394.10	11,517	6,768	.	0.172
Grenada	89, 703	5,571	GRENLEC	38.8	100	.	160*	0.3
Guyana	751,000[1]	1,365	Guyana Power and Light, Inc. (GPL), Linden Power Company Inc. (LPC) among others.	Less than 100	.	36	.	0.27
Haiti	8,500,000	630	Electricité d'Haïti (EDH)	270	2,785	936	.	0.26
Jamaica	2,780,132	4,172	Jamaica Public Service Company Limited (JPS)	Installed Cap. 621.7	158,000	540	.	0.25

[3] See Annex A for a complete overview of the sources for this table.
[4] *Measured in Millions of kWh †Grand Bahama Island only ^Antigua Island only

St. Kitts & Nevis	45,000	10,143	St. Kitts Electr. Dept./ NEVLEC	34.5	1082	- (0)-	1082	0.28
St. Lucia	155,000	5,689	LUCELEC	56.8	2612	.	2612	0.28
St. Vincent & the Grenadines	117,848	5,229	VINLEC	33.1	78	22	95*	0.3
Suriname	470,784	4,577	The Electric Utility Company of Suriname (EBS)	389		5040	.	0.040 (0.30 in remote areas)
Trinidad & Tobago	1,056,608	15,905	Trinidad and Tobago Electricity Commission	1416.7	400,900	.	.	0.14

In the Caribbean region it is important to differentiate between small island states comprising most Eastern Caribbean islands, large island states (e.g, Jamaica, Haiti, Dominican Republic, Trinidad & Tobago, etc.), and low-lying coastal states (e.g, Belize, Guyana, Suriname, etc). This simplistic categorization is based on population size, surface area and geographic location. Each state has its own challenges and capacities to tackle energy and waste issues.

It should also be noted that while each country has a unique set of economic and energy sector conditions, they share several common characteristics that are critical to the design of a waste-to-energy system as part of an integrated waste management strategy. These include:

- Small population size (population size range 45,000-300,000) for Small Island Developing States (SIDS);
- Medium population size (300,000-8,500,000) for the larger Antilles;
- Low to moderate income levels;
- In most cases a single monopoly electric utility (whether state or privately owned);
- Small overall electricity generation capacity (installed capacity ranges 22-240 MW) in SIDS;
- Medium size generation capacities (240-1,400 MW) for larger islands;
- Petroleum as the fuel of choice for power generation (only Belize, Dominica, Jamaica, Dominican Republic, Haiti, Suriname, and St. Vincent & the Grenadines have grid-installed renewables and small to large hydro facilities);
- Lastly, they all share high average retail electricity rates (0.14-0.45 US$/kWh) for the wider Caribbean.

An interesting development affecting energy generation and transport in the Caribbean has been the increase in the price of crude oil. Beginning in February 2008, the price of crude oil in international markets passed the US$100 per barrel mark, and has since then followed the upward trend and continued to increase. In July 2008, crude oil prices peaked at US$ 147 per barrel. Estimates indicate that crude oil prices will not retract to the 20 to 40 US dollars price range at which they had remained for over two decades until July 2004. Thus there is a need for added urgency to develop new energy alternatives based on indigenous renewable resources to cushion the impact of costly imported fossil fuels. Waste materials contain a considerable amount of energy and should therefore be considered as a source for energy generation and savings.

4. WASTE IMPACTS IN THE CARIBBEAN

During the 2008 International Coastal Cleanup Conference held in Montego Bay, Jamaica, it was published that a total of 6,781,537 garbage items were collected from shoreline and underwater sites in the wider Caribbean region. Almost 90 percent of this amount comprised debris from land based sources (UNDP, 2004). This case exemplifies the magnitude of waste related issues in the Caribbean which, in many cases, range from deficient waste collection and disposal methods to the lack of information about how to properly dispose of waste in tandem with the lack of monitoring of the quantity of waste generated and its composition.

4.1 Tourism

Tourism is one of the most important economic activities in the Caribbean, contributing one third to half of the GDP in most countries. With 22,281,000 stay-over visitors and 18,883,400 cruise passengers per year (2005)[5], the Caribbean region is four times more dependent on tourism than any other region in the world (Dixon et al, 2001). Visitor expenditure sums to a total of US$ 21.5 billion, of which 90 percent is spent by visitors arriving to the region by air. In this context, sustainable tourism becomes a key development priority and is also considered a major challenge in terms of implementing an adequate integrated waste management system that satisfies the sector's needs.

