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Integrated Waste Management including Renewable Energy Limits and Potential for Waste Management to Energy Generation in the Caribbean

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I- **Introduction**

Waste accumulation constitutes a special concern for environmental health in many cities and communities in the Caribbean. The lack of information on waste management performance and sustainability within the region as well as the need for increasing the energy mix to facilitate greater opportunities for national and regional energy security and reduction of electricity prices are among the main motivations to foster waste management practices to energy generation.

This paper describes the current situation of waste management in the Caribbean, highlighting the challenges and opportunities for energy generation and energy efficiency from waste management activities.

II-**The concept of Waste and Waste-to-Energy**

In this paper, waste is not ill defined in the conventional terms as Municipal Solid Waste (MSW)[1] or industrial hazardous waste, nor as waste water. ***Waste*** is defined *as the material components, energy or substances formed and disposed of as results of industrial, service, 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) that impede socio-economic development*.

This broader definition of waste leads to the need of recognizing that waste is inexorably interlinked with energy, because all products manufactured required an amount of basic materials and energy to extract, manufacture and transport it. Also recognition is raised that proper and responsible waste management and disposal results in recovering large quantities of materials or chemicals without losing their original economic value in tandem with the highest possible energy recovery (in some cases expressed as energy savings).

The term ***Waste-to-Energy*** in this paper is used to describe the overall package of alternatives to collect, treat and dispose of waste in a matter that follows or respects the basic principles of integrated waste management as Re-duce, Re-use and Re-cycle with a specific focus on Re-cover. This in other words means energy recovery or savings, this may create confusion with the purpose of recycling but in some cases recycling may lead to high energy intensive or net negative energy balance activities with the aim to reach high level or quality marketable products. In contrast with 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. from waste and leachate water, RDF,

[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.

forest/agricultural waste to organic waste) using a much wider range of conversion routes into a diversity of energy carriers (e.g. from biogas, electricity, fuels to compost).

III- **Energy Demand in the Caribbean**

Energy is an essential resource for maintaining and developing the modern society in the Caribbean nations. Two main factors are driving the demand for reliable and affordable energy services, 1) the continued net population growth, the need and increase of economic activities where energy is indispensable and 2) the ever increasing challenge for energy security due to external global fossil fuel market developments leading to expensive petroleum derived fuels as jet fuel, diesel, fuel oil, or gasoline and increasing competition of access to basic energy resources for power production and transport fuels. The table 1 below lists key demographic and energy sector characteristics for the Caribbean OAS Member States.

Table 1. Overview of Caribbean Energy Statistics[2,3,4,5,6,7]

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†	140.0	100	.	1,810 *	0.22
Barbados	280,946	13,605	The Barbados Light&Power Company Limited	240	20,046	.	.	0.30
Belize	300,000	4,098	Belize electricity Limited, CFE and BECOL	52	.	.	.	0.22
Dominica	78,000	4,333	DOMLEC	24	429	135	564	0.45
Dominican Republic	.	4,147	.	.	.	.	.	0.172
Grenada	89, 703	5,571	GRENLEC	38.8	100	.	160*	0.30
Guyana	765,000[8]	1,365	Guyana Power and Light, Inc. (GPL), Linden Power Company Inc. (LPC) among others.	Less than 100	.	.	.	0.27
Haiti	8,500,000	630	Electricité d'Haïti (EDH)	270	2,785	.	.	0.26
Jamaica	2,780,132	4,172	Jamaica Public Service Company Limited (JPS)	Installed Cap. 621.7	158,000	.	.	0.25
St. Kitts & Nevis	45,000	10,143	St. Kitts Electr. Dept./ NEVLEC	34.5	1082	.	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*	0.30
Suriname	470,784	4,577	The Electric Utility Company of Suriname (EBS)	Less than 180	.	.	.	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