Tourism generates substantial amounts of solid waste. In the Caribbean, it has been estimated that tourists generate twice as much solid waste per capita as local residents. Cruise ship passengers are estimated to produce as much as four times the amount of garbage per day compared to local populations (Dixon et al, 2001). They also generate substantial amounts of liquid waste, much of which goes untreated. In Trinidad and Tobago for example, some 150 small sewage treatment systems have been installed in hotels and housing developments. Many of these systems are poorly maintained and provide limited benefits.

In the Caribbean, the tourism cruise industry typically operates cruise ships that carry large numbers of passengers and visit island nations for a few hours. In some cases waste is offloaded and disposed of in the islands landfill sites. An average cruise vessel usually accommodates 2,400 passengers and a crew of 600. Because of their capacity, cruise ships can generate a tremendous amount of waste. This can be a considerable portion of the total daily waste generation of a small island. Depending on the number and frequency of cruise ships visiting an island, and whether waste is being disposed on the island, to monitor and operate a treatment system or landfill facility can become a challenge. Table 2 provides an overview of estimates of waste generation per 3,000 passenger cruise ship over a week time.

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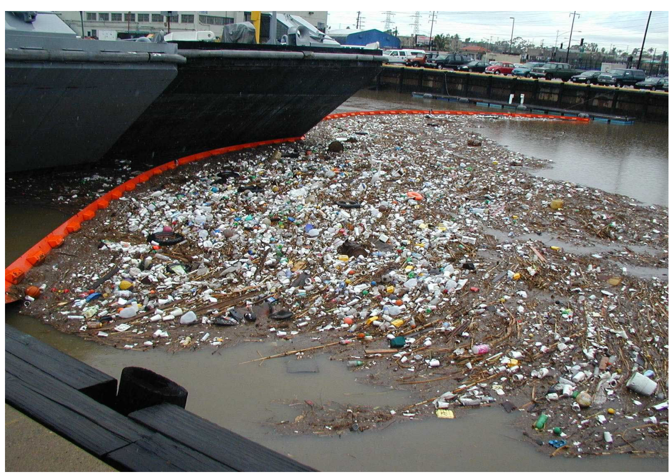
[5] Source: CARICOM presentation about "Intra-Caribbean air transportation, the CSME bridge", 2005, see: www.caricom.org/jsp/single_market/caribbean_connect/intra_carib_air_transportation_holder.ppt

Table 2
Estimates of Waste Generation per passenger in Cruise Ships[6]

Waste generation (3,000 passenger ship)	Amount of Waste
Gray water	1 million gallons per week
Sewage water	210,000 gallons per week
Oily bilge water	25,000 gallons per week
Hazardous / toxic waste	100 gallons per week
Solid waste	50 tons per week
Gas emissions (diesel engines)	?

In addition, these ships take in large quantities of ballast water, which is seawater pumped into the hulls of ships to ensure their stability at sea. This water is typically taken in at one port and then discharged at the ship's destination, which can introduce invasive species and serious diseases into Caribbean waters. A typical release of ballast water amounts to 1,000 metric tons. Under this panorama, a considerable amount of the water pollution in the Caribbean stems from ship-generated waste (including unprocessed waste and plastic products) which is in some cases illegally discharged into the ocean. Although most ships are registered in countries which are signatory to international environmental protocols and subject to standards for waste treatment, storage and disposal, there is increased evidence that cruise ship waste is reaching the shore of many Caribbean islands.

Figure 2
Example of Waste Reaching Coastal Shores[7]



[6] Source: Cruise Ship Pollution, available at http://www.surfrider.org/a-z/cruise.asp
[7] Source: National Marine Debris Monitoring Program

4.2 Urban and Coastal Zone Development

Coastal areas are the areas where most or all human activities take place, from business, residential and recreation means to transport facilities, industry, and other infrastructures. Coastal areas also comprise major habitats for marine growth and animals living in mangroves, estuaries and coral reefs. The actual interaction between urban coastal areas and the sea is essential. Some coastal cities of the Caribbean are densely populated; often the buildings are not connected to centralized sewage collection systems, and adequate waste collection facilities are not available. In some cases, because of least-cost considerations and the lack of adequate legal frameworks, waste water is discharged untreated in the sea and landfills are established too close to ecologically sensitive areas where leachate (waste water) can cause high levels of contamination. This triggers a variety of problems ranging from odor emissions to very serious impacts on coastal and marine ecosystems.

Septic tanks are the most common decentralized wastewater treatment systems. Regularly a sewage truck collects wastewater and transports it to septic and sludge facilities. For example, hotels are either connected to a sewage system or have simplified waste water treatment plants. Their water output is generally used for irrigation and sludge brought to landfills.

Figure 3
Waste Accumulation at Coastal areas in Santo Domingo, Dominican Republic[8]

4.3 Improper Waste Management

In many Caribbean islands, medical and industrial waste is not separated from domestic waste (with the exception of radioactive materials), thus exposing waste handlers to a wide array of health risks. In these cases, there is a high risk of disease from contact with human faecal matter; paper saturated with toxic substances; bottles containing chemical

[8]Source: http://www.callipygia600.com/allpictures/logpix/images/trash.jpg - September, 2002

residues; metal containers of pesticides and solvents; medical waste such as needles or bandages; and batteries containing heavy metals. Emanations from waste collection trucks travelling to and from disposal sites, dust from disposal operations, and the open burning of waste contribute to health problems, especially when these occur near residential areas. Other health risks are associated with the incidence of pulmonary diseases linked to exposure to biologically active agents (e.g., microorganisms and their metabolites and toxins), bio-aerosols, volatile compounds, or mold spores.

Many dumpsites or landfills have limited or no cover material. Therefore, precipitation percolates through the waste. Once in contact with decomposing solid waste, the percolating water becomes contaminated and flows out of the waste material becoming a contaminated liquid called leachate. As the waste decomposes through aerobic and anaerobic microbial action, increasing volumes of leachate are formed and permeate into the soil. Leachate can reach high organic concentrations, with high levels of dissolved solids, ammonia, nitrate, phosphate, chloride, potassium, as well as numerous heavy metals and refractory organic trace constituents (commonly including byproducts of decomposing solvents, pesticides, and polychlorinated biphenols) (Slack, Gronowb & Voulvoulisa, 2005). In addition, high numbers of fecal bacteria are typical, while viruses seldom survive in leachate because of their sensitivity to the low pH values common to leachate (Cointreau-Levine, n.d.). In cases where sanitary landfills do not comply with basic design requirements, waters infiltrating the soil contaminate the subterranean waters, which in many cases are the main source for fresh water in the Caribbean islands. This generates a cycle of bacterial contamination that directly affects the poorest populations and damages the ecosystem.

The Caribbean region is prone to weather related natural disasters such as flooding in low lying coastal zones in Guyana and Suriname, and increasingly intense and frequent hurricanes in the northern Antilles and the eastern Caribbean islands. These events also lead to a large amount of waste water and solid waste generation. When urban areas are flooded, water comes in contact with garbage, septic tanks or sewage systems carrying human waste. Pathogens and other dissolved toxic chemicals are disseminated and brought in direct contact with people, thus creating high public health risks. After a hurricane, large volumes of debris and construction waste are created that need proper collection, treatment and disposal. An integrated waste management strategy should be designed with these events in mind.