[2] Lambrides, M. et al., Project Document "Increasing the Sustainability of the Energy Sector in the Caribbean through Improved Governance and Management", Division of Sustainable Energy of the Organization of American States (OAS), 2006.
[3] Sources; http://www.barbadosenergy.com/ to convert: http://www.rigcooling.com/conversion_calculators/energy.htm (visited May, 2008)
[4] International Monetary Fund (IMF), World Economic Outlook, April 2008, website: http://www.imf.org/external/pubs/ft/weo/2008/01/weodata/weorept.aspx?sy=2006&ey=2013&scsm=1&ssd=1&sort=country&ds=.&br=1&c=311%2C336%2C263%2C313%2C316%2C343%2C339%2C361%2C321%2C362%2C243%2C364%2C366%2C369%2C328&s=NGDPDPC&grp=0&a=&pr1.x=46&pr1.y=11 (visited May, 2008).
[5] http://www.ttec.co.tt/announcements/revised_tarriff_structure/default.htm, http://www.blpc.com.bb/faqs/faqs.cfm?cat=Fuel_Adjustment,http://www.gasandoil.com/goc/company/cnl60460.htm, http://www.bel.com.bz/about_rates.asp, http://en.wikipedia.org/wiki/Electricity_sector_in_the_Dominican_Republic, http://www.grenadaworld.com/InvestorsGuide/Infrastructure/Electricity/tabid/493/Default.aspx,
[6] www.cehi.org.lc/.../Energy/ChristophMenkeInvestmentinRenewableEnergyandEnergyEfficiency%20Doesitpayback.pdf
[7] *Measured in Millions of kWh †Grand Bahama Island only ^Antigua Island only
[8] Estimated by UN 2003

In the Caribbean region it is important to differentiate between small island states (most of the Eastern Caribbean Islands), large island states (e.g. Jamaica, Haiti, Dominican Republic, Trinidad & Tobago, etc.) and low-lying coastal states (as 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 the energy and the waste issues.

On the other hand, while each of the countries 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 SIDS;
- Medium population size (300,000-8,500,000) for the larger Antilles;
- Low to moderate income levels;
- In most cases single monopoly electric utility (whether state or private owned);
- Small overall electricity generation capacity (installed capacity range 22-240 MW) in SIDS;
- Medium size generation capacities (240-1,400 MW) for larger islands;
- Petroleum dominates as fuel for power generation (only Dominica, Jamaica, Dominican Republic, Haiti, Suriname, and St. Vincent & the Grenadines have grid-installed renewables and small to large hydro);
- High average electricity costs (0.10-0.25 US$/kWh) for the wider Caribbean.

An important factor to the energy generation and transport for the Caribbean islands is that since the month of February of 2008, the international crude oil price has passed the US$100 per barrel price and has since followed a continued increasing trend. The figure 1 below, is an overview of the average international crude oil price development over the months February to May 2008.

Figure 1. International Average Crude Oil Price Development[9]

As of today the price has reached the US$ 134 per barrel point[10], which indicates that it is ever more crucial to develop energy alternatives from any indigenous renewable resources to cushion

[9] Source: Oil-Price.net website, http://oil-price.net/dashboard.php?lang=nl (visited 16 May, 2008)
[10] Source: http://oil-price.net/dashboard.php?lang=nl (visited 20-21 May, 2008)

the impact of the costly international fossil fuels. Waste materials contain considerable amount of energy and should therefore be considered as a source for energy generation or saving.

IV- **Waste impacts in the Caribbean**

During the 2008 International Coastal Cleanup Conference hosted 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 was debris from land based sources.[11] Such brief note exemplifies the magnitude of waste related issues in the Caribbean which, in many cases, ranges from deficient waste collection and disposal methods to poor information about the quantity of waste generated and its composition.

Tourism

Tourism is one of the most important economic activities in the Caribbean, contributing a third to a half of the GDP in most countries. The Caribbean is four times more dependant on tourism than any other region of the world with 22,281,000 stay-over visitors and 18,883,400 Cruise passengers a year (2005).[12] The Gross Visitor Expenditure sums to a total of US$ 21.5 billion of which 90% of all the foreign exchange spent by visitors is derived from those arriving by air. Being such an important economic pillar for Caribbean islands, tourism represents also one of the major areas of challenge to introduce a proper integrated waste management system.

Tourists generate 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.[13] Cruise ship passengers are estimated to produce as much as four times the amount of garbage per day as local populations.[14] 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 for hotels and other housing, and many are poorly maintained and provide limited benefits.[15]

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

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[11] UNEP tackling marine litter in the Caribbean, article retrieved from www.caribbeannetnews.com on April 24, 2008.
[12] Report No. 20453-LACJune 2000, TOURISM AND THE ENVIRONMENT IN THE CARIBBEAN: AN ECONOMIC FRAMEWORK DISCUSSION DRAFT, Environment Department The World Bank and The European Commission, Campbell, 1999
[13] University of the West Indies, 1999 (UWI, 1999)
[14] Report No. 20453-LACJune 2000, TOURISM AND THE ENVIRONMENT IN THE CARIBBEAN: AN ECONOMIC FRAMEWORK DISCUSSION DRAFT, Environment Department The World Bank and The European Commission, Campbell, 1999.
[15] Sweeting and others, 1998; UWI, 1999; CEHI, 1999

Table 2: Estimates of waste generation per passenger in Cruise Ships	
Waste generation (3,000 passenger ship) *1)*	**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)	?
Source: *1) Cruise Ship Pollution, available at http://www.surfrider.org/a-z/cruise.asp (visited May, 2008)*	

In addition, these ships take in large quantities of ballast water, which is seawater pumped into the hulls of ships to ensure stability. 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.[16] 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 legally/illegally discharged into the ocean. Although most ships are registered to 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.