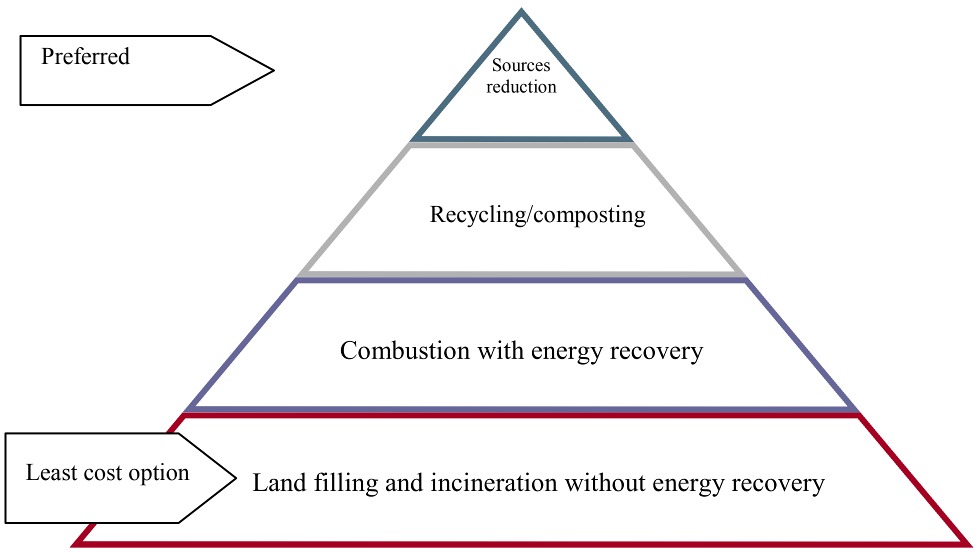
5. WASTE MANAGEMENT PRACTICES IN THE CARIBBEAN

5.1 Waste Management Systems

There are several commonalities in current Caribbean waste management systems. Waste materials are blended or contaminated with toxic components, due to limited know-how on separate collection alternatives and the perception that such waste collection processes are complex and expensive. Municipal solid waste is usually collected through labour-intensive means, in most cases by manually unloading containers to the collection truck.

The mixing of waste limits re-use, recycling and conversion alternatives. This practice also increases the costs and lowers the performance of existing waste treatment technologies. As the report of the Caribbean Regional Preparatory Meeting to review the Programme of Action for the Sustainable Development of Small Island Developing States[9] expressed, it is difficult to promote recycling initiatives due to inefficiency, financial constraints and limited scope of economies of scale. Additionally, the overall cost of waste disposal becomes higher, which explains the use of least-cost options such as dumpsites or landfills in most Caribbean nations. Figure 5 below shows the general waste treatment and disposal hierarchy within a waste management scheme (based on Schönning, 2006).

Figure 5
Waste Management Hierarchy



In some cases, agricultural equipment (trucks and tractors) is used to transport, deposit and compact waste in landfills. Waste is sometimes burned in the open to increase space volume. Other events or risks related to current landfill operation practices are:

- Scavenging and pests distribution;
- Spontaneous fires in dry conditions;
- Limited or no collection and treatment of leachate water;
- Lack of proper sorting and depositing; and
- Complexities with transporting, locating and compacting waste in wet conditions.

Hazardous materials and medical waste are not separated or handled in compliance with international safety standards because regulatory frameworks and enforcement agencies to monitor such waste treatment are either lacking or ineffective.

[9] The Caribbean Regional Preparatory Meeting to Review the Barbados Programme of Action for the Sustainable Development of Small Island Developing States was held in Port of Spain, Trinidad, October 6–10, 2003 see: http://www.un.org/special-rep/ohrlls/sid/Final_Report_of_the_Caribbean_Regional_Meeting_on_SIDS.pdf

5.2 Waste Management Statistics

Table 3 shows the percentage of the population served by a MSW collection system and the amount of waste generated by households, and industrial and commercial activities, in Caribbean OAS member states. Solid waste generation in the Caribbean ranges from about 27,000 to 945,000 metric tons per year. It should be noted that publicly available information is either limited or outdated.

Table 3
Waste Generation (weight or volume)

OAS Member States	Pop. Served by MSW collection (%/year)	Waste generated (000 metric tons) or (000 cu. Meter)			Total
		Industry	Commercial Activities	Households	
Antigua & Barbuda	100 (2005)			21 (2005)	?
Bahamas			n.d.	n.d.	239 (1998)
Barbados			n.d.	n.d.	329 (2005)
Belize	51.2 (2003)		524 (1997)	39 (1997)	563 (1997)
			525 (1998)	n.d.	?
		775 (2000)	561 (1999)	86 (2003)	?
Dominica	94 (2005)			21 (2005)	?
Dominican Republic	59.5 (2002)			1,016 (2005)	?
Grenada			n.d.	24 (2000)	?
Guyana			12 (1995)	31 (1995)	43 (1995)
			13 (1998)	34 (1998)	47 (1998)
			16 (2000)	41 (2000)	57 (2000)
Haiti					
Jamaica	76 (2001)		239 (1995)	358 (1995)	597 (1995)
			n.d.	n.d.	945 (1999)
			.	709 (2004)	?
St. Kitts & Nevis					?
St. Lucia			59 cu.m (1998)	114 cu.m (1998)	202 cu.m (1998)
			98 cu.m (1999)	138 cu.m (1999)	260 (1999)
			107 cu.m (2000)	135 cu.m (2000)	263 (2000)