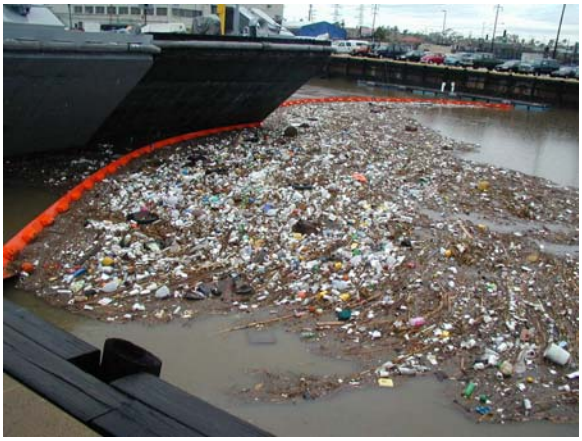

Figure 2. Example of waste reaching coastal shores[17]

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. This same coastal area consists also of major habitats for marine growth and animals which are reliant on vulnerable coastal mangroves, estuaries and coral reefs. The actual interaction between urban coastal areas and the sea is essential for its livelihood. Some cities in the Caribbean nations are among the highest density cities, with buildings not connected to a centralized sewage collection system nor proper waste collection facilities where in some cases waste water is discharged in sea. This type of pollution can cause a variety of problems, ranging from offensive odors, to

[16] Cruise Ship Pollution, available at http://www.surfrider.org/a-z/cruise.asp (visited May, 2008)
[17] Source: National Marine Debris Monitoring Program

algae blooms which make bathing unpleasant, to attracting jellyfish, and to serious health hazards.

The most common decentralized system is the use of septic tanks. Regularly a sewage truck collects waste water to transport to septic and sludge facilities. Hotel sectors are either connected to a sewage system or have simplified waste water treatment plants, this water output is generally used for irrigation and sludge brought to landfills.

Figure 3. Waste accumulation at coastal areas in the Dominican Republic[18]

Improper waste management

In many Caribbean islands, infectious medical wastes and toxic industrial wastes are not segregated from domestic waste (with the probable exception of radioactive materials), exposing the waste handlers to a wide array of risks. Where there is a high health risks from contact with human faecal matter, paper that may have become saturated with toxic materials, bottles with chemical residues, metal containers with residue pesticides and solvents, needles and bandages from hospitals, and batteries containing heavy metals. Exhaust vapours of waste collection trucks travelling to and from disposal sites, dust from disposal operations, and open burning of waste all contribute to communitarian's health problems, especially when located near residential areas. Another kind of health risk is related with the Bio-aerosols, incidence of pulmonary diseases, which are probably related to exposure to biologically active agents (e.g., microorganisms and their metabolites and toxins), volatile compounds, or mold spores.

Since many dumps or landfill have limited or no cover material, much of the rainfall runs over solid waste or infiltrates through solid waste extracts, dissolved and suspended constituents and thus becomes a contaminated liquid called leachate. As the waste decomposes through aerobic and anaerobic microbial action, waste-derived constituents increasingly become available to form leachate of greater toxic concentration. In the first several years after land disposal, leachate can reach high organic concentrations, with high concentrations of total dissolved solids, ammonia, nitrate, phosphate, chloride, potassium, as well as numerous heavy metals and refractory organic trace constituents (commonly including byproducts of decomposing solvents,

[18] Source: Waste accumulation at coastal areas in Santo Domingo, DR, September, 2002, website:http://www.callipygia600.com/allpictures/logpix/logpix.htm and http://www.callipygia600.com/allpictures/logpix/images/trash.jpg (visited May, 2008).

pesticides, and polychlorinated biphenols).[19] 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.[20] In cases of unprotected or no compliance to sanitary landfill design requirements, all this contaminated water infiltrates into the soil and contaminate the subterranean waters (which in many cases is the main source of fresh waters in the Caribbean islands). These generate a cycle of bacterial contamination that finally affects directly the population with limited resources and damages the general ecosystem.[21]

The Caribbean region is prune to weather related natural disasters as flooding in low lying coastal zones in Guyana and Suriname, increasingly intense and frequent occurring hurricanes in the eastern Caribbean islands. These events lead also to a large amount of waste water and solid waste generation, as water flooded in urban areas comes in contact with garbage, septic tanks or sewage systems carrying human wastes and distributes pathogen's and other dissolved toxics chemicals bringing people in direct contact. After hurricanes, as was the experience of Grenada, allot of debris and construction waste was created that need proper collection, treatment and disposal. An integrated waste management strategy should by designed with these events in mind.