St. Vincent & the Grenadines	100 (2002)		16 cu.m (2000)	11 cu.m (2000)	27 (2000)
					38 (2002)
Suriname					?
Trinidad & Tobago	90 (1995)	8 (1996)		425 (2002)	?
Sources: The Caricom Environment in Figures 2002, CARICOM retrieved from: http://www.caricomstats.org/Environpub.htm, Bahamas Environmental Science and Technology (BEST) Agency, Barbados Solid Waste Management Program see: http://www.solid.gov.bb, Environmental Statistics Country Snapshot, United Nations Statistics Division.					

Waste statistics are limited, unreliable and not regularly updated or made public. Without this crucial information it is difficult to enable policy makers, international organizations, the private sector, NGOs or other stakeholders to draft legislation, concept notes or action plans that are responsive to the region's waste management challenges. A comprehensive waste management program should comprise the compilation of relevant information on waste (i.e., amount of waste, waste composition, and potential uses of collected waste).

Waste composition is an important issue which should not be overlooked. Readily available information about the type of waste being generated is important to enable the drafting of an integrated waste management strategy. Major changes from organic to non-organic waste, constitute an additional challenge to the implementation of solid waste treatment technologies. Table 4 shows the municipal solid waste composition of two Caribbean nations.

Table 4
Municipal Solid Waste Composition in the Caribbean (by % of total)[10]

Component	St. Kitts	Trinidad and Tobago
Organics	27.2	26.7
Paper	20.5	19.7
Glass	8.1	10.5
Metals	8.8	10.4
Plastics	23.2	19.9
Textiles	7.4	7.3
Others	4.8	5.3
Organic fraction	47.7	46.4

The example above shows that organic municipal solid waste represents 40 to 50 percent[11] of the total volume of waste generated in St. Kitts and Trinidad and Tobago. This is an important piece of information to be taken into account if a country is considering bio-waste to energy options.

[10] Source: Garraway, 2002.
[11] The organic fraction is considered the sum of the categories organics and paper.

5.3 Regulatory Framework and Investments

Other important issues in waste management activities in the region are the definition and implementation of legal frameworks and regulations; investment needs and opportunities; and public education and participation. Some Caribbean nations such as Barbados, the Bahamas, St Kitts and Nevis, and Dominica have started regulating waste management practices as part of environmental protection measures. With regard to funding needs and opportunities, most countries have made important investments mainly in waste collection processes. Barbados, Belize, Jamaica, and Trinidad and Tobago resorted to external sources of funding to upgrade their waste management infrastructures. The waste management authorities of many Caribbean countries initiated public education programs geared toward encouraging public participation in solid waste management, including waste reduction, prevention of littering, and elimination of illegal dumpsites, among others.

The following are some external funds or technical assistance provided to the Caribbean nations for improving their waste management in the last decades:

- In 1993 a Solid Waste Management Program was commenced in Barbados, which entered into an agreement with the Inter-American Development Bank (IDB) and was integrated into the National Health Sector Development Plan (1993-2000);
- In 1995 the Organization of Eastern Caribbean States (OECS), including Antigua and Barbuda, Dominica, Grenada, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines, initiated the OECS Solid and Ship-Generated Waste Management Project with a duration of 8 years with financial resources in the form of grants, credits and loans from multiple development banks such as the World Bank;
- In 1998 the IDB provided a loan to the Government of the Bahamas for the creation of a Solid Waste Management Program; and
- In Jamaica the National Solid Waste Management Authority (NSWMA) (McHargh, 2004) was established in conjunction with the National Solid Waste Management Programme through the enactment of the 2001 National Solid Waste Management Act. Through this Act, the NSWMA is responsible for regulating the processing and disposal of household and municipal solid waste. It also aims at regulating the recycling, storage, transportation, treatment and disposal of household waste island wide.