V- **Waste Management practices in the Caribbean**

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 large cost factor to waste collection. Municipal solid waste commonly is collected through labour-intensive systems, in most cases by manually unloading containers to the collection truck. The mixed waste limits the re-use, recycling and conversion alternatives, increases the costs and lowers performance efficiencies of existing waste treatment technologies. Due to this inefficiency, financial constraints and limited scope due to limited economies of scale, it is difficult to promote recycling initiatives and also the overall cost of waste disposal becomes high which explains the large amount of application of the least cost option as a dump or the landfill in most Caribbean nations.[22] The next figure shows the options within a waste management scheme.[23]

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[19] Rein hart DR. A Review of Recent Studies on the Sources of Hazardous Compounds Emitted from Solid Waste Landfills: A US Experience. Waste Management and Research. Society Journal of the International Solid Waste Association. 1993; Vol. 11, No. 3: 257-68.

[20] Bessonov AS. Trichinellosis in the USSR (1983-1987), Tendency to Spreading. Wiadomosci-Parazytologiczne. 1992; Vol. 38, No. 3-4: 147-50.

[21] Author's conclusion

[22] REPORT OF THE CARIBBEAN REGIONAL PREPARATORY MEETING TO REVIEW THE PROGRAMME OF ACTION FOR THE SUSTAINABLE DEVELOPMENT OF SMALL ISLAND DEVELOPING STATES; www.sidsnet.org/docshare/other/20031104134625_Final_Report_of_the_Caribbean_Regional_Meeting_on_SIDS.doc

[23] Based in the concept of : Swedish Waste Management Magnus Schönning, First Secretary Embassy of Sweden Charting an Energy from Waste Future: Producing Clean Power from Municipal Biomass , Canadian Urban Institute Toronto, June 14 2006, The Sutton Place Hotel Embassy of Sweden, Ottawa, Magnus Schönning, First Secretary Embassy of Sweden http://www.canurb.com/media/Presentations/UL_19/MSchonning140606.pdf

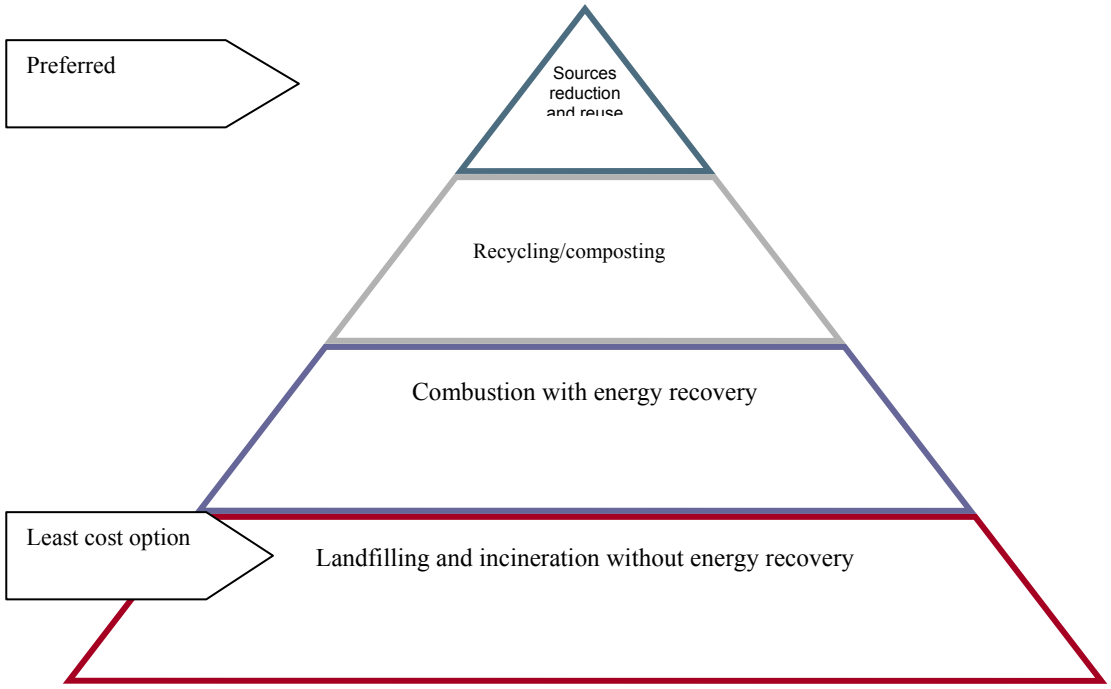

Figure 5. Waste Management Hierarchy[23]

Landfills are operated by using in some cases agricultural equipment (trucks and tractors) to transport, deposit and compact the waste in the landfill cell. In some cases the waste is burned in the open air to increase space volume, other types of events or risks related to current landfill operation practices are:

- Scavenging and Pests distribution
- Spontaneous fires in dry conditions
- No or limited collection and treatment of leachate water
- Lack of proper sorting and depositing
- Complexities with transporting, locating and compacting the waste in wet conditions

Hazardous materials and medical wastes are not separated or handled following international safety standards because in some cases the regulatory framework and enforcement system to control such wastes are usually non-existent or dysfunctional.

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, industrial and commercial activities in Caribbean OAS member states. Solid waste generation in the Caribbean ranges from about 27,000-945,000 metric tons per year. Note that the available information via public sources is very limited or in most cases 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)	?
Saint Kitts and 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 and the Grenadines	100 (2002)		16 cu.m (2000)	11 cu.m (2000)	27 (2000)
					38 (2002)
Suriname					?
Trinidad and Tobago	90 (1995)	8 (1996)		425 (2002)	?
Sources: The Caricom Environment in Figures 2002, CARICOM, 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 or not continuously updated or available via public media or means to enable policy makers, international organizations, private sector, NGO's or other stakeholders of Caribbean countries to draft legislation, concept notes or action plans to help resolving waste management challenges. This represents a great challenge for addressing the health, environmental, and other social and financial / economics matters linked to waste generation and waste collection. A comprehensive waste management program could incorporate the compilation of relevant information, i.e. amount of waste, waste composition, and potential use of the collected waste products.

Some countries as recently St. Kitts and Nevis, has undergone a shift in economic activities mainly from sugar cane production to tourism related activities that generated major changes in solid waste composition and challenges to the waste management authorities in these countries. In plain words, the waste composition is another important set of information to enable the drafting of an integrated waste management strategy. Major changes from organic to inorganic material, constitutes an additional challenge to the implemented 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)

Component	**St. Kitts** *1)*	**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

Source: 1) Garraway, E., Saint Kitts Solid Waste Characterization Study, OECS, Natural Resource Management Unit, Saint Lucia, 2002.

The organic fraction of the municipal solid waste is around the 40 – 50%, this is an interesting data when one considers bio-waste to energy options.

Regulatory framework and investments

Other important issues in waste management activities within 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 started regulating waste management activities as part of environmental protection measures. In regard to funding needs and opportunities, the majority of the countries make important investment mainly in waste collection process. Barbados, Belize, Jamaica, and Trinidad and Tobago have received external moneys for upgrading their waste management infrastructure.[24] Also, the waste management authorities of many Caribbean countries initiated public education programs oriented to encourage public participation in solid waste management, including waste reduction, prevention of littering, elimination of illegal dumps sites, among others.

[24] For more detail on this see the United Nations Environmental Programme island's website at http://islands.unep.ch/

Among the external funds or technical assistance provided to the Caribbean nations for improving the waste management in the last decades are:

- In 1993 a Solid Waste Management Program was commenced in Barbados, which entered into agreement with the IDB and was integrated into the National Health Sector Development Plan (1993-2000).[25]
- In 1995 the Organization of Eastern Caribbean States (OECS)[26] initiated the OECS Solid and Ship-Generated Waste Management Project with duration of 8 years with financial sources in the form of grants, credits and loans from multiple development banks as the World Bank.[27] An extension
- In 1998 the Inter-American Development Bank (IDB) provided a loan to Bahamian Government for the creation of a Solid Waste Management Program.[28]
- In Jamaica, in conjunction with the National Solid Waste Management Programme,[29] the National Solid Waste Management Authority (NSWMA),[30] established through the promulgation of the National Solid Waste Management Act, 2001. Through this Act, the NSWMA has responsibility for regulating the processing and disposal of domestic/municipal solid waste. It also aims to regulate the recycling, storage, transportation, treatment and disposal of domestic waste islandwide.