As the Experts Workshop on Environmentally Sound Technologies for Integrated Waste Management for Caribbean SIDS highlighted in December 2003, other initiatives in the Caribbean include:

- Support for Bahamas and Montserrat in landfill management;
- Support for Dominica in sanitary landfill monitoring;
- Support for Pan American Health Organization (PAHO) and Guyana in analyzing the solid waste sector;

- Support for evaluation of solid waste management services in the OECS and French Caribbean territories;
- Development of solid waste indicators for the OECS; and
- Assumption of responsibility for the Wider Caribbean Solid Waste and Recycling Alliance (known as RECARIBE)

In the international arena, several Caribbean nations have ratified conventions on the environment, such as the International Convention for the Prevention of Pollution from Ships (MARPOL), the Protocol Concerning Pollution from Land-based Sources and Activities in the Wider Caribbean Region (LBS) and the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (BASEL). Table 5 shows the multilateral environmental agreements ratified by Caribbean OAS member states.

Table 5
Multilateral Agreements Impacting Waste Management in the wider Caribbean

Caribbean OAS Member States	MARPOL[12]	LBS[13]	BASEL[14]
Antigua and Barbuda	AN5		CP
Bahamas	AN4		CP
Barbados	AN4		CP
Belize	AN5		CP
Dominica			CP
Dominican Republic	AN5	S	
Grenada			
Guyana	AN5		
Haiti			S
Jamaica	AN5		
Saint Kitts and Nevis	AN5		CP
Saint Lucia			CP
Saint Vincent and the Grenadines	AN5		CP
Suriname	AN5		
Trinidad and Tobago			CP
Source: United Nations Environment Programme (UNEP), Caribbean Environment Programme (2008). Retrieved from : *http://www.cep.unep.org/law/cartstatus.html#cartagena*			

[12] The original International Convention for the Prevention of Pollution from Ships (MARPOL) Convention was signed on 17 February 1973, but did not come into force. The current Convention is a combination of 1973 Convention and the 1978 Protocol. It entered into force on 2 October 1983. As at 31 December 2005, 136 countries, representing 98% of the world's shipping tonnage, were parties to the Convention. 'AN' is the number of Annexes accepted by the State.

[13] The LBS Protocol is the Protocol concerning the Pollution from Land-Based Sources and Activities (adopted in Aruba, 1999) as part of the Cartagena Convention (1983), which is the only wider Caribbean binding regional environmental treaty which most Caribbean OAS Member States, with exception of the Bahamas, Guyana, Haiti, St. Kitts and Nevis and Suriname have ratified.

[14] The Basel Convention is the Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal. The CP means Contracting Party and S means Signature.

5.4 Performance and Recent Developments

Over the last decade, the Caribbean has experienced significant improvements in waste management. These include more efficient collection systems and the implementation of recycling programs (e.g., glass in Trinidad; plastic, aluminum, and glass in the French West Indies and Barbados; and the use of used oils for electricity generation, heat, and land-farming applications in Antigua). Specialized environmental units have been established to facilitate the regulation and monitoring of waste disposal sites in Barbados, where 60% of the waste generated is recycled. In the Bahamas, hazardous waste is sorted by type and new facilities were built with a storage capacity of 2 years. Additionally, tipping fees based on waste volume and type were implemented, environmental conservation levies on imported goods were introduced, and public awareness and education campaigns on adequate waste disposal were organized. However, health, environment, social, economic and financial challenges associated with waste management remain unsolved. Comprehensive waste-to-energy management practices can become an effective response to such challenges as they also have the potential to address energy generation needs in many Caribbean nations. The following sections describe the opportunities and challenges related to waste-to-energy alternatives.

6. WHY FOCUS ON WASTE-TO-ENERGY?

Waste-to-Energy offers a creative and effective response to two major concerns of Caribbean nations: waste management and energy generation. Typically, a ton of MSW contains about one-third of the heating value of coal (8-12 MJ/kg received as MSW and 25-30 MJ/kg for coal) (International Energy Agency (IEA) Bioenergy, 2003). Municipal solid waste has a higher energy content if compared to sugarcane bagasse[15] which is widely used for bio-ethanol production. On the other hand, many Caribbean landfills are reaching their maximum capacity and are occupying valuable lands that could be used for other more financially or socially beneficial purposes. Ever increasing electricity costs driven by a high dependency on imported fossil fuels are stalling the economic development of many Caribbean nations. Higher fuel prices also increase the costs for collection and transportation of waste to landfills. In this context, waste-to-energy alternatives are extremely attractive.

When considering the conventional waste management hierarchy, which aims to Reduce, Re-use, Re-cycle, Re-cover and finally Dispose of waste, the quantity and quality of municipal solid waste should be taken into consideration along with the projected generation and the financial, regulatory, and technical capacity. It should be noted that application of the conventional waste management hierarchy is challenging in the Caribbean region for reasons such as:

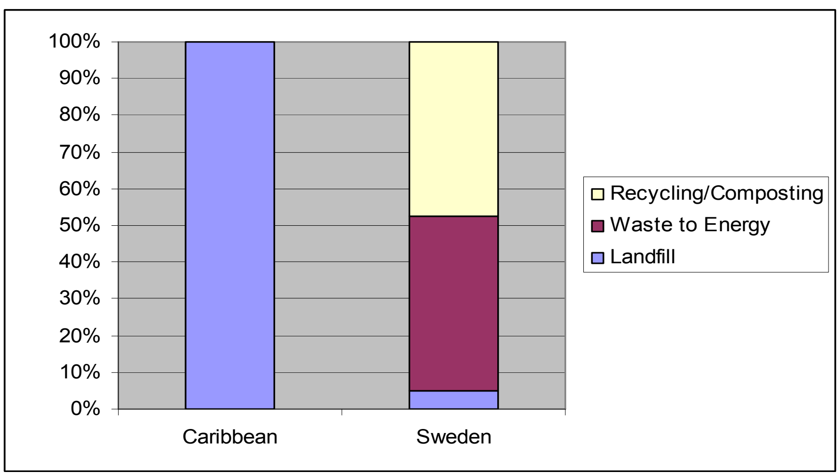
- There is no clear idea of how much waste is available and of what quality;
- Awareness on product re-use is limited and there are very few to no regulations to promote product re-use (limits re-use potential);

[15] Sugarcane bagasse has low heating values ranging from 4.8 to 9 MJ/kg.

- Awareness and incentives to enable adequate collection systems is most often limited to non-existent (limits recycling potential);
- There is limited economies of scale for recycling activities at the national level (limits in recycling potential particularly in SIDS);
- Waste comprises materials that are not recyclable, therefore it takes more energy to recycle them than it does to simply dispose of them;
- Landfills are quickly reaching their maximum capacity, thus there is a need to divert waste from landfills.

Although recycling activities seem limited in the Caribbean context, and they may be perceived as competing with other options in the waste management hierarchy, recycling and waste-to-energy go hand in hand. By improving recycling efficiencies for glass, plastic or metals, a cleaner or higher concentrated residual waste stream (e.g. organic waste stream) can be created that makes the application of waste-to-energy systems easier. In the next figure, one can see the current difference in waste treatment methods in the Caribbean compared to Sweden, a country that has managed to diversify its waste management system by incorporating waste-to-energy systems while maintaining high rates of recycling.

Figure 6
Difference in share of Waste Treatment Methods between the Caribbean Region and Sweden[16]



The Caribbean approach to waste management is focused almost exclusively on the use of landfills given the low price of land disposal and the low tipping fees. However, high fossil fuel prices are beginning to shift this paradigm and are becoming a great incentive to improve waste-to-energy solutions as a means to reduce energy costs and ameliorate energy security. Sweden is a good example of this, where only about 5% of the waste generated is dumped into landfills. The Swedish approach illustrates how recycling efforts go hand in hand with waste-to-energy alternatives.

[16] Source: Elaborated with data from the Swedish Environmental Protection Agency and the UNEP

6.1 Challenges to Waste-to-Energy in the Caribbean

The set up of an integrated waste management strategy requires the balancing of optimized waste reduction practices, recycling, recovery, and land filling of non-biodegradable waste. Waste-to-energy alternatives are just one segment of these complex interrelated waste treatment systems. Therefore a country or municipality should have a clear long term view and strategy in place with clear and practical objectives defined to assess and find the optimal balance to implement waste collection and treatment options.