Another initiative in the Caribbean includes:[31]

- Support for Bahamas and Montserrat in landfill management;
- Support for Dominica in sanitary landfill monitoring;
- Support for PAHO and Guyana in analysing 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 Alliance for Solid Waste & Recycling (known as RECARIBE)

On the international arena, several Caribbean nations have pledged and ratified international environmental related conventions as the MARPOL, Cartagena and Basel conventions.[32] These should function as a binding regulatory framework that in some sense guarantees private investors, international banks or financial bodies, investment security and the continuation of environmental improvement activities, or in this case, the continuation of long-term

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[25] Barbados Solid Waste Management Program see http://www.solid.gov.bb/

[26] The OECS represents the islands of Antigua and Barbuda, Dominica, Grenada, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines.

[27] Source: World Bank website: http://web.worldbank.org/external/projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P006970

[28] Source: Bahamas Environmental Science and Technology (BEST) Agency

[29] GOJ/Inter-American Development Bank(IDB) funded programme to develop new institutional and legislative arrangements for the solid waste sector and improve the operations at Riverton Disposal Site.

[30] Solid Waste Management Initiatives in Jamaica by Mellissa McHARGH, March 2004 www.eclipsbiz.com/JIEP/M_Mchargh_solid_waste.pdf

[31] Experts Workshop on Environmentally Sound Technologies for Integrated Waste Management for Caribbean Small Island Development States (SIDS), December 16th – 19th 2003.

[32] Source: Bahamas Environmental Science and Technology (BEST) Agency

implementation activities of integrated waste management strategies. 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[33]**	**LBS[34]**	**BASEL[35]**
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 Environmental Program (UNEP), Caribbean Environmental Program, site http://www.cep.unep.org/law/cartstatus.html#cartagena			

Performance and recent developments

In general, over the last decades, there have been significant improvements in the waste management industry in the Caribbean. These include more efficient collection systems, the development of some recycling programs, i.e. 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, and as a lubricant in Trinidad, as well, specialized environmental unit has been established to facilitate the regulation and monitoring of waste disposal sites in Barbados. Nowadays, in Barbados 60% of the total generated waste is collected by the private sector for recycling purposes.[36] In the Bahamas, new facilities were constructed with storage capacity of 2 years in order to sort hazardous waste by class type in order to ship[37]. Also, tipping fees based on tonnage of waste and waste type, environmental levies were introduced on imported goods, public awareness and education campaign were held on proper waste disposal.

[33] 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, are parties to the Convention. The AN is the amount of Annexes accepted by the State.

[34] 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), this is the only wider Caribbean binding regional environmental treaty of which most Caribbean OAS Member States are, with exception of the Bahamas, Guyana, Haiti, St. Kitts and Nevis and Suriname have ratified the Treaty.

[35] 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.

[36] Barbados Solid Waste Management Program see http://www.solid.gov.bb/

[37] Source: Bahamas Environmental Science and Technology (BEST) Agency

But there is still a huge gap to overcome the health, environmental, social and economic/financial challenges related to waste management. The identification of comprehensive waste management activities to energy generation could represent an efficient respond not only to such challenges but also for addressing the needs of energy generation in many Caribbean nations. The following sections describe the opportunities and challenges related to waste-to-energy alternatives.

VI-**Why focus on Waste-to-Energy?**

Waste-to-Energy offers a creative and effective response to two main areas of concern for Caribbean nations, being waste and energy issues. Typically, a ton of MSW contains about one-third of the calorific value of coal (8-12 MJ/kg as received MSW and 25-30 MJ/kg for coal).[38] MSW has high energy content if you consider sugarcane bagasse for example (with low heating values from 4.8 – 9 MJ/kg)[39] that is widely being used for bio-ethanol production. Also, landfills are reaching their maximum capacities in islands with limited space and valuable lands that could be used for other land uses. The waste-to-energy technologies are of-the-shelf systems and have proven track records. The ever increasing electricity prices due to the high dependency on imported fossil fuels is stagnating the macro-economic development of many island nations and creates conditions to make waste-to-energy alternatives more profitable. Higher fuel prices also increase the costs for collection and transportation of waste to landfills.

When considering the conventional waste management hierarchy, which is following the order of first aiming to Re-duce, Re-use, Re-cycle, Re-cover and finally Dispose waste, one has to take in mind the quantity and quality of the municipal solid waste, the projected generation and the financial, regulatory, and technical capacity of the location where this waste management system is needed. Even though one aims to follow the chronologic order of the waste hierarchy in the Caribbean, in particular small island states, this is challenging since:

- There is no clear idea of how much and what quality of waste is available (long-term strategy?);
- There is limited awareness and there are limited or difficult enforceable regulations to promote and facilitate product re-use (limits re-use potential);
- There is limited awareness and incentives in place to enable separate or adequate collection systems (limits recycling potential);
- There is limited economies of scale for recycling activities (limits recycling potential);
- Unfortunately, our waste streams consist of some materials that are not technically or economically feasible to recycle. Some of them would require more energy to recycle and to dispose of; this is the reason for why it is useful to apply waste-to-energy in our context and reality;
- Landfills are quickly exceeding their landfill capacity where more land is needed to build additional cells, where in small islands this can be a great challenge (need for diversion from landfills);

[38] Municipal Solid Waste and its role in Sustainability, A position paper prepared by IEA Bioenergy, EIA Bionergy, February, 2003.
[39] Sugar Energy Library, website: http://www.sugartech.co.za/extraction/bagasseCV/index.php (visited May 2008).