When delving into the Waste-to-energy alternatives a holistic approach must be adopted. This requires a complete assessment of the sources of waste, the types and quantities of waste produced, the waste-to-energy conversion routes, and the possible energy carriers or byproducts. Figure 7 highlights some of these aspects.

Figure 7
Example of a National Waste Stream Scheme

Source: Imports, Tourism, Industry, Commerce, Residential, Agriculture, etc.

↓

Type of Waste: MSW, Sewage water, Ship-Generated waste, agricultural waste, wood waste, etc.

↓

Conversion route: digestion, fermentation, composting, incineration, bio-chemical treatment, etc.

↓

Energy carrier or product: biogas, landfill gas, heat, electricity, fertilizer, cellulosic ethanol, bio-oil, desalinated water, etc.

The opportunities for fostering efficient waste management towards energy savings or production in the Caribbean are fraught with major barriers. These barriers include:

- Lack of reliable information on waste management practices;
- Lack of basic waste generation and composition data;
- Regulatory frameworks to improve waste management performance are either ineffective or lacking;
- Lack of policy and legal frameworks linking waste management with environment and energy issues;
- Planning capacity in waste-to-energy systems is either poor or lacking;
- High degree of resistance toward waste-to-energy systems, partly because they are perceived as environmentally detrimental;
- No fiscal incentives to facilitate energy generation and energy efficiency from waste management;
- Centralization and decentralization of waste management responsibilities;

- Insufficient funding to finance the creation of waste-to-energy systems and the implementation of modern waste management strategies;
- Need to develop and define sustainability criteria for waste-to-energy alternatives.

Deficient, ineffective or out-of-date regulatory and institutional frameworks can become barriers to integrated waste management. For instance, the Bahamas must deal with more than 16 landfills located on several islands. This creates complex relationships among local governments with regard to the management, finance, and supervision of waste management activities. In some Caribbean countries, specific activities such as sewage collection and treatment, and disposal of urban and commercial waste all fall under the responsibility of different government agencies and private firms. It therefore becomes difficult to apply consistent and effective waste management standards.

6.2 Response by the Energy and Climate Division, OAS/DSD

The Department of Sustainable Development at the OAS, via its Energy and Climate Change Division is implementing several feasibility studies in the Americas with the particular focus on Waste-to-Energy development. In Belize, considerable potential for a cellulosic ethanol market is envisioned, but critical assessment is essential to confirm this potential. The OAS has recently executed an in-country assessment to identify waste streams within the forestry, agricultural and waste management sectors that may have the potential to serve as feedstock for cellulosic ethanol production (a waste-to-energy technology). In Chile, the OAS has developed a waste-to-energy initiative to assess the volume of municipal solid waste generated by the city of Santiago and to determine its composition. Based on this information, practical and commercially viable technologies and schemes for the conversion of municipal solid waste to energy will be identified. These are two examples of ongoing activities within the DSD to contribute to climate change mitigation, improvement of waste management, and provision of reliable and affordable energy services.

7. CONCLUSIONS

As long as there is human presence and therefore socio-economic activities and no major shifts occur in the way products are manufactured and consumed, waste will continue to be generated. Waste-to-energy systems are dependant upon the continuous supply of an indigenous energy source, “waste” to increase the energy security of a nation and bring about socio-economic benefits while protecting the environment.

In order to enable Caribbean nations to implement efficient and sustainable waste management technologies the following must be addressed:

- A considerable focus is needed on the collection, monitoring and publication of basic waste generation and composition data;
- A clear overview of energy sector challenges per-country is needed;

- A description of current implemented waste management strategies and their performance is needed to identify appropriate systems for small island states and other Caribbean nations;
- A country-by-country macro-economic interdependency mapping has to be developed to identify the greatest contributors to waste generation, the linkages among several sectors of the economy and the long term development projections;
- The is need for improved inter-departmental communication and share of responsibilities and physical and land use planning;
- It will be important to create awareness and develop an educational program for schools that teach children the concept of recycling and reusing from an early age (long term)
- Use of Clean Development Mechanism (CDM) and other Carbon Credit mechanisms under the Kyoto Protocol or Voluntary Carbon Trading systems.

It should be noted that Waste-to-Energy systems represent a part of an integrated waste management strategy and are not in all cases the most sustainable solution.

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