For the time being, sustainable Waste-to-Energy systems have the potential to improve pollution prevention and environmental health while creating better social and economic opportunities and conditions, by providing jobs, triggering the growth of new small industries or environmental services and lowering the waste collection and treatment costs. Such potential gains could signify a tremendous response to the current environmental and socio-economic challenges among the Caribbean countries.

Although the above mentioned reasons for limits of recycling activities seem in competition with other options in the waste management hierarchy, recycling and waste-to-energy go hand in hand. By improving recycling efficiencies, a cleaner or higher concentrated residual waste stream can be created that makes the application of waste-to-energy systems easier. In the next figure, it is possible to see the current difference in waste treatment methods in Caribbean compared to Sweden.[40]

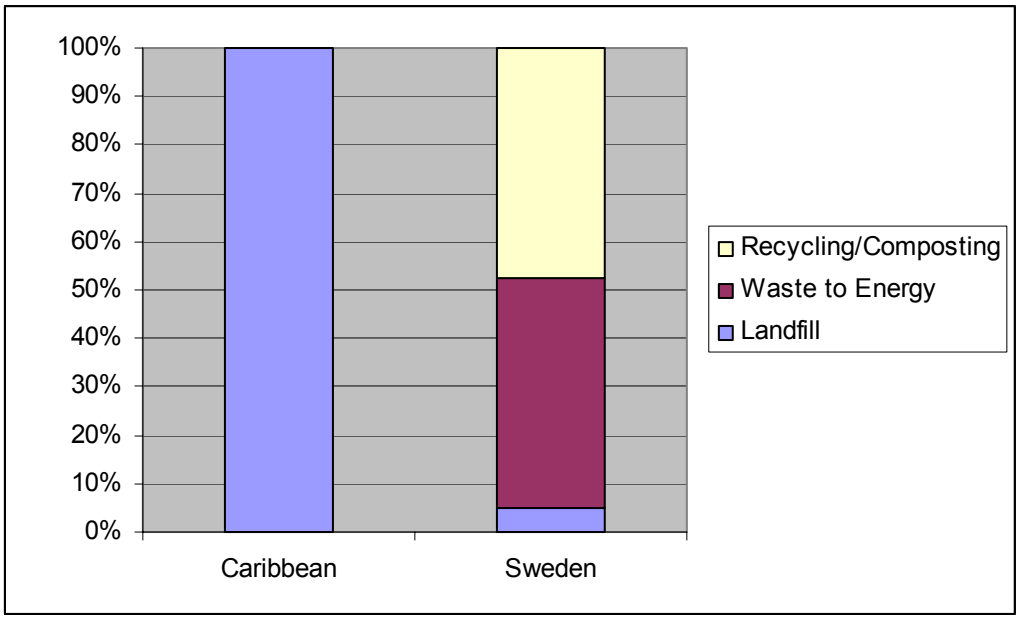


Figure 6. Difference in waste treatment methods between Caribbean and Sweden[41]

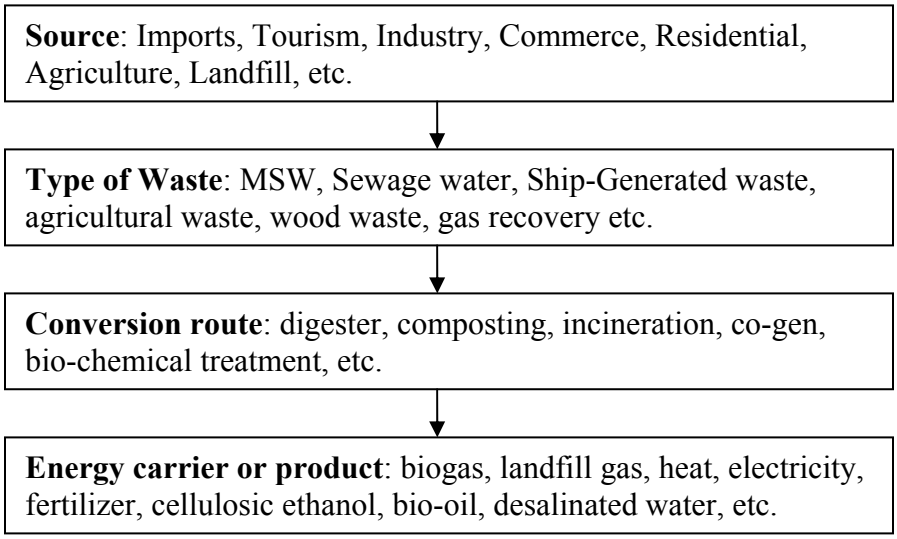
The Caribbean approach has for decades been focused on using landfills. And was in principle based on the low price of land disposal and low tipping fees to landfills that made this option more profitable compared to waste-to-energy options. But the high fossil fuel prices have shift the paradigm and have created an excellent incentive to improve waste-to-energy solutions as a way to decrease the energy prices and become less dependant on external fuel sources. Sweden is a good example where only about 5% of the generated waste is brought to the landfill. Also one can realize that recycling efforts go hand in hand with waste-to-energy alternatives.

[40] Swedish Environmental Protection Agency: www.naturvardsverket.se/
[41] Swedish Environmental Protection Agency: www.naturvardsverket.se/

VI-**Challenges to Waste-to-Energy**

Setting up integrated waste management strategies is a challenging balancing act between optimization of waste reduction, recycling, recovery activities, and landfilling of inert waste (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 one has to start with a holistic approach, this means that a complete national overview is required of the sources of the generation of waste, the types of waste produced, the possible waste-to-energy conversion routes and the final energy carrier or (by)-products outcome. See the next scheme that highlights these issues.



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

- Lack of reliable information on waste management practices applied in the Caribbean;
- Lack of basic waste generation and composition data;
- Weak and/or lack of regulatory framework to improve waste management performance;
- Lack of policy and legal frameworks linking waste management, environmental and energy issues;
- Poor or lack of resources planning to enhance the socioeconomic and environmental benefits from waste to energy;
- There is still a degree of public and political resistance towards waste-to-energy, partly since people perceive this as a waste-to-energy power plant with limited gas cleaning technologies to guarantee acceptable levels of emissions;
- No fiscal incentives to facilitate energy generation and energy efficiency from waste management;
- The challenge of centralizing or decentralizing waste management responsibilities;

- The needs for the commitments made to be honored by the international community;
- The need for the identification of funding at the national; intraregional and interregional levels;
- The capital investment in waste-to-energy power plants is considered prohibitive for Caribbean nations;
- The need to develop and define sustainability criteria for waste-to-energy alternatives.

The regulatory framework can be a barrier to foster integrated waste management if not well defined, for instance a country as the Bahamas has to deal with more than 16 landfills on separate island groups. This can create a complex relationship between departments of the local and centralized government for the management, finance, and supervision of waste management activities. In some Caribbean countries the specific activities as sewage collection and treatment, the collection, the treatment and the disposal of urban and commercial waste all fall under the responsibility of different government departments or the private sector. When there is no coherent management, events as privatized landfills being located in poorly located (e.g. near airports, wetlands, residential areas, water well fields or other areas with high groundwater tables) can occur and should be prevented.[42]

VII- **Conclusions**

As long as there is human presence and therefore socio-economic activities, waste will continue to be generated. Population growth, continuous changing economic activities, and further development and availability of products, all will results in a continuous increasing generation of waste. From the point of view of waste-to-energy there is a constant indigenous energy source supply to increase the energy security of a nation, given that this is done under strict sustainable development criteria.

In order to enable the Caribbean nations to select efficient and sustainable waste management technologies the following points of action are needed:

- A considerable focus is needed on the collection, monitoring and publication of basic waste generation and composition data;
- A clear overview of energy challenges is need per country;
- 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 performed to highlight the greatest contributors to waste generation and the inter-linkages between the several sectors of the economy and the long term development projections;
- Need for improved inter-departmental communication and share of responsibilities and physical and land use planning;
- Create conscious and develop an educational program in the schools to improve the recycle and reuse concept from childhood (long term)

[42] Source: Bahamas Environmental Science and Technology (BEST) Agency

- Use of Clean Development Mechanisms (CDM) and other Carbon Credit mechanisms under the Kyoto Protocol or Voluntary Carbon Trading systems.

Note that Waste-to-Energy systems only represent a piece of the complete picture and are not in all cases the most sustainable solution, therefore they should only be applied conform to a well defined integrated waste management strategy by the country in question.